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SECTION 01 11 10

SUMMARY OF WORK

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

This section covers a general description of the work required to upgrade the Tyee Lake Powerhouse Station Service System. This section is a general summary of the required work and is not all-inclusive. The work described within these specifications shall include but is not necessarily limited to the following:

a. Provide a written Sequence of Work describing the Contractors approach to replacing the 480V switchgear with minimal plant outages. Including work to be completed and equipment to be demolished prior to outages, outage plans, and demolition plans. The Contractor's Sequence of Work will be provided within 60 days of Notice to Proceed. Reference section 01 12 16.00 28 WORK SEQUENCE for outage requirements and Agency approach to work sequencing.

b. Agency shall provide transfer/trip schemes, auto diesel generator starts/stops, automation logic, SCADA programming, protective relay settings and annunciation systems prior to beginning commissioning. Contractor shall provide qualified personnel for installing and commissioning PLC programs, relay settings, transfer switch settings.

c. Provide a commissioning engineer to develop and submit to the Agency for approval a commissioning plan for all installed equipment.

d. Develop and submit to the Agency for approval logistics plans for shipping and delivery of equipment to the Tyee Lake facility prior to mobilization to site.

e. Develop and submit to the Agency for approval logistics plans for removal of equipment from the Tyee Lake facility.

f. Remove and dispose of two (2) 750kVA 13.8kV/480V transformers.

g. Remove and dispose of two (2) 480V Switchgear Cable Entrance Sections.

h. Remove and dispose of two (2) 15 kV Switchgear Sections.

i. Remove and dispose of one (1) 480 Switchgear.

j. Remove and dispose of all breakers and circuit cables from the Station Service Switchgear to the first point of termination.

k. Supply and install Eaton Magnum DS 1200A LV Switchgear line-up populated as indicated on the drawings.

l. Supply and install two (2) Eaton Type-C LV High Resistance Ground units integrated into Main Incoming section of switchgear as indicated on the drawings .

m. Supply and install two (2) ABB 500kVA, 13.8kV:277/480V Dry-type Transformers with integral primary termination compartments. Provide each transformer with TC-100 transformer monitors installed as part of the 480V switchgear.

n. Supply and install two (2) SEL-700G Generator Protective Relays as part of the 480V Switchgear.

o. Supply and install two (2) SEL-751 feeder protective relays as part of the 480V Switchgear.

p. Supply and install two (2) SEL-735 meters as part of the 480V Switchgear.

q. Supply and install one (1) PacSystems RX3i automation controller and I/O modules, communications modules, and remote modules to perform SCADA functionality, auto start-stop emergency diesel generation and other inherent integrated features.

r. Supply and install four (4) Eaton 480V, 400A Pow-R-Line panel boards (PPU1, PPU2, PPU3, & PDP-A) and one Eaton 480V, 250A Pow-R-Line panel board (PDP-A1). Panelboards to be populated as indicated on the drawings.

s. Supply and install one (1) Automatic Transfer Switch.

t. Supply and install one (2) Eaton 480V, 800A Pow-R-Line panel board populated as indicated on the drawings (PPCL & temporary).

u. Supply and install four (4) 15kV Breakers and switchgear.

v. Supply and install 480V & 15kV power conductors as specified on the drawings.

w. Supply and install 2(ea) 175KW diesel standby generators complete with 24hr fuel tanks and foundations. Remove and dispose of the existing standby generator and auxiliary equipment.

x. Supply and install power cables, instrumentation cables, network cables, current transformers (CT's), potential transformers (PT's), conduit, cable trays and ancillary equipment required for a complete and functioning system including programming of programmable logic controllers (PLC's), protective relays, arc flash protective schemes, metering and instrumentation relays.

y. Test and commission all installed equipment with the Agency's quality assurance personnel.

z. Train onsite personnel on all equipment functions, settings and safety requirements. Provide operations and maintenance (O&M) manuals for training and future operations and maintenance of all installed equipment.

aa. Solicit services of the Agencies Engineer to assist with update of relay settings and SCADA programming changes required during commissioning and startup.

1.3 CHANGES IN SPECIFICATIONS AND DRAWINGS

The Agency reserves the right to revise or amend the specifications and/or drawings prior to the date set for opening bids. Copies of such amendments will be furnished to all prospective bidders. If the revisions

and amendments require material changes in quantities or prices bid, or both, the date set for bid opening may be extended to enable bidders the opportunity to revise their bids. The amendment will include an announcement of the new date for opening bids.

1.4 DEFINITIONS

a. Wherever in the specifications, or upon the drawings, the words "directed", "required", "ordered", "designated", "prescribed", or words of like import are used, it shall be understood that the "direction", "requirement", "order", "designation", or "prescription" of the Agency is intended, and similarly the words "approved", "acceptable", "satisfactory", or words of like import shall mean "approved by" or "acceptable to" or "satisfactory to" the Agency unless otherwise expressly stated.

b. Where "as shown", "as indicated", "as detailed", or words of like import are used, it shall be understood that the reference is made to the drawings accompanying this contract unless stated otherwise.

c. The word "provided" as used herein shall be understood to mean "provided complete in place", that is, "furnished and installed".

d. Wherever in these specifications the work "weekend(s)" is used, it shall be understood to mean "Saturday, Sunday, and SEAPA Holidays", unless otherwise expressly stated.

e. Whenever in these specifications the word "Project" is used, it shall be understood to mean Tyee Lake Powerhouse.

f. Whenever in these specifications the words "dispose" is used, it shall be understood to mean completely removed from the Tyee Lake facility and not to remain onsite.

PART 2 - PRODUCTS - NOT USED

PART 3 - PRODUCTS - NOT USED

-- End of Section --

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WORK SEQUENCE

PART 1 GENERAL

The work covered by this section of the specifications consists of work common to more than one section of these TECHNICAL SPECIFICATIONS.

1.1 MAJOR ELEMENTS OF WORK

Tyee Lake Station Service Improvements Sequence of Work Summary:

This document describes the major elements of work to be performed during the Tyee Lake Station Service Improvements project. The intent of the Sequence of Work is to demonstrate a possible approach to reduce outages on Main Unit Generators to a minimum. The contractor shall submit a Sequence of Work to the Agency for approval within 60 days after Notice to Proceed. Sequence of Work submittals that do not demonstrate minimized outages similar to that as detailed below will not be accepted.

Work to be performed with NO outages

1.1.1 Install New Panelboards

Install new power panelboards PPU1, PPU2, PPU3, PPCL, the Automatic Transfer Switch, and the temporary 480V power panel in the new locations as specified on drawing TYEE-EL-4500 sheet 2. New panels PDP-A and PDP-A1 will need to be installed after panel HP-A has been uninstalled in future steps.

1.1.2 Temporary 480V Panel Feeders

Install and land temporary feeders from the temporary 480V panel to Power Panels PPU1, PPU2 & PPCL.

1.1.3 Install new Diesel Generators

Install new backup diesel generators EGEN-1 and EGEN-2 outside as well as all associated conduits as indicated on drawing TYEE-EL-4010 sheet 2.

1.1.4 Install New Conduits

Install new conduits from new panel boards to existing cable tray and devices as shown on the conduit layout drawings TYEE-EL-4500 sheets 1 through 3.

1.1.5 Pull New Feeders

Install new feeder cables (but do not terminate until future steps) from new panels PPCL, PPU1, PPU2, PPU3, PDP-A and PDP-A1 to the existing equipment as depicted in the cable schedule and in drawing TYEE-EL-4500 sheets 1 through 3. In cases where the cable needs to be run in an existing conduit that is already full, coil the remainder of the cable at the entry point of the conduit. These cables will be pulled through in

future steps.

Work to be performed with U2 Generator Outage

1.1.6 Transformer T2

De-energize Unit 2 generator. Isolate Station Service 750kva T2 transformer. Remove existing cable connections to T2 transformer. Remove switchgear bus and section of switchgear. Using existing switchgear section, install temporary cable to 480V temporary panel. Install contractor provided cover plate. The 750kva T2 transformer and temporary 480V panel will be used to provide temporary power to power panels PPU1, PPU2, and PPCL throughout construction to minimize outages. The temporary power panel breakers shall be sized according to the temporary one-line (see drawings for temporary 1-line), and will be used for spare PPCL panel breakers following completion of project.

1.1.7 Unit 2 Feeders

Isolate Unit 2 auxiliary equipment feeders from existing panels PDP-A & PDP-B, ensure feeders are not energized, remove old feeder cables and install new equipment feeders to the new PPU2 panel.

Test and perform interim commissioning on above equipment. After testing, U2 generator to remain de-energized until later when PPCL and PDP-A/PDP-A1 feeders are installed.

Work to be performed with U1 & U2 Generator Outages (10 hr maximum)

1.1.8 Demo Panel HP-A and Install Panels PDP-A & PDP-A1

De-energize Unit 1 generator. Isolate all feeders from existing panel HP-A, ensure feeders are not energized, identify and label feeder cables, disconnect from HP-A and leave coiled in place. Demo panel HP-A and install panels PDP-A & PDP-A1 in its place as shown on elevation drawing TYEE-EL-4100/1. Connect coiled equipment feeders from this step to new panels PDP-A & PDP-A1.

1.1.9 Station Auxiliary Feeders

Isolate station auxiliary feeders from existing panels PDP-A and PDP-B, ensure feeders are not energized, remove old feeder cables to the first point of termination and install new equipment feeders to the new PPCL, PDP-A and PDP-A1 panels.

1.1.10 Miracle Span & PDP-M Feeders

Disconnect the feeders for the Miracle Span Building panel and the Maintenance Building panel, PDP-M, from the 480V station service switchgear.

PDP-M: provide new conductors from PPCL and Manhole 2. Splice existing conductors in manhole.

Miracle Span Bldg: Provide new conductors from PPCL in existing conduit to new miracle span splice box.

1.1.11 Perform phase sequence checks and test all installed circuits.

After testing and performing interim commissioning on above equipment, energize U2 generator and synchronize to grid.

Work to be performed with U1 Generator Outage

1.1.12 Unit 1 Feeders

Isolate Unit 1 auxiliary feeders from existing panels PDP-A & PDP-B, ensure feeders are not energized, remove old feeder cables to the first point of termination and install new equipment feeders to the new PPU1 panel.

Test and perform interim commissioning on above equipment. After testing, U1 generator to remain de-energized until later when the new 480V station service switchgear is installed.

1.1.13 Demo existing emergency diesel generator

Place existing emergency diesel generator in manual control and isolate. Remove old feeder cable from diesel generator to 480V switchgear and demo old diesel generator.

1.1.14 Demo old metal-enclosed 480V switchgear and the old T1 750kva transformer, leaving existing station service 750kva oil filled transformer T2 energized and in existing location for the temporary feeders connected to the 480V temporary panel.

1.1.15 Install new metal enclosed 480V switchgear and new station service T1 500kva dry-type transformer.

1.1.16 Demo old metal-enclosed 15kV U1 generator switchgear.

1.1.17 Install new metal-enclosed 15kV U1 generator switchgear.

1.1.18 Install T1 to 15kV U1 generator switchgear feeders.

Test and perform interim commissioning on above equipment.

1.1.19 Install PPU1 feeders from new metal-enclosed switchgear breaker to power panel PPU1 and remove temporary feeder from 480V temporary panel.

1.1.20 Install EGEN-1 and EGEN-2 feeders from new metal-enclosed switchgear breakers to the new backup diesel generators.

Work to be performed with U1 and U2 Generator Outages (4hr max duration)

1.1.21 Install ATS/PPCL feeders from the new metal-enclosed switchgear breaker to the ATS for Power Panel PPCL and remove temporary feeder from 480V temporary panel.

1.1.22 Energize Generator U1 and synchronize to the grid. Energize new switchgear Main bus, power panels PPU1 and PPCL from the T1 500kva transformer through the new metal-enclosed 480V switchgear.

Work to be performed with U2 Generator Outage

1.1.23 Install PPU2 feeders from the new metal-enclosed switchgear breaker to power panel PPU2 and remove temporary feeder from 480V temporary panel.

1.1.24 Demo the the old, T2 750kva transformer.

1.1.25 Install the new T2 500kva dry-type transformer and connect the bus.

1.1.26 Demo old metal-enclosed 15kV U2 generator switchgear.

1.1.27 Install new metal-enclosed 15kV U2 generator switchgear.

1.1.28 Install T2 to 15kV U2 generator switchgear feeders.

Work to be performed with single Unit Outages

The following work consists of connecting, testing and commissioning annunciation, auto start/stop diesel generation, PLC and data acquisition and control. With the tie breaker open and a single main unit generator online, half of the circuits can be commissioned at a time with no interruption to generation of a single generator at a time.

1.1.29 Install and test annunciation circuits.

1.1.30 Install and test data acquisition and control logic to PLC.

1.1.31 Install and test auto start/stop functionality of emergency diesel generation.

1.1.32 Install and test breaker electrical interlocking schemes.

Note: Testing of breaker interlocks may require a multiple unit outage to minimize risk of synchronizing diesel generators to system grid out of phase, Contractor to verify.

1.1.33 Complete commissioning of all systems

1.2 SUBMITTALS

Agency approval is required for the following submittals:

SD-01 Preconstruction Submittals

Sequence Of Work: The Sequence of Work shall be submitted for approval within 60 days after notice to proceed.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

-- End of Section --

SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.1 DEFINITIONS

1.1.1 Submittal Descriptions (SD)

Submittals requirements are specified in the technical sections. Submittals are identified by Submittal Description (SD) numbers and titles as follows:

SD-01 Preconstruction Submittals

Submittals which are required prior to mobilization to the site:

Certificates of Insurance

Surety bonds

List of Subcontractors

Product Submittals

Construction Progress Schedule

Network Analysis Schedule (NAS)

Submittal Register

Schedule of prices or Earned Value Report

Health and Safety Plan

Work plan

Quality Control(QC) Plan

Environmental Protection Plan

SD-02 Shop Drawings

Drawings, diagrams and schedules specifically prepared to illustrate a complete design for construction of the work.

Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Contractor for integrating the product or system into the project.

Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be coordinated.

SD-03 Product Data

Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions and brochures illustrating size, physical appearance and other characteristics of materials, systems or equipment for some portion of the work.

Samples of warranty language when the contract requires extended product warranties.

SD-04 Samples

Fabricated or unfabricated physical examples of materials, equipment or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged.

Color samples from the manufacturer's standard line (or custom color samples if specified) to be used in selecting or approving colors for the project.

Field samples and mock-ups constructed on the project site establish standards by which the ensuring work can be judged. Includes assemblies or portions of assemblies which are to be incorporated into the project and those which will be removed at conclusion of the work.

SD-05 Design Data

Design calculations, mix designs, analyses or other data pertaining to the project.

SD-06 Test Reports

Report signed by authorized official of testing laboratory that a material, product or system identical to the material, product or system to be provided has been tested in accord with specified requirements. Unless specified in another section, testing must have been within three years of date of contract award for the project.

Report which includes findings of a test required to be performed by this specification on an actual portion of the work or prototype prepared for the project before shipment to job site.

Report which includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.

Investigation reports.

Daily logs and checklists.

Final acceptance test and operational test procedure.

SD-07 Certificates

Statements printed on the manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that the product, system, or material meets specification requirements. Must be dated after award of project contract and clearly name the project.

Document required of Contractor, or of a manufacturer, supplier, installer or Subcontractor through Contractor. The document purpose is to further promote the orderly progression of a portion of the work by documenting procedures, acceptability of methods, or personnel qualifications.

Confined space entry permits.

Text of posted operating instructions.

SD-08 Manufacturer's Instructions

Preprinted material describing installation of a product, system or material, Material Safety Data Sheets (MSDS), and including special notices concerning impedances, hazards, and safety precautions.

SD-09 Manufacturer's Field Reports

Documentation of the testing and verification actions taken by manufacturer's representative at the job site, in the vicinity of the job site, or on a sample taken from the job site, on a portion of the work, during or after installation, to confirm compliance with manufacturer's standards or instructions. The documentation must be signed by an authorized official of a testing laboratory or agency and state the test results; and indicate whether the material, product, or system has passed or failed the test.

Factory test reports.

SD-10 Operation and Maintenance Data

Data that is furnished by the manufacturer, or the system provider, to the equipment operating and maintenance personnel, including manufacturer's help and product line documentation necessary to maintain and install equipment. This data is needed by operating and maintenance personnel for the safe and efficient operation, maintenance and repair of the item.

This data is intended to be incorporated in an operations and maintenance manual or control system.

SD-11 Closeout Submittals

Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.

Submittals required for Guiding Principle Validation (GPV) or Third Party Certification (TPC).

Special requirements necessary to properly close out a construction contract. For example, Record Drawings and as-built drawings. Also, submittal requirements necessary to properly close out a major phase of construction on a multi-phase contract.

1.2 SUBMITTAL REGISTER

Contractor shall prepare and maintain a submittal register, as the work progresses. Thereafter, the Contractor is to track all submittals by

maintaining a complete list.

1.3 SUBMITTAL PROCEDURE

The Contractor shall submit to the Agency for approval submittals as required per the specifications in this contract. The Agency will respond with an acceptance or unacceptance letter by email to the Contractor's project manager. Submittals that are not accepted will have an Agency response with the specific reasons identified. The Contractor will be required to modify the design, equipment and/or submittal to address the deficiency(s) and resubmit to the Agency for approval. All submittals shall be submitted via email to the Agency's Representative. The Agency will notify the Contractor if the Agency's designated representative has changed and provide contact information for future submittals.

a. Submittal form: Provide submittals in electronic format, Adobe PDF or compatible PDF format. Coordinate with AGENCY for electronic transfer procedures.

SECTION 01 78 00.00 28

CLOSEOUT SUBMITTALS

PART 1 GENERAL

1.1 SUBMITTALS

The following shall be submitted in accordance with SECTION 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Warranty Management Plan
Two (2) sets of the warranty management plan containing information relevant to the warranty of materials and equipment incorporated into the construction project, including the starting date of warranty of construction. Furnish with each warranty the name, address, and telephone number of each of the guarantor's representatives nearest to the project location.

Warranty Tags
Two (2) record copies of the warranty tags showing the layout and design.

SD-10 Operation and Maintenance Data

System Training Manuals

Draft Operation and Maintenance Manuals and Parts Catalogs

Final Operation and Maintenance Manuals and Parts Catalogs

SD-11 Closeout Submittals

Contractors Red-Line As-Built Drawings

Final Approved Versions of As-Built Drawings

PART 2 PRODUCTS

2.1 OPERATIONS AND MAINTENANCE DATA

Operations and Maintenance Data shall cover the equipment required to be included in the O&M manual as specified in section 01 78 23.00 28 OPERATION AND MAINTENANCE DATA. Operations and Maintenance manuals and parts catalogs shall contain the following information:

a. Manufacturers' Owner's Manuals for all new equipment and operating systems.

b. Comprehensive Maintenance Table of all new equipment, and components.

c. List of spare parts and required maintenance supplies, including manufacturer's and Contractor's part numbering references.

d. Contractor's and Sub-Contractor's contact information.

e. Manufacturers' and Suppliers' contact information.

f. Warranty information on all new equipment and components.

g. Most recent Shop Drawings of all equipment and operating systems.

2.2 TRAINING

Provide information available from the manufacturers that is needed for use in training designated personnel to properly operate and maintain the equipment and systems. The Contractor shall provide the services of one or more authorized start-up engineers (Manufacturer's Representatives) as necessary to provide training in programming, operation and maintenance.

The training shall be provided for operators and maintenance personnel prior to project operation of the system. Provide at a minimum; two, four-hour class sessions; one class for operators and maintenance personnel to occur at the Tyee Lake Facility. A second training session shall be provided for both additional operators and maintenance personnel and include system managers and engineers. Each class session shall include enough material for a minimum class size of 5 students. Both training sessions shall occur prior to the Contractor leavingthe Tyee Lake Facility, and will not require a second trip to perform.

The Contractor shall submit system training manuals and documentation for approval 30 days prior to scheduled classes and shall furnish sufficient system training materials at the training classes for all students plus a minimum of 3 copies for project files. Whereaudio/visual materials are used in training classes, 3 copies of such materials shall be furnished to the Project for use in future training. It shall be the Contractor's responsibility to coordinate the training sessions with the Project to ensure minimum conflicts with ongoing Project work.

PART 3 EXECUTION

3.1 WARRANTY MANAGEMENT

3.1.1 Warranty Management Plan

Submit a warranty management plan in accordance with the requirements of this Section for Agency approval within 60 days prior to commissioning. Include within the warranty management plan all required actions and documents to assure that the Agency receives all warranties to which it is entitled. The plan shall be in narrative form and contain sufficient detail to render it suitable for use by future maintenance and repair personnel, whether tradesmen, or of engineering background, not necessarily familiar with this contract.

The term "status" as indicated below must include due date and whether item has been submitted or was accomplished. Assemble Agency approved information in a binder and turn over to the Agency upon acceptance of the work. The warranty period for workmanship shall be a one year period commencing immediately after the Agency has signed and dated a Notice of Completion of the project. The warranty period for materials and products shall also be for a one year period unless otherwise specified in specific Sections of the Technical Specifications.

The warranty period for materials and products shall commence upon the Agency's signed and dated Notice of Completion of the project.

The Warranty Management Plan must include, but is not limited to, the following:

a. Roles and responsibilities of all personnel associated with the warrantyprocess, including points of contact and telephone numbers within the organizations of the Contractors, sub-contractors, manufacturers or suppliers involved.

b. Listing and status of delivery of all Certificates of Warranty for extended warranty items.

c. A list for each warranted equipment, item, feature of construction or system indicating:

(1) Name of item.

(2) Model and serial numbers.

(3) Location where installed.

(4) Name and phone numbers of manufacturers or suppliers.

(5) Names, addresses and telephone numbers of sources of spare parts.

(6) Warranties and terms of warranty. Include one (1) year overall warranty of construction for workmanship. Items which have extended warranties must be indicated with separate warranty expiration dates. Refer to specific equipment warranties in other Sections contained herein.

(7) Cross-reference to warranty certificates as applicable.

(8) Duration of warranty period.

(9) Summary of maintenance procedures required to continue the warranty in force.

(10) Cross-reference to specific pertinent Operation and Maintenance manuals.

(11) Organization, names and phone numbers of persons to call for warranty service.

(12) Typical response time and repair time expected for various warranted equipment.

d. Procedure and status of tagging of all equipment covered by extended warranties.

e. Copies of instructions to be posted near selected pieces of equipment where operation is critical for warranty and/or safety reasons.

3.1.2 Contractor's Response to Construction Warranty Service Requirements

Following oral or written notification by the Agency, respond to construction warranty service requirements in accordance with the "Construction Warranty Service Priority List" and the three (3) categories of priorities listed below. Submit a report on any warranty item that has been repaired during the warranty period. Include within the report the cause of the problem, date reported, corrective action taken, and when the repair was completed. If the Contractor does not perform the construction warranty within the timeframe specified, the Agency will perform the work and backcharge the construction warranty payment item established.

a. First Priority Code 1. Perform onsite inspection to evaluate situation, and determine course of action within 48 hours of notification, initiate work within 72 hours of notification and work continuously to completion or relief.

b. Second Priority Code 2. Perform onsite inspection to evaluate the situation, and determine course of action within 7 days of notification, initiate work within 8 days of notification and work continuously to completion or relief.

c. Third Priority Code 3. All other work to be initiated within 3 work days of notification and work continuously to completion or relief.

d. The "Construction Warranty Service Priority List" is as follows:

(1) Code 1 - Transformers, Switchgear and HRG's

(2) Code 2 - Panelboards and Switchboards

(3) Code 3 - Relays, PLC's, Workmanship and all other warrantied items.

3.1.3 Warranty Tags

At the time of installation, tag each warranted item with a durable, oil and water resistant tag approved by the Agency. Attach each tag with a copper wire and spray with a silicone waterproof coating. The date of acceptance and the QC signature must remain blank until the project is accepted for beneficial occupancy. Show the following information on the tag.

a. Type of product/material_____.

b. Model number_____.

c. Serial number_____.

d. Contract number_____.

e. Warranty period_____from_____to_____.

f. Inspector's signature_____.

g. Contractor_____.

Address_____.

Telephone number_____.

h. Warranty contact_____.

Address_____.

Telephone number_____.

i. Warranty response time priority code_____.

j. WARNING - PROJECT PERSONNEL TO PERFORM ONLY OPERATIONAL MAINTENANCE DURING THE WARRANTY PERIOD.

3.2 MAINTAIN WORKING AS-BUILT CONTRACT DRAWINGS

The Contractor shall maintain a current and accurate record of the work as actually constructed in the form of working as-built drawings. Contractor shall mark as-built conditions on the contract drawings to show all work performed by the Contractor. As-built drawings shall incorporate all deviations from the design and modifications to the contract, however minor. Blue pencil shall be used to mark information added to the drawings and red pencil shall be used to mark information deleted from the drawings.

Contract drawings shall be maintained on-site duringconstruction. The completeness and accuracy of the marked as-built drawings must be verified by Agency Quality Assurance personnel prior to submission of progress payment requests. All deviations shall be noted on the updated As-Built drawings. The working as-built drawings shall be submitted to the Agency after all as-built conditions have been marked on both sets of drawings.

3.3 OPERATION AND MAINTENANCE MANUAL

Submit draft operation and maintenance manual and parts catalogs for approval at least 30 days prior to completion of on site work. The Agency will return a draft copy of the data either "APPROVED," or "RETURNED FOR CORRECTION." The Contractor shall resubmit corrections and additional data as directed by the Agency.

After final approval of the draft submission, the Contractor shall submit the final operation and maintenance manuals and parts catalogs for approval.

Assemble Operation and Maintenance Manual into an electronically bookmarked file using the most current version of Adobe Acrobat or similar software capable of producing PDF file format. Provide compact disks (CD) or data digital versatile disk (DVD) as appropriate, so that each one contains a complete O&M manual including operation, maintenance and record files, project record documents, and training videos. Include a complete bookmarked operation and maintenance directory.

3.3.1 CD or DVD Label and Disk Holder or Case

Provide the following information on the disk label and disk holder or case:
a. Project Title
c. Location
d. Construction Contract Number

e. Prepared For: (Contracting Agency)
f. Prepared By: (Name, title, phone number and email address)
g. Include the disk content on the disk label (i.e: O&M Manual)
h. Date

3.3.2 O&M Manual Tabbed Hard Copy

Provide one hard copy of the approved final version of the O&M manual upon completion of the project.

-- End of Section --

SECTION 01 78 23.00 28

OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.1 SUBMISSION OF OPERATION AND MAINTENANCE DATA

Submit Operation and Maintenance (O&M) Data specifically applicable to this contract and a complete and concise depiction of the provided equipment, product, or system, stressing and enhancing the importance of system interactions, troubleshooting, and long-term preventative maintenance and operation. The Contractor shall compile and prepare O&M data including clarifying and updating the original sequences of operation to as-built conditions. Organize and present information in sufficient detail to clearly explain O&M requirements at the system, equipment, component, and subassembly level. Include an index preceding each submittal.

1.1.1 Package Quality

Documents must be fully legible. Poor quality copies and material with hole punches obliterating the text or drawings will not be accepted.

1.1.2 Package Content

Data package content shall be as shown in the paragraph titled "Schedule of Operation and Maintenance Data Packages." Comply with the data package requirements specified in the individual technical sections, including the content of the packages and addressing each product, component, and system designated for data package submission, except as follows. Commissioned items without a specified data package requirement in the individual technical sections shall use a General Data Package.

1.1.3 Changes to Submittals

Manufacturer-originated changes or revisions to submitted data shall be furnished by the Contractor if a component of an item is so affected subsequent to acceptance of the O&M Data. Changes, additions, or revisions required by the Agency for final acceptance of submitted data, shall be submitted by the Contractor within 30 calendar days of the notification of this change requirement.

1.1.4 Review and Approval

The Contractors Commissioning Authority (CA) shall review the commissioned systems and equipment submittals for completeness and applicability. The CA shall verify that the systems and equipment provided meet the requirements of the Contract documents and design intent, particularly as they relate to functionality, energy performance, water performance, maintainability, sustainability, system cost, indoor environmental quality, and local environmental impacts. The CA shall communicate deficiencies to the Agency. Upon a successful review of the corrections, the CA shall recommend approval and acceptance of these O&M manuals to the Agency. This work shall be in addition to the normal review procedures for O&M data.

1.1.5 Electronic Copies

The Contractor shall provide electronic copies of the O&M material in the form of a CD-ROM. The CD's shall be submitted with the hard copies of the O&M manuals. The documents placed on the CD-ROM shall be in Adobe PDF. All documents shall be "Read Only."

1.1.5.1 O&M Database

Develop a database from the O&M manuals that contains the information required to start a preventative maintenance program.

1.2 TYPES OF INFORMATION REQUIRED IN O&M DATA PACKAGES

1.2.1 Operating Instructions

Include specific instructions, procedures, and illustrations for the following phases of operation for the installed model and features of each system:

1.2.1.1 Safety Precautions

List personnel hazards and equipment or product safety precautions for all operating conditions.

1.2.1.2 Operator Prestart

Include procedures required to install, set up, and prepare each system for use.

1.2.1.3 Startup, Shutdown, and Post-Shutdown Procedures

Provide narrative description for Startup, Shutdown and Post-shutdown operating procedures including the control sequence for each procedure.

1.2.1.4 Normal Operations

Provide narrative description of Normal Operating Procedures. Include Control Diagrams with data to explain operation and control of systems and specific equipment.

1.2.1.5 Emergency Operations

Include Emergency Procedures for equipment malfunctions to permit a short period of continued operation or to shut down the equipment to prevent further damage to systems and equipment. Include Emergency Shutdown Instructions for fire, explosion, spills, or other foreseeable contingencies. Provide guidance and procedures for emergency operation of all utility systems including required valve positions, valve locations and zones or portions of systems controlled.

1.2.1.6 Operator Service Requirements

Include instructions for services to be performed by the operator such as lubrication, adjustment, inspection, and recording gage readings.

1.2.1.7 Environmental Conditions

Include a list of Environmental Conditions (temperature, humidity, and other relevant data) that are best suited for the operation of each product, component or system. Describe conditions under which the item equipment should not be allowed to run.

1.2.2 Preventive Maintenance

Include the following information for preventive and scheduled maintenance to minimize corrective maintenance and repair for the installed model and features of each system. Include potential environmental and indoor air quality impacts of recommended maintenance procedures and materials.

1.2.2.1 Lubrication Data

Include preventative maintenance lubrication data, in addition to instructions for lubrication provided under paragraph titled "Operator Service Requirements":

a. A table showing recommended lubricants for specific temperature ranges and applications.

b. Charts with a schematic diagram of the equipment showing lubrication points, recommended types and grades of lubricants, and capacities.

c. A Lubrication Schedule showing service interval frequency.

1.2.2.2 Preventive Maintenance Plan and Schedule

Include manufacturer's schedule for routine preventive maintenance, inspections, tests and adjustments required to ensure proper and economical operation and to minimize corrective maintenance. Provide manufacturer's projection of preventive maintenance work-hours on a daily, weekly, monthly, and annual basis including craft requirements by type of craft. For periodic calibrations, provide manufacturer's specified frequency and procedures for each separate operation.

1.2.3 Corrective Maintenance (Repair)

Include manufacturer's recommended procedures and instructions for correcting problems and making repairs.

1.2.3.1 Troubleshooting Guides and Diagnostic Techniques

Include step-by-step procedures to promptly isolate the cause of typical malfunctions. Describe clearly why the checkout is performed and what conditions are to be sought. Identify tests or inspections and test equipment required to determine whether parts and equipment may be reused or require replacement.

1.2.3.2 Wiring Diagrams and Control Diagrams

Wiring diagrams and control diagrams shall be point-to-point drawings of wiring and control circuits including factory-field interfaces. Provide a complete and accurate depiction of the actual job specific wiring and control work. On diagrams, number electrical and electronic wiring and pneumatic control tubing and the terminals for each type, identically to actual installation configuration and numbering.

1.2.3.3 Maintenance and Repair Procedures

Include instructions and a list of tools required to repair or restore the product or equipment to proper condition or operating standards.

1.2.3.4 Removal and Replacement Instructions

Include step-by-step procedures and a list required tools and supplies for removal, replacement, disassembly, and assembly of components, assemblies, subassemblies, accessories, and attachments. Provide tolerances, dimensions, settings and adjustments required. Instructions shall include a combination of text and illustrations.

1.2.3.5 Spare Parts and Supply Lists

Include lists of spare parts and supplies required for maintenance and repair to ensure continued service or operation without unreasonable delays. Special consideration is required for facilities at remote locations. List spare parts and supplies that have a long lead-time to obtain.

1.2.4 Corrective Maintenance Work-Hours

Include manufacturer's projection of corrective maintenance work-hours including requirements by type of craft. Corrective maintenance that requires completion or participation of the equipment manufacturer shall be identified and tabulated separately.

1.2.5 Appendices

Provide information required below and information not specified in the preceding paragraphs but pertinent to the maintenance or operation of the product or equipment. Include the following:

1.2.5.1 Product Submittal Data

Provide a copy of all Product Data submittals required in the applicable technical sections.

1.2.5.2 Manufacturer's Instructions

Provide a copy of all Manufacturer's Instructions submittals required in the applicable technical sections.

1.2.5.3 O&M Submittal Data

Provide a copy of all Operation and Maintenance Data submittals required in the applicable technical sections.

1.2.5.4 Parts Identification

Provide identification and coverage for all parts of each component, assembly, subassembly, and accessory of the end items subject to replacement. Include special hardware requirements, such as requirement to use high-strength bolts and nuts. Identify parts by; make, model, serial number, the National Stock Number (NSN), current sources\vendor names for the parts, their respective addresses and telephone numbers, the purchase price, and current replacement costs for each part. Provide

clear and legible illustrations, drawings, and exploded views to enable easy identification of the items. When illustrations omit the part numbers and description, both the illustrations and separate listing shall show the index, reference, or key number that will cross-reference the illustrated part to the listed part. Parts shown in the listings shall be grouped by components, assemblies, and subassemblies in accordance with the manufacturer's standard practice. Parts data may cover more than one model or series of equipment, components, assemblies, subassemblies, attachments, or accessories, such as typically shown in a master parts catalog.

1.2.5.5 Personnel Training Requirements

Provide information available from the manufacturers that is needed for use in training designated personnel to properly operate and maintain the equipment and systems. The Contractor shall provide the services of one or more authorized start-up engineers (Manufacturer's Representatives) as necessary to provide training in programming, operation and maintenance. The training shall be provided for operators and maintenance personnel prior to project operation of the system. Provide at a minimum; two, four-hour class sessions; one class for operators and maintenance personnel to occur at the Tyee Lake Facility. A second training session shall be provided for both additional operators and maintenance personnel and include system managers and engineers. Each class session shall include enough material for a minimum class size of 5 students.

Both training sessions shall occur prior to the Contractor leaving the Tyee Lake Facility, and will not require a second trip to perform. The Contractor shall submit system training manuals and documentation for approval in accordance with SECTION 01 78 00.00 28.

1.2.5.6 Testing Equipment and Special Tool Information

Include information on test equipment required to perform specified tests and on special tools needed for the operation, maintenance, and repair of components.

1.2.5.7 Testing and Performance Data

Include completed prefunctional checklists, functional performance test forms, and monitoring reports. Include recommended schedule for retesting and blank test forms.

1.2.5.8 Contractor Information

Provide a list that includes the name, address, and telephone number of the General Contractor and each Sub-Contractors who installed the product or equipment, or system. For each item, also provide the name address and telephone number of the manufacturer's representative and service organization that can provide replacements most convenient to the project site. Provide the name, address, and telephone number of the product, equipment, and system manufacturers.

1.3 TYPES OF INFORMATION REQUIRED IN CONTROLS O&M DATA PACKAGES

Include a Data Package 5 for general data and the following for control systems:

a. Copies of all checkout tests and calibrations performed by the

Contractor.

b. Marking of all system sensors on the as-built floor plan with their control system designations.

1.4 SCHEDULE OF OPERATION AND MAINTENANCE DATA PACKAGES

Furnish the O&M data packages specified in individual technical sections. The required information for each O&M data package is as follows:

1.4.1 Data Package 1

a. Safety precautions

b. Cleaning recommendations

c. Maintenance and repair procedures

d. Warranty information

e. Contractor information

f. Spare parts and supply list

1.4.2 Data Package 2

a. Safety precautions

b. Normal operations

c. Environmental conditions

d. Lubrication data

e. Preventive maintenance plan and schedule

f. Cleaning recommendations

g. Maintenance and repair procedures

h. Removal and replacement instructions

i. Spare parts and supply list

j. Parts identification

k. Warranty information

l. Contractor information

1.4.3 Data Package 3

a. Safety precautions

b. Operator prestart

c. Startup, shutdown, and post-shutdown procedures

d. Normal operations

e. Emergency operations

f. Environmental conditions

g. Lubrication data

h. Preventive maintenance plan and schedule

i. Cleaning recommendations

j. Troubleshooting guides and diagnostic techniques

k. Wiring diagrams and control diagrams

l. Maintenance and repair procedures

m. Removal and replacement instructions

n. Spare parts and supply list

o. Product submittal data

p. O&M submittal data

q. Parts identification

r. Warranty information

s. Testing equipment and special tool information

t. Testing and performance data

u. Contractor information

1.4.4 Data Package 4

a. Safety precautions

b. Operator prestart

c. Startup, shutdown, and post-shutdown procedures

d. Normal operations

e. Emergency operations

f. Operator service requirements

g. Environmental conditions

h. Lubrication data

i. Preventive maintenance plan and schedule

j. Cleaning recommendations

k. Troubleshooting guides and diagnostic techniques

l. Wiring diagrams and control diagrams

m. Maintenance and repair procedures

n. Removal and replacement instructions

o. Spare parts and supply list

p. Corrective maintenance man-hours

q. Product submittal data

r. O&M submittal data

s. Parts identification

t. Warranty information

u. Personnel training requirements

v. Testing equipment and special tool information

w. Testing and performance data

x. Contractor information

1.4.5 Data Package 5

a. Safety precautions

b. Operator prestart

c. Start-up, shutdown, and post-shutdown procedures

d. Normal operations

e. Environmental conditions

f. Preventive maintenance plan and schedule

g. Troubleshooting guides and diagnostic techniques

h. Wiring and control diagrams

i. Maintenance and repair procedures

j. Removal and replacement instructions

k. Spare parts and supply list

l. Product submittal data

m. Manufacturer's instructions

n. O&M submittal data

o. Parts identification

p. Testing equipment and special tool information

q. Warranty information

r. Testing and performance data

s. Contractor information

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 03 60 00

CONCRETE DEMOLITION, REPAIR OF CONCRETE SURFACES, AND EQUIPMENT FOUNDATIONS

PART 1 GENERAL

1.1 General Information

The work covered by this section consists of furnishing all material, labor, and equipment, and performing all work for the removal of concrete, the restoration of the concrete surfaces to the required lines and grades, and placement of equipment foundations in locations required. The Contractor shall provide protection from concrete dust and water damage to existing and new equipment. The Contractor shall take effective measures to control gas, vapor, fumes, dust, slurry and mist during concrete removal operations.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referenced to in the text by basic definition only.

ACI INTERNATIONAL (ACI)

ACI 318/318R	(2005; Errata 2005) Building Code Requirements for Structural Concrete and Commentary

ASTM INTERNATIONAL (ASTM)

ASTM A 185/A 185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A 615/A 615M	(2009b) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C 94/C 94M	(2009a) Standard Specification for Ready-Mixed Concrete
ASTM C 881/C 881M	(2010) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 1107/C 1107M	(2011) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	(2011) Occupational Safety and Health Standards

29 CFR 1926 (2011) Safety and Health Regulations for Construction

1.3 SUBMITTALS

Approval is required for all submittals. The following shall be submitted in accordance with SECTION 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Concrete Removal and Disposal Plan: Submit within thirty (30) calendar days prior to removal.

Core Drilling Procedure: Submit for approval sixty (60) days prior to commencement of core drilling work; submit together with ConcreteImaging Report.

Concrete Imaging Report: Submit for approval sixty (60) days prior to commencement of core drilling work; submit together with Core Drilling Procedure.

Repair Procedure of Concrete Surfaces: Submit for approval thirty (30) calendar days prior to performing repair, a procedure for repair of concrete surfaces shall be submitted for approval. Repair work shall not proceed without an approved procedure.

Generator Concrete Pad Design:Submit for approval sixty calendar days prior to installation of concrete foundation for standby generators.

SD-03 Product Data

Generator Concrete Pad Material Data: Submit for approval Thirty calendar days prior to installation of concrete foundation for standby generators. Including but not limited to concrete mix, onsite mixing methods, concrete addatives, and reinforcement.

1.4 Concrete Removal and Disposal Plan

The Contractor shall provide a written concrete removal and disposal plan prior to commencement of any concrete work showing, removal methods and equipment to be used, expected noise levels and duration. Include methods and location for the disposal of waste concrete and wastewater.

1.5 Standby Generator Foundations

Provide a single concrete foundation sized to accommodate both generators supplied with adequate working space between the units. Contractor will provide foundation design based on the packaged engine-generator sets provided. Foundation designs will be engineered and stamped by an engineer licensed in the State of Alaska.

a. Foundation design will include a concrete encased grounding electrode for generator grounding.

b. Minimum separation between units as required by the generator manufacturer and working space requirements, whichever is larger

PART 2 PRODUCTS

2.1 NON-SHRINK GROUT

Non-shrink grout shall be inorganic, non-metallic, non-gas-liberating cement-based grout meeting all requirements of ASTM C 1107/C 1107M; concrete shall have a minimum 28-day compressive strength of 5000 psi; and shall have no shrinkage (0.0 percent) and a maximum 2.0 percent expansion in the hardened state.

2.2 EPOXY ADHESIVE GROUT

Epoxy adhesive grout shall be two part epoxy adhesive meeting all requirements of ASTM C 881/C 881M.

2.3 READY-MIX CONCRETE

Ready-mixed concrete shall conform to ASTM C 94/C 94M. Specified compressive strength shall be 4000 psi at 28 days (90 days if pozzolan is used). The maximum nominal size coarse aggregate shall be 3/4 inch, in accordance with ACI 318/318R. The air content shall be between 4.5 and 7.5 percent. The slump shall be between 2 and 5 inches. The maximum water cement ratio shall be 0.50.

2.4 REINFORCING STEEL

Reinforcing steel bar shall conform to the requirements of ASTM A 615/A 615M, Grade 60. Welded steel wire fabric shall conform to the requirements of ASTM A 185/A 185M. Details of reinforcement not shown shall be in accordance with ACI 318/318R, Chapters 7 and 12.

2.5 Formwork

Design and engineer the formwork as well as its construction in accordance with ACI 301 Section 2 and 5 and ACI 347R. Fabricate of wood, steel, or other approved material. Submit formwork design prior to the first concrete placement.

2.6 Form Coatings

Provide form coating in accordance with ACI 301.

PART 3 EXECUTION

3.1 GENERAL SAFETY

3.1.1 General

All site work shall be accomplished in compliance with EM 385-1-1, 29 CFR 1910 and 29 CFR 1926 as applicable.

3.1.2 Electrical Hazards

The work areas may be in proximity of energized electrical equipment. Contractor is required to formally train and document safety training for all workers required to work in this area. Spray over onto live equipment is hazardousto workers and equipment and shall not be permitted. Signed safety training sheets will be required tobe turned into Agency's Representative to document worker safety training.

3.2 GAS, VAPOR, FUME, DUST, SLURRY AND MIST CONTROL IN POWERHOUSE

All necessary measures shall be taken to effect maximum control of all gases, vapors, fumes, dust, slurry and mists created by Contractor operations under this contract. To the maximum extent possible, all dust and dirt shall be removed by vacuum cleaning and mopping, unless otherwise directed by the Contracting Officer. The required Control program shall include the following:

a. Provision of exhaust ducts which shall discharge outside the powerhouse structure where mechanical ventilation is used. Ventilation systems shall comply with requirements of 29 CFR 1910.94 and 29 CFR 1926.57.

b. Controlled operation of power-driven tools.

c. Furnishing and removing of approved dust preventatives in areas which cannot be properly rendered free from excessive dusting by vacuum cleaning and mopping or other methods.

d. Vacuum cleaning and mopping (or other acceptable method) of spaces within the powerhouse where dust accumulates.

e. Only air, electrical, propane, or battery-driven equipment may be used inside the powerhouse.

f. The powerhouse is pressurized to prevent dust infiltration from the outside. All doors shall be kept closed when not being used.

g. Blocking doors for extended periods shall not be permitted unless agreed upon in writing by the Agency's Representative.

h. Methods to prevent exposure of employees to inhalation, ingestion, skin absorption, or contact with any material or substance at concentrations above those specified in 29 CFR 1910.1000, 29 CFR 1926.55 and .58.

3.3 TEMPORARY BARRIER

Temporary barriers for the control of dust and debris shall be constructed as required by the Agency's Representative. The design of the barriers shall be submitted for approval, as part of the Concrete Removal and Disposal Plan.

3.4 REMOVAL METHOD

3.4.1 General

Concrete shall be removed in a manner that will not fracture the surrounding concrete. Maintain a safety ground fromthe powerhouse ground system to the frame of the concrete cutting tool during cutting operations to avoid electrical shock hazards. Reinforced concrete removal shall result in flush, level smooth surface at the lines and grades shown on the drawings. Care shall be taken not to damage reinforcing bar in the existing concrete intakedeck. Explosive or chemical demolition will not be allowed. Adequate equipment shall be provided to remove the pieces of concrete safely and without damage to the surrounding structure. Slurry or tailings generated from sawing or drilling operations shall be confined

to the immediate area, and disposed of by vacuuming and mopping. If during any cutting or core drilling activity copper tailings are produced, the Contractor shall report such findings in writing to the Agency's Representative. Additional dust control measures shall be implemented per paragraph "GAS, VAPOR, FUME, DUST, SLURRY AND MIST CONTROL IN POWERHOUSE" for work inside the powerhouse.

3.4.2 Recommended Procedure

Saw cutting, core-drilling, wire cutting or any combination thereof is the recommended method for the concrete removal to be done as part of this contract. In addition to cutting, chipping or grinding may be used to bring the concrete profile to the final finished grade. When the portion of concrete to be removed is of such a magnitude hat it cannot be extracted in a single piece, additional cutting shall be performed to allow the concrete to be removed in several easily movable sections.

3.4.3 Saw Cutting

Saw cutting shall be performed at the locations shown on the contract drawings. The saw cuts shall be done using a diamond-bladed saw. Saw cuts shall be straight and uniform.

3.4.4 Core Drilling

Prior to core drilling the Contractor shall research the area to avoid and identify existing embedded ground wires, conduit, piping and raceways. Contractor shall refer to reference drawings to assure drill patterns are likely to miss existing reinforcing, ground wires and conduit. Research of the area shall include concrete imaging techniques such as radiographic imaging, ground penetrating radar, or electromagnetic field detection. Contractor shall submit a Concrete Imaging Report describing the findings and locating the embedded items on a concrete outline drawing of the area. Drill pattern shall be adjusted to miss embedded obstructions. All core drilling equipment shall be securely grounded during cutting operations to avoid electrical shock hazards. Core drilling procedure shall be submitted for Agency approval. No core drilling shall be done without Agency approval.

3.4.5 Chipping

When required, concrete removed by saw cutting, core drilling, or stitch drilling shall be brought to the final required lines and grades by using lightweight chipping hammers, bush hammers grinding or other approved means. Chipping operations shall be such that the over breakage does not exceed 2 inches or extend below the existing grade.

3.4.6 Exposed Reinforcement

In all areas where concrete removal will leave exposed reinforcing bars except for the interiors of cored penetrations, the local area around the bar or conduit shall be chipped back to a depth necessary to allow the bar to be burned off 1 1/2 inches back from the final finished concrete surface shown on the drawings, the conduit or bar shall be burned off 1 1/2 inches from the final finished concrete surface shown on the drawings, and the area shall be patched with an approved non-shrink grout bringing it to required final lines and grades as shown on the drawings.

3.4.7 Existing Concrete Strength

The existing concrete to be removed may be expected to range in strength from about 3000 to over 6000 psi. The nominal aggregate size of the concrete is unknown. Zones of honeycomb concrete may also be encountered during the drilling process.

3.4.8 Existing Embedded Items

Embedded items in the path of the concrete cutting or drilling operations include, but are not limited to:

a. Reinforcing steel as well as minor embedded steel at various distances from the concrete faces.

b. Steel anchors and form tie backs used in placement of the existing concrete. The number and kind are unknown.

c. Electrical Conduit.

3.4.9 Concrete Cutting Tolerances

a. The concrete cut through the existing concrete shall be accurately located. Wire or saw cuts shall be within 1/8 inch of plan dimensions.

b. The core drill holes through existing concrete shall be accurately located and drilled. During the drilling operation, the drill wobble should be minimized to assure a true and straight hole to meet the specified tolerances.

3.4.10 Quality Control

A quality control system for the concrete cutting operation shall be established and maintained. The system shall be sufficient to maintain tolerances such that the final concrete cutting conforms to the tolerances outlined in this section of the specifications. The Agency reserves the right to inspect this control system to determine if the tolerances are being adhered to, and direct the Contractor to correct and repair any deviations from these tolerances.

3.4.11 Concrete Disposal

All concrete removed or concrete waste shall become the property of the contractor and shall be disposed off site in accordance with applicable regulations.

3.4.12 Disposal Of Waste Water And Concrete Debris

The method used in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces shall be such that it does not stain, discolor, or affect exposed surfaces of the structure and is not allowed to enter the river or reservoir. As some Project drains lead to the river, waste water shall not be disposed of in Agency drains. The method for disposing of wastewater shall be as per the written concrete removal plan. The method for disposing of concrete debris shall be such that it is not allowed to enter the river or reservoir and shall be included in the written concrete removal plan.

3.4.13 Repair Of Concrete Surfaces

Restoration of the concrete surfaces shall be to the required lines and grades shown using a Agency approved method. Repair Procedure of Concrete Surfaces shall be submitted for shall be submitted for approval. Repair work shall not proceed without an approved procedure. The repair procedure shall include detailed information on all materials and methods used. If piping, conduit or ground wires are damaged during core drilling or concrete excavation, a sufficient area of the concrete to allow the ground wire, conduit, or piping to be repaired shall be excavated by saw cutting the perimeter of the area to a depth of 1 1/2 to 2 inches and then completing the remaining excavation needed using a brush hammer taking care to preserve embedded reinforcing steel intact.

3.5 EQUIPMENT FOUNDATIONS

Equipment foundations complying with this specification shall be provided for equipment as specified elsewhere or shown on the drawings.

3.5.1 Housekeeping Pads

Housekeeping pads are not required for new equipment.

3.5.2 Steel Channel Foundations

Structural steel channel foundations, complete with bolts and drilled holes for anchoring to the floor, shall be furnished for supporting the new cubicle assembly as indicated on the drawings. Channel construction, placement, and drilling shall be as required for mounting the equipment. The channels shall be designed for flat mounting flush with the top of the housekeeping pad. The channels shall be leveled, shimmed and anchored through the new housekeeping pad into to the existing concrete floor slab.

3.5.3 Concrete Anchorage

Concrete anchors used to provide seismic restraint to the equipment, where not specified on the drawings, shall be at minimum 1/2-inch in diameter and meet provisions of SECTION 13 48 00.00 26 with required embedment depth measured only in the existing concrete floor slab.

-- End of Section --

SECTION 13 48 00.00 26

SEISMIC RESTRAINT FOR MECHANICAL AND ELECTRICAL EQUIPMENT

PART 1 GENERAL

1.1 SCOPE OF WORK

The work covered in this section consists of furnishing all labor, equipment and materials to provide seismic restraints, anchors, and manufacturers seismic certifications.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. References are subject to the most recent revisions as of the date of this contract award.

ASTM INTERNATIONAL (ASTM)

ASTM A 153/A 153M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 36/A 36M	Carbon Structural Steel
ASTM A 53/A 53M	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 572/A 572M	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A 603	Zinc-Coated Steel Structural Wire Rope
ASTM A 653/A 653M	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASME INTERNATIONAL (ASME)

ASME B18.2.1	Square, Hex, Heavy Hex, andAskew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws. (Inch Series)
ASME B18.2.2	Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

1.3 SUBMITTALS

The following shall be submitted in accordance with SECTION 01 33 00

SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings
Submit within 120 calendar days of Notice to Proceed.

SD-03 Product Data

Concrete Anchors
Submit manufacturer's product data within 120 calendar days after receiving the Notice to Proceed.

Seismic Equipment Certification
Submit within 120 calendar days of Notice to Proceed, together with Design Calculations and Results.

SD-05 Design Data

Structural Design Calculations for Seismic Restraints
Submit within 120 calendar days of Notice to Proceed

1.4 DESIGN STANDARDS

1.4.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the equipment and systems below.

1.4.2 Requirements for Equipment Certification

Contractor shall provide Seismic Equipment Certification supported by testing or analysis stating the seismic capability of the equipment.

1.5 EQUIPMENT

Seismic certification and seisic installation detail drawings for the following equipment shall submited by the Contractor in accordance with the requirements of this specification:

(1) Two (2) 500kva Dry Type Transformers
(2) One (1) Automatic Transfer Switch
(3) 480V Panelboards
(4) 480V Switchgear
(5) 13.8kV Switchgear
(6) Standby Generators

1.6 DEFINITIONS

Sway Brace. An assembly intended to be attached to piping, conduit, bus, or raceways to resist horizontal earthquake loads.

Four-Way Brace. A sway brace intended to resist differential movement in all horizontal directions.

Lateral Brace. A sway brace intended to resist differential movement perpendicular to the axis of piping, conduit, bus, or raceways.

Longitudinal Brace. A sway brace intended to resist differential

movement parallel to the axis of piping, conduit, bus, or raceways.

Undercut anchor. Undercut concrete anchors are bearing-type anchors designed to be installed in cured concrete in a hole with a conical undercut near its blind end.

Expansive anchor. Expansive concrete anchors are designed to be installed in cured concrete in a straight hole. Anchorage relies on an torque-controlled expansion wedge and the friction developed between the drilled hole and the expanded wedge.

Adhesive anchor. Adhesive concrete anchors are designed to be installed in cured concrete in a straight hole drilled with a roto-impact drill. Anchorage relies on a chemical adhesive bond to the threaded rod and to the concrete.

Expansion Joint. Expansion /contraction joint separating two adjacent, structurally independent sections of the Powerhouse.

PART 2 PRODUCTS

2.1 BOLTS AND NUTS

Hexhead bolts, and heavy hexagon nuts shall meet the requirements of ASME B18.2.1, ASME B18.2.2, or ASTM A 325. Bolts and nuts exposed to weather shall be galvanized in accordance with ASTM A 153/A 153M.

2.2 SWAY BRACING

Material used for members listed in this section, shall be structural steel conforming with the following:

a. Plates, rods, and rolled shapes, ASTM A 36/A 36M, or ASTM A 572/A 572M, Grade 503.

b. Wire rope, ASTM A 603.

c. Tubes, Grade B.

d. Pipes, ASTM A 53/A 53M, Type E or S, Grade B.

e. Light gauge angles, less than1/4 inch thickness, ASTM A 653/A 653M.

2.3 CONCRETE ANCHORS

Submit manufacturer's product data. Manufacturer's product data submittal shall include but is not limited to detail drawings showing dimensions, material data, allowable loads and detailed installation instructions, anchor test data in accordance with ICC ES Evaluation Services Reports (ESR).

PART 3 EXECUTION

3.1 Sway Bracing Required for Equipment

Provide sway bracing for equipment supported from overhead floor or roof structural systems as shown on the drawings.

3.2 EXPANSION JOINTS

Equipment shall not normally be rigidly attached on each side of an expansion joint. For systems which are rigidly attached on each side of a an expansion joint, flexible connections or system configurations that are capable of accommodating displacements equal to twice the full width of the joint in both orthogonal directions or a minimum of 2-inches in both orthogonal directions shall be provided. A individual seismic sway brace shall not be attached to the structure on each side of a joint.

3.3 CONCRETE ANCHORS

Provide anchors as shown on the drawings.

3.4 QUALITY ASSURANCE

3.4.1 Contractor's Installation Qualification

Concrete anchors shall only be installed by individuals qualified to install the type and class of concrete anchors indicated on the drawings. The individual shall be qualified by installing an anchor as per manufacturer's instructions in the position indicated on the drawings and then having that anchor tested by Contractors personnel as per this specification and manufacturer's recommendations. The location where Contractor Qualification Testing is performed shall be at a location approved by the Agency. Any anchors installed as part of the testing and not used shall be removed and the hole repaired with non-shrink grout.

Contractor shall provide written notice of Contractor's Qualifications Testing 10 days prior to performing the testing. Contractor Qualification Testing shall be witnessed by the Agency.

3.4.2 Concrete Anchor Testing

3.4.2.1 General

The Contractor shall test expansion, undercut, and chemically bonded anchors in place after installation at no further cost to the Agency. Testing shall be performed on anchor bolts as described below. Concrete Anchor Test Reports shall be submitted within ten (10) days of the completion of any on-site testing performed. At least one anchor of each type and class of anchor shall be tested. Testing shall be done on not less than ten percent (10%) of the total installed anchors and at least one anchor for every piece of equipment containing more than two anchors. The test load shall correspond to the manufacturer's allowable load.

3.4.2.2 Torque Wrench Testing

Torque wrench testing shall only be performed if recommended by the anchor manufacturer. Torque wrenches shall be calibrated at the beginning the job. The applied torque shall be between 20 and 80 percent of wrench capacity. If any anchor fails the test, similar anchors not previously tested shall be tested until 10 consecutive anchors pass. Failed anchors shall be retightened and retested to the specified torque; if the anchor still fails the test, it shall be replaced and retested.

3.4.2.3 Direct Pull Testing

Chemically bonded anchors shall be tested by applying a pullout load using

a hydraulic ram attached to the anchor bolt. Other types of anchors may also be tested by direct pull testing as recommended by the anchor manufacturer. The load shall be applied to the anchor without removing the nut; when that is not possible, the nut shall be removed and a threaded coupler shall be installed of the same tightness as the original nut. The test setup shall be checked to verify that the anchor is not restrained from withdrawing by the base plate, the test fixture, or any other fixtures.

The support for the testing apparatus shall be at least 1.5 times the embedment length away from the bolt being tested. Each tested anchor shall be loaded to the allowable tension value for the anchor. The anchor shall have no observable movement at the test load. Anchors shall not spin in the hole. If any anchor fails the test, similar anchors not previously tested shall be tested until 100 percent pass.

Failed anchors shall be retightened and retested to the specified load; if the anchor still fails the test, it shall be replaced and retested.

-- End of Section --

SECTION 26 00 00.00 26

GENERAL ELECTRICAL WORK AND EQUIPMENT

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

This section specifies the electrical equipment and work required to provide, install, test and connect to the existing Tyee Lake Powerhouse facility. This section specifies additional miscellaneous requirements that are not covered in other sections. All other sections as they pertain to equipment type and function shall be adhered to in addition to requirements of this section where applicable. Miscellaneous equipment that is not covered in other sections will be covered here, however this section does not take precedence over other sections.

Contractor shall provide all equipment and systems fully operational per the plans and specifications.

All work shall be in accordance with NFPA 70 and IEEE C2. Omission of details on the drawings or in the specifications shall not be construed as permitting deviations from Code requirements.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. References are subject to the most recent revisions as of the date of this contract award.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C80.1	American National Standard for Electrical Rigid Steel Conduit (ERSC)

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	National Electrical Safety Code
IEEE C37.90	Standard for Relays and Relay Systems Associated With Electric Power Apparatus

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA AB 3	Molded Case Circuit Breakers and Their Application
NEMA FB 1	(Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA ICS 1	Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	Standard for Controllers, Contactors, and Overload Relays Rated 600 V

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 360	Standard for Liquid-Tight Flexible Steel Conduit
UL 489	Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 50	Enclosures for Electrical Equipment, Non-environmental Considerations
UL 514B	Conduit, Tubing and Cable Fittings

1.3 SUBMITTALS

The following shall be submitted in accordance with SECTION 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Equipment Crate Size, Storage Location and Proposed Routing at Site

Submit no less than 60 days prior to equipment delivery

Transformer Removal Procedure
Submit no less than 30 days prior to start of on-site construction.

SD-02 Shop Drawings

Mimic Bus;
Submit no less than 60 days prior to start of construction.

Transformer Installation Detail Drawings
Submit no less than 60 days prior to start of construction.

SD-03 Product Data

Equipment

After notice to proceed and at least 90 days prior to mobilization, submit manufacturer's data, drawings, catalog cuts,

and wiring diagrams. Submitted manufacturer's data sheets shall be color copies of the original documents and be of good quality, easily read and marked or highlighted indicating the specific equipment being submitted and labeled as to which equipment (by designation) the submitted equipment is installed with and show compliance with the contract specifications. Manufacturer's data sheets submitted for the O&M manuals shall be the original documents and not be copies. As a minimum, submittals shall be required for, but not be limited to, the following:

a. Conduit, Cable Tray, Fittings, And Hangers
b. Outlet and Junction Boxes
c. Special Boxes, Enclosures, Cabinets, and Wireway
d. Terminal Blocks
e. Nameplates
f. Switches
g. Indicating lights
h. Relays
i. Instruments
j. Switchgear
k. PLC Equipment
l. Molded Case Circuit Breakers
m. Meters
n. Panelboards
o. Test Switches
p. Automatic Transfer Switch
q. Panelboards
r. Wiring Devices
s. Standby Generators

SD-06 Test Reports

Field Test Reports;
Submit within 14 days after completion of tests.

SD-08 Manufacturer's Instructions

Spare Parts;
Submit within 60 days prior to onsite work.

1.3.1 Submission of Test Results

Submit five (5) signed copies within fourteen (14) days after test completion.

1.4 GENERAL REQUIREMENTS

1.4.1 Materials, Equipment and Installation

New and unused materials and equipment shall be furnished. Defective material or equipment damaged in the course of installation shall be replaced or repaired. The removal of electrical equipment will include the disconnection of existing conduits, associated wiring, and cables. In some cases existing wiring and cables disconnected shall be removed and replaced with new materials. Testing shall be performed to check the installation of and the proper operational functions of the accessory electrical equipment per SECTION 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING. The installations shall be in accordance with the National

Electrical Code, NFPA 70, and the National Electrical Safety Code, IEEE C2. Omission of details on the drawings or in the specifications shall not be construed as permitting deviations from Code requirements.

1.4.2 Standard Products

Material and equipment shall be the standard products of manufacturers regularly engaged in the manufacture of these products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.4.3 Environmental Requirements

Communication, control, and protective equipment shall be rated for continuous operation in ambient environmental conditions of 0 degrees C to 50 degrees C (32 degrees F to 120 degrees F), and 0 percent to 90 percent relative humidity, noncondensing. Power equipment shall be rated as required in the plans and these specifications.

1.4.4 Storage and Handling

Electrical equipment shall be shipped as completely assembled and wired as feasible so as to require a minimum of installation work. All electrical material and equipment delivered to site shall, until immediately prior to installation, be protected from damage from environmental exposures and construction activities. Special care shall be taken for panelboards, transformers, switchgear, motors and control equipment. Control equipment shall include, but not be limited to, PLC equipment, relaying equipment, meters, wire and cables, and various types of switches. The above equipment and devices shall be kept dry and free from precipitation and condensation during storage, installation, and after installation. All electrical equipment shall be stored in completely enclosed containers and in a humidity-controlled environment. Method of on-site storage and storage containers will be subject to approval by the Agency.

1.4.5 Corrosion Prevention

Equipment shall be protected to prevent deterioration from corrosion. The general requirements are specified below; however, other corrosion-resisting treatments that are the equivalent of those specified may be used.

a. Fastenings and Fittings. Screws, bolts, nuts, pins, studs, springs, washers and other miscellaneous fastening devices and fittings shall be of corrosion-resistant material or shall be treated in an approved manner to render them resistant to corrosion. Fasteners exposed directly to the weather shall be of corrosion-resisting material.

b. Corrosion-Resisting Materials. Corrosion-resisting steel, copper, brass, bronze, copper-nickel-copper alloys are acceptable corrosion-resisting materials.

c. Corrosion-Resisting Treatments. Treatments shall be in accordance with ASTM A 123/A 123M or ASTM A 153/A 153M.

d. Finish. Final painting shall be done in accordance with paragraph NEW EQUIPMENT.

1.5 General

The Contractor shall provide all work required for complete and functional 480V switchgear replacement as shown on the drawings and specified herein.

PART 2 PRODUCTS

2.1 CONDUIT SYSTEMS

2.1.1 Conduit and Fittings,and Hangers

All conduit shall be galvanized rigid steel, except where specifically shown or specified otherwise. Manufacturer's descriptive literature shall be submitted for approval for conduit, cable tray, fittings, and hangers.

a. Rigid Steel. Rigid steel conduit shall conform to ANSI C80.1 and shall be zinc-coated both inside and outside by hot-dip galvanizing method. Thin-wall or EMT conduit shall not be allowed at any location.

b. Flexible Steel. Flexible conduit shall be liquid tight metal and shall conform to UL 360, shall have a hot-dip galvanized steel core, copper ground wire and a waterproof extruded cover. Use shall be limited to equipment connections not exceeding 36 inches.

c. Fittings. Fittings for rigid conduit shall be threaded and conform to UL 514B. Fittings for flexible conduit shall provide positive bonding, and shall conform to UL 514B.

2.1.2 Outlet and Junction Boxes

a. Provide cast type boxes: Cast boxes and covers shall conform to NEMA FB 1. All cast boxes shall be supplied with integral cast hubs or with factory-brazed hubs. All hubs shall be factory threaded.

2.2 TERMINAL BLOCKS

2.2.1 General

Terminal blocks shall be removable and of the binding, fillister or washer-head screw type, or stud type with contact and locking nuts. Each terminal shall be not less than No. 10 in size, having length and space for connecting at least two No. 12 AWG conductors to each terminal. Terminal blocks shall be provided to terminate all external cables and shall contain at least four spare terminals or 10 percent, whichever is greater. Terminal blocks shall be rated, at minimum, for 90 degree C terminations. Manufacturer's descriptive literature shall be submitted for approval.

2.2.2 Control Signal Type

All terminal blocks for control signal wiring, shall be sliding link disconnect molded or fabricated type with barriers, rated not less than 600 volts with 30 ampere capacity and shall be similar or equal to States terminal blocktype NT.

2.2.3 Short-Circuiting Type

Short-circuiting type terminal blocks shall be furnished for all current transformer secondary leads and shall have provision for shorting together

all leads from each current transformer without first opening any circuit.

2.2.4 Power Terminal Blocks

Terminal blocks for 120 VAC and 480 VAC and all DC connections in terminal cabinets shall be rated not less than 600 volts and of adequate capacity for the conductors. The terminals shall be of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two ring-tongue terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, screws shall have hexagonal heads. Conducting parts between connected terminals shall have adequate contact surface and cross-section to operate without overheating. Each connected terminal shall have the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.2.5 Rail Terminal Blocks

Terminal blocks for connection to the PLC shall be modular, rail mounted devices, rated not less than 600 Volts and 20 Amperes. Individual terminal block thickness shall not exceed 0.24 inch. The terminal connections shall be pressure type with length and space for connection of at least two No. 14 AWG stranded conductors on each end of the feed-through. The terminal contacts shall be designed to prevent the terminated wires from being loosened by vibration or by normal pulling forces. Mounting rails and end covers shall be provided for the terminal block assemblies. White or other light colored marking strips, shall be provided for circuit designation. Each connected terminal of each block shall have the circuit designation or wire number placed on the marking strip with permanent marking fluid. Twenty percent reversible or spare marking strips shall be furnished.

2.2.6 Marking

White or other light-colored plastic marking strips, fastened by screws to each terminal block, shall be provided for wire designations. Marking strips for rail terminal blocks may be fastened by another means than screws. The Agency's wire number shall be shown for each connected terminal on the marking strips with permanent marking fluid.

2.3 BOXES, CABINETS, AND ENCLOSURES

2.3.1 General

Special boxes, enclosures, cabinets, and wireway shall be provided as shown and specified herein. Boxes of 170 cubic inches interior volume or less are considered as conduit outlet boxes. All boxes, cabinets, and enclosures having an interior volume in excess of 170 cubic inches will be considered to be special insofar as compliance with these specifications is concerned.

Conduit entrance locations shall be as shown on the contract drawings or as required. Brackets for mounting of internal equipment shall be supplied. Shop drawings submitted for special cast and sheet metal boxes and enclosures shall indicate the internal volume and the contract drawing sheet on which the individual assemblies are shown.

Cabinet and enclosure type shall conform to NEMA 250.

2.3.2 Steel Cabinets and Boxes

Steel cabinets, junction, splice and pull boxes, and other steel boxes and enclosures and their doors and trim shall conform to Underwriter's Laboratories, Inc., Standard UL 50 for Cabinets and Boxes except as noted below. Sheet steel used in cabinets, special boxes or enclosures, shall be not lighter than No. 12 U.S. Standard gage, and cover fastening screws shall be placed not more than eight inches apart along the perimeter of a box. Special steel boxes, cabinets, doors, and covers shall be made of galvanized sheet steel or shall be hot-dip galvanized after fabrication.

Junction and pull boxes shall be furnished with covers of the same gage metal as the box. Hubs shall be provided where required by the type of enclosure. T & B "Bullet Hub" or Myers "Scru-tite" fittings or approved equal are acceptable.

Concentric ring knockouts will not be allowed for conduit entrances. Galvanizing damaged during fabrication or field installation or drilling shall be repaired. Where standard NEMA type enclosures are not indicated on the drawings, control cabinets and other surface mounted enclosures shall be NEMA Type 12 as modified herein. Holes will be permitted in NEMA Type 12 enclosures for mounting provisions and for cover mounted devices.

Doors, handles, trim, panels and gutters shall be furnished as specified or shown.

2.4 RELAYS (CONTROL, AUXILIARY, LOCKOUT, UNDERVOLTAGE)

Control relays shall be of the electrically operated, magnetically held type except as otherwise stated, and shall be 125 VDC. Contact rating designation shall be A600 or N600, as required, 10 amperes continuous. Relays shall meet the applicable requirements of IEEE C37.90, NEMA ICS 1 and NEMA ICS 2.

Where timing relays are used, they shall have instantaneous and time delay contacts as required. The timer shall have a front-accessible dial for manual adjustment of the time delay over the indicated range.

Undervoltage relays (device 27) shall be adjustable over a range of 50 to 10 percent of rated voltage. Contacts shall close for loss of voltage. Manufacturer's descriptive literature shall be submitted for approval.

2.5 MIMIC BUS

Mimic Bus shall be provided as indicated on the Contract Drawings. Mimic bus layout for the 480V Switchgear shall be submitted by the Contractor for approval and be based on the station service one-line drawings and switch layout as shown on the drawings. Mimic bus shall be made of anodized aluminum or an approved equal, 3/16 inch by ½ inch in size, and shall be finished in a color Orange to represent the 13800 volt bus and in dark green to represent the 480 volt bus.

2.6 CONTROL, INSTRUMENT AND SELECTOR SWITCHES

Control, instrument and selector switches shall be of the rotary switchboard type rated for alternating-current operation at 600 volts, or direct-current operation at 250 volts, as applicable. Provide Eaton E34 or equal. Each switch shall be provided with ample contact stages including spare contacts where shown on thedrawings to perform the functions of the

control system. Each switch shall be provided with an escutcheon clearly marked to show each operating position. Switch identifications and handle positions shall be engraved on escutcheons or may be provided on separate nameplates. Escutcheon engravings shall be white on a black background. Switches provided for circuit breaker control and reset shall have a pistol-grip handle and a mechanical target to indicate the last operating position of the switch. LED lights shall be installed immediately above each circuit breaker switch for open/close indication. Spring operated control switches with trip solenoids used as auxiliary relays shall be provided with at least two extra contracts in additions to those needed for required duties and shall be reset only by use of the operating handle and tripped only by the mechanism in the rear of the panel. Manufacturer's descriptive literature shall be submitted for approval for all switches.

2.7 ESCUTCHEONS AND NAMEPLATES

Identifying nameplates shall be provided and are in addition to manufacturer's nameplates and shall be made of 1/16-inch thick laminated sheet plastic or of 1/32-inch thick anodized aluminum engraved to provide white letters on a black background. All nameplates shall be fastened to enclosures in proper positions with black finished round-head screws. In general, each control switch shall be provided with an identifying nameplate in addition to an escutcheon plate to show operating position. Nameplates designations shall be submitted for approval. Nameplates for cabinets shall match the contract drawings.

2.8 INDICATING LAMP ASSEMBLIES

Indicating Lamp Assemblies shall be of the switchboard type, insulated for 125-volt dc service, with appropriate colored caps and integrally mounted resistors for 125-volt service. Lamps shall be long-life LED type with a minimum normal life span of 50,000 hours. Color caps shall be made of material, which will not be softened by the heat from the lamps. Indicating lights shall be visible from at least 20 ft. away. Lamps shall be replaceable from the front of the panels, and any special tools required for lamp replacement shall be furnished. Insofar as practicable, all color caps shall be similar and interchangeable, and all lamps shall be of the same type and rating. Manufacturer's descriptive literature shall be submitted for approval for all indicating lights.

2.9 SWITCHBOARD TERMINATIONS

Preinsulated confined-crimped ring-tongue terminals or indented ring-tongue terminals shall be used on all wires terminated on screw or stud terminals. Terminals shall be properly sized for the wire and color coded for different size wire, for easy inspection. All screw terminals shall have toothed lock washers and all stud terminals shall have contact nuts and either locking nuts or lock washers. Terminal blocks shall be as per paragraph 2.2 TERMINAL BLOCKS.

2.10 PLC EQUIPMENT

2.10.1 General

PLC equipment shall be provided as part of the switchgear to monitor and perform real-time control of station service equipment. The PLC programming will be provided by the Agency. The Contractor will install, test, and commission the programming. The operator stations, engineering station and control room HMI's will be furnished and programmed by the

Agency. All other components required for a complete and operable system shall be provided by the Contractor.

PLC equipment shall be PAC Systems Rx3i by General Electric as shown on the drawings. PLC equipment shall be chassis-mounted and located in the 480V switchgear as shown on the drawings. Provide manufacturers standard warranty and submit per section 01 78 00.00 28 CLOSEOUT SUBMITTALS.

2.10.2 Functional Requirements

The PLC will have both automatic and manual modes of operation. The PLC will normally operate in automatic mode. In automatic mode, the PLC will monitor equipment status and will perform automatic control actions as appropriate to optimize operation of the station service system. In manual mode, the PLC will also monitor equipment status but will not perform automatic control actions; this mode will permit operators and maintenance personnel to have complete control of the equipment for non-routine situations. The operator will be able to monitor all equipment and perform all control actions from HMI equipment located in the control room.

2.11 MOLDED-CASE CIRCUIT BREAKERS

Molded case circuit breakers not specified in the PANELBOARDS AND SWITCHBOARDS SECTION 26 28 00.00 26 shall conform to the applicable requirements of UL 489 and NEMA AB 3 and NEMA ICS 2, shall be fully rated, and shall have voltage ratings and interrupting ratings stated. For circuit breakers of the same ampere frame size, 3 pole and 2 pole circuit breakers shall be the same width as 3 single pole and 2 single pole circuit breakers respectively. The circuit breakers shall be manually-operated and shall have trip-free operating mechanisms of the quick-make, quick-break type. All poles of each breaker shall be operated simultaneously by means of a common handle, and shall be enclosed in a common molded plastic case. The contacts of multi-pole breakers shall open simultaneously when the breaker is tripped manually or automatically. The operating handles shall clearly indicate whether the breakers are in "On", "Off", or "Tripped" position. Molded case breaker installation shall be such that the breaker can be locked in the open position for equipment maintenance. The circuit breakers shall be of the individually-mounted, stationary type, shall all be products of the same manufacturer, and shall be interchangeable when of the same frame size. Each circuit breaker shall be provided with mechanical pressure type terminal lugs for single-conductor stranded copper cables of the size required by the specifications or as shown. Commercial type circuit breakers similar to Westinghouse Quicklag or Siemens Energy & Automation Type ITE EQ shall not be acceptable.

2.12 MAINTENANCE

2.12.1 Spare Parts

All spare parts shall be duplicates of the original parts furnished and interchangeable therewith. The spare parts shall be packaged for long term protection and storage. The packaging shall be legibly labeled to identify the spare parts. A list of the furnished spare parts shall be included in the Operation and Maintenance Manual. The following spare parts for the equipment specified in this contract section shall be provided.

a. Six (6) spare fuses of each type and rating used.

b. Two (2) spare indicating light assemblies of each type used.

c. Ten (10) spare lamps of each type used in indicating lights.

d. Two (2) spare sets of master control switch replacement contacts of each 10 or fraction thereof of each type used.

e. One (1) spare replacement protective relay of each type used.

f. One (1) spare switch (control, instrument, selector) of each type used.

g. One (1) spare test switch of each type used.

i. One (1) spare multifunction meter of each type used.

j. Two (2) spare indicating light lenses of each color used.

k. One (1) spare circuit breaker of each type used. Breakers provided with temporary panel can be counted as spares where interchangeable.

l. One (1) gallon of paint in quart containers to exactly match the finish of the new switchgear, switchboars, panelboards, and transformers.

PART 3 EXECUTION

3.1 CONDUIT SYSTEMS

3.1.1 Installation

All leads from devices and accessories shall be run in rigid galvanized conduit and connected to terminal blocks in the cabinet. All conduit runs installed shall be terminated at devices or connection boxes and at the terminal cabinet in tapped holes having not less than 3-1/2 pipe threads, or in standard pipe-threaded couplings or nipples integral with or welded to the device or cabinet. Similar pipe-threaded connections shall be provided on the terminal cabinet for attaching incoming conduit. Other conduit connections shall be made with cast metal boxes and outlet fittings having threaded outlets and gasketed covers. No running threads on conduit will be permitted. Clamp-backs shall be used for mounting to concrete. Conduit, fittings and accessories shall be installed in accordance with details shown and as specified herein:

a. All conduit bends shall have a radius of not less than ten times the conduit's inside diameter.

b. No threadless fittings or running thread couplings shall be used.

c. Metal conduits shall be cut only with a tool approved for the purpose. Roller type pipe cutters shall not be used on conduits. All cuts shall be square and the conduit opening shall not be constricted. After cutting and threading, conduit ends shall be reamed to remove rough edges and burrs and the entire conduit shall be thoroughly cleaned to remove all cuttings, dirt and oil from its interior. Threads shall be clean cut. Threaded joints in metal

conduit and terminations in cast boxes shall have the threads coated with an approved joint compound, and shall be screwed tight to make the joint watertight and to provide electrical continuity of a given conduit system. Suitable watertight conduit hubs and bushings shall be provided where conduit terminates within a box, terminal cabinet or accessory that has no threaded hub or fitting to receive threaded conduit.

d. All new conduit shall be installed in such a manner as to insure against trouble from the collection of trapped condensation and all runs shall be arranged to avoid traps wherever possible. Existing embedded conduits abandoned in place shall have the conduit stub capped to prevent dirt and water entry. Each abandoned conduit shall be labeled at both ends indicating it being abandoned and the location of the other end.

e. Pull boxes shall be furnished and installed, complete with covers, in conduit runs as required by the NEC and good practice in the trade, and per this section regardless of whether the boxes are specified on the drawings.

f. Conduit shall be installed with a minimum of bending and cutting. Conduits not dimensioned as to location shall be installed approximately where shown with limited adjustment to avoid interference with other work. Conduit shall be rigidly attached with approved supports and anchors to the surface over which it is run. The maximum spacing of supports for the exposed conduit shall be 10 feet, and within 3 feet of any enclosure or box. Supports for exposed conduit on concrete surfaces shall be fastened securely to the concrete with approved anchors. Wooden, fibrous, or similar plugs inserted into the concrete will not be accepted. Concrete anchors shall be as per SECTION 13 48 00.00 26.

g. The entire metallic conduit system installed by the Contractor shall be electrically continuous and thoroughly grounded. No welding or brazing of the grounding conductor to the conduit will be allowed. All grounding connections to the conduit shall be made by means of grounding bushings or by an approved pressure type connector.

h. Conduits terminating in cast boxes shall be made up in approved threaded hubs unless otherwise indicated. Cast boxes and enclosures with threaded hubs shall be provided with proper size hubs to fit conduit being installed. Threaded reducers will not be permitted.

3.1.2 Special Boxes, Cabinets, and Enclosures

All boxes, cabinets, and enclosures shall be straight and true with horizontal or vertical structural lines. The final installation shall not be out of plumb more than 1/4 inch over the full length nor be deformed more than 1/16 inch per linear foot nor more than a total of 1/4 inch in any surface. Exposed cabinets on concrete surfaces shall be fastened with anchors near each corner. All boxes and cabinets shall be cleaned of concrete and grout after the forms are removed and boxes with gasketed covers shall be closed immediately. The gaskets shall be treated with graphite or other approved paste at the time the cover is fastened to the box.

3.2 WIRE AND CABLE

3.2.1 General

For the purposes of this contract, the term "internal wiring" shall be used to designate factory installed wiring in equipment furnished for installation, and the term "external wiring" shall be used to designate the Contractor's field installed wiring. Conduit and cable schedules are shown in the contract drawings, and indicate information on conduit and cable numbers, sizes and estimated lengths, number and insulation ratings of conductors, the function and operating voltage of circuits, and the terminations of conduits and cables. Although estimated cable lengths are indicated on the cable schedule, the Contractor shall be responsible for determining the actual cable length required to make an installation of all new cables. Splicing of cable runs shall not be allowed. Reference SECTION 26 05 19.00 26, INSULATED WIRE AND CABLE and this section.

3.2.2 External Wiring

All external wire and cable shall conform to SECTION 26 05 19.00 26, INSULATED WIRE AND CABLE, of these specifications. All wire and cable shall be installed in accordance with National Electrical Code requirements. All necessary materials, tools and equipment required for proper handling and installation of wire and cable in conduits and elsewhere shall be furnished. Except for spares, each wire and cable shall be connected to the associated equipment at both ends, and shall be continuous and without splices between the equipment termination points. Wire and cable shall be pulled in a manner which will preclude damage to the conductor, insulation or jacket. Any cable damaged during installation shall be removed and replaced. Installation of wire and cable shall include installation of all supporting devices and all terminations required to complete the circuits as required. Wire and cable shall not be pulled into conduit runs until the conduit has been checked and determined to be clean and dry by pulling a clean, dry, tight fitting rag through each run (this includes existing conduits as well as new conduits). Only approved lubricants may be used to facilitate pulling of conductors. Cables shall be placed straight and parallel in the trays.

3.2.3 Internal Wiring

All enclosures and devices shall be completely wired to designated terminal blocks for connection to external devices. The manufacturers standard cables and methods of cable terminations may be used for wiring and terminations performed at the factory. Any power wiring extending beyond the equipment shall be terminated at 600-volt terminal blocks. Special attention shall be given to terminal wiring arrangements on the terminal blocks to permit individual conductors of each external cable to be terminated on adjacent terminal points.

3.2.4 Terminations

All control cable and wire connections shall be made at terminal blocks or terminal studs with ring-tongue indented terminals. The shield and shield insulating jacket of shielded signal cables and conductors, if applicable, shall be maintained to a point as close to the terminals as possible. The shield insulating jacket shall not be stripped from the shield except where necessary to make the ground connection. All signal cable shields shall be grounded at one end only. Each connected terminal of each block shall have the circuit designation or wire number placed on the marking

strip with permanent marking fluid. Terminal block wire designations shall be made with white or other light-colored plastic marking strips, fastened by screws. For each connected terminal, the manufacturer's wire number and Agency's wire number shall both be shown on the marking strips with permanent marking fluid. Two marking strips shall be furnished with each block, to accommodate the two sets of wire numbers. Except for motor leads, the conductors shall be either terminated on screw or stud terminals or a separate adjacent terminal block shall be provided as indicated on the drawings. Either locking nuts or lock washers shall be used on all stud terminals. Where not otherwise indicated, phasing shall be A-B-C from left to right, from top to bottom and from front to back when facing the front of the equipment. Where control and signal cables cannot be immediately terminate at both ends, the end of each cable not terminated shall marked to indicated termination location and shall be capped or taped so that conductors are insulated from each other, the equipment, and ground until connections to the associated equipment can be made.

3.2.5 Identification

All multiple-conductor cables shall be clearly identified with the cable designation by either embossed one-inch diameter brass tags or by embossed aluminum band markers. Tags or band markers shall be securely fastened to the cables at each termination, junction or pull box, and as required at other points of access. Wires and individual conductors of control and power cables shall be identified with non-metallic tube-type markers at each termination. Tube-type markers shall be suitable for contact with rubber or neoprene or plastic. Tubing shall be sized to fit the wire being marked and shall have black marking on a light colored background. Where individual conductors are run in cable trays, markers shall be securely fastened to the conductors every fifty feet, and shall be sized to fit the wire being marked and shall have black marking on a light colored background. Installed markers shall be uniform in position on the wire and legends shall be visible when wires are terminated on terminal blocks or equipment. Identification on each tag and marker shall include both the source and destination location as shown in the contract drawings or as directed.

3.3 GROUNDING

3.3.1 General

Ground connections to the existing grounding system shown on the drawings shall be made complete to all equipment installed under this contract whether or not specifically shown or detailed on the drawings. The main items to be grounded on the include the transformers, bus steel support structures, steel covers for the abandoned conduit stubs, and the transformer support structures. Other items to be grounded include, but not limited to, the piping, motor frames, power receptacles, light fixtures, metal framework supporting or surrounding electrical equipment, switchgear, switchboards, panelboards, cabinets, and conduit. Where required to make conduits and other metallic runs electrically continuous, approved copper jumpers or bonding shall be provided.

3.3.2 Ground Conductors

All new branch circuits and feeders shall have a ground conductor, sized in accordance with NFPA 70 Article 250 whether or not specifically shown or detailed on the drawings. Ground conductors shall be installed as

continuous pieces of copper cable whenever possible. Exposed ground cable runs shall be supported to follow conduit, equipment or concrete wall contours. Support clamps or clips shall be of corrosion resistant metal and existing equipment bolts or screws shall be used where possible for fastening. Drilling of equipment housings or frames will be permitted only when approved. Concrete anchors shall be used for wall fastening.

3.3.3 Ground Connections

All exposed connections and taps shall be made with approved bolted or compression connectors unless otherwise shown on the drawings. Soldered, brazed, or welded type connections will not be permitted. If any ground connections are to be embedded, the connection shall be of the molded powdered metal weld CADWELD type or approved equal.

3.4 NEW EQUIPMENT

Interior and exterior steel surfaces of the housings, special boxes, cabinets, enclosures and new control panel sections shall be thoroughly cleaned and then, if not galvanized, receive a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces shall be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Exterior surfaces shall be primed, filled where necessary, and given not less than two coats of quick air-drying lacquer or synthetic enamel with semigloss finish, ANSI No. 61 light gray in color. Lead-based paints shall not be used. Spare paint shall be furnished to repair any damage in the exterior finish after the equipment has been installed.

3.5 EXISTING EQUIPMENT

Any paint damaged during modifications to existing equipment shall be repaired, by degreasing, sanding, feather-edging, priming, and finishing with an approved paint of matching color. Tiny nicks and other similar damage may, if approved, be repaired with matching finish color alone.

3.6 DISPOSAL OF REMOVED EQUIPMENT

All removed equipment which is not reutilized or specifically addressed in the contract drawings or specifications as being delivered to the Agency, shall become the property of the Contractor. The Contractor shall submit a Equipment Removal and Disposal Plan to be approved by the Agency. Outline procedures for removal and disposal of switchgear, switchboards, and transformers. Plan shall include plans for disposal of all other construction waste.

3.7 FOUNDATIONS

Existing foundations may be reused or modified to meet new equipment manufacturers foundation requirements. Existing foundations not being reused shall be removed flush with concrete floor and repaired as per Section 03 06 00, CONCRETE DEMOLITION AND REPAIR.

Anchorage for new equipment shall be as per Section 13 48 00.00 26 SEISMIC RESTRAINT FOR MECHANICAL AND ELECTRICAL EQUIPMENT and as shown on the drawings. Equipment Certifications of Seismic Requirements shall be submitted per Section 13 48 00.00 26 SEISMIC RESTRAINT FOR MECHANICAL AND

ELECTRICAL EQUIPMENT.

3.8 DELIVERY, STORAGE, AND HANDLING

Equipment shall be packaged for shipment to and for the convenience of handling and storage at Tyee Lake Powerhouse. The equipment shall be shipped as completely assembled and wired as feasible so as to require a minimum of installation work. Any instrument, relay, meter, or other device which cannot withstand the hazards of shipment when mounted in place shall be carefully packed and shipped separately. These devices shall be marked with identification where they are to be mounted and shall be clearly identified so that they can be readily remounted and reconnected.

Eachshipping package shall be provided with removable lifting channels with eye bolts for attachment of crane slings to facilitate lifting and handling. Finished painted surfaces and metal work shall be wrapped suitably orotherwise adequately protected from damage during shipment. Parts shall be prepared for shipment so that slingsfor handling may be attached readily while the parts are in the railway car or truck.

Equipment crated forshipment shall be of such size, including crate, that will pass through an existing hatch opening. The Contractor shall investigate and verify openings and routing through which equipment and packaging must pass atthe storage and installation sites. Equipment shipping container sizes and proposed routing shall be submitted to the Agency for approval. The shipment shall be transported and handled as packaged by the manufacturer. Crating and other packing shall not be removed until the equipment is adjacent to and ready to be mounted in its permanent location. Equipment Crate Size, Storage Location and Proposed Routing at Site shall be be submitted for approval.

Shipping equipment to Alaska is by barge and subject to rough environments. Once equipment arrives in Wrangell, the Contractor will be responsible to arrange a second barge to ship the equipment to Tyee Lake Powerhouse. The Agency will take ownership of the equipment after Final Completion of the project is issued in writing from Agency to Contractor.

Unloading of equipment at the Tyee Lake facility will be the responsibility of the Contractor.

Agency furnished equipment is not available for the size of the T1 and T2 transformers and so the Contractor will be required to provide suitable equipment to unload and transport materials at the Tyee Lake Powerhouse until it is installed in its final location.

-- End of Section --

SECTION 26 05 13.00 26

MEDIUM-VOLTAGE CABLE

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

This section provides specifications for replacement of the 15kv Station Service Transformer feeders.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B 3	(2001; R 2007) Soft or Annealed Copper Wire
ASTM B 33	(2010) Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 48	(2009) Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 386	(2006) Separable Insulated Connector Systems for Power Distribution Systems Above 600 V
IEEE 400	(2012) IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5 kV and Above
IEEE 1202	(2006) Flame-Propagation Testing of Wire and Cable

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA WC 71/ICEA S-96-659	(2014) Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Acceptance Testing Specifications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1685	(2000) Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

1.3 SUBMITTALS

The following shall be submitted in accordance with SECTION 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Submit within 180 days after Notice To Proceed:

Medium-Voltage Cable

Medium-Voltage Cable Terminations

Cable Cleats

Cable Identification

SD-06 Test Reports

Submit three certified copies within 10 days after completion of tests:

Factory Inspection and Tests

Insulation Resistance Test

High Potential Test

Shield Resistance Test

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 General

The cables shall be furnished one length to a reel or coil. Each length, and the outside of each reel or coil, shall be plainly marked or tagged to indicate the cable length, voltage rating, conductor size, and manufacturer's lot number and reel number. Cables for exclusively DC applications shall be identified as such. Reels shall remain the property of the Contractor. Cables on reels shall be stored in an area reserved for that purpose and protected from damage. Reels shall be stored with the axis hole parallel to the horizontal plane. Cables on reels stored laying flat on the side of the reel will not be accepted. Reels shall be rolled only in the direction indicated by the manufacturer. cables shall be unreeled or uncoiled slowly to prevent damage to the sheath by sudden bending. unreeling or uncoiling shall be stopped if kinks appear and

shall not proceed until kinks have been removed. Kinked cable will be rejected. Improperly handled cable may be rejected.

1.5 INSPECTION AND TESTS

1.5.1 General

Inspection and tests of wire and cable furnished under these specifications shall be made by and at the plant of the manufacturer. Testing in general shall comply with Part 7 of NEMA WC 71/ICEA S-96-659 or Section 9 of NEMA WC 74/ICEA S-93-639 as applicable. Specific tests required for particular materials, components, and completed cables shall be as specified in the sections of the above standards applicable to those materials, components, and cable types. Tests shall also be performed in accordance with the additional requirements specified below. In addition to the manufacturer's routine sample testing, each reel provided must have passed an insulation resistance test. No wire or cable may be shipped until after the manufacturer's test reports have been submitted and approved.

1.5.2 Flame Tests

All single-conductor cable assemblies shall pass IEEE 1202 flame tests (formerly under IEEE 383) or UL 1685 flame tests. Single-conductor cables and individual conductors of multiple-conductor cables shall pass the flame test of Part 7.8 of NEMA WC 71/ICEA S-96-659 or Section 10.6 of NEMA WC 74/ICEA S-93-639 as applicable. If such tests, however, have previously been made on identical cables, these tests need not be repeated. Instead, certified reports of the original qualifying tests shall be submitted.

1.5.3 Independent Tests

The Agency may at any time make visual inspections, continuity or resistance checks, insulation resistance readings, power factor tests, or DC high-potential tests at field test values. A cable's failure to pass these tests and inspections, or failure to produce readings consistent with acceptable values for the application, will be grounds for rejection of the cable.

PART 2 PRODUCTS

2.1 MEDIUM-VOLTAGE CABLE

2.1.1 General

All wire and cable shall be provided by the Contractor and shall conform to the requirements specified herein. Characteristics, including conductor size, stranding, number of conductors, rated circuit voltage, cabling, and other requirements for each type of service, shall be as indicated on the drawings, or as specified under the detailed requirements of these specifications for the particular construction or use, unless otherwise stated.

2.1.2 Wire and Cable Schedule

Wire and cable shall be furnished in accordance with the requirements of the Conduit and Cable Schedules, and as indicated on the drawings.

Estimated quantities listed in the Conduit and Cable Schedules are approximate for bidding purposes and shall be verified by the Contractor.

2.1.3 Governing Standards

Materials, construction and tests, unless otherwise specified, shall conform to the applicable requirements of NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639 as applicable.

2.2 MATERIALS

2.2.1 Submittal Requirements

The Contractor shall submit catalog data to the Agency for review and/or approval as indicated in the submittal register. Data shall demonstrate compliance with the specifications requirements for all wire and cable types to be provided.

2.2.2 Rated Circuit Voltages

All wire and cable shall have minimum rated circuit voltages in accordance with NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639 as applicable.

2.2.3 Conductors

2.2.3.1 Material for Conductors

Conductors shall conform to all the applicable requirements of Part 2 of NEMA WC 71/ICEA S-96-659 or Section 2 of NEMA WC 74/ICEA S-93-639 as applicable and shall be annealed copper wire conforming to ASTM B 3. Copper conductors may be bare, or tin-alloy-coated, if required by the type of insulation used. Tin-coated copper conductors shall conform to ASTM B 33. Conductors shall be stranded as required by subparagraph entitled Stranding.

2.2.3.2 Size

Minimum wire size shall be No. 2 AWG for 15kV cable.

2.2.3.3 Stranding

Conductor stranding classes cited herein shall be as defined in Appendix G of NEMA WC 71/ICEA S-96-659 and Appendix H of NEMA WC 74/ICEA S-93-639 as applicable. All conductors shall have class B stranding.

2.2.4 Insulation

2.2.4.1 Insulation Voltage Rating and Insulation Level

The rated voltage of the insulation shall be 15,000 volts for all circuits operating above 5,000 volts, with 133 percent insulation level.

2.2.4.2 Insulation Material

Except as otherwise specified, insulation shall be cross-linked thermosetting polyethylene (XLPE) type or an ethylene-propylene rubber (EPR) type meeting the requirements of Section 4.1 of NEMA WC 71/ICEA S-96-659 for types R, X, or E, or Section 4.1 of NEMA WC 74/ICEA S-93-639 as applicable. Polyvinyl Chloride (PVC)

insulation and thermoplastic type T insulation will not be accepted.

2.2.4.3 Insulation Thickness

The insulation thickness for each conductor shall be based on its rated voltage and insulation material for 133% insulation levels.

a. Single-Conductor Cables Rated 5kV and Higher - The insulation thickness for single-conductor cables rated 5kV and higher shall be as required NEMA WC 74/ICEA S-93-639 Section 4 Tables for XLPE and EPR.

b. Multiple-Conductor Cables Cables Rated 5kV and Higher - The insulation thickness of the individual conductors of multiconductor cables cables rated 5kV and higher shall be as required by NEMA WC 74/ICEA S-93-639 Section 4 Tables for XLPE and EPR.

2.2.4.4 Insulation Shielding

Shielding shall be provided for all cables rated 5kV and higher. Shielding for all cables rated 5kV and higher shall conform to the requirements of Sections 5 and 6 of NEMA WC 74/ICEA S-93-639.

2.2.5 Jackets

All cables shall have jackets meeting the requirements of Section 7.1 of NEMA WC 74/ICEA S-93-639 as applicable, and as specified herein. Individual conductors of multiple-conductor cables shall be required to have jackets only if they are necessary for the conductor to meet other specifications herein. Jackets of single-conductor cables and of individual conductors of multiple-conductor cables, except for shielded cables, shall be in direct contact and adhere or be vulcanized to the conductor insulation. Multiple-conductor cables and shielded single-conductor cables shall be provided with a common overall jacket, which shall be tightly and concentrically formed around the core. Repaired jacket defects found and corrected during manufacturing are permitted if the cable, including jacket, afterward fully meets these specifications and the requirements of the applicable standards.

2.2.5.1 Jacket Material

The jacket shall be one of the materials listed below, in accordance with the applicable paragraphs of Part 5 of NEMA WC 71/ICEA S-96-659 and Section 7 of NEMA WC 74/ICEA S-93-639. Polyvinyl chloride compounds will not be permitted. Variations from the materials required below will be permitted only if approved for each specific use, upon submittal of sufficient data to prove that they exceed all specified requirements for the particular application.

a. Heavy-duty black neoprene (CR-HD).

b. Heavy-duty chlorosulfonated polyethylene (CSPE-HD).

c. Heavy-duty cross-linked (thermoset) chlorinated polyethylene (CPE-XL-HD).

2.2.5.2 Jacket Thickness

The minimum thickness of the jackets at any point shall be not less than 80 percent (80%) of the respective nominal thicknesses specified below:

a. Thickness of the jackets of the individual conductors of multiple-conductor cables shall be as required by the tables in Part 5 of NEMA WC 71/ICEA S-96-659 or the tables of Section 7 of NEMA WC 74/ICEA S-93-639 as applicable, and shall be in addition to the conductor insulation thickness for the insulation used. Thickness of the outer jackets or sheaths of the assembled multiple-conductor cables shall be as required by Part 5 of NEMA WC 71/ICEA S-96-659 or Section 7 of NEMA WC 74/ICEA S-93-639 as applicable.

b. Single conductor cables, if nonshielded, shall have a jacket thickness as required by the tables in Part 5 of NEMA WC 71/ICEA S-96-659. If shielded, the jacket thickness shall be as required by the tables in Part 5 of NEMA WC 71/ICEA S-96-659 or the tables of Section 7 of NEMA WC 74/ICEA S-93-639 as applicable.

2.2.6 Cabling

Individual conductors of multiple-conductor cables shall be assembled with flame and moisture resistant fillers and binders, and a lay conforming to Part 6 of NEMA WC 71/ICEA S-96-659 or Section 8 of NEMA WC 74/ICEA S-93-639 as applicable, except that flat twin cables will not be permitted. Fillers shall be used in the interstices of multiple-conductor round cables with a common covering where necessary to give the completed cable a substantially circular cross section. Fillers shall be non-hygroscopic material, compatible with the cable insulation, jacket, and other components of the cable. The rubber-filled or other approved type of binding tape shall consist of a material that is compatible with the other components of the cable and shall be lapped at least 10 percent of its width.

2.2.7 Dimensional Tolerance

The outside diameters of single-conductor cables and of multiple-conductor cables shall not vary more than 5 percent and 10 percent, respectively, from the manufacturer's published catalog data.

2.3 SPECIAL WIRE AND CABLE

2.3.1 Ground Conductors

Ground conductors shall be bare, soft-drawn, Class A or B stranded copper cables sized in accordance with NFPA 70, NEMA WC 71/ICEA S-96-659 Part 6, or NEMA WC 74/ICEA S-93-639 Section 8 as applicable.

2.3.2 Jumper Cables

Unshielded jumper cables may be used only for internal direct connection of bus to surge protection devices within a circuit breaker enclosure or transformer enclosure. Cables listed as Jumper Cable with the appropriate voltage rating may be used.

2.4 MEDIUM-VOLTAGE CABLE TERMINATIONS

2.4.1 General

Medium-voltage cable terminations shall meet IEEE 48 requirements for Class 2, rated 15 kV. Terminations shall utilize stress cones with long barrel, NEMA two-hole or four-hole compression-type terminals approved for

connection to copper conductors. The shield and shield insulating jacket of shielded cables shall be maintained to a point as close to the terminals as possible. The shield insulating jacket shall not be stripped from the shield except where necessary to make the ground connection. All cable shields shall be grounded at one end only unless otherwise indicated. Grounding shall comply with Section 26 05 26.00 26, GROUNDING.

2.4.2 Cold-Shrink Type

Terminator shall be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber or similar material resistant to atmospheric contamination, ultra violet rays, and oxidative decomposition. Termination shall not require heat or flame for installation. Termination kit shall contain all necessary materials, except lugs may be separate.

2.4.3 Heat-Shrinkable Type

Terminator shall consist of a uniform cross-section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is non-tracking, and is resistant to atmospheric contamination, ultra violet rays, and oxidative decomposition. Skirts or sheds shall be heat-shrinkable and of the same material. Termination kit shall contain all necessary materials, except lugs may be separate.

2.4.4 Load Break and Nonload Break Types

Load-break and nonload-break terminations shall meet IEEE 386 requirements.

PART 3 EXECUTION

3.1 INSTALLATION INSTRUCTIONS

3.1.1 General

For the purposes of this contract, the term "internal cabling" shall be used to designate the equipment manufacturers factory installed cable furnished with the furnished equipment, and the term "external cabling" shall be used to designate field installed cable. Schedules of external cable are as shown in the drawings, showing information on cable numbers, sizes and estimated lengths, number of conductors, the function, and origins and terminations. Although estimated cable lengths are shown on the schedule for bidding purposes, the Contractor shall be responsible for determining the actual cable length required to make an installation of all new cables without splices. Different voltages shall not be run within the same multiconductor cable. The Contractor shall submit the manufacturer's cable installation instructions.

3.1.2 External Cabling

All external cable shall conform to paragraph MEDIUM-VOLTAGE CABLE. All cable shall be installed in accordance with NFPA 70 requirements. All necessary materials, tools and equipment required for proper handling and installation of wire and cable in conduits, cable trays, and elsewhere shall be furnished by the Contractor. Each cable shall be terminated at the associated equipment at both ends, and new cable shall be continuous and without splices between the equipment termination points. Cables left

unterminated for future termination by others shall have both exposed ends enclosed by a heat-shrink insulating boot of the same voltage rating as the cable and of a material compatible with the cable jacket material. Any cable damaged during installation shall be removed and replaced. Installation of cable shall include installation of all supporting devices and all terminations required to complete the circuits as required.

3.1.3 Phasing

All terminal connections for power cables and conductors shall be made in such manner that the phasing will be as marked on the equipment and indicated on the contractors as-built drawings. The Contractor shall verify phasing on existing wiring before disconnecting and removing. The Contractor is also responsible for verifying that the phasing on new wiring is the same rotation as presently existing wiring. Normal phasing for existing equipment is A-B-C from left to right, from top to bottom and from front to back when facing the front of the equipment but Contractor shall verify. After cables have been terminated and the connection torqued, insulate all exposed parts to the cable's voltage rating.

3.1.4 Cable Pulling Requirements

Cable shall be pulled in a manner which will preclude damage to the conductor, insulation or jacket. Cable shall be pulled by the conductor and not by the insulation, jacket, or sheath. Pulling tension shall not exceed the manufacturer's recommended maximum. Strain gages shall be used when pulling cable if any kind of mechanical pulling device is required for installation. Where the puller is attached to the outer jacket of a cable pulling tension shall be limited to 100 lbs. Caution should be used to avoid exceeding the side wall rating of the cable. Any cable or conductor damaged during installation shall be removed and replaced with equivalent cable or conductor. Installation of cable shall include installation of all supporting devices and all terminations and identifications required to complete the circuits as shown on the drawings and as required.

3.1.4.1 Cable Pulling Calculations

Contractor to submit pulling calculations for cables pulled into conduit.

3.1.5 Installation in Conduit

Cable shall not be pulled into conduit runs until the conduit has been checked and determined to be clean and dry by pulling a clean, dry, tight fitting rag through each run. Only approved lubricants may be used to facilitate pulling of conductors.

3.1.6 Installation in Cable Trays

Cable pulling sheaves of adequate size shall be used where necessary to prevent damage to the cable. Cables shall be placed straight and parallel in the trays in a flat spaced arrangement. There shall be minimum crossing of cables in trays. Cables shall be secured to the tray with cable cleats designed for short circuit withstand bracing and installed at the manufacturer's recommended spacing. Identification markers shall be installed at at each end of the cable per paragraph 'Cable Identification". After all work in the area containing new cables is complete, the trays shall be thoroughly cleaned of all dirt and trash generated by the new cable installation. Cable moved in the cleaning

process shall be repositioned and final cable positions in the trays checked and corrected if necessary.

3.1.7 Bends

The minimum radius to which an insulated conductor or a multiconductor cable may be bent, without specific approval, whether permanently or temporarily during installation, shall be 12 times the overall diameter of the completed cable for tape shielded cables and 10 times the overall diameter for other cables. For multiconductor cable, follow manufacturer's recommendation for type of cable involved.

3.1.8 Cable Cleats

Cleats shall be provided for securing cables in cable tray. Cleats for supporting the weight of cables installed in vertical wireways shall be as required per NFPA 70 for adequate support. The size of each clamp shall be in accordance with the manufacturer's recommendations for each diameter and weight of cable to be secured or supported.

3.1.9 Splices

Splices will be permitted only with written approval from the Agency. All splices shall be made in accessible cabinets, boxes or outlets. No splices will be allowed inside conduits. Splices shall be made with solderless compression connectors and either a heat shrink or a cold shrink splice kit rated at 133 percent insulation installed per manufacturer's instructions.

3.1.10 Terminations

All cable shields shall be grounded at one end only unless otherwise indicated. Heat shrink, cold shrink or tape type stress cone terminating and splice kits shall be installed in accordance with the cable manufacturer's recommendations and as approved. Installation of the stress cone terminations shall be as described in the kit instructions, except the taping of conductor terminals shall be extended over the terminal fitting and the terminal of the device to which the conductor is attached.

3.1.11 Cable Identification

All cables shall be identified on both ends by the designations as shown on the Contract FIO drawings or as otherwise shown on approved shop drawings. All cables shall be clearly identified with the cable designation by either embossed 1-inch diameter brass tags, by embossed aluminum band markers, by tube-type markers as described in subparagraph Marking, or by 1-inch acrylic tags marked as described in subparagraph Marking. Tags or band markers shall be securely fastened to the cables at each termination, junction or pull box, where cables enter or leave cable trays, and as required at other points of access. Cables and individual conductors of multiconductor cables shall be identified with markers at each termination. Installed markers shall be uniform in position on the cable and legends shall be visible when conductors are terminated at the equipment.

3.1.11.1 Marking

Tubing shall be sized to fit the wire being marked and shall have black

marking on a light colored background. Tube-type markers shall be suitable for contact with the type of insulation material used. Tubing shall have permanent black marking on a light-colored background. The markers shall have been tested by an independent testing laboratory or by the manufacturer to indicate that the markers will not stain or discolor when subjected to an accelerated aging test while in contact with wire insulating materials and ultraviolet light exposure.

3.1.12 Ground Conductors

New grounding conductors will not be required with new medium voltage cables.

3.2 FIELD ACCEPTANCE TESTING

3.2.1 Testing

Testing shall be per IEEE 400 and NETA ATS recommended procedures.

a. Submit Test Reports in accordance with referenced standards in this section.

b. After completion of the installation and prior to energizing the conductors, perform wire and cable continuity and insulation tests as herein specified.

c. Contractor must provide all necessary test equipment, labor, and personnel to perform the tests, as herein specified.

d. Field Acceptance Testing and submittals shall be performed as described herein.

e. Isolate completely all wire and cable from all extraneous electrical connections at cable terminations and joints. Substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices must be used to isolate the circuits under test.

f. Suitable records shall be kept of all tests, indicating the insulation-resistance tests, high voltage tests, continuity tests, phase rotation tests high potential tests, and conductor identification markings. A duplicate record of all tests shall be furnished to the Agency. Prior to testing, the wire and cable test record form shall be submitted for approval. Test reports shall provide room for the Agency's signature. After installation, but just prior to terminal connection, each conductor shall be tested as follows:

(1) Perform a Conductor Continuity Test on each wire and each individual conductor of a multiconductor cable to insure correct connections end-to-end.

(2) Perform a Shield Continuity Test on each cable shield to insure correct connections end-to-end.

(3) Perform a Shield Resistance Test on each cable shield. Shield resistance shall be less than 10 ohms per 1000 feet of cable.

(4) Perform an Insulation Resistance Test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential must be 1000 volts DC for 2.4kV rated cable, and 2500 volts DC for 5kV and 15kV rated cable. Minimum insulation resistance values must not be less than 500 Megohms for 2.4kV rated cable, 1000 Megohms for 5kV rated cable, and 5000 Megohms for 15kV rated cable.

(5) Perform High Potential Test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential must be 23kV AC for 5kV rated cable, and 44kV AC for 15kV rated cable. The Contractor may perform DC testing only with the approval of the cable manufacturer at 36kV DC for 5kV rated cable, and 64kV DC for 15kV rated cable.

(6) Perform a Phase Rotation Test on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment clockwise, facing the source.

(7) Tests shall be witnessed by the Agency and the wire and cable installation test reports shall be submitted in accordance with Section 01 33 00, SUBMITTAL PROCEDURES.

3.2.2 Acceptance

Final acceptance will depend upon the successful performance of wire and cable under test. Conductor shall not be energized until the final test reports are reviewed and approved by the Agency.

-- End of Section --

SECTION 26 05 19.00 26

INSULATED WIRE AND CABLE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. References are subject to the most recent revisions as of the date of this contract award.

ASTM INTERNATIONAL (ASTM)

ASTM B 3	Soft or Annealed Copper Wire
ASTM B 33	Tinn-Coated Soft or Annealed Copper Wire for Electrical Purposes
ASTM B 8	Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 383	Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA WC 57	Control Cables
NEMA WC 70	Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658
NEMA WC 74	Standard for 5-46 kV Shielded Power Cable for use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	National Electrical Code - 2011 Edition

1.2 SUBMITTALS

The following shall be submitted in accordance with SECTION 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Submit within 180 days after Contract Award:

Insulated Wire and Cable

Special Wire And Cable

SD-06 Test Reports

Submit within 10 days after completion of tests:

Insulation-Resistance Test

Two certified copies of test reports shall be submitted.

Continuity Test

Two certified copies of test reports shall be submitted.

Phase-Rotation Tests

Two certified copies of test reports shall be submitted.

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 General

The cables shall be furnished one length to a reel or coil. Each length, and the outside of each reel or coil, shall be plainly marked or tagged to indicate the cable length, voltage rating, conductor size, and manufacturer's lot number and reel number. Cables for exclusively DC applications shall be identified as such. Reels shall remain the property of the Contractor.

1.3.2 Marking

Tube-type markers shall be used at each terminating end of the conductor and shall be suitable for contact with the type of insulation material used. Tubing shall be sized to fit the wire being marked and shall have black marking on a light colored background. Tubing shall have permanent black marking on a light-colored background. The markers shall have been tested by an independent testing laboratory to indicate that the markers will not stain or discolor after 20 years' service when subjected to an accelerated aging test while in contact with wire insulating materials. Designations shall be as shown on the Contract drawings or as otherwise shown on approved shop drawings.

1.4 INSPECTION AND TESTS

1.4.1 General

Inspection and tests of wire and cable furnished under these specifications shall be made by and at the plant of the manufacturer. The Agency may perform further tests before or after installation. Testing in general shall comply with Part 6 of NEMA WC 57, Section 6 of NEMA WC 70, or Section 9 of NEMA WC 74 as applicable. Specific tests required for particular materials, components, and completed cables shall be as specified in the sections of the above standards applicable to those materials, components, and cable types. Tests shall also be performed in accordance with the additional requirements specified below.

1.4.2 High-Voltage Test Source

Where the applicable standards allow a choice, high-voltage tests for cables to be used exclusively on DC circuits shall be made with DC test

voltages. Cables to be used exclusively on AC circuits shall be tested with AC test voltages. If both AC and DC will be present, on either the same or separate conductors of the cable, AC test voltages shall be used.

1.4.3 Flame Tests

All multiple-conductor and single-conductor cable assemblies shall pass IEEE 383 flame tests, paragraph 2.5, using the ribbon gas burner. Single-conductor cables and individual conductors of multiple-conductor cables shall pass the flame test of Part 3 of NEMA WC 57 Section 6 of NEMA WC 70, or Section 7.1 of NEMA WC 74 as applicable. If such tests, however, have previously been made on identical cables, these tests need not be repeated. Instead, certified reports of the original qualifying tests shall be submitted.

1.4.4 Independent Tests

The Agency may at any time make visual inspections, continuity or resistance checks, insulation resistance readings, power factor tests, or DC high-potential tests at field test values. A cable's failure to pass these tests and inspections, or failure to produce readings consistent with acceptable values for the application, will be grounds for rejection of the cable.

PART 2 PRODUCTS

2.1 INSULATED WIRE AND CABLE

2.1.1 General

All wire and cable used for power, control, metering, and relaying systems shall be provided by the Contractor and shall conform to the requirements specified herein. Characteristics, including conductor size, stranding, number of conductors, rated circuit voltage, cabling, and other requirements for each type of service, shall be as indicated on the drawings or as specified under the detailed requirements of these specifications for the particular construction or use, unless otherwise stated.

2.1.2 Wire and Cable Schedule

Wire and cable shall be furnished in accordance with the requirements of the Conduit and Cable Schedule. Estimated quantities and sizes listed in the Conduit and Cable Schedules are approximate for bidding purposes. Asbuilt Conduit and Cable schedules shall be submitted indicating accurate lengths and routes of all cables installed under this contract.

2.1.3 Governing Standards

Materials, construction and tests, unless otherwise specified, shall conform to the applicable requirements of NEMA WC 70 and NEMA WC 74 as applicable.

2.2 MATERIALS

2.2.1 Submittal Requirements

The Contractor shall submit catalog data to the Agency for review and/or approval as indicated in the submittal register. Data shall demonstrate

compliance with the specifications requirements for all Wire and Cable types to be installed.

2.2.2 Rated Circuit Voltages

All wire and cable shall have minimum rated circuit voltages in accordance with NEMA WC 70 and NEMA WC 74.

2.2.3 Conductors

2.2.3.1 Material for Conductors

Conductors shall conform to all the applicable requirements of Section 2 of NEMA WC 70 or Section 2 of NEMA WC 74 as applicable and shall be annealed copper wire conforming to ASTM B 3. Copper conductors may be bare, or tin-alloy coated, if required by the type of insulation used. Tin-coated copper conductors shall conform to ASTM B 33. Conductors shall be solid or stranded as required by subparagraph entitled Stranding.

2.2.3.2 Size

Minimum wire size shall be No. 12 AWG for power and lighting circuits; No. 10 AWG for current transformer secondary circuits; No. 14 AWG for potential transformer, relaying, and control circuits; and No. 16 AWG for annunciator circuits.

2.2.3.3 Stranding

Conductor stranding classes cited herein shall be as defined in Appendix G of NEMA WC 70 and Appendix H of NEMA WC 74 as applicable. Conductors No. 10 AWG and smaller shall have Class B stranding as defined in Table 1 of ASTM B 8. Any conductors used between stationary and moving devices, such as hinged doors or panels, shall be Class H or K stranding. All other conductors shall have class B stranding.

2.2.4 Insulation

2.2.4.1 Insulation Voltage Rating and Insulation Level

The rated voltage of the insulation shall be 600 volts for all circuits operating below 2,000 volts, with 100 percent insulation level. The rated voltage of the insulation shall be 5,000 volts for all circuits operating above 2,000 volts and below 5000 volts, with 133 percent insulation level. The rated voltage of the insulation shall be 15,000 volts for all circuits operating above 5,000 volts, with 133 percent insulation level.

2.2.4.2 Insulation Material

Except as otherwise specified, insulation shall be cross-linked thermosetting polyethylene (XLPE) type or an ethylene-propylene rubber (EPR) type meeting the requirements of Section 3 of NEMA WC 70 or Section 4 of NEMA WC 74 as applicable. Polyvinyl Chloride (PVC) insulation will not be accepted.

2.2.4.3 Insulation Thickness

The insulation thickness for each conductor shall be based on its rated circuit voltage.

a. Single-Conductor Cables, 2,000 Volts and Below - The insulation thickness for single-conductor cables rated 2,000 volts and below shall be as required by NEMA WC 70.

b. The insulation thickness for single-conductor cables rated over 2000 volts shall be as required by Section 4 of NEMA WC 74.

c. Multiple-Conductor Control Cables - The insulation thickness of multiple-conductor cables used for control and related purposes shall be as required by NEMA WC 70 or NEMA WC 74 as applicable.

2.2.4.4 Insulation Shielding

Shielding, where specified for control cables rated below 2,000 volts, shall conform to the requirements of Part 4 of NEMA WC 57. Shielding for cables rated over 2000 volts shall comply with Sections 5 and 6 of NEMA WC 74.

2.2.4.5 Tray Cable

Provide tray rated cables UL Listed as TC per UL Standard 1277 where conductors are routed in cable tray. For cables routed unprotected to conduit or equipment outside of the cable tray provide cables UL Listed as TC-ER (Exposed Run) per UL Standard 1277.

2.2.5 Jackets

All cables shall have jackets meeting the requirements of Part 4 of NEMA WC 57, Section 4.1 of NEMA WC 70 or Section 7.1 of NEMA WC 74 as applicable, and as specified herein. Individual conductors of multiple-conductor cables shall be required to have jackets only if they are necessary for the conductor to meet other specifications herein. Jackets of single-conductor cables and of individual conductors of multiple-conductor cables, except for shielded cables, shall be in direct contact and adhere or be vulcanized to the conductor insulation. Multiple-conductor cables and shielded single-conductor cables shall be provided with a common overall jacket, which shall be tightly and concentrically formed around the core. Repaired jacket defects found and corrected during manufacturing are permitted if the cable, including jacket, afterward fully meets these specifications and the requirements of the applicable standards.

2.2.5.1 Jacket Material

The jacket shall be one of the materials listed below, in accordance with the applicable paragraphs of NEMA WC 70 and NEMA WC 74. Polyvinyl chloride compounds will not be permitted. Variations from the materials required below will be permitted only if approved for each specific use, upon submittal of sufficient data to prove that they exceed all specified requirements for the particular application.

a. Heavy-duty black neoprene (DCR-HD).

b. Heavy-duty chlorosulfonated polyethylene (CSPE-HD).

c. Heavy-duty cross-linked (thermoset) chlorinated polyethylene (CPE-XL-HD).

2.2.5.2 Jacket Thickness

The minimum thickness of the jackets at any point shall be not less than 80 percent of the respective nominal thicknesses specified below:

a. Thickness of the jackets of the individual conductors of multiple-conductor cables shall be as required by Section 4.1 of NEMA WC 70 or Section 7.1 of NEMA WC 74 as applicable, and shall be in addition to the conductor insulation thickness for the insulation used. Thickness of the outer jackets or sheaths of the assembled multiple-conductor cables shall be as required by Section 4.1 of NEMA WC 70 or Section 7.1 of NEMA WC 74 as applicable.

b. Single conductor cables, if nonshielded, shall have a jacket thickness as specified in Section 4.1 of NEMA WC 70. If shielded, the jacket thickness shall be in accordance with the requirements of Section 4.1 of NEMA WC 70, or Section 7.1 of NEMA WC 74 as applicable.

2.3 CABLE IDENTIFICATION

2.3.1 Color-Coding

Only one color-code method shall be used for each cable construction type. Colored braids will not be permitted. Control cable color-coding shall be in accordance with ICEA S-58-679 identification table 1, method 2. Power cable color-coding for 208/120 volt systems, 4.16kV systems, and for 13.8kV systems shall be black for Phase A, red for Phase B, blue for Phase C, and white for grounded neutral. Color coding for 480/277 volt systems shall be brown for Phase A, orange for Phase B, yellow for Phase C, and gray for grounded neutral. Green shall be used only for grounding conductors if insulated.

Exceptions may be granted if color coding as listed in this section are not readily available. For multiconductor cables, with all black current carrying conductors, identify phases. For multiconductor cables that are not black for all current carrying conductors, the color scheme shall be identified at the point of origin and point of termination to indicate what phase corresponds with what color.

2.3.2 Cabling

Individual conductors of multiple-conductor cables shall be assembled with flame-and moisture-resistant fillers, binders, and a lay conforming to Part 5 of NEMA WC 57, Section 5 of NEMA WC 70, or Section 8 of NEMA WC 74 as applicable, except that flat twin cables will not be permitted. Fillers shall be used in the interstices of multiple-conductor round cables with a common covering where necessary to give the completed cable a substantially circular cross section. Fillers shall be non-hygroscopic material, compatible with the cable insulation, jacket, and other components of the cable. The rubber-filled or other approved type of binding tape shall consist of a material that is compatible with the other components of the cable and shall be lapped at least 10 percent of its width.

2.3.3 Dimensional Tolerance

The outside diameters of single-conductor cables and of multiple-conductor cables shall not vary more than 5 percent and 10 percent, respectively, from the manufacturer's published catalog data.

2.4 SPECIAL WIRE AND CABLE

2.4.1 Control Panel Shop Wiring

Wiring for factory assembled control panels or assemblies of electrical components for miscellaneous equipment shall be manufacturers standard.

PART 3 EXECUTION

3.1 INSTALLATION INSTRUCTIONS

3.1.1 General

For the purposes of this contract, the term "internal wiring" shall be used to designate the manufacturers factory installed wiring furnished with the furnished equipment, and the term "external wiring" shall be used to designate field installed wiring. Schedules of wire and cable are as shown in the drawings, showing information on cable numbers, sizes and estimated lengths, number of conductors, the function, and origins and terminations. Although estimated cable lengths are shown on the schedule for bidding purposes, the Contractor shall be responsible for determining the actual cable length required to make an installation of all new cables without splices. Different voltages shall not be run within the same multiconductor cable. The Contractor shall submit the manufacturer's installation instructions.

3.1.2 External Wiring

All external wire and cable shall conform to paragraph INSULATED WIRE AND CABLE. All wire and cable shall be installed in accordance with NFPA 70 requirements. All necessary materials, tools and equipment required for proper handling and installation of wire and cable in conduits, cable trays, and elsewhere shall be furnished by the Contractor. Except for spares, each wire and cable shall be connected to the associated equipment at both ends, and new cable shall be continuous and without splices between the equipment termination points. Spares shall have exposed ends taped over and labeled as "spare". Wire and cable shall be pulled in a manner which will preclude damage to the conductor, insulation or jacket. Wire and cable shall be pulled by the conductor and not by the insulation, jacket, or sheath. Pulling tension shall not exceed the manufacturer's recommended maximum. Any cable damaged during installation shall be removed and replaced. Installation of wire and cable shall include installation of all supporting devices and all terminations required to complete the circuits as required. Wire and cable shall not be pulled into conduit runs until the conduit has been checked and determined to be clean and dry by pulling a clean, dry, tight fitting rag through each run. Only approved lubricants may be used to facilitate pulling of conductors.

3.1.3 Terminations

All cable and wire connections shall be made at terminal blocks with lugs approved for connection to copper conductors. The shield and shield insulating jacket of shielded signal cables and conductors, if applicable, shall be maintained to a point as close to the terminals as possible. The shield insulating jacket shall not be stripped from the shield except where necessary to make the ground connection. All signal cable shields shall be grounded at one end only.

3.1.4 Wire Markings

All multiple conductor cables shall be clearly identified with the cable designation by either embossed 1-inch diameter brass tags or by embossed aluminum band markers. Tags or band markers shall be securely fastened to the cables at each termination, junction or pull box, where cables enter or leave cable trays, and as required at other points of access. Wires and individual conductors of control and power cables shall be identified with non-metallic tube type markers at each termination. Installed markers shall be uniform in position on the wire and legends shall be visible when wires are terminated on terminal blocks or at the equipment. Designations on markers shall be as shown on the contract drawings or as otherwise shown on approved shop drawings. All cable markings shall identify the location from, the circuit number and the location to at a minimum.

3.1.5 Installation in Conduit

Wire and cable shall not be pulled into conduit runs until the conduit has been checked and determined to be clean and dry by pulling a clean, dry, tight fitting rag through each run. Only approved lubricants may be used to facilitate pulling of conductors.

3.1.6 Bends

The minimum radius to which an insulated conductor larger than No. 8 AWG, or a multiple conductor cable may be bent, without specific approval, whether permanently or temporarily during installation, shall be 12 times the overall diameter of the completed cable for tape shielded cables and 10 times the overall diameter for other cables. In these instances where this radius is not possible, approval will be required for minimum radii as specified in NFPA 70. For multiple conductor cable, follow manufacturer's recommendation for type of cable involved.

3.1.7 Cable Clamps

Clamps for protecting and supporting the weight of cables installed in vertical wireways shall be as required per NFPA 70 for adequate support. The size of each clamp shall be in accordance with the manufacturer's recommendations for each diameter and weight of cable to be supported or protected.

3.1.8 Splices

Splices will not be permitted unless approved by the Agency.

3.1.9 Ground Conductors

A ground conductor shall be run for all circuits. If not an integral part of a multiple conductor cable, a separate ground conductor shall be provided. Ground conductors shall be installed as continuous pieces of copper cable whenever possible. Exposed ground cable runs shall be supported to follow conduit, equipment or concrete wall contours. Support clamps or clips shall be of corrosion resistant metal and existing equipment bolts or screws shall be used where possible for fastening. Drilling of equipment housings or frames will be permitted only when approved. Concrete anchors shall be used for wall fastening.

3.2 FIELD ACCEPTANCE TESTING

3.2.1 Testing

a. Submit Test Reports in accordance with referenced standards in this section.

b.After completion of the installation and splicing, and prior to energizing the conductors, perform wire and cable continuity and insulation tests as herein specified before the conductors are energized.

c. Contractor must provide all necessary test equipment, labor, and personnel to perform the tests, as herein specified.

d. Field Acceptance Testing and submittals shall be performed as described in Sections 26 08 01.00 26, SYSTEMS TESTING AND COMMISSIONING, and as described herein. Where testing and/or submittals is duplicated between these Sections, the testing and /or submittals need not be duplicated; however, the more stringent requirements shall apply.

e. Isolate completely all wire and cable from all extraneous electrical connections at cable terminations and joints. Substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices must be used to isolate the circuits under test.

f. Suitable records shall be kept of all tests, indicating the insulation-resistance tests, high voltage tests, continuity tests, and conductor identification markings. A duplicate record of all tests shall be furnished to the Agency. Prior to testing, the wire and cable test record form shall be submitted for approval. Test reports shall provide room for the Agency's signature. After installation, but just prior to terminal connection, each conductor shall be tested as follows:

(1) Perform Insulation-Resistance Test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential must be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Take readings after 1 minute and until the reading is constant for 15 seconds. Minimum insulation-resistance values must not be less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes 8AWG and smaller insulation resistance testing is not required.

(2) Perform Continuity Test to insure correct cable connection (i.e correct phase conductor, grounded conductor, and grounding conductor wiring) end-to end. Any damages to existing or new electrical equipment resulting from Contractor's mis-wiring will be repaired and re-verified at Contactors's expense. All repairs must be approved by the CO prior to acceptance of the repair.

(3) Conduct Phase-Rotation Tests on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment clockwise, facing the source.

(4) Tests shall be witnessed by the Agency and the wire and cable installation test reports shall be submitted.

3.2.2 Acceptance

Final acceptance will depend upon the successful performance of wire and cable under test. Conductor shall not be energized until the final test reports are reviewed and approved by the Agency.

3.3 CONDITION ASSESSMENT OF EXISTING 600 VOLT CABLES

3.3.1 General

All power cables are to be replaced to the first point of termination with the exception of PDP-M and Miracle Span feeders as indicated on the drawings.

3.3.2 Test Procedure

Each cable shall be disconnected at both ends and given an Insulation Resistance test at 500 volts DC for one minute. After the cable has discharged, the test shall be repeated at 1,000 volts DC for one minute. The leakage current shall be observed and recorded for each cable, and the resistance of each cable at completion of each test shall be recorded. If any one cable of a three-phase feeder fails the test criteria, or if the cables as a group are not within specified tolerances as specified below, all three cables of the feeder shall be replaced.

3.3.3 Failure Criteria for Each Feeder

A feeder shall be considered a failure if:

a. The insulation resistance of any one cable of the feeder is less than two megohms at either test voltage.

b. The leakage current rises and fails to stabilize in any one cable of the feeder during the one minute test at either test voltage.

c. The insulation resistance between any of the three cables differs by more than 25 percent of the lowest insulation resistance reading at either test voltage.

-- End of Section --

SECTION 26 05 26.00 26

GROUNDING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. References are subject to the most recent revisions as of the date of this contract award.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	National Electrical Safety Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	National Electrical Code - 2011 Edition

UNDERWRITERS LABORATORIES (UL)

UL 467	Grounding and Bonding Equipment

1.2 GENERAL REQUIREMENTS

1.2.1 Standard Products

Unless otherwise indicated, the materials and equipment to be furnished under this specification shall be the standard products of manufacturers regularly engaged in the production of such items and shall be the manufacturer's latest standard marketed design.

1.2.2 Workmanship

All work shall be completed in a thorough and workmanlike manner and shall conform to the best modern practice in the class of work regardless of any omission in the drawings and specifications.

PART 2 PRODUCTS

Products shall conform to the respective publications and other requirements specified below. Materials and equipment not listed below shall be as specified elsewhere in this section. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.1 GROUND CONDUCTORS

Ground conductors shall be bare, soft-drawn, Class A or B stranded copper cables sized in accordance with NFPA 70 of the size shown on the drawings and shall be installed as continuous pieces of cable whenever possible. Ground conductors size No. 10 and smaller shall be Class B stranded. Ground conductors size No. 6 and larger shall be Class A stranded.

Reference Section 26 05 19.00 26, INSULATED WIRE AND CABLE, where applicable.

2.2 GROUND CONNECTIONS

All exposed connections and taps shall be made with UL 467 approved pressure type connectors. Solder type connectors will not be permitted. Surfaces to be jointed shall be thoroughly cleaned and dry. Oxidation shall be removed.

PART 3 EXECUTION

3.1 GENERAL

The ground system shall comply with Article 250 of NFPA 70, paragraph 123 of IEEE C2, the contract drawings, and the following specifications. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved pressure type connectors.

3.2 GROUND CONDUCTORS

A green or bare equipment grounding conductor, sized in accordance with NFPA 70, or larger if shown on the drawings, shall be provided, regardless of the type of conduit. Equipment grounding bars shall be provided in all panelboards. The equipment grounding conductor shall be carried back to the service entrance grounding connection or separately derived grounding connection. All equipment grounding conductors, including metallic raceway systems used as such, shall be bonded or joined together in each wiring box or equipment enclosure. Test continuity of metallic raceways and grounding conductors to assure that they are wired or bonded into the facility UFER ground. Metallic boxes and enclosures, if used, shall also be bonded to these grounding conductors by an approved means per NFPA 70. When boxes for receptacles, switches, or other utilization devices are installed, any designated grounding terminal on these devices shall also be bonded to the equipment grounding conductor junction with a short jumper.

3.3 GROUNDING CONNECTIONS

All equipment shall be grounded as shown on the drawings and as required by NFPA 70.

-- End of Section --

SECTION 26 05 33.00 26

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C80.1	(2005) Rigid Steel Conduit - Zinc Coated

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2009) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA 1	(2010) Standard for Good Workmanship in Electrical Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA FB 1	(2007) Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
NEMA ICS 6	(1993; R 2006) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011) National Electrical Code - 2011 Edition

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007) Electrical Rigid Metal Conduit-Steel
UL 50	(2007) Enclosures for Electrical Equipment
UL 360	(2009) Liquid-Tight Flexible Steel Conduits
UL 467	(2007) Grounding and Bonding Equipment

UL 514A	(2004) Metallic Outlet Boxes
UL 514B	(2004) Conduit, Tubing and Cable Fittings
UL 870	(2008) Wireways, Auxiliary Gutters, and Associated Fittings

1.2 SUBMITTALS

The following shall be submitted in accordance with SECTION 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Manufacturer's descriptive data shall include catalog cuts, literature, and other data as necessary to describe details of construction, methods of installation or mounting, and input/output interface characteristics which verify conformance with specifications. Where a catalog sheet covers more than one size or type of equipment, the specific item contemplated shall be identified in the catalog sheet by underlining or other suitable means. Items not applicable shall be marked out. Submit within 30 days of Notice To Proceed:

Liquid Tight Flexible Steel Conduit

Rigid Metal Conduit

Rigid Metal Conduit Fittings

Conduit Hangers;

Wireways;

Boxes and Enclosures;

1.3 WORKMANSHIP

All work shall be completed in a neat and workmanlike manner and shall conform to the best modern practice in the class of work regardless of any omission in the drawings and specifications. Accepted industry practices are as described in NECA 1 and other ANSI approved installation standards.

PART 2 PRODUCTS

2.1 CONDUIT

2.1.1 Liquid Tight Flexible Steel Conduit

Conduit shall conform to UL 360. Conduit shall have an interlocked flexible galvanized steel core with a permanently bonded exterior gray polyvinyl chloride jacket. Conduits 1-1/4 inch and smaller shall have an internal copper bonding conductor wound spirally in the space between each convolution for the equipment ground provided by the manufacturer. Flexible conduit shall only be used on connections to equipment, and shall have a maximum length of 36 inches.

2.1.2 Rigid Metal Conduit

Rigid metal conduit shall be minimum 3/4-inch trade size and shall, in addition, be zinc coated (galvanized) both inside and outside by the hot-dip method and shall conform to UL 6 and ANSI C80.1.

2.2 CONDUIT FITTINGS

a. Rigid metal conduit fittings shall be threaded and cadmium- or zinc-coated (by hot-dipped galvanizing or by electroplating) on the inside and outside and shall conform to NEMA FB 1, UL 467, and UL 514B. Fittings shall be galvanized cast or malleable iron. Expansion fittings shall be UL Listed and shall allow up to 4 inches of movement. Design of expansion fittings shall be similar to O-Z Gedney Type AX series.

b. Liquid-tight Flexible Metal Conduit Fittings shall meet the requirements of UL 514B and NEMA FB1. Only steel or malleable iron materials are acceptable. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.

2.3 CONDUIT HANGERS

a. Conduit hangers shall be fabricated from two or more galvanized steel hanger rods, a galvanized steel horizontal member, U-bolts, clamps, and other attachments as necessary for securing hanger rods and conduits. Hanger rods shall be not smaller than 3/8-inch diameter and threaded either full length or for a sufficient distance at each end to permit at least 1-1/2 inches of adjustment. Horizontal members shall be standard structural steel shapes such as angles or channels, 1-1/2 by 1-1/2 inch or 1-5/8 by 1-5/8 inch, 12 gauge, cold-formed, lipped channel, and designed to accept special spring-held hardened steel nuts for securing hanger rods or other attachments. Nuts and clamps shall be compatible with the channel. Two or more channels may be welded together to form horizontal members of greater strength. All members shall be hot-dip galvanized after fabrication in accordance with ASTM A 123/A 123M or ASTM A 153/A 153M as applicable.

b. Conduit hangers shall be capable of supporting a load equal to the sum of the weights of the conduits and wires, the weight of the hanger itself, plus 200 pounds. The stress at the root of the thread of the hanger rods shall be not more than 9,475 psi at design load. The horizontal member shall be sized such that the maximum stress will be not more than 12,650 psi at design load. Hanger assemblies shall comply with the applicable requirements of SECTION 13 48 00.00 26, SEISMIC RESTRAINT FOR MECHANICAL AND ELECTRICAL EQUIPMENT.

2.4 WIREWAYS

Wireways shall be Listed to UL 870. Wireways and all fittings and connectors shall be made of sheet metal. Covers and bodies of wireways shall otherwise have minimum thickness equal to 18 gauge steel. Seams shall be continuously welded and ground smooth, with no screws or bolts protruding into the inside of the wireway. All edges and corners shall be rounded and smooth. All covers and connectors including elbows, tees, crosses, nipples, and closure plates shall be gasketed. Metallic wireways shall be NEMA Type 12.

2.5 BOXES AND ENCLOSURES

2.5.1 General

Each box shall have not less than the volume required by NFPA 70 for number of conductors enclosed in box. Boxes for metallic raceways, 6- by 4- by 4-inches nominal size and smaller, shall be of the cast-metal hub type. Boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces shall be gasketed. Cast-metal boxes with 3/32-inch wall thickness are acceptable. Boxes larger than 6- by 4- by 4-inch nominal size shall be NEMA Type 12. Boxes in other locations shall be sheet steel.

2.5.2 Outlet Boxes

Outlet boxes shall conform to UL 514A. Fittings shall conform to UL 514B. All outlet boxes, conduit fittings, pull boxes, and switch boxes shall be hot-dip zinc coated after fabrication, or shall have zinc or cadmium electroplated finish. Outlet boxes shall be not less than 1-1/2 inches deep. Device boxes located outdoors, imbedded or concealed in concrete or CMU walls, or in damp locations shall be cast type, with gasketed weatherproof covers.

2.5.3 Steel Cabinets And Boxes

Steel cabinets and boxes, and other steel enclosures and their doors shall conform to NEMA 250 and UL 50. Control enclosures shall conform to NEMA ICS 6. No box shall have less than four cover fastening screws. Junction and pull boxes shall be furnished with covers of the same gage metal as the box. All cabinets shall be furnished with doors, gaskets and trims. Doors shall be equipped with flush or semi concealed hinges, with a vault type handle and a three-point catch. Identifying nameplates shall be provided on the front of the doors with designations as shown on the contract drawings. Insulating standoffs, panels, and rail for mounting equipment shall be provided as required.

PART 3 EXECUTION

3.1 CONDUIT

3.1.1 General

The conduit installation shall be made in accordance with these specifications, the National Electrical Code, and as shown on the drawings and shall include all rigid and flexible conduits, boxes, and all necessary fittings. The necessary precautions shall be exercised to prevent the entrance and lodgment of grout, concrete, dirt, plaster, or trash in conduit, fittings and boxes during the course of installation. Conduit that has been crushed or deformed in any way shall not be installed. Bends and offsets in rigid conduit shall be made with a conduit bending machine for conduit 1-1/4 inch or larger. Electrical continuity of the conduit system shall be maintained. Damaged galvanized surfaces shall be repaired with galvanizing repair compound in accordance with ASTM A 780. All installed empty conduit shall be provided with an approved nylon pull rope with tensile strength equal or greater than No. 12 AWG. Complete all mechanical work of installing conduit before installing wire. Unless otherwise indicated, raceways shall be concealed where possible within finished walls, ceilings, and floors other than slabs-on-grade. Care shall be taken to maintain electrical continuity of

the conduit system to provide a safe ground path for fault currents by tightening each coupling and connection in the conduit system as tightly as possible.

3.1.2 Pull Wires

A pull wire shall be inserted in each empty raceway if the raceway is more than 50 feet in length and contains more than the equivalent of two 90-degree bends, or where the raceway is more than 150 feet in length. The pull wire shall be of No. 14 AWG zinc-coated steel, or of plastic having not less than 200-pound tensile strength. Not less than 10 inches of slack shall be left at each end of the pull wire.

3.1.3 Changes in Direction of Runs

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

3.1.4 Exposed Conduit

3.1.4.1 General

Exposed conduit shall be installed to avoid interference with other work. Structural steel shall not be cut, drilled or bent to avoid interference except with written approval. Exposed conduit shall be installed to conform to the shape of the surface over which it is run and shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Supports shall be used at entrance or exit from all conduit fittings, boxes, cabinets and changes of direction of conduit. Bolts, pipe straps and all other supporting hardware for exposed conduit shall be hot dip galvanized after fabrication.

3.1.4.2 Conduit Inspection

After an exposed conduit system is installed, or after conduit has been placed in a steel stud wall and prior to placement of the outside surface, it will be given a visual inspection and, if directed, a mandrel shall be drawn through the conduit in the presence of the Contracting Officer. Should the mandrel fail to pass through the conduit, a new bend or length of conduit shall be installed at the points of obstruction.

3.1.5 Exposed Raceways

Raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Exposed installations, in this paragraph, include raceways under raised floors or above accessible ceilings.

3.1.6 Supports

Metallic conduits and tubing, and the support system to which they are attached, shall be securely and rigidly fastened in place to prevent vertical and horizontal movement at intervals of not more than 10 feet and

within 3 feet of boxes, cabinets, and fittings, with approved pipe straps, wall brackets, conduit clamps, conduit hangers, threaded C-clamps, beam clamps, or ceiling trapeze. Cutting the main reinforcing bars in reinforced concrete beams or joists shall be avoided when drilling holes for support anchors. Holes drilled for support anchors, but not used, shall be filled. Cables and raceways shall not be supported by ceiling grids. Conduits shall be fastened to sheet-metal boxes and cabinets with two locknuts where required by NFPA 70, where insulating bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, a single locknut and bushing may be used. Threadless fittings for electrical metallic tubing shall be of a type approved for the conditions encountered.

3.1.7 Expansion Fittings

Expansion fittings shall be installed in exposed conduit runs every 100 feet maximum, and at all crossings of concrete expansion joints. Expansion fittings shall have a bonding jumper connecting the conduits together.

3.1.8 Grounding of Conduit System

The entire metallic conduit system shall be electrically continuous and bonding jumpers shall be used across all expansion fittings and between conduits entering and leaving electrical utility vaults and panelboards and cabinets. Insulated ground bushings shall be used to bond metallic conduits. Conduits terminating at cabinets and panel boards shall be grounded at the equipment by grounding bushings connected to the grounding system by a No. 8 wire. Conduit runs shall be grounded at both ends.

3.1.9 Coordination

The conduit shall be installed in the most direct and workmanlike manner so that interference between piping, ducts, conduit, mechanical, electrical, and structural features will be avoided. In case interference does develop, the Contracting Officer will decide which work shall be relocated regardless of which work was first installed. The rerouting shall be made without additional cost to the Agency. The Contractor shall carefully examine existing equipment installations to determine that new installations can be made without interference with other work.

3.1.10 Cutting and Threading

All cuts shall be made with a hacksaw or a cutter-type tool approved for this use. Roller type pipe cutters shall not be used on conduits. All cuts shall be square and the conduit opening shall not be constricted. After cutting and threading, conduit ends shall be reamed to remove burrs, and the entire conduit shall be thoroughly cleaned to remove all cuttings, dirt and oil from its interior. Threads shall be clean-cut. No running threads will be permitted. Conduit unions shall be used where standard couplings cannot be used. All conduit joints shall be wrench tight.

3.1.11 Thread Compound

Conduit joints and connections shall be made conductive, watertight and rustproof by the application of a blend of colloidal copper and rust inhibitors. Each threaded joint shall be thoroughly cleaned to remove all cutting oil before the compound is applied.

3.1.12 Bends

Wherever possible, bends in conduit runs shall have a radius of not less than 10 times the diameter nominal size. All bends shall be free from cracks and indentations.

3.1.13 Termination at Sheet Metal Boxes

Unless conduit hubs are provided, conduit shall be securely fastened to sheet metal boxes and cabinets with a locknut on both inside and outside and terminated with an insulated ground bushing. The conduit shall be of such length that when a bushing is screwed tight against the end of the conduit, no appreciable space will be left between bushing and locknut. The locknuts shall be tightened against the box without deforming the box.

3.1.14 Termination at Cast Boxes

Conduits terminating in cast boxes shall be made up in approved threaded hubs or bosses unless otherwise indicated. Conduit shall be corked or plugged with rags or similar packing material before the concrete is poured.

3.1.15 Outlet Boxes as Part of Conduit System

The Contractor shall be responsible for furnishing and installing junction and pull boxes, complete with covers, in the wiring or raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. When a pull box or special fitting is required to make a short radius bend to reach an outlet box, such pull box or fitting shall be furnished as part of the conduit installation even if not so indicated on the contract drawings.

3.2 WIREWAYS

Install the wireways level, straight, and true to line or grade within + 1/8-inch in 10 feet and within an accumulative maximum of 1/2-inch. Vertical structures shall be plumb within a tolerance of 1/8-inch per 10 feet of length. Install hold-down clamps or fasteners at all support points. Use clamps or fasteners to secure all covers as recommended by the wireway manufacturer. Install all connectors and splices in locations recommended by the wireway manufacturer. Install all hardware so that no sharp projections will occur in the path of the cables.

3.3 BOXES AND ENCLOSURES

3.3.1 General

Boxes shall be provided in the wiring or raceway systems wherever required by NFPA 70 for pulling of wires, making connections, and mounting of devices or fixtures. Pull boxes shall be furnished with screw-fastened covers. Indicated elevations (if any) are approximate, except where minimum mounting heights for hazardous areas are required by NFPA 70.

3.3.2 Installation

All boxes shall be straight and true with horizontal or vertical structural lines. The final installation shall not be out of plumb more than 1/4-inch over the full length nor be deformed more than 1/16-inch per linear foot nor more than a total of 1/4-inch in any surface. All boxes

and cabinets shall be cleaned of debris. Gaskets for gasketed boxes shall be treated with graphite or other approved paste at the time the cover is assembled to the box to prevent it from sticking. Cabinet trims shall be aligned and adjusted to the building wall. Blank covers shall be installed on boxes where devices are not indicated. Open knockouts shall not be permitted. Unused conduit openings shall be plugged with an approved fitting. Avoid cutting the main reinforcing bars in reinforced concrete beams or joists when drilling holes for support anchors.

3.3.3 Temporary Transformer Cover

The T2 750kva oil filled transformer will be used to provide temporary power to the new panelboards. The transformer 480V main paddle connections will be exposed after removal of the 480V switchgear unless a cover is installed. The Contractor is required to cover the temporary exposed paddles with sheet metal. The measured size of the exposed opening is 84 -inches in height by 54-inches wide. The sheet metal covering shall be thick enough to provide protection in the event a worker leans on it, not to collapse and make contact with the 480V paddles. The material type, thickness and rigidity for the cover shall be similar to the existing Switchgear exterior cabinet material for safety.

-- End of Section --

SECTION 26 08 01.00 26

SYSTEMS TESTING AND COMMISSIONING

PART 1 GENERAL

1.1 DESCRIPTION

a. This Section covers the testing and commissioning of electrical equipment installed under this contract. This Section expands and clarifies requirements described in the Commissioning paragraphs of the individual specification sections and the Sequence of Work.

b. The work under this contract alters and interfaces with numerous systems within an operating Powerhouse. Therefore, final acceptance of installed equipment shall consist of the commissioning of the installed work and the verification of the overall Agency system. The Contractor has lead responsibility for the commissioning of the installed work and the Agency has lead responsibility for the verification of the overall Agency system.

c. The Contractor shall furnish labor and material to accomplish and complete the commissioning as specified herein.

1.1.1 ROLES AND RESPONSIBILITIES

During commissioning, the Agency, the Contractor, and the Equipment Manufacturer will each have roles and responsibilities which will be phase dependent as follows:

1.1.2 Construction Test Phase

During the Construction Test Phase, the Contractor will have the lead role and shall perform all contract required inspections and tests. The Agency will perform contract administration and quality assurance for commissioning activities during the construction test phase. The Equipment Manufacturer will perform commissioning activities required by its separate supply contract, at the factory or the facility as necessary.

1.1.3 Pre-Operational Test Phase

During the Pre-Operational Test Phase, the Contractor will have the lead role and will be responsible for coordination, performance, and oversight of commissioning activities. The Contractor shall perform its commissioning activities and provide support for the Manufacturers commissioning activities during this phase. The Equipment Manufacturers will be responsible to perform commissioning activities required under their separate supply contracts, as coordinated with the Contractor and the Agency.

1.1.4 Operational Test Phase

During the Operational Test Phase, the Contractor will have the lead role and will be responsible for coordination, performance, and oversight of commissioning activities. The Contractor shall perform its commissioning activities and provide support for the Agency commissioning activities during this phase. The Equipment Manufacturer(s) will be responsible to

perform commissioning activities required under their separate supply contracts with the Contractor.

1.2 APPLICABILITY

This Section applies to all sections of these specifications unless otherwise indicated in the individual sections.

1.3 REFERENCED PUBLICATIONS

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

NETA ATS-2021	Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1248	(2007) Guide for the Commissioning of Electrical systems in Hydroelectric Power Plants

1.4 SUBMITTALS

The following shall be submitted in accordance with SECTION 01 33 00, SUBMITTAL PROCEDURES unless otherwise indicated below:

SD-01 Preconstruction Submittals

Equipment Removal, Installation, and Testing Plan and Schedule

Field Test Plans

Commissioning Agent's qualifications

Submit within 180 days after notice to proceed.

SD-06 Test Reports

Field Test Reports

Conductor Insulation Resistance Test Report

Conductor Continuity and Labeling Test Report

Circuit Functionality Test Report

Submit within 10 days after test complete.

1.5 GENERAL REQUIREMENTS

1.5.1 Sequence of Work

Work under this contract will require outages to energized systems. Proper sequencing of the work shall be required to minimize the duration of all outages of the generating units and the DC system. All equipment

outages shall be coordinated with the Agency before any work commences.

1.5.2 Equipment Removal, Installation, and Testing Plan and Schedule

The Contractor shall submit at least 90 days prior to the starting work date the proposed step-by-step Equipment Removal, Installation, and Testing Plan and Schedule, hereinafter also referred to throughout these specifications as the "Sequence of Work" or the "Cutover Plan". The Equipment Removal, Installation, and Testing Plan and Schedule shall include those activities and requirements listed in all specification sections in this contract, and this section. The plan shall include a detailed sequential list of activities, duration of each activity, and duration of all outages required. Equipment outages shall be coordinated with the Agency. This plan shall be updated and resubmitted for approval at least monthly. No work will be allowed to commence until the plan is approved.

1.5.3 Constraints and Outages

There will be multiple outage phases required. During the summer months, it is critical to maintain at least one Main Unit Generator online at Tyee Lake for system support. There are a few short outages that may be required where both Tyee Lake Units require de-energization. It is the Contractor's responsibility to minimize these types of full plant outages. The construction sequence will be critical in maintaining availability and operability of the plant during the change-out of the equipment. Temporary outages of individual circuits will be required as loads are transferred from the existing equipment to the new equipment. Outages shall be kept to a minimum and shall be coordinated with the Agency prior to submittal of the Equipment Removal, Installation, and Testing Plan and Schedule. Refer to section 01 21 16.00 28 Work Sequence for outage duration requirements and propose work sequence. It is expected that the Contractor will maximize the pre-outage work and minimize the outage work.

1.6 QUALIFICATIONS

1.6.1 Contractor's Commissioning Agent

The Contractor shall furnish a Commissioning Agent with a minimum of five (5) years experience in preparing commissioning plans and performing commissioning testing of hydroelectric generator equipment of at least two (2) similar units of 10 MW or larger. The Commissioning Agent shall be an employee of the Contractor with the authority to make decisions on behalf of the company and to direct the Contractor's on-site workforce during the commissioning activities. The Commissioning Agent's qualifications shall be submitted in résumé format for Agency approval within 180 calendar days after receipt of Contract Award.

1.7 GENERAL RESPONSIBILITIES OF CONTRACTORS'S COMMISSIONING AGENT

The responsibilities of the Contractor's Commissioning Agent shall include, but not be limited to:

a. Coordinate with subcontractors of the Contractor to provide the Equipment Removal, Installation, and Testing Plan and Schedule, and monthly updates.

b. Attend scheduled commissioning coordination meetings.

c. Prepare and submit detailed inspection and test plans required by the contract technical specifications.

d. Provide oversight of the Contractor's commissioning activities, including subcontractors of the Contractor, for all commissioning phases.

e. Submit Field Test Reports, confirming in writing the proper installation and performance of electrical equipment installed. Verification of Submission of Construction Test Phase test results.

f. On-site oversight of commissioning tests and inspections for installed or modified equipment during the Test Phases.

g. Providing oversight of craftworkers during Pre-Operational and Operational Test Phases.

1.8 RESPONSIBILITIES OF CONTRACTORS'S COMMISSIONING AGENT DURING CONTRACTORS'S COMMISSIONING

The responsibilities of the Contractor's Commissioning Agent during the Contractor's Commissioning shall include, but not be limited to:

a. Coordinate with subcontractors of the Contractorto provide the Equipment Removal, Installation, and Testing Plan and Schedule, and monthly updates.

b. Attend commissioning coordination meetings.

c. Certify and submit results of Conductor Insulation Resistance Test Report, Conductor Continuity and Labeling Test Report, and Circuit Functionality Test Report.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 GENERAL INFORMATION

Following installation, the equipment shall be inspected, tested, and commissioned following applicable procedures listed in IEEE 1248.

3.2 FIELD TESTING

a. During the construction and installation of electrical equipment, the Contractor shall perform the necessary inspections to ensure that the installation is in accordance with manufacturer's instructions and the design documents.

b. Detailed testing shall be performed on all installed equipment as specified in the technical specification sections of this contract to ensure that operation and performance conform to contract documents. All tests shall be witnessed by the Agency. Field Test Plans shall be submitted for approval per paragraph 1.4. The Contractor shall notify the Agency not less than 30 days prior to starting any test. All Field Test Reports shall be submitted prior to the commissioning tests.

c. The following data shall be recorded and submitted for all tests:

(1) Description of test.
(2) Description of equipment tested.
(3) Calibration information to include a list of each instrument used during testing stating calibration requirements by the instrument manufacturer and the calibration history of the instrument. The calibration history shall include dates calibrated and calibration procedures used.
(4) Description of operation of all affected system components.

3.3 CONTRACTOR'S COMMISSIONING AND TESTING

The following testing is required as part of the Contractor's commissioning process:

a. Insulation Resistance Test: All required conductors shall successfully pass an insulation resistance test at the values specified within the individual specification sections. The Contractor shall tabulate these test results, certify them, and submit them prior to the system commissioning.

b. Conductor Continuity Test (100% of all Conductors). All conductors shall successfully pass a continuity test between each termination. Proper termination shall also be verified for each conductor. The Contractor shall tabulate these test results, certify them, and submit them prior to the system commissioning.

c. Circuit Functionality Test. All circuits installed by the Contractor shall be given a complete functionality test, verifying that devices operate properly, and that the function of the circuit is as designed. This shall include tracing and verifying energy and/or signals are present at each point in the circuit at the proper time and in the proper sequence. The Contractor shall also verify that conductors and terminations are properly labeled. The Contractor shall tabulate these results, certify them, and submit them prior to the system commissioning.

3.3.1 CONTRACTORS COMMISSIONING AND TESTING EQUIPMENT LIST

When submitting testing and commissioning plans as specified, the Contractor shall refer to Standard NETA ATS-2021 for guidance on testing and commissioning procedures. This standard contains a comprehensive list of required tests and check points. The Contractor is not restricted to the lists in NETA ATS-2021, but may be required by equipment manufactures or other specification sections in this contract to perform additional tests, which shall also be included in the submitted testing and commissioning plans.

The following are estimates of commissioning activities that shall be performed on all equipment installed under this contract. The list contains, but is not limited to the following:

a. Test and Commission one (1) 480V Magnum DS Switchgear lineup with interlocks, tie breakers, meters, indication, Arc Flash loop sensors and ancillary equipment.

b. Test and Commission two (2) 480V Generators.

c. Test and Commission two (2) 500kva dry type transformers.

d. Test and Commission one (4) 480V panelboard without drawout circuit breakers.

e. Test and Commission annunciation circuits for the main 480V switchgear and emergency diesel generators.

f. Test and Commission programmable logic controller to include remote operation of all 480V switchgear breakers, metering display in PLC program, auto start-stop of emergency diesel generators, annunciation of PLC failure, programmable breaker interlocks and all other applicable programmed logic.

g. Test and Commission four (4) 15kV Switchgear breakers.

This Testing and Commissioning equipment list is not intended to be all inclusive, but is intended to be used as a guide by the Contractor in developing Testing and Commissioning Plans to be submitted as per this contract. The Contractor shall be responsible for including Testing and Commissioning Plans for all equipment installed under this contract and to include other plans as prescribed by equipment manufacturers or by the Agency.

3.4 AGENCY COMMISSIONING AND TESTING

After the Contractor has completed all testing required under these specifications, the Agency will conduct an independent verification of the results and a system commissioning procedure. The Contractor shall participate in these activities by reviewing and becoming familiar with the Agency commissioning plan, and by participating in the commissioning process. The Contractor shall provide one or more fully qualified craftsmen to assist in the testing, by taking readings, observing equipment, verifying settings, and making adjustments as instructed by the Commissioning Engineer.

-- End of Section --

SECTION 26 12 16

DRY-TYPE TRANSFORMERS

PART 1 GENERAL

1.1 GENERAL INFORMATION

This SECTION covers the supply and testing requirements for two (2)dry-type transformers.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASME INTERNATIONAL (ASME)

ASME B1.1	(2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.12.01	(2005) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.12.50	(1981; R 1998) Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Volt 601 to 34,500 Volts

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2003) Acceptance Testing Specifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2003) Enclosures for Electrical Equipment (1000 Volts Maximum)

1.3 SUBMITTALS

Agency approval is required for the following submittals:

SD-02 Shop Drawings

Outline and Assembly Drawings

Outline and assembly drawings of the transformers shall be submitted for approval within 120 calendar days after notice to proceed to demonstrate that the equipment will conform to the requirements and intent of the specifications.

SD-05 Design Data

Transformer Ratings

The transformer(s) ratings shall be submitted for approval within 120 calendar days after notice to proceed to demonstrate that the equipment will conform to the requirements and intent of he specifications.

Surge Arresters & Snubber

Surge arrestors and snubber circuti for the 15kV/480V 500kva transformers. Submit within 120 days after notice to proceed.

SD-06 Test Reports

Factory Acceptance Test Report

The official factory acceptance test report for each transformer shall be submitted within 30 days of completion of all tests.

Field Test Report

The field test reports shall be submitted within 30 days of completion of all field acceptance tests.

SD-08 Manufacturer's Instructions

Factory Test Procedure

The manufacturer's factory test procedures shall be submitted for review and approval 60 days prior to the scheduled date of factory acceptance testing.

Field Test Procedure

The manufacturer's field test procedures shall be submitted for review and approval 60 days prior to the scheduled date of field testing after delivery at Tyee Lake Powerhouse.

Transformer Shipping Plan

The manufacturer's transformer shipping plan shall be submitted for review and approval 60 days prior to the scheduled date of delivery at the Tyee Lake

Powerhouse. SD-11 Closeout Submittals

Warranty

Submit within 30 days prior to construction of equipment onsite.

1.4 WARRANTY

Units shall be warranted by the manufacturer from manufacturing defects for a period of 2 years after installation at Tyee Lake Powerhouse. See Section 01 78 00.00 28 CLOSEOUT SUBMITTALS for information regarding Warranty Management. Submit transformers manufacturer warranty for Agency

approval.

PART 2 PRODUCTS

2.1 GENERAL

The Tyee Lake Station Service transformers shall be ABB 500 kva, vacuum pressure impregnated (VPI) type, 13.8kV/480V Delta-Wye-Grounded, 3-phase, 60hz with 95/60kv Basic Insulation ratings, and an impedance of not less than 5% or approved equal. Transformers supplied as part of this Contract shall meet all applicable industry standards and requirements as listed in IEEE C57.12.0. Units below 500 kVA three-phase ratings shall also meet the requirements of IEEE C57.12.50 and units above 500 kVA shall also meet the requirements of IEEE C57.12.51.

2.1.1 Transformer Requirements

The Contractor shall submit outline and assembly drawings, and transformer ratings for review to demonstrate that the transformers meet all requirements in this SECTION.

2.1.1.1 Outline And Assembly Drawings

Outline and assembly drawings drawings shall include the following, at a minimum:

(1) Transformer nameplate information. Drawings shall be provided for each transformer nameplate, as required in Part 2 of this specification, paragraph titled "NAMEPLATES".

(2) Layout and dimensions of the assembled transformer, including base structural supports and center of gravity. An elevation view for each side of the transformer, a plan view, and a sectional view(s) showing the locations of the high and low voltage leads, shall be provided.

2.1.1.2 Transformer Ratings

Transformer Ratings submittals shall demonstrate the equipment will conform to the requirements and intent of the specifications. The submittal shall include, at a minimum, all specific ratings called out in this SECTION.

2.2 SERVICE CONDITIONS

2.2.1 General

Unless specified below, units shall be built for operation in indoor, ventilated enclosures in a non-hazardous environment meeting the usual service conditions outlined in Paragraph 4.1 of IEEE C57.12.01.

2.3 RATINGS

2.3.1 Cooling Classes

All units shall be rated for ventilated self-cooled operation, Class AA.

2.3.2 Key ratings

All units supplied shall be three-phase transformers with the following

preferred continuous power ratings, voltages, and connections:

NAME	KVA	VOLTAGE	CONNECTION
T1	500	13800-480	Delta-GrdY
T2	500	13800-480	Delta-GrdY

2.3.3 Winding taps

The 500 kVA transformers do not require taps, but may be included.

2.3.4 Impedance Voltage

Transformers shall be built to the standard impedance levels listed in Table 4 of IEEE C57.12.51, within a tolerance of ±7.5%:

b) Transformers shall be built to manufacturers standard however shall not have an impedance less than 5.0%.

2.3.5 Basic Lightning Impulse Insulation Level

2.3.5.1 Line Terminals

BIL levels for the low voltage windings shall be the standard values of BIL shown in Table 5 of IEEE C57.12.01. Transformers shall be insulated at 30kV, all other 13.8 kV windings shall be insulated at 90 kV.

2.3.5.2 Neutral Terminals

Windings designated as GrdY may be insulated for reduced neutral BIL in accordance with Paragraph 5.10.2 of IEEE C57.12.01.

2.3.6 Sound Level

Sound levels shall not exceed the class AA three-phase ratings listed in Table 8 of IEEE C57.12.01.

2.4 CONSTRUCTION

2.4.1 Insulation System

Transformer coils shall be impregnated using a VPI process. Coils shall be pre-heated before application of resin. Resin shall be pressure impregnated under several cycles of vacuum followed by positively pressurized dry-air or nitrogen to assure complete impregnation free of voids or air pockets. Windings shall be completely cured via oven. After landing the coils on the core and completing final adjustments, the entire assembly shall be treated with resin and oven-baked until fully cured.

2.4.2 Windings

Windings shall be copper.

2.4.3 Core

The transformer core steel shall be high-grade, grain oriented, silicon steel with a high magnetic permeability. Magnetic flux density in the core steel shall be below the saturation point. Core construction shall be designed to minimize core losses, excitation current, and noise levels.

2.4.4 Temperature Rise

The average winding temperature rise, as measured by resistance, shall be:

NAME	°C TEMPERATURE RISE
T1	80
T2	80

2.4.5 Enclosures and Mounting

2.4.5.1 General

Enclosures shall be of a totally enclosed, dead-front, freestanding construction. All enclosures shall be constructed to prevent inadvertent access to energerized parts and the ingress of solid foreign objects. Enclosures shall be constructed to a minimum of Type 1 as defined in NEMA 250, or equivalent, unless defined otherwise in this specification. The enclosure shall be constructed such that all points are solidly bonded to the cubicle ground connection. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. All bolts, studs, machine screws, nuts, and tapped holes shall be in accordance with ASME B1.1.

2.4.5.2 Substation Enclosures

Units T1 and T2 will be installed in the continuous metal-clad distribution switchgear lineup. The enclosures shall be paint-matched to the the lineup.

2.4.5.3 Seismic Requirements

All cubicles shall meet the seismic requirements of Section 13 48 00.00 26, SEISMIC RESTRAINT FOR MECHANICAL AND ELECTRICAL EQUIPMENT.

2.4.5.4 Surge Arresters & Snubbers

Surge arresters and parallel snubber circuits for each phase shall be mounted in the terminal compartment for each 13.8 kV nominal winding supplied under this Contract.

Surge arresters shall be metal-oxide, station class, with a MCOV of 15.3 kV, constructed in accordance with the requirements of IEEE C62.11. The Contractor shall submit the surge arrester design test results for each type of arrester provided and the surge arrester conformance test results shall be submitted for each arrester provided. All tests shall be performed in accordance with IEEE C62.11.

Provide snubber circuits with surge capacitors, non-inductive resistors, and current limiting fuses rated for the application.

2.5 SHORT-CIRCUIT CHARACTERISTICS

Transformers T1 and T2 shall be built to Category I short circuit requirements as defined in IEEE C57.12.01. All other transformers supplied shall be built to Category II short circuit requirements.

2.6 NAMEPLATES

The transformer shall be provided with a cast bronze, stainless steel, or anodized aluminum nameplate conforming to the requirements of IEEE C57.12.01, Table 13. In addition to the requirements of Table 13, the nameplate shall also include the following information:

(a) Date of Manufacture
(b) Manufacturing plant location and address
(c) Agency contract number

2.7 MONITORING

2.7.1 General

Each transformer shall include a Eaton TC-100 type temperature monitor mounted on a side panel such that it is easily read during normal operation. The same temperature monitor product shall be provided for each transformer monitored. Two (2) total transformer monitors shall be supplied under this SECTION.

2.7.2 Inputs

The transformer temperature monitor shall utilize four inputs: winding 1, winding 2, winding 3, and ambient temperature. Input RTDs shall be placed in the anticipated hottest spot of each winding assembly. The monitor shall operate off of a 120 VAC supply. RTDs shall be of the type recommended for the selected monitor.

2.7.3 Outputs

At a minimum, two (2) programmable Form C contacts, rated for operation on a 125 VDC system, shall be available for overtemperature alarm and trip functions. A 4-20ma output proportional to the hottest winding temperature shall be provided.

2.7.4 Communication

The temperature monitor shall include communications provisions for utilizing MODBUS RTU protocol. Winding temperature shall be integrated into the existing Tyee Lake SCADA systems by Modbus protocols.

PART 3 EXECUTION

3.1 FACTORY TESTING

3.1.1 General

Each transformer shall receive the full set of routine tests as defined in IEEE C57.12.01, Table 17, based on size classifications. The requirements in this paragraph constitute minimum testing requirements and do not preclude the manufacturer from performing any standard tests as part of the manufacturing process.

3.1.2 Additional Tests

All transformers 150 kVA and above shall receive the following additional, design, or special tests:

(a) Insulation power factor testing

(b) Insulation resistance testing

(c) Core insulation resistance testing, if the core is not solidly grounded

(d) One transformer of each design shall receive audible sound level testing.

3.1.3 Factory Acceptance Tests Procedure

The Contractor shall submit a transformer Factory Test Procedure for all units. The tests procedure shall include the following information, at a minimum,:

(a) an estimated schedule of testing durations

(b) descriptions of each test, including connections and equipment. Blank or sample test sheets are acceptable assuming the equipment type and configuration matches the proposed transformer being tested.

(c) test levels for each test, where applicable

(d) manufacturer acceptance values for each test

(e) Calculated values

3.1.4 Factory Acceptance Test report

Within 30 days of completing all tests, the manufacturer shall submit a factory acceptance test report for each unit.

3.2 SHIPMENT

Transformers designed for indoor operation shall be thoroughly protected against the entrance of dust, rain shipping by barge, transfer from barge to barge and placement on site will be the sole responsibility of the Contractor. The Contractor shall submit for approval a Transformer Shipping Plan detailing the Contractors shipping method and shipping protection. The Agency may reject transformers subjected to excessive moisture or contamination due to improper protection during shipment. Transformer cabinets showing visible signs of impact or trauma upon arrival may be rejected by the Agency. The Agency will not be responsible for shipping costs on rejected transformers.

3.3 FIELD TESTING AND ACCEPTANCE

3.3.1 General

The Contractor shall perform field acceptance testing to verify that each transformer is undamaged from shipping and fit for service. A field test procedure shall be submitted for approval 60 days prior to field acceptance testing. The procedure shall include the required tests, listed below, at a minimum, in addition to a schedule showing expected durations, and a list of test equipment used to complete testing.

3.3.2 Inspections

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

Visual and mechanical inspection

(a) Compare equipment nameplate information with specifications and approved shop drawings.

(b) Inspect physical and mechanical condition. Check for damaged or cracked insulators.

(c) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(d) Perform specific inspections and mechanical tests as recommended by manufacturer.

(e) Verify correct equipment grounding.

3.3.3 Required Electrical Tests and Values

The Contractor shall perform the following electrical tests, at a minimum, after installing the unit in its final location. This list shall not preclude any field testing required for warranty purposes:

(a) Perform insulation resistance tests between windings and each winding to ground and calculate the polarization index. The polarization index shall be greater than 1.0.

(b) Perform power factor testing

(c) Perform turns-ratio tests. Turns-ratio tests shall not deviate more than 0.5% from adjacent coils or the factory test results.

(d) If the core is not solidly grounded, perform a core insulation resistance test. The core insulation resistance shall be greater than 1.0 megaohm at 500 VDC test value.

(e) Perform an applied voltage test at no more than 75% of the factory value

3.3.4 Test Report

A field test report for each transformer shall be submitted within 30 days of completion of tests. The test report shall contain all tests completed, with test equipment used for each test.

3.3.5 Commissioning

The Contractor shall be responsible for performing all equipment commissioning required by the equipment manufacturers and as noted in SECTION 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING of this contract.

3.3.6 Field Applied Painting

The Contractor shall touch-up any paint damage caused to the enclosure paint through the course of this Contract by applying the manufacturer's recommended paint system in accordance with manufacturer's instructions.

-- End of Section --

SECTION 26 13 13

MEDIUM VOLTAGE METAL-CLAD SWITCHGEAR

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A240/A240M	(2022b) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A653/A653M	(2022) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D149	(2020) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 32	(1972; R 1997) Standard Requirements, Terminology, and Test Procedures for Neutral Grounding Devices

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C37.09	(2018; Errata 2019; Corr 2021) Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
IEEE C37.20.2A	(2020) Metal-Clad Switchgear Amendment 1: Control and Secondary Circuits and Devices, and All Wiring
IEEE C37.20.3	(2013) Standard for Metal-Enclosed Interrupter Switchgear
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

1.2 SYSTEM DESCRIPTION

Provide custom built medium voltage switchgear as shown on the plans and as specified herein to replace existing switchgear. New switchgear to be custom fabricated to fit within existing switchgear footprint and match existing bus connections to generator. Seismic details must conform to International Building Code and 12 48 00.00 26 SEISMIC RESTRAINT FOR MECHANICAL AND ELECTRICAL EQUIPMENT.

1.3 RELATED REQUIREMENTS

Sections 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING and 26 00 00.00 10 GENERAL ELECTRICAL WORK AND EQUIPMENT to this section, with the additions and modifications specified herein.

1.4 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.5 SUBMITTALS

Agency approval is required for all submittals. Submit the following in

accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchgear Drawings

SD-03 Product Data

Switchgear

SD-06 Test Reports

Switchgear Design Tests

Switchgear Production Test

Acceptance Checks and Tests

SD-10 Operation and Maintenance Data

Switchgear Operation and Maintenance, Data Package 5

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals

Equipment Test Schedule

1.6 QUALITY ASSURANCE

1.6.1 Contractor Quality Control

Field verify all exiting medium voltage dimensions. Contractor shall be responsible to provide switchgear that fits in the existing footprint with new bus connections matching existing generator bus.

1.6.2 Product Data

Include manufacturer's information on each submittal for each component, device and accessory provided with the switchgear including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings.

b. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the all circuit breakers provided.

1.6.3 Switchgear Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, circuit breakers, NGR, CT, PT, surge protector, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. The drawings must show adequate clearance for operation, maintenance, and replacement of operating equipment devices. Include the nameplate data, size, and capacity on submittal. Also include applicable federal, military, industry, and technical society publication references

on submittals. Include the following:

a. One-line diagram including breakers, fuses, current transformers, and meters.

b. Outline drawings including front elevation, section views, footprint, shipping splits, rigging plan, and overall dimensions.

c. Bus configuration including dimensions and ampere ratings of bus bars.

d. Markings and NEMA nameplate data including fuse information (manufacturer's name, catalog number, and ratings).

e. Circuit breaker type, interrupting rating, and trip devices, including available settings.

f. Wiring diagrams and elementary diagrams with terminals identified and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main breaker. Provide electronic format curves using SKM's Power Tools for Windows device library electronic format or EasyPower device library format depending on installation modeling software requirements.

1.6.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for not less than 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer.

1.6.5.1 Material and Equipment Manufacturing Date

Products manufactured more than 1-year prior to date of delivery to site are not acceptable.

1.7 MAINTENANCE

1.7.1 Switchgear Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23.00 28 OPERATION AND MAINTENANCE DATA.

1.7.2 Spare Parts

Provide spare parts as specified below. Provide spare parts that are of the same material and workmanship, meet the same requirements, and are interchangeable with the corresponding original parts furnished.

a. Quantity 2 - Fuses of each type and size.

1.8 WARRANTY

Switchgear shall be warrantied by the manufacturer from manufacturing defects for a period of 2 years after delivery at Tyee Lake Powerhouse. See Section 26 00 00.00.26 GENERAL ELECTRICAL WORK AND EQUIPMENT for information regarding Warranty Management. Submit switchgear manufacturer warranty for agency approval.

1.9 SHIPPING

a. The Contractor shall provide written notification to the Agency 14 calendar days prior to shipment of equipment.

b. The switchgear shall be shipped as completely assembled and wired as feasible. The switchgear and any other equipment shall be wrapped suitably or otherwise protected from damage during shipment. All electrical material delivered to site, shall until immediately prior to installation, be protected from damaging environmental and construction activities. The equipment shall be kept dry and free from precipitation and condensation during storage, installation, and after installation. All electrical equipment shall be stored in completely enclosed containers and in a humidity-controlled environment. Method of on-site storage and storage containers will be subject to approval by the Agency Representative.

PART 2 PRODUCTS

2.1 METAL-CLAD SWITCHGEAR

IEEE C37.20.2.

2.1.1 Ratings

Provide equipment with the following ratings:

a. Voltage rating: 15.0 kilo-volts AC, three-phase, high resistance grounded. For high resistance grounded systems, the conductors from the neutral point to the connection point at the impedance must utilize copper conductors employing the same insulation level and construction as the phase conductors.

b. Short Circuit Rating: 25kA rms symmetrical amperes.

c. UL listed and labeled for its intended use.

d. Impulse Withstand (Basic Impulse Level: 95 KV).

f. Momentary Current Ratings must be equal to the circuit breaker close and latch rating.

g. System voltage: 13.8KV nominal, three-phase, grounded, 60 hertz.

h. Continuous current rating of the main bus: 1200 amperes.

2.1.2 Construction

Provide the following:

a. Dead-front, metal-clad, draw-out, switchgear assembly of vertical sections, each with vacuum circuit breakers, surge protection, and neutral ground resistor.

Switchgear must be constructed to fit within the existing switchgear footprint with buswork aligned to connect with existing generator bus.

Switchgear must be front and side accessible. Provide front and side vertical section covers with full length hinges. Provide additional vertical sections to house accessories related to the switchgear functions.

b. Switchgear: Vertical sections bolted together to form a rigid assembly and front and rear aligned as indicated.

c. All circuit breakers: Front accessible with rear load connections.

d. Compartmentalized switchgear: Vertical grounded metal barriers between the front device section, the main bus section, and the cable compartment.

e. Moisture resistant coating: Applied to all rough-cut edges of barriers.

2.1.2.1 Enclosure

Provide the following:

a. Stationary Structure:

(1) The switchgear must consist of sections including circuit breaker compartments and auxiliary compartments assembled to form a rigid self-supporting completely enclosed structure providing steel barriers between sections.

(2) The sections must be divided by metal barriers into the following separate compartments: Circuit breakers, instrument, main bus, surge protection, NGR, auxiliary devices and cable.

b. Indoor Enclosure: NEMA ICS 6 Type 1.

d. Enclosure: Bolted together with removable bolt-on side and hinged covers.

e. Doors: Provided with stainless steel pad-lockable vault handles with a three point latch.

f. Bases, frames and channels of enclosure: Corrosion resistant and fabricated of ASTM A240/A240M type 304.

g. Base: Includes any part of enclosure that is within 3 inches of concrete pad.

h. Galvanized steel: ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable.

i. Paint color: Factory applied finish, ASTM D1535 light gray No. 61 or No. 49 over rust inhibiting primer on treated metal.

j. Paint coating system: Comply with IEEE C57.12.28 for galvanized steel.

k. Infrared viewing windows: Install to allow the use of an infrared camera or thermal imager direct line of site to inspect electrical connections without requiring the opening of panels and doors. These windows are intended to allow thermographers the ability to inspect the electrical equipment without directly exposing themselves to live electrical components and energized devices.

2.1.2.2 Bus Bars

Provide the following:

a. Bus bars: Copper with silver-plated contact surfaces.

(1) Phase bus bars: Insulated with an epoxy finish coating powder or insulating sleeve providing a minimum breakdown voltage per ASTM D149.

b. Make bus connections and joints with hardened steel bolts and nuts. Provide conical disk spring washers under each nut and bolt.

c. Main-bus (through bus): Rated at the full ampacity of the main throughout the switchgear.

d. Minimum 1/4 by 2 inch copper ground bus secured to each vertical section along the entire length of the switchgear.

2.1.2.3 Circuit Breaker Compartments

a. Each circuit breaker must be draw-out metal-clad vacuum circuit breaker. The stationary primary disconnecting contacts must be silver-plated copper and mounted within glass polyester, porcelain, or molded cycloaliphatic epoxy at 27kV support bushings. The movable contacts and springs must be mounted on the circuit breaker element for ease of inspection/maintenance.

b. Entrance to the stationary primary disconnecting contacts must be automatically covered by metal shutters when the circuit breaker is withdrawn from the connected position to the test or disconnected position or removed from the circuit breaker compartment. Ground bus must be extended into the circuit breaker compartment to automatically ground the breaker frame with high-current spring type grounding contacts located on the breaker chassis when in the test and connected

positions. Guide rails for positioning the circuit breaker and all other necessary hardware must be an integral part of the circuit breaker compartment. Blocking devices must interlock breaker frame sizes to prevent installation of a lower ampere rating or interrupting capacity element into a compartment designed for one of a higher rating.

2.1.2.4 Auxiliary Vertical Sections and Compartments

a. Provide auxiliary sections consisting of potential and current transformers, surge protection, and neutral grounding resistor, as indicated.

2.1.2.5 Medium Voltage Cable Terminations

See Section 26 05 13.00 26 MEDIUM VOLTAGE CABLE.

2.1.2.6 Circuit Breakers

The vacuum circuit breakers must be electrically-operated, three-pole, circuit interrupting devices rated for 1200 amperes continuous at 15kV and 95kV BIL. Breakers must be designed for service on a 15kV system with a short-circuit capacity of not less than 25,000 amperes symmetrical. Rating must be based on IEEE C37.013a. Circuit breakers must be draw-out mounted with position indicator, operation counter, auxiliary switches, and primary and secondary disconnect devices. Circuit breakers must have one vacuum circuit interrupter per phase.

Circuit breaker must be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism normally charged by a universal motor. Provide for manual charging of the mechanism through a manual handle on the vacuum circuit breaker. Circuit breaker control voltage must be 125VDC from an external power source.

a. Contacts: Silver-plated, multi-finger, positive pressure, self-aligning type for main draw-out contacts.

b. Each draw-out breaker must be provided with three-position operation. The connected position and the test/disconnect position must be clearly identified by an indicator on the circuit breaker front panel.

(1) Connected position: Contacts are fully engaged. Breaker must be tripped before it can be racked into or out of this position.

(2) Test/disconnect position: Position must allow for complete testing and operation of the breaker without energizing the primary circuit.

(3) Withdrawn (removed) positions: Places breaker completely out of compartment, ready for removal.

c. Secondary control circuits must be connected automatically with a self-aligning, self-engaging plug and receptacle arrangement when the circuit breaker is racked into the connected position.

d. An interlocking system must be provided to prevent racking a closed circuit breaker to or from any position. An additional interlock must automatically discharge the stored-energy operating mechanism springs upon removal of the breaker out of the compartment.

e. Provision for secondary control plug to be manually connected in test position.

f. A minimum of 4 auxiliary contacts (2a 2b) for external use.

2.1.2.7 Circuit Breaker Remote Racking

Provide a remote racking mechanism to allow an operator to rack a circuit breaker in or out from at least 20 feet away from the front of the equipment.

2.1.2.8 Control Power Supply

a. Control power will be provided from existing 125V DC battery system.

2.1.3 Instrument Transformers

IEEE C57.13, as applicable.

a. Current transformers: Each breaker compartment must have provision for front-accessible mounting of up to four current transformers per phase (ANSI standard relay accuracy), two on bus side and two on cable side of circuit breaker. The current transformer assembly must be insulated for the full voltage rating of the switchgear. The current transformers wiring must be Type SIS No. 10 AWG copper.

b. Potential transformers: Transformers must be drawout type, 60 Hz, with voltage ratings and ratios coordinated to the ratings of the associated switchgear, relays, meters, and instruments. Potential transformers must be with two fuses in the primary. Fuses must be current limiting and sized as recommended by the potential transformer manufacturer.

c. All leads from each individual instrument transformer shall be brought out to switchgear terminal blocks. Instrument transformer secondary circuits shall be grounded at the switchgear terminal blocks. All secondary leads shall be grounded together at the instrument transformer for shipping. All instrument transformers shall conform to the applicable grounding requirements of IEEE C57.13.

d. The Contractor shall provide Relay Curves for Instrument Transformers. Submit typical ratio and phase angle curves for each type and rating of all voltage and current transformers supplied with the equipment.

2.1.4 Heaters

Provide 120-volt heaters in each switchgear section. Heaters must be of sufficient capacity to control moisture condensation in the compartments and must be sized 250 watts minimum. Heaters must be controlled by a thermostat located inside each section. Thermostats must be industrial type, high limit, to maintain compartments within the range of 60 to 90 degrees F. Energize electric heaters in switchgear assemblies while the equipment is in storage or in place prior to being placed in service. Provide method for easy connection of heater to external power source.

2.1.5 Pilot and Indicating Lights

Provide LED type pilot and indicating lights, color as indicated on the

drawings.

2.1.6 Terminal Boards

Refer to Section 26 00 00.00 26 GENERAL ELECTRICAL WORK AND EQUIPMENT. Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Provide short-circuiting type terminal boards associated with current transformer. Terminate conductors for current transformers with ring-tongue lugs. Identify each terminal to indicate the load served.

2.1.7 Wire Marking

Refer to Section 26 05 19.00 26 INSULATED WIRE AND CABLE. Mark control and metering conductors at each end. Provide factory installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Provide a single letter or number on each sleeve, elliptically shaped to securely grip the wire, and keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Indicate on each wire marker the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.1.8 Surge Arresters

Provide one surge arrester for each bus. Surge arresters must conform to IEEE C62.11 for station class and must be rated 15 kV.

2.1.9 Control Wiring

Minimum wire size shall be No. 12 AWG for power and lighting circuits; No. 10 AWG for current transformer secondary circuits; No. 14 AWG for potential transformer, relaying, and control circuits; and No. 16 AWG for annunciator circuits.

2.1.10 Neutral Grounding Resistor

The neutral grounding resistor assembly must comply with IEEE 32. The assembly shall meet the following:

a. The resistor element must be stainless steel or cast-iron and rated 380 amperes for a 10 second duty.

b. Provide a single phase neutral grounding transformer rated 15kVA with 13,800V primary and 120/240V secondary.

c. The grounding transformer and resistor must be installed in a section of the switchgear and shall be provided with all necessary supports and mounting hardware. To conform to seismic requirements, the enclosure, including screening and support framing, must have two finish coats applied over a prepared substrate. The color of the finish coats shall be the same as the color of the associated switchgear.

d. A stress-relief terminator must be provided and arranged to permit the proper termination of the No. 15kV shielded neutral cable entering the

enclosure from the top. An approved type and size of terminal lug must also be provided and arranged for the field termination of the No. 4/0 AWG bare copper grounding cable entering the section from the bottom.

e. One current transformer shall be provided and housed in the resistor section. The current transformer shall have the ratio shown.

2.2 MANUFACTURER'S NAMEPLATE

Provide a nameplate on each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.3 FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchgear, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Identify on each nameplate inscription the function and, when applicable, the position. Provide nameplates as specified in section 26 00 00.00 10 GENERAL ELECTRICAL WORK AND EQUIPMENT.

2.4 SOURCE QUALITY CONTROL

2.4.1 Factory Inspection and Testing

2.4.1.1 General

Each item of equipment supplied under this Contract shall be given the manufacturer's routine factory inspections and tests and also other tests, as specified below, to insure successful operation of all parts of the assemblies. The Agency reserves the right to witness tests. Provide Equipment Test Schedule for tests to be performed at the manufacturer's test facility. All tests required shall be witnessed by the Agency Representative, unless waived in writing, and no equipment shall be shipped until it has been approved for shipment. Submit required test schedule and location and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Factory tests shall have been performed on circuit breakers identical to those furnished under this Contract. Certified Factory Test Reports and Certifications of Switchgear and Breakers shall be submitted. Factory tests shall be as described in IEEE C37.09 as applicable for the specified ratings of the circuit breakers to be furnished under this Contract. The Contractor's submittal shall identify all tests which were performed to certify compliance with standards and the Contractor shall permit review of design test data, oscillograph tracings, and other information by the Agency.

If any factory tests are performed on circuit breakers or components to be furnished under this Contract, the affected items shall be inspected after testing to ensure that no damage or wear has occurred. Any items, which may have had the lifetime and reliability, expected of new and unused equipment degraded by the tests shall be replaced,

or if approved by the Agency, repaired.

A certified statement shall be provided by the manufacturer of the circuit breakers that factory tests in accordance with IEEE C37.09 have been performed on power circuit breakers of the same design, construction, and ratings as those furnished under this Contract and standards and verifying the circuit breakers will operate satisfactorily under normal and short-circuit conditions when applied within their ratings.

Factory Test Procedure shall be submitted prior to factory testing. The factory test equipment and test methods used shall conform to the applicable requirements of ANSI, IEEE and NEMA standards, and shall be subject to approval. The witnessing representatives of the Contractor and the Contracting Officer shall sign all test reports. Factory Inspection and Test Reports shall be submitted after completion of the tests.

a. Perform production tests on each circuit breaker housing for this Project, complying with IEEE C37.09.

(1) Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.

(2) Conduct an alignment test with master circuit breaker to verify all interfaces.

(3) Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.

(4) Perform the control wiring dielectric test at 1500 V for one minute.

(5) Perform the dielectric test on primary and secondary circuits.

b. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE C37.09.

(1) Perform mechanical operation tests to ensure proper functioning of the switch.

(2) Conduct an alignment test with master cell to verify all interfaces and interchangeability.

(3) Verify the contact gap. Perform terminal-to-terminal resistance test.

(4) Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence. Operate the circuit breakers over the range of minimum to maximum of the control voltage.

(5) Perform the control wiring dielectric test at 1500 V for one minute.

(6) Set the contact gap.

2.4.2 Switchgear Design Tests

IEEE C37.20.2A or IEEE C37.20.3 as applicable. Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification. Required tests shall be as follows:

a. Design Tests

1. Dielectric test

2. Rated continuous current test

3. Short-circuit current withstand tests

4. Mechanical endurance tests

5. Flame-resistance tests

6. Rod entry tests

2.5 ARC FLASH WARNING LABEL

Provide warning label for switchgear. Locate this self-adhesive warning label on the outside of the enclosure warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.6 MIMIC BUS LABELING

Provide a mimic bus on the front of the equipment to diagrammatically show the internal bus structure of the lineup.

PART 3 EXECUTION

3.1 INSTALLATION

a. Installation shall comply with the general construction requirements of Section 26 00 00.00 26, GENERAL ELECTRICAL WORK. The work under this Contract is subject to the safety clearances and operating procedures currently practiced by the Agency. All the construction activities shall be coordinated with the Agency Representative so that the construction will not adversely affect the daily operation of the powerhouse. Safety clearances shall be obtained before opening, entering or working on any existing electrical equipment. Unless otherwise specified, execution of all installation work shall be in accordance with the National Electrical Code, NFPA 70, and the National Electrical Safety Code. If a deviation from the above standards is specifically shown or specified, the drawings and specifications shall govern. Omission of details on the drawings or in the specifications shall not be construed as permitting deviations from the Code requirements.

b. The Contractor shall submit to the Agency Representative for approval a Work Plan for Coordination of electrical outages and equipment installation, to be updated on a weekly basis. Activities which are hazardous, affect plant operation, or require participation by Agency personnel, shall be included in the plan. The Work Plan shall contain a

schedule of when outages will be required. The plan shall indicate which persons on each shift are responsible for superintendence and safe clearance.

3.2 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.2.1 Medium-Voltage Switchgear

IEEE C37.20.2, IEEE C37.20.2A and IEEE C37.20.3 as applicable.

3.2.2 Meters and Instrument

Transformers ANSI C12.1.

3.2.3 Galvanizing Repair

Repair damage to galvanized coatings caused by handling, transporting, cutting, welding, or bolting. Make repairs in accordance with ASTM A780/A780M, zinc rich paint. Do not heat surfaces that repair paint has been applied to.

3.3 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.3.1 Interior Location

Mount switchgear on existing concrete slab. Concrete work must be as specified in Section 03 60 00 CONCRETE DEMOLITION, REPAIR OF CONCRETE SURFACES, AND EQUIPMENT FOUNDATIONS.

3.4 FIELD QUALITY CONTROL

3.4.1 General

After completion of the installation of the equipment and accessories, the Contractor shall perform routine and complete operational tests as necessary to insure proper installation and verify proper operation. Field testing of switchgear and breakers shall be per IEEE C37.09, NETA ATS, and manufacturers recommended procedures. Routine tests shall include but not be limited to inspections and tests for mechanical alignment, damage to equipment porcelain or painted surfaces, electrical continuity of external circuits, voltage transformer phase rotation.

a. All switchgear components shall be tested including circuit breakers, NGR, NGR transformer, CTs and PTs.

b. Equipment shall be inspected, adjusted, tested and commissioned following applicable procedures listed in IEEE 1248. The Contractor shall be responsible for performing all equipment commissioning required by the equipment manufacturers and as noted in SECTION 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING of this contract.

c. Testing shall include all testing recommended in the referenced standards. All test equipment shall have been calibrated within one year of testing. Submit calibration test reports that include test equipment manufacturer, serial number, range and test equipment calibration certificate. Records of exact test voltage, current, etc.

and results shall be recorded. Test data shall include the name of the test engineer and the date the tests were performed.

d. Submit a field test procedure plan for approval, listing the routine and operational tests to be conducted. The tests shall be witnessed by an Agency Representative. The Contractor shall furnish five certified copies of all Field Test Reports, including complete test data on all tests. Reports of all witnessed tests shall be signed by the witnessing representatives of the Contractor and the Contracting Officer. The costs of performing all tests shall be borne by the Contractor and shall be included in the prices bid for the items of equipment in the Schedules. The routine and operational tests shall be as outlined below and as recommended by the manufacturer and the Field Service Engineer.

3.4.2 Performance of Acceptance Checks and Tests

Perform all tests in accordance with the field test procedure plan and the manufacturer's recommendations. The Agency will witness formal tests after receipt of written certification that preliminary tests have been completed and that system is ready for final test and inspection.

3.4.3 QUALIFICATIONS OF FIELD ENGINEERING SERVICE PERSONNEL

The Contractor shall provide qualified field engineering service personnel who are fluent in the English language to supervise, test, and install the new equipment specified in this section and related equipment of the same manufacturer during installation. The personnel shall have a minimum of two years experience in the installation and testing of medium voltage switchgear and vacuum circuit breakers. The Contactors Field Engineering Service Supervisor shall certify that the equipment has been installed in accordance with the manufacturers recommendations and all warranties are in effect. The field engineering service personnel shall be present during both the Contractor's commissioning of equipment and for the Agency's commissioning of the system, per Section 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING. The Contractor shall provide the Agency with a current resume for all field engineering service personnel.

3.4.4 CONTRACTOR FURNISHED TRAINING OF AGENCY PERSONNEL

a. A qualified training engineer shall be provided who is fluent in the English language to provide training on the breakers and the trip units. The personnel shall have a minimum of two years experience in the installation and testing of power circuit breakers and associated microprocessor or trip units.

b. A Qualified Training Engineer will instruct Project personnel on the theory, operation and maintenance of the new switchgear and trip units. The courses for the maintenance personnel shall be of eight hours minimum duration (one full working day). In addition to the maintenance courses there shall be two courses for operational personnel that will be a minimum of two hours each. The training for the operators will be scheduled to cover different shifts so that all may attend. The training shall be conducted for approximately 10 Agency employees at the Project for each session. The maintenance course shall include breaker, trip unit, theory of operation, calibration, programming and repair of the equipment provided, routine maintenance, and trouble analysis and safety precautions. The operations course shall include equipment design, theory of operation,

use of displays and explanation of trip and alarm messages. Demonstrations shall be on the actual equipment furnished, to the maximum extent possible. Course material shall use to the maximum extent possible, the site-specific operation and maintenance data that the Contractor is providing for the project. The Agency may videotape the training sessions for future use. The Contractor shall submit for Agency approval, a training outline detailing course topics, material, and subjects. Agency reserves the right to schedule the training with the Contractor on a date that is acceptable to the needs of the Agency to include constraints outside the scope of the construction project.

-- End of Section --

SECTION 26 23 10.00 26

480 VOLT STATION SERVICE SWITCHGEAR

PART 1 GENERAL

1.1 GENERAL

These specifications include the design, fabrication, assembly, wiring, testing, and delivery of the 480 volt switchgear, including integration with the equipment specified in SECTIONS 26 23 15.00 26, 480 VOLT HIGH RESISTANCE GROUNDING (HRG) SYSTEM, and 33 72 33.14 26, POWER SYSTEM RELAY PROTECTION, and 26 12 16 DRY-TYPE TRANSFORMERS.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2008) Code for Electricity Metering
ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASME INTERNATIONAL (ASME)

ASME B1.1	(2003; R2008) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2006) Pipe Threads, General Purpose (Inch)

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2009) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B 187/B 187M	(2011) Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1248	(1998; R 2007) Commissioning of Electrical Systems in Hydroelectric Power Plants
IEEE C2	(2007) National Electrical Safety Code
IEEE C37.16	(2009) Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V

	and below) and DC 3200 V and below) Power Circuit Breakers
IEEE C37.20.1	(2002; R 2007) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C57.13	(2008) Standard Requirements for Instrument Transformers
IEEE C57.13.3	(2006) Grounding of Instrument Transformer Secondary Circuits and Cases

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 62271-200	(2011) AC Metal-Enclosed Switchgear and Controlgear for Rated Voltages Above 1 kV and Up To and Including 52 kV

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C37.50	(1989; R 1995; R 2000) American National Standard for Switchgear--Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011) National Electrical Code - 2011 Edition

UNDERWRITERS LABORATORIES (UL)

UL 44	(2010) Thermoset-Insulated Wires and Cables
UL 1581	(2001; Reprint Oct 2009) Electrical Wires, Cables, and Flexible Cords

1.3 SUBMITTALS

Agency approval is required for all submittals. The following shall be submitted in accordance with SECTION 01 33 00 SUBMITTAL PROCEDURES:

Preconstruction Submittals

Submit within 90 days after Notice To Proceed:

Work Plan;

Contractor Furnished Training of Agency Personnel;

Shop Drawings

Submit within 60 days after Notice To Proceed:

a. Circuit Breakers.

b. Instrument Transformers.

c. Switchgear cubicles.

d. Terminal Blocks.

e. Surge Arresters.

f. Nameplates.

g. Ammeter.

h. Voltmeter.

i. Auxiliary and Interposing Relays.

j. Timing Relay.

k. Wire and Cable.

l. Protective Relays.

m. Remote Racking Device.

n. Infra-Red Viewing Windows.

o. Circuit Breaker TCC: Submit the characteristic curves of the individual breaker trip elements. The trip curves shall either be programmed into the revision of the TCC module of the SKM Program or sufficient data will be supplied to allow the curves to be programmed into the TCC module.

Submit within 120 days after Notice To Proceed:

Schematic Diagrams and Connection Diagrams;

Product Data

Submit within 60 days after Notice To Proceed:

a. Circuit Breakers;

b. Instrument Transformers;

c. Switchgear cubicles;

d. Terminal Blocks;

e. Surge Arresters;

f. Nameplates;

g. Ammeter;

h. Voltmeter;

i. Auxiliary and Interposing Relays;

j. Timing Relay;

k. Wire and Cable;

l. Protective Relays;

m. Remote Racking Device;

n. Infra-Red Viewing Windows;

Submit within 90 days after Notice To Proceed:

Relay Curves for Instrument Transformers;

Accessories and Spare Parts List;

Maintenance Switch

Breaker Lifting Device

Test Reports

Submit within 75 days after Notice To Proceed:

Design Test Reports;

Submit no later than 30 days prior to tests:

Factory Test Procedure;

Field Test Procedure;

Submit no later than 30 days after completion of tests:

Factory Inspection and Test Reports;

Submit no later than 10 days after completion of tests:

Field Test Reports;

Certificates

Submit within 90 days after Notice To Proceed:

Certifications of Seismic Requirements

Certifications of Switchgear and Breakers

Operation and Maintenance Data

480 Volt Station Service Switchgear

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

Closeout Submittals

Submit within 60 days after completion of work:

As-Built Drawings;

a. Circuit Breaker Switchgear Manufacturer's Installation Drawings and

Details.

b. Circuit Breaker Controls and Schematic Diagrams.

1.4 WARRANTY

Switchgear shall be warrantied by the manufacturer from manufacturing defects for a period of 2 years after delivery at Tyee Lake Powerhouse. See Section 01 78 00.00 28 CLOSEOUT SUBMITTALS for information regarding Warranty Management. Submit switchgear manufacturer warranty for agency approval.

1.5 GENERAL REQUIREMENTS

1.5.1 General

a. The Contractor is required to accomplish all coordination between manufacturers to ensure successful integration of all components of the station service switchgear including the protective relays, PLC, HRG, surge arrestors, snubber and transformers in order to provide assurance to the Agency that critical requirements are met.

b. The Contractor shall submit complete submittals for 480 Volt Station Service Switchgear, to include, but not limited to, complete manufacturer's data sheets, installation and trouble shooting manuals, parts listings, and equipment descriptions for all equipment installed under this Contract.

1.5.2 Delivery, Storage, and Handling

Refer to Section 26 00 00.00 26 GENERAL ELECTRICAL WORK AND EQUIPMENT.

a. The Contractor shall provide written notification to the Agency 14 calendar days prior to shipment of equipment.

b. The switchgear shall be shipped as completely assembled and wired as feasible. The switchgear and any other equipment shall be wrapped suitably or otherwise protected from damage during shipment. All electrical material delivered to site, shall until immediately prior to installation, be protected from damaging environmental and construction activities. The equipment shall be kept dry and free from precipitation and condensation during storage, installation, and after installation. All electrical equipment shall be stored in completely enclosed containers and in a humidity-controlled environment. Method of on-site storage and storage containers will be subject to approval by the Agency Representative.

1.5.3 Qualifications

Each manufacturer shall have a minimum of five years experience with the production of equipment of the same type and rating.

1.6 MATERIALS, EQUIPMENT AND INSTALLATION

New materials and equipment shall be furnished and any defective material or equipment damaged in the course of installation shall be replaced or repaired. Testing shall be performed to check the installation of and the proper operational functions of the electrical equipment. The installations shall be in accordance with the National Electrical Code,

NFPA 70, and the National Electrical Safety Code, IEEE C2, except where otherwise specifically shown or specified, in which case the drawings and specifications shall govern. Omission of details on the drawings or in the specifications shall not be construed as permitting deviations from Code requirements.

1.6.1 Standard Products

Material and equipment shall be the standard products of manufacturers regularly engaged in the manufacture of these products and shall essentially duplicate items that have been in satisfactory use for at least two years prior to bid opening.

1.6.2 Corrosion Prevention

1.6.2.1 General

All equipment shall be protected to prevent deterioration from corrosion. The general requirements are specified below; however, other corrosion-resisting treatments that are the equivalent of those specified may be used.

1.6.2.2 Fastenings and Fittings

Screws, bolts, nuts, pins, studs, springs, washers and other miscellaneous fastening and fittings shall be of corrosion-resistant material or shall be treated in an approved manner to render them resistant to corrosion. All fastenings which are to be exposed directly to the weather shall be of corrosion-resisting material.

1.6.2.3 Corrosion-Resisting Materials

Corrosion-resisting steel, copper, brass, bronze, copper-nickel-copper alloys are acceptable corrosion-resisting materials.

1.6.2.4 Corrosion-Resisting Treatments

Treatments shall be in accordance with ASTM A 123/A 123M or ASTM A 153/A 153M.

1.6.2.5 Finish

Final painting shall be done in accordance with paragraph PAINTING.

1.6.3 Storage and Handling

Materials and equipment shall be suitably protected from dampness, dust, and physical damage.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

a. The equipment furnished and the work performed under this Contract shall be in conformance with the applicable provisions of ANSI & IEEE standards. The Contractor shall furnish documentation substantiating that the circuit breaker design and assembly are ANSI certified.

b. Basis of Design and preferred switchgear for this project is Eaton Magnum DS switchgear with configuration as shown on the drawings. Circuit breaker to be of the the UL 1066 air power circuit breaker type. Additional customizations as specified herein and as shown on the drawings including integration of transformers, HRG, Snubbers, Surge Protection, Arc Flash sensors, PLC, and protective relays.

b. All materials, components, and equipment shall conform to the requirements of these specifications. Materials, components, and equipment shall be free from defects and imperfections, of recent manufacture, and shall have mechanical and electrical properties suitable for the intended use. All materials, components, and equipment not manufactured by the Contractor shall be products of other recognized reputable manufacturers meeting the requirements of subparagraph Qualifications. Insofar as practicable, devices and equipment used for the same or similar services shall be of the same make and type, and shall be interchangeable when of the same rating.

2.1.2 Device Arrangement

Power cables in conduit will enter the switchgear from the top and bottom as shown on the Contract drawings. The preferred arrangement of the switchgear is indicated on the Contract drawings and shall be such that existing embedded feeders may enter the appropriate cabinets. Bottoms shall be open to the maximum extend practicable to allow for variations in cable entry from existing embedded conduits. Any proposed deviation from this arrangement shall be submitted to the Agency Representative for approval. The design of the switchgear and arrangement of devices shall be such that adequate space is provided for inspection and maintenance of wiring, terminals, and devices. Equipment on the rear of the panels shall be so mounted that the studs of the equipment mounted on the front of the panels will be accessible without removing any device.

2.1.3 Connections

All bolts, studs, machine screws, nuts, and tapped holes shall be in accordance with ASME B1.1. Threads for sizes 1/4-inch to 1-inch, inclusive, shall be NC or UNC series. The sizes and threads of all valves, pipe and fittings, conduit and fittings, tubing and fittings, and connecting equipment shall be in accordance with ASME B1.20.1. Manufacturer's standard thread and construction may be used on small items which, in the opinion of the Agency Representative, are integrally replaceable, except that threads for external connections to these items shall meet the above requirements.

2.2 480 VOLT STATION SERVICE SWITCHGEAR

Except as otherwise specified or indicated, the design, construction, and tests of the switchgear shall conform to the applicable requirements:

1. ANSI-C37.20 - Switchgear assemblies
2. ANSI-C37.13 - Low voltage power circuit breakers
3. ANSI-C37.17 - Trip devices
4. UL 1558 Low Voltage Switchgear
5. UL 1066 Low Voltage Power Circuit Breakers

The switchgear shall be of the totally-enclosed, free-standing, dead-front type, built on a framework of structural steel. The framework and

structure shall be sufficiently rigid to withstand operation of the equipment or any stresses due to short circuits. Each switchgear assembly shall contain two main bus sections connected by a bus tie circuit breaker. Each main bus section shall be connected to a supply transformer through a main supply circuit breaker. The two main supply circuit breakers and the bus tie circuit breaker shall be electrically operated and will normally be remotely controlled. Automatic bus transfer shall be provided as specified in subparagraph Automatic Bus Transfer. The switchgear shall have instruments, control accessories, and other equipment mounted on the front panels and inside the switchgear as shown and as specified. Remote racking provisions shall be provided for the breaker cubicles.

2.2.1 Assembly And Detail Drawings

Contractor will coordinate with manufacturer to prepare and submit assembly and detailed drawings and data to demonstrate that all parts of the equipment will conform to the requirements and intent of the specifications. The drawings and data shall include sectional views of switchgear units, description of removable elements, all relays and other devices, equipment lists, and nameplate schedules.

2.2.2 Outline Drawings

Equipment manufacturer will prepare and submit outline drawings for coordination, by the Contractor, of equipment and physical location. Drawings shall include the overall dimensions and weights of the equipment; the size and location of conduit and cable entrances; details of provisions for bolting equipment to the floor, walls, and ceilings; the equipment crate sizes and proposed routing to the installation site within the facility.

2.2.3 Schematic Diagrams And Connection Diagrams

Schematic diagrams shall show the one line diagrams of the switchgear assembly, complete assembly full line connection diagram, and control logic showing that the equipment will function in a way to meet the requirements and intent of the specifications. All controls and external connections indicated by the Contract drawings shall be accounted for. Point to point connection or wiring diagrams shall show all terminal blocks and connections between the blocks and switchgear equipment, and shall provide a space at least 3 inches below and adjacent to the terminal blocks in which external circuits, conduits or connections may be shown. The wiring diagrams shall be made as seen by an observer of the actual wiring, and space shall be provided for the addition of devices where mounting space exists on the structure. Drawings shall also show the proposed arrangement of terminal blocks and supports for incoming cables. Additional information on outgoing circuits will be provided by the Agency when the drawings are received for approval, and shall be added to the drawings by the Contractor.

2.2.4 Enclosure And Framework

a. Enclosure shall be made of selected smooth sheet steel panels, suitably supported. Doors and panels used to support instruments and other devices and barriers between compartments shall not be less than No. 11 sheet metal gauge. Exposed panels on the front and ends of the enclosure shall be bent angle or channel edges with all corner seams welded and ground smooth, or shall be the manufacturer's equivalent

construction as approved. The front outside surfaces shall not be drilled or welded for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front.

b. Ventilating openings shall be required and shall preferably be of the grille type. All ventilating openings shall be provided with corrosion-resistant insect-proof screens on the inside.

c. Infra-red (IR) viewing windows shall be provided on the rear of the switchgear enclosures, minimum one window for each main bus breaker lug connection and each bus tie circuit breaker lug connection, to allow IR sensing of each breaker in the closed position under load conditions without having to open the enclosure. Windows shall feature a removable steel or aluminum security cover over a 4-inch crystal sightglass. Windows shall also be provided for each feeder breaker, unless the switchgear manufacturer can show that such installation is impractical due to the design of the bus-breaker connections. Windows shall be on the front or rear of the enclosure as recommended by the manufacturer for optimum viewing. The IR windows shall be the switchgear manufacturer's standard product, or a third-party product that is UL certified and arc-flash tested to the kA rating of the breakers or higher, meeting the applicable requirements of IEC 62271-200, and installed with the coordination and approval of the switchgear manufacturer.

2.2.5 Buses And Connections

Copper bars and shapes for main bus and ground bus conductors shall conform to the requirements of ASTM B 187/B 187M. All primary connections including the power connections to the line side of the circuit breakers shall be by bus bar. The main bus segments shall have a continuous current-carrying capacity of 2,400 amperes and the feeder bus segments shall have a continuous current-carrying capacity as shown on the drawings conforming to IEEE C37.20.1. The buses shall have mechanical and thermal capacities coordinated with the interrupting rating of the power supply circuit breakers. Bus bars shall be of hard-drawn copper. Shop splices and tap connections shall be brazed, pressure-welded or bolted. All splices for field assembly shall be bolted. Where bolted connections are used, contact surfaces shall be silver- or tin-plated. The buses shall be mounted on insulating supports of wet process porcelain, glass polyester, or suitable molded material. All primary connections including the power connections to the line side of the circuit breakers shall be by bus bar.

2.2.6 Circuit Breakers

2.2.6.1 General

a. Provide Eaton Magnum MDS power circuit breakers or equal.

b. Breakers shall be 3-pole, dead-front, drawout type rated 600 volts AC, conforming to the requirements of IEEE C37.16, NEMA C37.17, and UL listed for installation in the switchgear. Breakers shall be independent electrically-operated with the closing mechanism designed for operation on 125 volts DC, with frame sizes as indicated. Circuit breakers shall have a short-circuit interrupting capacity of not less than 50,000 rms symmetrical amperes at 600 volts AC.

c. Each drawout type circuit breaker shall completely enclosed in a metal compartment. Access to the circuit breakers shall be provided

through hinged steel doors. Access to instrument and relay wiring, instrument transformers and fuses, shall also be through hinged doors. All hinged doors shall have bent angle or channel edges, invisible hinges and suitable latches or fastenings. Access to the switchgear bus compartments shall be through removable bolted panels, cover plates or hinged doors. Covers shall be provided over readily accessible energized portions to prevent hazards to personnel when withdrawing or inserting the breakers.

d. All circuit breakers of the same frame size and type of operation shall be interchangeable.

e. Suitable means shall be provided for removing and handling the drawout circuit breakers. These means may include support from the top of the switchgear enclosure without interference with incoming or outgoing wiring.

f. Each circuit breaker shall be provided with functional components in accordance with Table 1 of IEEE C37.13, including means for manual emergency tripping and manual closing for maintenance operation. Each feeder breaker shall be provided with a Digitrip RMS 1150 or approved equal, over-current tripping device consisting of long-time-delay, short-time-delay elements, and instantaneous elements. Provide each breaker with switch or button to engage temporary maintenance mode settings. Automatic breaker trip on overcurrent functions shall not be disabled by loss of DC control power.

g. At least four auxiliary switch contacts shall be provided on each breaker in addition to the contacts required for interlock. At least two spare auxiliary switch contacts, one normally-open and one normally-closed, shall also be provided on each electrically-operated breaker. Overcurrent trip alarm contacts, with means for manual reset, shall be furnished as indicated.

2.2.6.2 Bus Supply and Bus Tie Circuit Breakers

a. The Bus Supply and Bus Tie Circuit Breakers circuit breakers shall be rated 1,200 amperes frame size with continuous current ratings as indicated on the drawings.

b. The two power supply circuit breakers, emergency diesel generator breakers, and the bus tie circuit breakers shall be electrically interlocked so that only two of the three breakers can be in the closed position at the same time. The breakers shall be electrically interlocked through cell switches or secondary disconnects to prevent breaker operation except when the breaker is in the test position. Sufficient breaker auxiliary switch contacts and cell switches shall be provided to accomplish the required breaker control and interlocking system as shown.

c. Each main and tie breaker shall be equipped with a manually-resetable bell alarm contact to energize the annunciator circuit only when the breaker is automatically tripped on a fault or overload.

d. The two tie breakers shall be separated by physical space and blast barriers.

2.2.6.3 Feeder and Emergency Generator Circuit Breakers

The feeder and emergency generator breakers mounted in the 480V switchgear shall be rated 800 amperes frame size, with continuous current ratings as indicated on the drawings.

2.2.6.4 Automatic Bus Transfer

The 480 volt switchgear shall be configured with an automatic bus transfer scheme. The new breakers shall have sufficient auxiliary contacts to allow the bus transfer scheme to function. The automatic transfer arrangement shall be as shown by the schematic diagrams and shall incorporate the following functions (normal operation will be with both supply breakers closed and the bus tie breakers open):

a. Loss of voltage on one bus shall cause the associated supply breaker to trip and the bus tie breakers to close.

b. Automatic transfer control will cease to function if either of the supply breakers or the bus tie breaker trip on overcurrent.

c. Recovery of voltage from one of the two normal sources shall (after a time delay) open the bus tie breakers and close the associated supply breaker.

d. Recovery of voltage from both normal sources shall (after a time delay) open the bus tie breakers and close both the supply breakers.

e. After pickup by the voltage relays, the bus transfer operation shall be accomplished within approximately 1 second.

2.2.7 Wiring

In addition to the requirements for Special Wire and Cable in Section 26 05 19.00 26, INSULATED WIRE AND CABLE, switchgear wiring shall meet the following requirements:

a. All control wire, including wire for removable elements, shall be stranded copper switchboard wire with 600 volt insulation, type SIS as listed in NFPA 70. The wire shall comply with the requirements of UL 44 and shall pass the VW-1 flame test of UL 1581. Hinge wire shall have Class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. Minimum wire size for all other control wiring shall be No. 14 AWG.

b. A suitable wiring duct system shall be installed for all interpanel wiring and shall provide easy access for inspection and replacement of wiring. All wiring shall be installed in wiring channels and ducts as far as possible. Each wire shall be properly protected where it leaves a channel or duct.

c. Wiring, where not installed in channels or ducts, shall be formed into compact wire bundles suitably bound together and properly supported. Bindings and supports shall not cause damage or cold flow of the insulation. Groups of exposed wires shall be run straight horizontally or vertically with short-radius right-angle bends. Wiring supports shall be of heavy-gage rustproof material or steel with rust-resisting finish equivalent to sherardizing or cadmium-zinc plating. There shall be no splices in the wiring and all connections

shall be made at terminal studs or terminal blocks with ring-tongue indented terminals. All screw terminals shall have toothed lockwashers and all stud terminals shall have contact nuts and either locking nuts or lockwashers. Each conductor shall be identified at each end with a permanently machine-embossed black identification on white plastic tubular shrink-on marker and as shown on the connection diagram terminal blocks.

d. Any control wiring within high-voltage compartments shall be completely shielded in a protective metal enclosure. Interpanel terminal blocks shall be used for interconnecting the wiring between adjacent panels at shipping splits. Hinge wire shall be used between stationary panels and swinging panels or swinging doors and shall be formed in vertical wire loops which shall provide rotation around the longitudinal axis of the conductors. Instrument transformer secondary circuits where required shall be grounded at the switchgear. All leads from each individual instrument transformer shall be brought out to terminal blocks.

e. All current transformer secondary leads shall be routed through metal conduits separately from all other wiring, to short-circuiting terminal blocks in the control cabinet or in a separate cabinet. Current transformer terminal blocks shall be isolated by barriers from operating mechanism and control circuits if they are in the control cabinet. Grounding shall comply with IEEE C57.13.3.

f. Terminal blocks and internal wiring shall be provided to all breaker spare auxiliary contacts and control device spare contacts for the connection of remote circuits. Terminal blocks shall be provided to terminate all external cables and shall contain at least 10 percent spare terminals. Suitable provisions shall be made for training and supporting incoming cables from the point of entrance to their termination on terminal blocks. All terminal blocks shall be accessible from the front of the switchgear unit with the front door open and the circuit breaker in the operate position. Drawings showing the proposed arrangement of terminal blocks and supports for incoming cables shall be submitted for approval.

g. Special attention shall be given to wiring and terminal arrangement to permit the individual conductors of an external cable to be conveniently grouped for connection to adjacent terminal points. Suitable entrance locations shall be indicated on the Contactors shop drawings for entrance of all external control cables.

h. The wire or terminal point designations used on the Contactors wiring diagrams and printed on terminal block marking strips may be according to the Contactors standard practice; however, additional wire and cable designations for identification of remote or external circuits shall be required, and drawings submitted for approval will be so marked and returned to the Contactors for additional designations. Drawings may require revision of external circuit connections, terminal and wire designations and wire grouping when submitted for approval.

2.2.8 Terminals And Installation

a. External control wiring terminating within the assembly housings shall be furnished and installed by the Contactor. All new control wiring leaving equipment shall be run to and terminated on terminal

blocks. Terminal blocks and internal wiring shall be provided as required for connection of existing remote circuits to all spare auxiliary and alarm contacts, remote annunciators, remote control switches, and pilot devices and remote indicating lights where such devices are specified or existing and applicable to the equipment involved. There shall be no splices in the wiring and all connections shall be made at terminal blocks. Terminal blocks shall be added for wiring to existing devices having leads instead of terminals. Indented terminals, Burndy Type YAV10 or an approved equal, shall be used on all wires terminated on screw terminals. All screw terminals shall have toothed lock washers and all stud terminals shall have contact nuts and either locking nuts or lock washers.

b. All external control cables and power cables shall enter the switchgear as shown on the drawings.

2.2.9 Terminal Blocks

Terminal blocks shall conform to the requirements of Section 26 00 00.00 26 GENERAL ELECTRICAL WORK.

2.2.10 Equipment Grounding

In addition to the requirements of Section 26 05 26.00 26 GROUNDING, the switchgear assembly shall have a full-length interior ground bus bar to which the housing, framework, cable supports, bus supports, and non-current carrying metallic parts of all equipment and conduits is grounded to insofar as practicable. The operating mechanism of the drawout units shall be permanently grounded, ground contacts shall be provided to automatically connect the movable element to the ground buses. These connections shall make before the main disconnecting devices upon insertion, and break after the main disconnecting devices upon withdrawal. Grounding shall conform toIEEE C37.20.1 except that the ground conductor shall have a continuous current-carrying capacity not less than 25 percent of the continuous rating of the circuit breakers.

2.2.11 Molded Case Circuit Breakers

Molded case circuit breakers for control power sources shall conform to the applicable paragraphs in Section 26 00 00.00 26 GENERAL ELECTRICAL WORK.

2.2.12 Nameplates

Each item of equipment mounted on the switchgear which does not have a suitable designation included as an integral part of the device shall be provided with an engraved nameplate or with other approved suitable means of identification. Nameplates shall be as per Section 26 00 00.00 26 GENERAL ELECTRICAL WORK.

2.2.13 Foundations

Existing foundations may be reused or modified as recommended by the switchgear manufacturer to accommodate the replacement equipment. Existing foundations not being reused shall be removed flush with the powerhouse floor and repaired as per Section 03 60 00, CONCRETE DEMOLITION AND REPAIR, prior to installing the switchgear manufacturer's recommended foundation. Anchorage shall be as per Section 13 48 00.00 26 SEISMIC RESTRAINT FOR MECHANICAL AND ELECTRICAL EQUIPMENT and as shown on the

drawings. Switchgear Certifications of Seismic Requirements shall be submitted per Section 13 48 00.00 26 SEISMIC RESTRAINT FOR MECHANICAL AND ELECTRICAL EQUIPMENT.

2.2.14 Remote Racking Devices

One (1) remote racking device, Eaton MRR1000 or approved equal shall be provided. The remote racking devices shall be a portable unit that may be positioned in front of any bus or feeder breaker in the switchgear to rack the breaker in or out remotely. The device shall include a wheeled assembly with brakes, a power module capable of exerting up to 10 pounds of positive pressure and 100 foot-pounds of torque in the braked position to rack the breakers in and out with 15 inches of horizontal traverse, status indicator lights on the assembly visible from all directions, vertical height adjustment, and a control pendant with a minimum 25-foot cord. Power supply for the racking device shall be 120 volts AC, 15 amps. The remote racking device shall be the switchgear manufacturer's standard system designed for racking the breakers provided. If the switchgear manufacturer does not offer such a remote racking device, a different manufactured system may be provided if certified to rack the breakers provided with the switchgear.

2.2.15 Rail Mounted Lifting Device

One (1) rail mounted Breaker Lifting Device shall be provided. The rail shall be engineered by the manufacturer of the switchgear to be integrated as part of the gear. The rail mounted lifting device shall be rated for lifting the largest size breakers and have suitable length to place the breaker on the ground.

2.2.16 Portable Testing Unit

One portable test kit, Eaton MTK2000 or approved equal shall be provided. The test kit shall provide provisions to perform secondary injection testing of any breaker using standard 120V AC, 15A, single phase, 60Hz power supply.

2.3 CONTROL SWITCHES

2.3.1 General

Each Magnum DS breaker shall have an Open/Close control switch mounted on the secondary terminal compartment door. All control switches shall be of the rotary switchboard type with handles on the front and the operating contact mechanisms on the rear of the panels; Provide Eaton E34 or equal. All control switches shall be suitable for operation on 600-volt AC or 250-volt DC circuits. All such switches shall be capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. The switches shall be capable of continuously carrying 20 amperes without exceeding a temperature rise of 30 degrees C. The single-break inductive load interrupting rating of switches shall be not less than 1.5 amperes for 125 volts DC or 10 amperes for 115 volts AC. All control switches shall have lockout provisions.

2.3.2 Switch Features

a. Control and instrument switches shall be suitable for the intended use and shall have the features shown on the schematic diagrams and

switch development drawings. The switches shall have modern handles or keys of pistol grip, oval, round notched or knurled type, and shall be black color unless otherwise specified.

b. Control switches for electrically-operated circuit breakers shall be 3 position momentary-contact type with spring return to neutral position, and shall have modern-black, heavy duty pistol grip handles. Circuit breaker control switches shall have mechanical operation indicators to show the last manual operation of the switches, and shall have slip contacts when so indicated or required.

2.4 MAINTENANCE SWITCHES

An Arc Flash Reduction Maintenance Switch shall be provided and installed for every breaker. Each switch shall be located near the breaker it is designed for and be clearly identified with "ON/OFF" markings and "Maintenance Mode" labels. The maintenance switches shall be rotary type switches with a lockable cover. Indication shall be provided by illumination of the each switch individually or a separate indicating light and shall be blue in color. The switches indication shall be wired to the breaker associated with the switch to indicate the unit is in maintenance mode and arc flash has been reduced.

2.5 ARC FLASH DETECTION

Switch gear will be provided with Two (2) SEL-751A relays with arc flash cards capable of supporting 8 sensors. Arc Flash Detection shall be fiber loop sensors for each bus section. Contractor shall be responsible for field installation of the fiber arc flash detection sensors and wiring to relays.

Contractor shall provide SEL-C804 type fiber optic arc fault sensors. Contractor to determine lengths and terminations.

2.6 INDICATING METERS

Electrical indicating instrument relays shall comply with the applicable portions of ANSI C12.1 and ANSI C39.1. Unless otherwise indicated, electrical indicating instruments shall be of the semi-flush, back-connected, dustproof, direct-reading, switchboard type with digital readout. The accuracy of each instrument shall be within 0.5 percent of full scale. Each instrument shall be accurately calibrated for use with the associated instrument transformers, and shall have the indicated scale or a scale suitable for the application, where a specific scale is not indicated.

All meters to be provided with serial communications means: Modbus RS-485.

2.6.1 Multimeters

Provide a digital multimeter for each switchgear bus. Each meter shall provide per phase % THD (Total Harmonic Distortion) and individual harmonic monitoring to the 40th order for voltage and current, and shall provide Volts, Amps, kW, kVAR, PF, kVA, Frequency, kWh, kVAh, kVARh, 1 KYZ pulse output, on board meter limit exceeded alarm. Additionally shall have the capability to provide a waveform view of real time harmonic distortion on a PC from an embedded WEB server, record waveforms up to 512 samples per cycle, and provide 768 Megabytes for data logging.

2.7 WATTHOUR METERS

Wattmeters shall be provided for both Station Service transformers. Watthour meters shall be semi-flush, back-connected, dustproof, direct-reading, switchboard type, digital, with Modbus RS-485 communications capability. Watthour meters shall conform to ANSI C12.1 and ANSI C12.20. Watthour meters shall be of the switchboard type having a 15-minute, cumulative form, demand register. Watthour meters shall be accurately calibrated for use with the associated instrument transformers. Provide SEL-735 meters or equal.

2.8 INDICATING LAMP ASSEMBLIES

Indicating lamp assemblies shall be of the switchboard type, insulated for 125-volt dc service, with appropriate colored caps and integrally mounted resistors for 125-volt service. Color caps shall be made of material which will not be softened by the heat from the lamps. Lamps shall be long-life light emitting diode type with a minimum normal life span of 50,000 hours. Indicating lights shall be visible from at least 20 feet away. Lamps shall be replaceable from the front of the panels and any special tools required for lamp replacement shall be furnished. Insofar as practicable, all color caps shall be similar and interchangeable, and all lamps shall be of the same type and rating.

2.9 ESCUTCHEONS

Each control switch shall be provided with an escutcheon clearly marked to show each operating position. The switch identifications shall be engraved on the escutcheon plates or on separate nameplates. The escutcheon and nameplate markings shall be subject to approval.

2.10 INSTRUMENT TRANSFORMERS

2.10.1 General

a. All leads from each individual instrument transformer shall be brought out to switchgear terminal blocks. Instrument transformer secondary circuits shall be grounded at the switchgear terminal blocks. All secondary leads shall be grounded together at the instrument transformer for shipping. All instrument transformers shall conform to the applicable grounding requirements of IEEE C57.13. Thermal rating of instrument transformers shall be 1.33.

b. The Contractor shall provide Relay Curves for Instrument Transformers. Submit typical ratio and phase angle curves for each type and rating of all voltage and current transformers supplied with the equipment.

2.10.2 Voltage Transformers

a. Voltage (Potential) Transformers, except as otherwise specified, shall conform to the applicable requirements of IEEE C57.13. The voltage transformers shall be of the indoor dry or compound-filled type with a minimum full-wave impulse level of 10 kV. The voltage rating shall be as indicated on the drawings, and the thermal rating for a 55 degrees C ambient shall not be less than 750 volt-amperes. Voltage transformers shall have a relay and metering accuracy of 0.3W, 0.3X, 0.3Y, 0.6Z.

b. Each voltage transformer shall be mounted in separate switchgear compartments in a fused rollout tray with stabs that disconnect the voltage transformer when the tray is pulled out. Transformer shall be provided with current limiting fuses for each phase connection on the primary side. Transformer secondary side will be fused in the switchgear low voltage compartment. Fuses shall be located so as to be readily accessible. Fuses shall be able to withstand maximum possible energizing current, but capable of interrupting the circuit in case of a short-circuit on the secondary winding. Each voltage transformer low voltage connection shall be connected to a terminal block in the switchgear low voltage compartment.

2.10.3 Current Transformers

2.10.3.1 General

The quantity, ratios, and functions of the current transformers shall be as shown on the drawings. Current transformers, except as otherwise specified, shall conform to the applicable requirements of IEEE C37.20.1, IEEE C57.13, and IEEE C57.13.3. Current transformers shall be of the dry or compound-insulated type revenue grade, and shall be provided with a suitable means of mounting and for grounding the frame. Each current transformer secondary lead shall be connected to a terminal block of the short-circuiting type and shall be conveniently located to permit short-circuiting the secondary windings without requiring access to the primary bus compartments. The polarity of the current transformers shall be plainly marked. The current transformers shall be shorted at the terminals of each of the current transformers for shipping. All current transformers shall be suitable for continuous operation at the full-rated voltage and current at a frequency of 60 Hz. All current transformers shall be designed to withstand, without damage, the thermal and mechanical stresses resulting from short-circuit currents corresponding to ratings of the breakers in the circuits to which they are connected. Current transformers shall have a continuous thermal current rating factor based on 30 deg C average ambient air temperature of a minimum of 1.33. Current transformer secondary leads shall be not smaller than No. 10 AWG.

2.10.3.2 Window or Bushing Type Current Transformers

Current transformers installed in the 480 volt switchgear shall be window or bushing type current transformers unless otherwise noted. Window or bushing type current transformers shall have a minimum full-wave insulation level of 600 volts when installed. When the current transformers are installed in the switchgear the installation shall meet the requirements for a 10-kV BIL rating as listed in Table 2 of IEEE C57.13 for test voltage applied between the bus and transformer secondary terminals.

2.10.3.3 Wound and Bar Type Current Transformers

If used, wound and bar type current transformers installed in 480 volt systems shall be rated 600 volts and shall have a minimum full-wave impulse level of 10 kV.

2.10.3.4 Rating

Current transformers with ratios between 75:5 and 300:5 shall have a combination metering / relaying rating of 0.6 B-0.1 / C50. Current transformers with ratios between 400:5 and 500:5 shall have a combination

metering / relaying rating of 0.3 B-0.1 / C100. Current transformers with ratios between 600:5 and 1000:5 shall have a combination metering / relaying rating of 0.3 B-0.5 / C200. The 1200:5 current transformers shall have a combination metering / relaying rating of 0.3 B-1.8 / C200 or better.

2.11 PAINTING

a. Metal surfaces of the switchgear assemblies shall be finished and painted in accordance with IEEE C37.20.1. Accessories and interior surfaces shall be finished in accordance with manufacturer's standard practices.

2.12 FACTORY INSPECTION AND TESTS

2.12.1 General

a. Each item of equipment supplied under this Contract shall be given the manufacturer's routine factory inspections and tests and also other tests, as specified below, to insure successful operation of all parts of the assemblies. All tests required shall be witnessed by the Agency Representative, unless waived in writing, and no equipment shall be shipped until it has been approved for shipment. The Contractor shall notify the Agency Representative sufficiently in advance of the test date, so that the Agency Representative can make arrangements to be present for testing.

b. Factory tests shall have been performed on circuit breakers identical to those furnished under this Contract. Certified Factory Test Reports and Certifications of Switchgear and Breakers shall be submitted. Factory tests shall be as described in IEEE C37.50 and NEMA SG 3 as applicable for the specified ratings of the circuit breakers to be furnished under this Contract. The Contractor's submittal shall identify all tests which were performed to certify compliance with standards and the Contractor shall permit review of design test data, oscillograph tracings, and other information by the Agency.

c. If any factory tests are performed on circuit breakers or components to be furnished under this Contract, the affected items shall be inspected after testing to ensure that no damage or wear has occurred. Any items, which may have had the lifetime and reliability, expected of new and unused equipment degraded by the tests shall be replaced, or if approved by the Agency, repaired.

d. A certified statement shall be provided by the manufacturer of the circuit breakers that factory tests in accordance with IEEE C37.50 have been performed on power circuit breakers of the same design, construction, and ratings as those furnished under this Contract and standards and verifying the circuit breakers will operate satisfactorily under normal and short-circuit conditions when applied within their ratings.

e. Factory PLC Testing: At the factory test the Agency personnel shall install PLC programming and perform functional testing of PLC I/O to ensure proper factory wiring. Factory shall make switchgear and PLC equipment available and shall assist in the PLC testing as part of the overall switchgear testing.

f. Factory Test Procedure shall be submitted prior to factory

testing. The factory test equipment and test methods used shall conform to the applicable requirements of ANSI, IEEE and NEMA standards, and shall be subject to approval. The witnessing representatives of the Contractor and the Contracting Officer shall sign all test reports. Factory Inspection and Test Reports shall be submitted after completion of the tests.

2.12.2 Breaker Assembly Tests

Each low-voltage air circuit breaker assembly shall be subjected to the Production Tests described in IEEE C37.20.1, except as modified or supplemented below.

2.12.2.1 Assembled Equipment

The assembled equipment shall be checked for mechanical adjustment, alignment of roll out assemblies and devices mounted thereon to ensure proper fit and insertion into cubicles in existing switchgear assembly. The combined assembly of breaker and switchgear will be checked for adequacy of fastenings and general good workmanship.

2.12.2.2 Wiring

Control, instrument and relay wiring shall be given a point-to-point check, and the correctness of the control wiring shall be verified by actual operation of the compartment devices.

2.12.2.3 Breaker Assembly

Each breaker assembly, shall be subjected to a 1-minute power frequency withstand dielectric test of 2,200 volts AC as recommended in NEMA C37.50 Paragraph 3.5.2. Control, instrument and relay wiring shall be subjected to a 1-minute, power frequency withstand dielectric test of 1,500 volts AC to ground unless the required test voltage is reduced per NEMA C37.50 Paragraph 3.5.2 (3), (4), (5).

2.12.2.4 Circuit Breaker

Each low-voltage power circuit breaker shall be given the production tests described in NEMA C37.50. Each circuit breaker shall be thoroughly checked for proper operation and all necessary adjustments shall be made. Shunt trip coils shall be checked for proper operation.

2.13 ACCESSORIES

Handling and testing accessories needed to remove, replace, test and maintain the drawout type air circuit breakers shall be furnished. The accessories shall include the following:

a. Two - Set of test plugs for drawout relays.

b. Two - Sets of keys for key interlocks.

c. One - Remote racking devices.

d. One - Hoist, cart or other suitable means for breaker removal and handling.

e. Two - Complete sets of all special wrenches and tools required for

the installation, maintenance and repair of the breakers.

f. One - Portable test set by the same manufacturer as the static trip devices to check the operation of the static trip devices without the need for high primary circuit current.

2.14 SPARE PARTS

Spare parts shall be duplicates of the original parts furnished, and shall be interchangeable therewith. Parts shall be listed on the Accessories and Spare Parts List. The following spare parts shall be furnished for each type and frame size of drawout circuit breaker, except that only one spare is required where parts are applicable to all types and frame sizes of the circuit breakers:

a. One - Complete spare breaker of each type provided.

b. One - Control relay of each type and rating for electrically-operated breakers.

c. One - Auxiliary switch complete for electrically-operated breakers.

d. One - Manual operating mechanism handle for drawout feeder air circuit breakers.

e. Twelve - Fuses of each type and size for voltage transformers.

f. Two - Switchboard meters of each type provided.

PART 3 EXECUTION

3.1 EQUIPMENT INSTALLATION

a. Installation shall comply with the general construction requirements of Section 26 00 00.00 26, GENERAL ELECTRICAL WORK. The work under this Contract is subject to the safety clearances and operating procedures currently practiced by the Agency. All the construction activities shall be coordinated with the Agency Representative so that the construction will not adversely affect the daily operation of the powerhouse. Safety clearances shall be obtained before opening, entering or working on any existing electrical equipment. Unless otherwise specified, execution of all installation work shall be in accordance with the National Electrical Code, NFPA 70, and the National Electrical Safety Code. If a deviation from the above standards is specifically shown or specified, the drawings and specifications shall govern. Omission of details on the drawings or in the specifications shall not be construed as permitting deviations from the Code requirements.

b. The Contractor shall submit to the Agency Representative for approval a Work Plan for Coordination of electrical outages and equipment installation, to be updated on a weekly basis. Activities which are hazardous, affect plant operation, or require participation by Agency personnel, shall be included in the plan. The Work Plan shall contain a schedule of when outages will be required. The plan shall indicate which persons on each shift are responsible for superintendence and safe clearance. The operation of existing 480 volt equipment is critical to operation of the plant.

3.2 FIELD INSPECTION, TESTING AND COMMISSIONING

3.2.1 General

After completion of the installation of the equipment and accessories, perform routine and complete operational tests as necessary to insure proper installation and verify proper operation. Field testing of switchgear and breakers shall be per IEEE C37.20.1 and applicable IEEE 1248 recommended procedures. Routine tests shall include but not be limited to inspections and tests for location and mechanical alignment, damage to equipment porcelain or painted surfaces, electrical continuity of external circuits, voltage transformer phase rotation.

a. Following installation, the equipment shall be inspected, adjusted, tested and commissioned following applicable procedures listed in IEEE 1248 and the Contractor shall be responsible for performing all equipment commissioning required by the equipment manufacturers and as noted in SECTION 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING of this contract.

b. Testing shall include all testing recommended in the referenced standards. All test equipment shall have been calibrated within one year of testing. Test report shall include test equipment manufacturer, serial number, range and test equipment calibration certificate. Records of exact test voltage, current, etc. and results shall be recorded. Test data shall include the name of the test engineer and the date the tests were performed.

c. PLC Field Testing: Agency personnel shall provide PLC programming and perform functional testing of PLC I/O to ensure proper factory and field wiring. Contractor shall assist in the PLC testing as part of the overall switchgear testing.

d. Submit a field test procedure plan for approval, listing the routine and operational tests to be conducted. The tests shall be witnessed by an Agency Representative. The Contractor shall furnish five certified copies of all Field Test Reports, including complete test data on all tests. Reports of all witnessed tests shall be signed by the witnessing representatives of the Contractor and the Contracting Officer. The costs of performing all tests shall be borne by the Contractor and shall be included in the prices bid for the items of equipment in the Schedules. The routine and operational tests shall be as outlined below and as recommended by the manufacturer and the Field Service Engineer.

3.2.2 Low Voltage Breakers

At a minimum the following testing shall be performed:

a. Test breaker contact resistance with the resistance measured in micro-ohms. Manufacturer shall provide data on maximum allowable contact resistance.

b. Verify proper breaker rollout assembly alignment with switchgear. Verify that the main breaker stabs on the breaker assembly properly align with and engage the switchgear bus. Verify that the auxiliary breaker contacts and breaker controls align with and properly connect to the switchgear controls.

c. Verify racking mechanism interlocks. Breaker cannot be inserted or removed unless the breaker is in the open position. If there is a test position, verify operation of breaker in test position.

d. Test all breaker controls, auto transfer, interlocks, emergency trips and alarms in accordance with the schematics and specifications. Testing shall include operation of the breaker from local and remote controls and in both the test and the operate positions.

e. Each low-voltage power circuit breaker shall be given the tests described in NEMA C37.50. Close and trip coils shall be checked for proper operation. Each circuit breaker shall be thoroughly checked for proper operation and all necessary adjustments shall be made.

f. Test all breaker trip settings at the final settings.

g. Test accuracy and polarity of all instrument transformer - CT & VT's. The voltage and current transformers shall be subjected to routine tests in accordance with paragraph 4.7.2 of IEEE C57.13. Five copies of typical ratio and phase angle tests shall be furnished for each type and rating of instrument transformer.

h. Program meters. Check calibration and accuracy of meters.

3.3 QUALIFICATIONS OF FIELD ENGINEERING SERVICE PERSONNEL

The Contractor shall provide qualified field engineering service personnel who are fluent in the English language to supervise, test, and install the new equipment specified in this section and related equipment of the same manufacturer during installation. The personnel shall have a minimum of two years experience in the installation and testing of new equipment made by the manufacturer used. The Contactors Field Engineering Service Supervisor shall certify that the equipment has been installed in accordance with the manufacturers recommendations and all warranties are in effect. The field engineering service personnel shall be present during both the Contractor's commissioning of equipment and for the Agency's commissioning of the system, per Section 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING. The Contractor shall provide the COR with a current resume for all field engineering service personnel.

3.4 CONTRACTOR FURNISHED TRAINING OF Agency PERSONNEL

a. A qualified training engineer shall be provided who is fluent in the English language to provide training on the breakers and the trip units. The personnel shall have a minimum of two years experience in the installation and testing of power circuit breakers and associated microprocessor or trip units. The Training Engineer shall have attended a factory provided training course on the breakers and trip units.

b. A Qualified Training Engineer will instruct Project personnel on the theory, operation and maintenance of the new switchgear and trip units. The courses for the maintenance personnel shall be of eight hours minimum duration (one full working day). In addition to the maintenance courses there shall be two courses for operational personnel that will be a minimum of two hours each. The training for the operators will be scheduled to cover different shifts so that all may attend. The training shall be conducted for approximately 10

Agency employees at the Project for each session. The maintenance course shall include breaker, trip unit, theory of operation, calibration, programming and repair of the equipment provided, routine maintenance, and trouble analysis and safety precautions. The operations course shall include equipment design, theory of operation, use of displays and explanation of trip and alarm messages. Demonstrations shall be on the actual equipment furnished, to the maximum extent possible. Course material shall use to the maximum extent possible, the site-specific operation and maintenance data that the Contractor is providing for the project. The Agency may videotape the training sessions for future use. The Contractor shall submit for Agency approval, a training outline detailing course topics, material, and subjects. Agency reserves the right to schedule the training with the Contractor on a date that is acceptable to the needs of the Agency to include constraints outside the scope of the construction project.

-- End of Section --

SECTION 26 23 15.00 26

HIGH RESISTANCE GROUNDING (HRG) SYSTEM - LOW VOLTAGE (480V)

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

a. This section covers the supply and installation of two (2) 480V high resistance grounding (HRG) systems at The Tyee Lake Powerhouse. The systems will be connected to the wye point of each of the 2 Station Service 500kva transformers.

b. The Station Service HRG systems will be installed as part of the 480V metal enclosed switchgear.

c. The grounding equipment for each system shall include a resistor, single-pole hook-stick-operated disconnecting switch, and the associated wiring.

d. The Station Service HRGs shall be an Eaton Type C-HRG part number N4WNCRNDF46 or approved equivalent.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred from within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007) National Electrical Safety Code
IEEE 32	(1972; R 1990) Requirements, Terminology, and Test Procedures for Neutral Grounding Devices
IEEE C37.20.1	(2015) Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007) National Electrical Code

1.3 SUBMITTALS

Agency approval is required for the following submittals:

SD-02 Shop Drawings

Outline Drawings

Submit within 120 days after notice to proceed.

Connection/Assembly Drawings

Submit within 120 days after after notice to proceed.

As-Built Drawings

Drawings which accurately depict the as-built configuration of the installation shall be submitted within 30 days of acceptance of HRG(s) installation.

SD-03 Product Data

Within 180 calendar days after receipt of the notice to proceed, submit manufacturer's data, drawings, catalog cuts, and wiring diagrams. Submitted manufacturer's data sheets shall be color copies of the original documents and be of good quality, easily read and marked or highlighted indicating the specific equipment being submitted and labeled as to which equipment (by designation) the submitted equipment is installed with and show compliance with the contract specifications. Manufacturer's data sheets submitted for the O&M manuals shall be the original documents and not be copies. As a minimum, submittals shall be required for but not be limited to the following:

Grounding Resistors
Wire
Terminal blocks
Current Transformers
Nameplates

Catalog cuts, brochures, circulars, specifications, product data, and printed information shall provide sufficient detail and scope to verify compliance with the requirements of the contract documents.

SD-06 Test Reports

Factory Tests
Within 30 days after testing has been completed,
Provide five certified copies of all factory tests.

Field Tests
Within 30 days after testing has been completed,
Provide five certified copies of all field tests.

SD-10 Operation and Maintenance Data

Training Outline

SD-11 Closeout Submittals

Warranty

Submit within 30 days prior to construction of equipment

1.4 WARRANTY

Units shall be warranted by the manufacturer from manufacturing defects for a period of 2 years after installation at Tyee Lake Powerhouse. See

Section 01 78 00.00 28 CLOSEOUT SUBMITTALS for information regarding Warranty Management. Submit HRG's manufacturer warranty for agency approval.

PART 2 PRODUCTS

2.1 HIGH RESISTANCE GROUNDING EQUIPMENT (HRG)

a. The HRG shall be an integral assembly of the Station Switchgear.

b. The assemblies shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to Contractor supplied floor sills. Bases of the assemblies shall be suitable for rolling directly on pipes without skids.

c. Each unit forming part of the assemblies shall be a self-contained housing. Control compartments, and resistor compartments shall be segregated by means of steel barriers. All components shall be accessible via removable panel covers.

d. All equipment furnished under this contract shall meet the requirements of NFPA 70, and other standards as specified in this document. Finished painted surfaces and metal work shall be wrapped suitably or otherwise adequately protected from damage during shipment.

2.2 MATERIALS

All copper bus bars, conduit, fittings, connections, wire, wire markings, conductors, and terminal blocks shall conform to Section 26 00 00.00 10 GENERAL ELECTRICAL WORK AND EQUIPMENT.

2.3 RESISTORS

a. The sets of grounding resistors for the Station Service Switchgear shall be rated on a 1 minute rating.

b. All resistors shall conform to IEEE 32 except that they shall be insulated for not less than 600 V AC and the rated maximum temperature of the resistors shall not exceed 415 degrees Celsius when mounted inside cubicle with natural air cooling. The resistors shall have taps wired out to a convenient front accessible terminal block.

c. All resistors shall be heavy-duty industrial type, wirewound design. Each resistor tube shall have a stamped steel rating nameplate. The resistor assembly shall be interconnected with suitable wire size as required for the circuit current. The resistors shall have mounting brackets for mounting in the cubicles. All steel support materials shall be corrosion-resistant steel or hot-dipped galvanized. The units shall be completely isolated from ground. Terminals shall be provided to allow connection with separate lugs of both 600 kCMIL and 12 AWG wire.

2.4 WIRING/TERMINATIONS

a. The switchgear manufacturer shall provide suitable terminal blocks for secondary wire terminations and a minimum of 10% spare terminals shall be provided. One control circuit cutout device shall be provided in each control circuit. Switchgear secondary wire shall be #14 AWG, type SIS rated 600 volt, 90 degrees C, furnished with wire

markers at each termination. Wires shall be terminated on terminal blocks with marker strips numbered in agreement with detailed connection diagrams.

b. Neutral terminal for wye connected system shall be suitable for #6 AWG to 600 kCMIL power cables.

c. Current Transformers shall be wired to shorting terminal blocks within the HRG enclosure for access by relay leads.

2.5 ENCLOSURES

The HRG systems described in these specifications shall be indoor NEMA 1 construction, panel mounted in the Station Service Switchgear with devices arranged as shown on contract drawings. The Contractor will submit to the Agency for approval switchgear manufacturer drawings indicating installation and access for the HRG within the Station Service Switchgear

a. Each unit shall be enclosed in a dead-front fabricated housing and provided with metal partitions or barriers as required. Exterior panel surfaces shall be free from holes, seams, dents, weld marks, loose scale, or other imperfections, and shall not be drilled or welded for attachment of wiring, resistors, or other devices where such holes or fastenings will be visible from the exterior. All ferrous fasteners shall have a rust-resistant finish, and all bolts and screws shall be provided with lock washers or other approved locking devices. The hinges for all doors shall be of the fully concealed type. Manufacturer's standard ventilating openings shall be provided as required for proper ventilation. Intake vents shall be filtered, and both intake and exhaust vents shall be provided with corrosion-resistant insect-proof screens on the inside.

b. Interior and exterior surfaces of equipment enclosures shall be thoroughly cleaned after fabrication, and then shall receive a rust inhibitive phosphatizing in accordance with IEEE C37.20.1 requirements.

2.6 NAMEPLATES

a. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all control devices as indicated on the drawings. Nameplates shall be laminated plastic, white characters on black background, and secured with screws. Characters shall be 3/16-inch high, minimum. Furnish master nameplate giving HRG system designation, voltage and ampere ratings, manufacturer's name, catalog number, and general order number. Per SECTION 26 00 00.00 10 GENERAL ELECTRICAL WORK AND EQUIPMENT.

b. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

2.7 FINISH

The finish shall consist of a coat of gray (ANSI-61), thermosetting, polyester powder paint applied electrostatically to pre-cleaned and phosphatized steel and aluminum for internal and external parts.

PART 3 EXECUTION

3.1 FACTORY TESTS

a. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with latest version of ANSI and NEMA standards.

(1) Completely test the high-resistance grounding system for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment.

(2) The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute between live parts and ground in accordance with IEEE C37.20.1.

b. A certified test report of all standard production tests shall be available to the Agency.

3.2 FIELD QUALITY CONTROL

a. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contracr in installation, testing and startup of the equipment specified under this section. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and field tests of the assembly and components contained therein. Each item of equipment supplied under this contract shall be given the routine field tests to ensure successful operation of the systems. The test equipment and the test methods used shall conform to the applicable requirements of ANSI Standards and IEEE Standards and shall be subject to the approval of the Agency.

b. Submit two (2) copies of the manufacturer's field startup report.

3.3 TESTING AND COMMISSIONING

3.3.1 Testing

As a minimum, the following tests shall be performed:

a. Disconnect Switches shall be tested by a one-minute power frequency dielectric test.

b. Resistors shall be tested by the applied-potential test in accordance with paragraph 10.3.2 and ac resistance in accordance with paragraph 10.1.4 of IEEE 32.

3.3.2 Commissioning

The Contractor shall be responsible for performing all equipment commissioning required by the equipment manufacturers and as noted in SECTION 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING of this contract.

3.4 DRAWINGS

3.4.1 As-built drawings

As-built drawings shall be submitted in accordance with SECTION 01 78 00.00 28 CLOSEOUT SUBMITTALS. As-built drawings shall indicate internal wiring connections, terminal block wiring, and location of terminations of external wiring.

3.4.2 Outline Drawings

Provide outline drawings of the cubicle together with weights and overall dimensions. These drawings shall include the overall dimensions of the equipment; the size and location of conduit and cable entrances; details of provisions for bolting equipment to the floor, and seismic certification.

3.4.3 Connection/Assembly Drawings

Provide connection and assembly drawings. The drawings and data shall include sectional and plan views, schematic diagrams, assembly ratings, cable termination sizes, equipment lists, and nameplate schedules. The wiring diagram shall show connections among the components to the terminal blocks in the cabinet. Drawings shall indicate all wire numbers and termination points.

3.5 INSTALLATION OF HIGH RESISTANCE GROUND EQUIPMENT (HRG)

a. All the construction activities shall be coordinated with the Agency so that the construction will not adversely affect the daily operation of the powerhouse. Contractor shall provide to the Agency written request for all outages 14 calendar days in advance of each outage. Operations will review the request and notify the Contractor 7 calendar days in advance if the requested outage is possible. If the requested dates are not possible, then operations will notify the Contractor when an outage will be allowed. All switching will be done by Agency personnel.

b. Unless otherwise specified, execution of all installation work shall be in accordance with NFPA 70, IEEE C2 and IEEE Standards C37. If a deviation from the above standards is specifically shown or specified, the drawings and specifications shall govern. Omission of details on the drawings or in the specifications shall not be construed as permitting deviations from the Code requirements.

c. Contractor shall install HRG equipment as indicated on drawings in compliance with the manufacturer's connection/assembly drawings.

d. Electrical equipment and accessories shall be installed so interference with existing piping, ducts, cable trays, conduit, architectural, and structural features will be avoided. If interferences develop, the Agency will decide which work shall be relocated. The Contractor shall not cut or weaken structural portions of the powerhouse in installing equipment and accessories unless specifically approved in writing.

e. Contractor shall install HRG equipment and enclosure, complete with all primary and secondary connections. Equipment shall be securely fastened.Paint as required to repair damage to paint from shipping or

installation.

g. Ground HRG system to the Station Service ground with a minimum of #2/0 copper grounding conductor. Connect the cubicle ground bar to the station grounding system with a minimum of a #2/0 copper grounding conductor.

3.6 CONTRACTOR-FURNISHED TRAINING FOR AGENCY PERSONNEL

Before the HRG equipment is placed into service, and the O&M manuals approved, the HRG manufacturer's Field Engineering Services shall instruct Project Personnel on the theory, operation and maintenance of the new HRG. The course shall be of 4 hours minimum duration and two separate sessions shall be conducted for approximately six Agency employees at the Project for each session. The course may occur in conjunction with other training as indicated in 26.23.10.00 26 and does not require additional hours if training is adequate to cover all requirements for each respective section.

The course shall include HRG design and theory of operation, construction of the actual equipment furnished, routine maintenance, trouble analysis, instruction on the unit operation and setting, any special shipping and handling procedures, and safety precautions. Demonstrations shall be on the actual equipment furnished, to the maximum extent possible. Major overhaul procedures shall be covered briefly, with greater emphasis on emergency procedures. Course material shall include the use of site-specific operations and maintenance manuals to the maximum extent possible. The operations and maintenance manuals shall be submitted well in advance, to allow time for review and approval, just prior to the training. The Agency may video tape the training sessions for future use. A minimum of 60 calendar days prior to training, the Contractor shall submit for Agency approval, a training outline detailing course topics, material and subjects. The Contractor shall notify the Agency 14 calendar days in advance of the dates of the training so that arrangements can be made to permit the scheduling of the Project's personnel.

3.7 QUALIFICATIONS OF FIELD ENGINEERING SERVICE PERSONNEL

The Contractor shall provide qualified field engineering service personnel who are fluent in the English language to supervise, test and install the HRG equipment. The personnel shall have a minimum of two (2) years experience in the installation and testing of new HRG equipment. The Field Engineering Service Supervisor shall certify that the equipment has been installed in accordance with the manufacturer's recommendation and all warranties are in affect.

3.8 RELAY SETTINGS

The relays shall be set in the field by the Contractor in accordance with the coordination study provided by the Agency. The Contractor shall coordinate with the Agency for transmittal of the coordination report and relay settings.

-- End of Section --

SECTION 26 28 00.00 26

PANELBOARDS

PART 1 GENERAL

1.1 GENERAL INFORMATION

1.1.1 Summary

These specifications include supply, installation, and testing of 480VAC switchboards. Including, but not limited too, PPU1, PPU2, PPU3, PPCL, PCP-A, PCP-A1, and the temporary panelboard.

1.2 REFERENCES PUBLICATIONS

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B 187/B 187M	(2006) Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.20.1	(2002; R 2007) Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA PB 1	(2006; Errata 2008) Panelboards
NEMA PB 2	(2006) Deadfront Distribution Switchboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011) National Electrical Code
NFPA 70 E	(2009) Electrical Safety in the Workplace

UNDERWRITERS LABORATORIES (UL)

UL 489	(2009) Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 50	(2007) Enclosures for Electrical Equipment
UL 67	(2009) Standard for Panelboards

UL 61010-1	(2004; R2005) Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

1.3 SUBMITTALS

The following shall be submitted in accordance with SECTION 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
Submit within 120 days after notice to proceed

480VAC Switchboard Arrangement Drawings

SD-03 Product Data
Submit within 120 days after notice to proceed

480 Volt Panelboards and Switchboards
Accessories and Spare Parts List

SD-07 Certificates
Submit within 10 days after test completion

Factory Tests

SD-10 Operation and Maintenance Data
Submit no later than 60 days prior to construction

Operation and Maintenance Manuals

SD-11 Closeout Submittals
Submit no later than 30 days prior to construction

Warranty

1.4 WARRANTY

Switchboards and Panelboards shall be warranted by the manufacturer from defects for a period of 2 years after installation at Tyee Lake Powerhouse. See Section 01 78 00.00 28 CLOSEOUT SUBMITTALS for information regarding Warranty Management. Submit panelboard and switchboard manufacturers warranty for Agency approval.

1.5 GENERAL REQUIREMENTS

1.5.1 General

The Contractor shall submit a complete set of Operation and Maintenance Manuals meeting the requirements of SECTION 01 78 23.00 28 to include, but not limited to, complete manufacturer's data sheets, installation and trouble shooting manuals, parts listings, and equipment descriptions for switchboards and panelboards PPU1, PPU2, PPU3, PPCL, PCP-A, PCP-A1, and the temporary panelboard provided under this contract. Information in these manuals shall be new and original, not copies. Submit as per paragraph "SUBMITTALS".

PART 2 PRODUCTS

2.1 480 VOLT PANELBOARDS

Except as otherwise specified or indicated, the design, construction and tests of the switchboards and panelboards shall conform to the applicable requirements of NEMA PB 2. The panelboards shall be of the totally-enclosed dead-front type, built on a framework of structural steel. The framework shall be sufficiently rigid to withstand any stresses due to short circuits. Panelboards PPU1, PPU2, PPU3, PPCL, PCP-A and PCP-A1 and the temporary panelboard shall be of the Eaton Pow-R-Line 4D type or approved equal. They shall be molded case, front accessible, front connected with through door design. PDP-A and PDP-A1 shall be Eaton Pow-R-Line 3 or approved equal.

2.1.1 Buses And Connections

Copper bars and shapes for main bus and ground bus conductors shall conform to the requirements of ASTM B 187/B 187M. Bus bars shall be of hard-drawn copper. The buses shall be mounted on insulating supports of wet process porcelain, glass polyester, or other approved suitable molded material.

2.1.2 Feeder Circuit Breakers

a. UL 489. UL Listed and labeled, standard rated branch breakers, electrically or manually operated, low-voltage molded-case circuit breaker, with a short-circuit current rating as indicated.

b. Breaker frame size as indicated.

c. Series rated circuit breakers are unacceptable.

d. Molded case circuit breakers shall be 3-pole, dead-front, rated 600 volts AC, Eaton JGS, JGH or JGC for the PPU1, PPU2 and PPU3 boards. The PPCL boards shall be single drawout with similar type Eaton breakers for circuits under 400 ampere and be of the types LGS, LGH or LGC for circuits 400 ampere or greater. All circuit breakers of the same frame size shall be interchangeable. Suitable means shall be provided for removing and handling the circuit breakers. Covers shall be provided over readily accessible energized portions to prevent hazards to personnel when withdrawing or inserting the breakers.

e. All feeder circuit breakers of the MCCB type shall have a lockable handle in the open position for safe work clearances.

2.2 PANELBOARDS

Provide panelboards consisting of assemblies of molded-case circuit breakers with buses and terminal lugs for the control and protection of branch circuits to motors, heating devices and other equipment operating at 480 volts ac or less. Provide UL 67 labeled panelboards. "Loadcenter" type panels are not acceptable. Provide panelboards for installation in surface-mounted cabinets accessible from the front only, as shown on the drawings. Provide panelboards that are fully rated for a short-circuit current of 22,000 symmetrical amperes RMS AC.

2.3 ARRANGEMENT DRAWINGS

Submit drawings showing the arrangement of the 480VAC panelboards including front elevation, circuit breaker arrangement, and one line of power distribution.

2.4 ENCLOSURES

2.4.1 Panelboard

Panelboard enclosures shall be NEMA 1 construction and meet the requirements of UL 50 and NEMA PB 1. All cabinets shall be fabricated from sheet steel of not less than No. 11 gage, with full seam-welded box ends. Cabinets shall be finished ANSI 61 gray. Front edges of cabinets shall be form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. All cabinets shall be fabricated so that no part of any surface on the finished cabinet shall deviate from a true plane by more than 1/8 inch. The distribution panelboard doors shall be fitted with a combined catch and lock, except that doors over 24 inches long shall be provided with a three-point latch having a knob with a T-handle, and a cylinder lock. Two keys shall be provided with each lock, and all locks shall be keyed alike. Finished-head cap screws shall be provided for mounting the panelboard fronts on the cabinets.

2.5 BUSES

2.5.1 Panelboard

All buses shall be of copper and shall be tin or silver-plated throughout. Copper bars and shapes for bus conductors shall conform to the applicable requirements of ASTM B 187/B 187M. The sizes of buses and the details of panelboard construction shall meet or exceed the requirements of NEMA PB 1. Suitable provisions shall be made for mounting the bus within panelboards and adjusting their positions in the cabinets. Multiple section panelboards, where required, shall be of the same short circuit rating and come with properly rated through-feed or sub-feed lugs for the interconnection of the multiple sections. Terminal lugs required to accommodate the conductor sizes shown on the drawing, shall be provided for all branch circuits. A grounding lug suitable for 2/0 AWG wire shall be provided for each panelboard.

2.6 PAINTING

Interior and exterior steel surfaces of equipment enclosures shall be thoroughly cleaned and then receive a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces shall be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Exterior surfaces shall be primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish. Equipment color shall be ANSI 61 gray.

2.7 SPARE PARTS

Spare parts shall be duplicates of the original parts furnished, and shall be interchangeable therewith. Parts shall be listed on the Accessories and Spare Parts List. The following spare parts shall be furnished:

a. 1 - One complete spare breaker of each voltage and type provided over 100A.

b. 2 - Two complete spare breakers of each voltage and type provided up to and including 100A.

Spare breakers may be located in the panelboards. If there are unavailable positions for spares as required, the spare breakers shall be provided in the manufacturers recommended shipping box.

PART 3 EXECUTION

3.1 INTERNAL WIRING

The Manufacturers standard cables and methods of cable terminations may be used between equipment within the enclosures. Wire and cable shall otherwise comply with the requirements of SECTION 26 00 00.00 26. Wiring, where not installed in channels or ducts, shall be formed into compact wire bundles suitably bound together and properly supported. Any wiring, sizes 10 AWG and smaller, extending beyond the equipment cubicles shall be terminated at 600 Volt terminal blocks within the equipment enclosure. Any wiring, sizes 8 AWG and larger, extending beyond the equipment cubicles shall be terminated directly at its respective circuit breaker. Special attention shall be given to terminal wiring arrangements on the terminal blocks to permit individual conductors of each external cable to be terminated on adjacent terminal points. The wire (terminal point) designations used on the wiring diagrams may be according to the manufacturers standard practice; however, additional wire and cable designations for identification of external circuits may be required. Prints of wiring and terminal drawings submitted for approval shall be marked and returned to the Contractor for addition of the Agency's designations to the terminal strips, along with any rearrangement of points required.

3.2 INSTALLATION

The installation phase of this work includes but is not limited to the work described herein. Installation shall be done in accordance with the contract drawings. Any equipment that is received in sections shall be reassembled in the field using a method that ensures all electrical ratings and manufacturer's warranties are maintained.

3.3 INSPECTION AND TESTS

3.3.1 Inspection

All apparatus furnished and all work performed shall be subject to inspection and no apparatus shall be installed until all required tests or inspections have been made or certified copies of reports of tests have been accepted. Acceptance of apparatus or waiving of the inspection thereof shall in no way relieve the Contractor of the responsibility for furnishing apparatus meeting the requirements of these specifications.

3.3.2 Tests

Each item of equipment furnished shall be tested as required below to demonstrate the item is free from electrical and mechanical defects and conforms to the requirements of the specifications. All tests required

herein shall be witnessed by the Agency, unless waived in writing, and no equipment shall be shipped until it has been approved for shipment. The Agency shall be notified a minimum of 15 days in advance of the date of the tests, so that arrangements can be made for the Agency to be present at and witness the tests. The test equipment and the test methods used shall conform to the applicable requirements of ANSI, IEEE, and NEMA standards and shall be subject to approval. Five certified copies of the reports of all tests recording all data obtained during any given test shall be furnished. The cost of performing all tests shall be borne by the Contractor and shall be included in the price bid. Operational tests shall be made on the equipment in conjunction with the tests specified elsewhere.

3.3.3 Safety

The Contractor shall provide and use personnel protective equipment and safety devices such as protective barriers and danger signs to protect and warn personnel in the test vicinity. The Contractor shall compy with NFPA 70E. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.4 Field Testing

a. Field Acceptance Testing and submittals shall be performed as described herein.

b. Field testing shall be performed in the presence of the Agency. The Contractor shall notify the Agency 14 calendar days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspection recommended by the manufacturer unless specifically waived by the Agency. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. All field test reports will be signed and dated by the Contractor.

c. Standard factory tests shall be performed on the equipment provided under this section.

d. The field tests shall include but not be limited to:

(1) Continuity and insulation resistance tests of external wiring . Reference SECTION 26 05 19.00 26.

(2) Circuit breaker open/close operation.

e. Field test reports shall be submitted in accordance with Paragraph "Submission of Test Results" in SECTION 26 00 00.00 26.

3.3.5 Operating Tests

After the installation is completed, and at such time as the Agency may direct, the Contractor shall conduct operating tests for approval as directed in SECTION 26 08 01.00 26. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with SECTION 26 00 00.00 26.

3.4 COMMISSIONING

The Contractor shall be responsible for performing all equipment commissioning required by the equipment manufacturers and as noted in SECTION 26 08 01.00 26.

3.5 ACCEPTANCE

Final acceptance of the equipment will not be given until the Contractor has successfully completed all tests and after all defects in installation, material, or operation have been corrected.

-- End of Section --

SECTION 26 28 21.00 40

AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 10 Part 2	(2020) Industrial Control and Systems, Part 2: Static AC Transfer Equipment

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 1008	(2022) UL Standard for Safety Transfer Switch Equipment

1.2 SUBMITTALS

Agency approval is required for submittals. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Connection Diagrams

Fabrication Drawings

Installation Drawings

SD-03 Product Data

Equipment and Performance Data

Contacts

Indicating Lights

Terminal Board

Enclosures

SD-06 Test Reports

Qualification Testing

Operation Tests

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

SD-11 Closeout Submittals

Warranty

1.3 WARRANTY

Transfer switches shall be warranted by the manufacturer from defects for a period of 2 years after installation at Tyee Lake Powerhouse. See Section 01 78 00.00 28 CLOSEOUT SUBMITTALS for information regarding Warranty Management. Submit panelboards and switchboard manufacturers warranty for Agency approval.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide an automatic transfer switch with closed transition back to normal source. Transfer switch will be configured to operate with two utilities sources. Provide the capability for manual transfer in either direction. Provide contactor type transfer switch with Eaton ATC-900 microprocessor based automatic controller, or equal.

Submit connection diagrams showing the relations and connections of contacts, indicating lights, and terminal board by showing the general physical layout of all controls and the interconnection of the two sources.

Submit fabrication drawings for contacts, indicating lights, terminal board enclosures, and accessories, consisting of fabrication and assembly details to be performed in the factory.

Submit installation drawings for automatic transfer equipment in accordance with paragraph INSTALLATION.

Submit equipment and performance data for automatic transfer equipment including useful life, test, system functional flows, safety features, and mechanical automated details.

2.1.1 Performance Requirements

2.1.1.1 Application

Provide an automatic transfer switch capable of transferring the load from the normal power source to second power source and back to normal source when restored. Provide a switch that is solenoid-operated, mechanically held, double-throw, rated for continuous duty, capable of transferring in

100 milliseconds or less, and conforming to the applicable requirements of UL 1008 and NFPA 70, Article 700, except as herein modified.

Provide an automatic transfer switch of the three-pole type for three-phase application. Provide a solid neutral conductor connection for neutral transfer from the normal source to the emergency source.

2.2 COMPONENTS

2.2.1 Contacts

Provide main contacts with a wiping-action silver alloy that are protected against arcing. Ensure that auxiliary contacts and control transfer relay contacts have a minimum continuous-current rating of not less than 10-amperes inductive at 120 volts ac. Provide the following for auxiliary contacts:

a. Secondary source contacts, normally open when the switch is in the normal position, that close when the switch is in the second source position

Use form C auxiliary contacts.

2.2.2 Indicating Lights

Furnish an automatic transfer switch with two indicating lamps: one light to indicate that the switch is operating on source 1, and the other light to indicate that the switch is operating on source 2. Fuse each indicating circuit.

2.2.3 Terminal Board

Provide a contactor automatic transfer switch terminal board for internally wired control devices, indicating lights, auxiliary contacts, and internal control devices or auxiliary switches to a common output terminal board. Wire the internal functions to facilitate remote connections or monitoring.

2.2.4 Enclosures

Provide an automatic transfer switch enclosure with solid, code-gage, 14-gage, minimum sheet metal, NEMA 250, Type 1, with the manufacturer's standard finish.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Qualification Testing

Provide test data for the furnished unit or an identical unit. Ensure tests meet the general use requirements of UL 508. Subject the complete automatic transfer switch to a test as outlined in NEMA ICS 10 Part 2. One cycle of operation tests under the UL 508 test requirements consists of a transfer of load from the normal source to the emergency source and retransfer to the normal source. Test the switch operating time and the sense relay pickup and dropout times.

2.3.2 3.3.1 Inspection

All apparatus furnished and all work performed shall be subject to

inspection and no apparatus shall be installed until all required tests or inspections have been made or certified copies of reports of tests have been accepted. Acceptance of apparatus or waiving of the inspection thereof shall in no way relieve the Contractor of the responsibility for furnishing apparatus meeting the requirements of these specifications.

2.3.3 3.3.2 Tests

Each item of equipment furnished shall be tested as required below to demonstrate the item is free from electrical and mechanical defects and conforms to the requirements of the specifications. All tests required herein shall be witnessed by the Agency, unless waived in writing, and no equipment shall be shipped until it has been approved for shipment. The Agency shall be notified a minimum of 15 days in advance of the date of the tests, so that arrangements can be made for the Agency to be present at and witness the tests. The test equipment and the test methods used shall conform to the applicable requirements of ANSI, IEEE, and NEMA standards and shall be subject to approval. Five certified copies of the reports of all tests recording all data obtained during any given test shall be furnished. The cost of performing all tests shall be borne by the Contractor and shall be included in the price bid. Operational tests shall be made on the equipment in conjunction with the tests specified elsewhere.

PART 3 EXECUTION

3.1 INSTALLATION

Install automatic transfer switches as indicated, and in accordance with the manufacturer's instructions. Fully align and install wall-mounted enclosures at the indicated mounting height. Fasten in place as indicated in manufacturer's seismic installation instructions.

3.2 Field Testing

a. Field Acceptance Testing and submittals shall be performed as described herein.

b. Field testing shall be performed in the presence of the Agency. The Contractor shall notify the Agency 14 calendar days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspection recommended by the manufacturer unless specifically waived by the Agency. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. All field test reports will be signed and dated by the Contractor.

c. Standard factory tests shall be performed on the equipment provided under this section.

d. The field tests shall include but not be limited to:

(1) Continuity and insulation resistance tests of external wiring. Reference SECTION 26 05 19.00 26.

e. Field test reports shall be submitted in accordance with Paragraph "Submission of Test Results" in SECTION 26 00 00.00 26.

3.3 3.3.6 Operating Tests

After the installation is completed, and at such time as the Agency may direct, the Contractor shall conduct operating tests for approval as directed in SECTION 26 08 01.00 26. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with SECTION 26 00 00.00 26.

3.4 3.4 COMMISSIONING

The Contractor shall be responsible for performing all equipment commissioning required by the equipment manufacturers and as noted in SECTION 26 08 01.00 26.

3.5 3.5 ACCEPTANCE

Final acceptance of the equipment will not be given until the Contractor has successfully completed all tests and after all defects in installation, material, or operation have been corrected.

-- End of Section --

SECTION 26 32 15.00

ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES

PART 1 GENERAL

Provide two 175kW diesel generators in separate weatherproof enclosures with 24hr runtime belly fuel tanks. Generators will be factory configured to allow remote operation via the plant SCADA system and be capable of parallel operation with the other. Provide design after award for generator foundation.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.11	(2022) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2022) Power Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A234/A234M	(2023a) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

ASTM D975	(2020) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P	(1995) Performance Standard for Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1	(2000; R 2011) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation
IEEE 43	(2013) Recommended Practice for Testing Insulation Resistance of Rotating Machinery
IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 115	(2019) Guide for Test Procedures for Synchronous Machines: Part I Acceptance and Performance Testing; Part II Test Procedures and Parameter Determination for Dynamic Analysis
IEEE 120	(1989; R 2007) Master Test Guide for Electrical Measurements in Power Circuits
IEEE 519	(2022) Standard for Harmonic Control in Electrical Power Systems
IEEE C2	(2023) National Electrical Safety Code
IEEE C50.12	(2005; R 2010) Standard for Salient Pole 50 HZ and 60 Hz Synchronous Generators and Generation/Motors for Hydraulic Turbine Applications Rated 5 MVA and above
IEEE C57.13.1	(2006; R 2012) Guide for Field Testing of Relaying Current Transformers

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2021) International Building Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60034-2A	(1974; ED 1.0) Rotating Electrical Machines Part 2: Methods for Determining Losses and Efficiency of Rotating

	Electrical Machinery from Tests (Excluding Machines for Traction Vehicles) Measurement of Losses by the Calorimetric Method

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 3046	(2002, 2006, 2009, 2001) Reciprocating Internal Combustion Engines - Performance--Part 1, 3, 4, 5, 6
ISO 8528	(1993; R 2018) Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets--Part 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) Motors and Generators
NEMA PB 1	(2011) Panelboards
NEMA/ANSI C12.11	(2006; R 2019) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2024) Flammable and Combustible Liquids Code
NFPA 37	(2021) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2023) National Electrical Code
NFPA 99	(2021; TIA 20-1; TIA 21-2) Health Care Facilities Code
NFPA 110	(2022) Standard for Emergency and Standby Power Systems

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J537	(2016) Storage Batteries

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 60	Standards of Performance for New Stationary Sources

UNDERWRITERS LABORATORIES (UL)

UL 142	(2006; Reprint Jan 2021) UL Standard for Safety Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

1.2 RELATED MATERIALS

Section 26 00 00.00 26 GENERAL ELECTRICAL WORK AND EQUIPMENT, and Section 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING apply to this section, except as modified herein.

1.3 SUBMITTALS

Agency approval is required for submittals. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Engine-Generator Set and Auxiliary Equipment

Auxiliary Systems

Detailed Drawings

Acceptance

SD-03 Product Data

Harmonic Requirements

Engine-Generator Set Efficiencies

Emissions

filters

special tools

Heat Exchanger

Generator

Manufacturer's Catalog

Site Welding

Spare Parts

Onsite Training

Vibration-Isolation

Instructions

Experience

Field Engineer

General Installation

Exciter

SD-05 Design Data

Performance Criteria

Sound Limitations

Integral Main Fuel Storage Tank

Day Tank

Power Factor

Heat Exchanger

Time-Delay on Alarms

Cooling System

Vibration Isolation

Battery Charger

Capacity Calculations for Engine-Generator Set

Torsional Vibration Stress Analysis Computations

Capacity Calculations for Batteries

Turbocharger Load Calculations

SD-06 Test Reports

Performance Tests

Factory Inspection and Tests

Factory Tests

Onsite Inspection and Tests

Acceptance Checks and Tests

Functional Acceptance Tests

Maintenance Procedures

Operation and Maintenance Manuals

Inspections

Functional Acceptance Test Procedure

SD-07 Certificates

Cooling System

Vibration Isolation

Prototype Test

Reliability and Durability

Fuel System Certification

Start-Up Engineer

Instructor's Qualification Resume

Sound Limitations

Site Visit

Current Balance

Materials and Equipment

Factory Inspection and Tests

SD-09 Manufacturer's Field Reports

Engine Tests

Generator Tests

Assembled Engine-Generator Set Tests

SD-10 Operation and Maintenance Data

Preliminary Assembled Operation and Maintenance Manuals

Submit in accordance with Section 01 78 23.00 28 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Training Plan

1.4 QUALITY ASSURANCE

1.4.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication and installation must also conform to the code.

1.4.2 Site Welding

For all welding, qualify procedures and welders in accordance with ASME BPVC SEC IX.

a. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1.

b. Submit a copy of qualifying procedures and a list of names and identification symbols of qualified welders and welding operators.

c. Submit a letter listing the welder qualifying procedures for each welder, complete with supporting data such as test procedures used, what was tested to, and a list of the names of all welders and their identification symbols.

d. Perform welder qualification tests for each welder whose qualifications are not in compliance with the referenced standards. Notify the Agency 24 hours in advance of qualification tests which must be performed at the work site, if practical.

1.4.3 Vibration Limitation

Limit the maximum engine-generator set vibration in the horizontal, vertical, and axial directions to 6 mils (peak-peak RMS), with an overall velocity limit of 0.95 inches/second RMS, at rated speed for all loads through 110 percent of rated speed. The engine-generator set must be provided with vibration isolation in accordance with the manufacturer's standard recommendation. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

1.4.4 Torsional Analysis

Submit torsional analysis including prototype testing or calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus/minus 10 percent.

1.4.5 Performance Data

Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Also submit a description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

1.4.6 Experience

Each component manufacturer must have a minimum of 3 years' experience in

the manufacture, assembly and sale of components used with stationary engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler must have a minimum of 3 years' experience in the manufacture, assembly and sale of stationary engine-generator sets for commercial and industrial use. Submit a statement showing and verifying these requirements.

1.4.7 Field Engineer

The engine-generator set manufacturer or assembler must furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer must have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets. Submit a letter listing the qualifications, schools, formal training, and experience of the field engineer.

1.4.8 Detailed Drawings

Submit detailed drawings showing the following:

a. Base-mounted equipment, complete with base and attachments, including anchor bolt template and recommended clearances for maintenance and operation.

b. Starting system.

c. Fuel system.

d. Cooling system.

e. Exhaust system.

f. Electric wiring of relays, breakers, programmable controllers, and switches including single line and wiring diagrams.

g. Lubrication system, including piping, pumps, strainers, filters, electric heater, controls and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, including wiring schematics.

j. One-line schematic, wiring diagrams, field power and control wiring schematics of the generator, exciter, regulator, governor, and instrumentation.

k. Panel layouts.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set rigging points and lifting instructions.

1.4.9 Auxiliary Systems Engine-Generator Set and Auxiliary Equipment Drawing Requirements.

Submit drawings pertaining to the engine-generator set and auxiliary equipment, including but not limited to the following:

a. Certified outline, general arrangement (setting plan), and anchor bolt details. Show total weight and center of gravity of assembled equipment on the steel sub-base.

b. Detailed elementary, schematic wiring, and interconnection diagrams of the engine starting system, jacket coolant heating system, engine protective devices, engine alarm devices, engine speed governor system, generator and excitation system, and other integral devices.

c. Detailed elementary, schematic wiring; and interconnection diagrams of the fuel system, starting battery system, engine-generator control panel, generator circuit breaker.

d. Dimensional drawings or catalog cuts of exhaust silencers, radiator, fuel day tanks, fuel oil cooler, valves and pumps, intake filters, vibration isolators, and other auxiliary equipment not integral with the engine-generator set.

1.4.10 Vibration Isolation System Certification

Submit certification from the manufacturer that the vibration isolation system will reduce the vibration to the limits specified in the paragraph VIBRATION ISOLATION.

1.4.11 Fuel System Certification

When the fuel system requires a fuel oil cooler as described in the paragraph FUEL OIL COOLER, submit certification from the engine manufacturer that the fuel system design is satisfactory.

1.5 DELIVERY, STORAGE, AND HANDLING

Properly protect materials and equipment, in accordance with the manufacturers recommended storage procedures,before, during, and after installation. Protect stored items from the weather and contamination. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

Deliver equipment on pallets or blocking wrapped in heavy-duty plastic, sealed to protect parts and assemblies from moisture and dirt. Protect and prepare batteries for shipment as recommended by the battery manufacturer. Store auxiliary equipment at the site in covered enclosures, protected from atmospheric moisture, dirt, and ground water.

1.6 EXTRA MATERIALS

Provide one set of special tools and two sets of filters required for maintenance. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. One handset must be provided for each electronic governor when required to indicate and/or change governor response settings. Furnish one gallon of identical paint used on engine-generator set in manufacturer's sealed container with each engine-generator set.

Wrenches and tools specifically designed and required to work on the new equipment, which are not commercially available as standard mechanic's tools, must be furnished to the Agency.

Provide operating instructions for the engine-generator set and auxiliary equipment laminated between matte-surface thermoplastic sheets and suitable for placement adjacent to corresponding equipment. After approval, install operating instructions where directed.

1.7 MAINTENANCE SERVICES

Submit the operation and maintenance manuals and have them approved prior to commencing onsite tests.

1.7.1 Operation Manual

Provide O&M Data as indicated by section closeout and O&M. The manual must include:

a. Step-by-step procedures for system startup, operation, and shutdown;

b. Drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems with their controls, alarms, and safety systems.

1.7.2 Maintenance Manual

Provide O&M Data as indicated by section closeout and O&M. In addition to the requirements of the O&M sections the manual must include:

a. Procedures for each routine maintenance item, procedures for troubleshooting, factory-service, take-down overhaul, and repair service manuals, with parts lists.

b. The manufacturer's recommended maintenance schedule.

c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components.

d. A list of spare parts for each piece of equipment and a complete list of materials and supplies needed for operation.

1.8 SITE CONDITIONS

Protect the components of the engine-generator set, including cooling system components, pumps, fans, and similar auxiliaries when not operating and provide components capable of the specified outputs in the following environment:

a. Site Location: Tyee Lake Hydro Facility, Wrangell, Alaska.

b. Site Elevation: 25 feet above mean sea level.

c. Ambient Temperatures:

(1) Maximum 80 degrees F.

(2) Minimum 10 degrees F.

d. Design Wind Velocity: 10 mph.

e. Prevailing Wind Directions: South and East.

f. Seismic Zone: Zone 3 as defined by ICC IBC.

g. Coastal Marine Environment: Enclosures to be corrosion resistant, sealed and gasketed. Submit data on enclosure corrosion resistance showing 30 year lifetime.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include: air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; engine exhaust system; fuel belly tanks, and insulated enclosure. Submit certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

b. Provide each engine-generator set consisting of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and all other necessary ancillary equipment which may be mounted separately. Assemble sets having a capacity of 750 kW or smaller and attach to the base prior to shipping. Sets over 750 kW capacity may be shipped in sections. Provide set components that are environmentally suitable for the locations shown and that are the manufacturer's standard product offered in catalogs for commercial or industrial use. Provide a generator strip heater for moisture control when the generator is not operating. Identify any nonstandard products or components and the reason for their use.

2.1.1 Rated Output Capacity

Provide each engine-generator-set with rated output capacity as shown on the drawings. The engine capacity must be based on the following:

a. Engine burning diesel fuel conforming to ASTM D975, Grade 2-D at an ambient temperature of 85 degrees F. For stationary engines operated in the United States, diesel fuel requirements are found in 40 CFR 60 Subpart IIII.

b. Engine cooled by a radiator fan mechanically driven by the engine or remote with a motor driven fan.

c. Engine cooled by coolant mixture of water and ethylene glycol, 50 percent by volume of each.

2.1.1.1 Performance Class

The voltage and frequency behavior of the generator set must be in accordance with ISO 8528 operating limit values for performance Class G1, G2, G3 or G4 as follows.

2.1.2 Power Ratings

Power ratings must be in accordance with EGSA 101P.

2.1.3 Transient Response

The engine-generator set governor and voltage regulator must cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set must respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

2.1.4 Reliability and Durability

Submit a reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposed to meet this specification, in similar service. Certification may be based on components, i.e. engines used with different models of generators and generators used with different engines, and does not exclude annual technological improvements made by a manufacturer in the basic standard-model component on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets the performance requirements specified. Provide a list with the name of the installations, completion dates, and name and telephone number of a point of contact.

2.1.5 Parallel Operation

Configure each engine-generator set specified for parallel operation for automatic or manual parallel operation. Each set must be capable of parallel operation with one or more sets on an isolated bus.

2.1.6 Load Sharing

Configure each engine-generator set specified for parallel operation to automatically load share with other sets by proportional loading. Proportional loading must load each set to within 5 percent of its fair share. A set's fair share is its nameplate-rated capacity times the total load, divided by the sum of all nameplate-rated capacities of on-line sets. Incorporate both the real and reactive components of the load.

2.1.7 Engine-Generator Set Enclosure

Provide engine-generator set enclosures that are corrosion resistant, fully weather resistant and suitable for a marine environment. The enclosure must contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Provide access doors to controls and equipment requiring periodic maintenance or adjustment. Provide removable panels for access to components requiring periodic replacement. The enclosure must be capable of being removed without disassembly of the engine-generator set or removal of components other than the exhaust system. The enclosure must reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

2.1.8 Vibration Isolation

Provide an engine-generator set with a vibration isolation system in accordance with the manufacturer's standard recommendation. Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor plus description of seismic qualification of the engine-generator mounting, base, and vibration isolation. Submit torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus 10 percent. Design and qualify vibration isolation systems as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

2.1.9 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within a specified time. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the automatic transfer switch within the starting time specified.

2.2 NAMEPLATES

Provide the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment for each major component of this specification. Provide plates and tags sized so that inscription is readily legible to operating or maintenance personnel and securely mounted to or attached in proximity of their identified controls or equipment. Lettering must be normal block lettering, a minimum of 0.25 inch high. As a minimum, provide nameplates for:

Engines	Economizers
Generators	Transformers (CT & PT)
Regulators	Day tanks
Pumps and pump motors	Governors
Heat exchangers (other than base mounted)	Air Starting System

Where the following equipment is not provided as a standard component by the engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger	Heaters
Switchboards	Exhaust mufflers

Switchgear	Silencers
Battery	Exciters

2.2.1 Materials

Construct ID plates and tags of 16 gage minimum thickness bronze or stainless steel sheet metal engraved or stamped with inscription. Construct plates and tags not exposed to the weather or high operational temperature of the engine of laminated plastic, 0.125 inch thick, matte white finish with black center core, with lettering accurately aligned and engraved into the core.

2.2.2 Control Devices and Operation Indicators

Provide ID plates or tags for control devices and operation indicators, including valves, off-on switches, visual alarm annunciators, gages and thermometers, that are required for operation and maintenance of provided mechanical systems. Plates or tags must be minimum of 0.5 inch high and 2 inches long and must indicate component system and component function.

2.2.3 Equipment

Provide ID plates of a minimum size of high and 5 inches long on provided equipment indicating the following information:

a. Manufacturer's name, address, type and model number, serial number, and certificate of compliance with applicable EPA mission standards;

b. Contract number and accepted date;

c. Capacity or size;

d. System in which installed; and

e. System which it controls.

2.3 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices such that proper operation of the equipment is not impaired.

2.4 MATERIALS AND EQUIPMENT

Submit certification stating that where materials or equipment are specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

2.4.1 Circuit Breakers, Low Voltage

UL 489.

2.4.2 Filter Elements

Provide the manufacturer's standard fuel-oil, lubricating-oil, and combustion-air filter elements.

2.4.3 Instrument Transformers

NEMA/ANSI C12.11.

2.4.4 Pipe (Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A53/A53M, or ASTM A106/A106M steel pipe. Pipe smaller than 2 inches must be Schedule 80. Pipe 2 inches and larger must be Schedule 40.

2.4.4.1 Flanges and Flanged Fittings

ASTM A181/A181M, Class 60, or ASME B16.5, Grade 1, Class 150.

2.4.4.2 Pipe Welding Fittings

ASTM A234/A234M, Grade WPB or WPC, Class 150 or ASME B16.11, 3000 lb.

2.4.4.3 Threaded Fittings

ASME B16.3, Class 150.

2.4.4.4 Valves

MSS SP-80, Class 150.

2.4.4.5 Gaskets

Manufacturer's standard.

2.4.5 Pipe Hangers

MSS SP-58.

2.4.6 Electrical Enclosures

NEMA ICS 6.

2.4.6.1 Panelboards

NEMA PB 1.

2.4.7 Electric Motors

Provide electric motors that conform to the requirements of NEMA MG 1. Motors must have sealed ball bearings and a maximum speed of 1800 rpm. Motors used indoors must have enclosed frames. Alternating current motors larger than 1/2 Hp must be of the squirrel-cage induction type for operation on 208 volts or higher, 60 Hz, and three-phase power. Alternating current motors 1/2 Hp or smaller, must be suitable for operation on 120 volts, 60 Hz, and single-phase power. Direct current motors must be suitable for operation on 125 volts.

2.4.8 Motor Controllers

Provide motor controllers and starters that conform to the requirements of NFPA 70 and NEMA ICS 2.

2.5 ENGINE

Each engine must operate on No. 2-D diesel fuel conforming to ASTM D975, must be designed for stationary applications and must be complete with ancillaries. The engine must be a standard production model shown in the manufacturer's catalog describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance. The engine must be naturally aspirated, supercharged, or turbocharged. The engine must be 4-stroke-cycle and compression-ignition type. The engine must be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. The engine must have a minimum of two cylinders. Opposed-piston type engines must have more than four cylinders. Each block must have a coolant drain port. Equip each engine with an over-speed sensor.

ISO 3046. Diesel engines must be four-cycle naturally aspirated, or turbocharged, or turbocharged and intercooled; vertical in-line or vertical Vee type; designed for stationary service. Engines must be capable of immediate acceleration from rest to normal speed without intermediate idle/warm up period or pre-lubrication to provide essential electrical power. Two-cycle engines are not acceptable.

2.5.1 Sub-base Mounting

Mount each engine-generator set on a structural steel sub-base sized to support the engine, generator, and necessary accessories, auxiliaries and control equipment to produce a complete self-contained unit as standard with the manufacturer. Design the structural sub-base to properly support the equipment and maintain proper alignment of the engine-generator set in the specified seismic zone. In addition, provide sub-base with both lifting rings and jacking pads properly located to facilitate shipping and installation of the unit. Factory align engine and generator on the sub-base and securely bolt into place in accordance with the manufacturer's standard practice. Crankshaft must have rigid coupling for connection to the generator. Base materials shall be corrosion-proof and suitable for marine environment.

2.5.2 Assembly

Completely shop assemble each engine-generator set on its structural steel sub-base. Paint entire unit with manufacturer's standard paints and colors. After factory tests and before shipping, thoroughly clean and retouch painting as necessary to provide complete protection.

2.5.3 Turbocharger

If required by the manufacturer to meet the engine-generator set rating, provide turbine type driven by exhaust gas from engine cylinders, and direct connected to the blower supplying air to the engine intake manifold.

2.5.4 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.5.5 Miscellaneous Engine Accessories

Provide the following engine accessories where the manufacturer's standard design permits:

a. Piping on engine to inlet and outlet connections, including nonstandard companion flanges.

b. Structural steel sub-base and vibration isolators, foundation bolts, nuts, and pipe sleeves.

c. Level jack screws or shims, as required.

d. Rails, chocks, and shims for installation of sub-base on the foundation.

e. Removable guard, around fan. Support guard, on engine sub-base, to suit manufacturer's standard.

2.5.6 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.6 FUEL SYSTEM

Provide fuel system conforming to the requirements of NFPA 30 and NFPA 37 and containing the following elements.

2.6.1 Pumps

Pumps must be duplex or horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve. Provide motor and controller in accordance with the paragraphs ELECTRIC MOTORS and MOTOR CONTROLLERS, respectively.

2.6.1.1 Main Pump

Provide engines with an engine driven pump. The pump must supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. Base the fuel flow rate on meeting the load requirements and all necessary recirculation.

2.6.1.2 Auxiliary Fuel Pump

Provide auxiliary fuel pumps to maintain the required engine fuel pressure, if either required by the installation or indicated on the drawings. The auxiliary pump must be driven by a dc electric motor powered by the starting/station batteries. Automatically actuate the auxiliary pump by a pressure-detecting device.

2.6.2 Fuel Filter

Provide a minimum of one full-flow fuel filter for each engine. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark the inlet and outlet connections of the filter.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.6.3 Relief/Bypass Valve

Provide a relief/bypass valve to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.6.4 Integral Main Fuel Storage Tank

Provide each engine with an integral main fuel tank. Each tank must be factory installed and provided as an integral part of the generator manufacturer's product. Provide each tank with connections for fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and float switch assembly. Provide a fuel return line cooler as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank must be below the flash point of the fuel. Mount the tank within the enclosure for each engine-generator set provided with weatherproof enclosures. The fuel fill line must be accessible without opening the enclosure.

a. All Tanks: UL 142. Provide integral in skid or double wall (110 percent containment) fuel tanks with a minimum capacity of 24 hours of engine-generator set operation at fully-rated load. Epoxy coat day tanks inside and prime and paint outside. Construct tanks of not less than 3/16 inch steel plate with welded joints and necessary stiffeners on exterior of tank. Provide a braced structural steel framework support. Weld tank top tight. Provide 4 1/2 inch square inspection port with a 2 inch NPT fill connection and spill box. Provide proper normal and emergency venting for the primary tank and emergency venting only for the containment basin in accordance with UL 142 requirements.

b. Leak Detector Switch for All Tanks: Actuates when fuel is detected in containment basin, stops fuel transfer pump, and closes the fuel oil solenoid valve.

c. Control Panel for All Tanks: Provide tank controls integral with generator control panel or seperately mounted next to generator controller. Control panel must include the following accessories.

(1) Critical low fuel alarm contacts for shut down of engine.

(2) Low-low level fuel alarm LED.

(3) Low-low level fuel alarm contracts for remote annunciator.

(4) Critical high level fuel alarm LED.

(5) Leak detecting alarm LED.

(6) Alarm horn.

d. Tank Gages for All Tanks: Provide buoyant force type gages for fuel tanks with dial indicator not less than 4 inches in size and arranged

for top mounting. Calibrate each reading dial or scale for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

e. Integral Base Tanks Used as Primary Tank: Provide a 2 inch opening at the tank fill port, fitted an overfill prevention valve (OPV). Additionally, the fill opening must be perpendicular to the tank in order to allow operation of the OPV. Integral base tank must be sized and configured such that the filling and venting nozzles are outside the generator cabinet for ease of accessibility, inspection, and maintenance. Level gage must be in the line of sight from the fill port.

2.6.4.1 Capacity

Each tank must have capacity to supply fuel to the engine for an uninterrupted 24-hours at 100 percent rated load without being refilled.

2.6.4.2 Local Fuel Fill

Each local fuel fill port on the tank must have a screw-on cap.

2.6.4.3 Fuel Level Controls

Provide tanks with a float-switch assembly to perform the following functions:

a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

2.6.4.4 Arrangement

Integral tanks may allow gravity flow into the engine. Gravity flow tanks and any tank that allows a fuel level above the fuel injectors must have an internal or external factory installed valve located as near as possible to the shell of the tank. The valve must close when the engine is not operating. Provide integral day tanks with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection must be welded pipe.

2.6.5 Fuel Oil Cooler

Provide an air cooled fuel oil cooler if the temperature of the fuel returned to the tank from the engine will cause overheating of the tank fuel above the maximum fuel temperature allowed by the engine manufacturer when operating at maximum rated generator power output and low fuel level in the tank. The fuel oil cooler must be furnished by the engine manufacturer for the application and the installation must be complete including piping and power requirements.

2.7 LUBRICATION

Provide engine with a separate lube-oil system conforming to NFPA 30 and NFPA 37. Pressurize each system by engine-driven pumps. Vent the crankcase in accordance with the manufacturer's recommendation. Do not

vent the crankcase to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, must be piped to vent to the outside. The system must be readily accessible for service such as draining, refilling, etc. Each system must permit addition of oil and have oil-level indication with the set operating. The system must utilize an oil cooler as recommended by the engine manufacturer.

2.7.1 Lube-Oil Filter

Provide one full-flow filter for each pump. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark inlet and outlet connections.

2.7.2 Lube-Oil Sensors

Equip each engine with lube-oil pressure sensors located downstream of the filters and provide signals for required indication and alarms. Submit two complete sets of filters, required for maintenance, supplied in a suitable storage box. Provide these filters in addition to filters replaced after testing.

2.7.3 Precirculation Pump

Provide a motor-driven precirculation pump powered by the station battery, complete with motor starter, if recommended by the engine manufacturer.

2.8 COOLING SYSTEM

Provide each engine with its own cooling system to operate automatically while its engine is running. The cooling system coolant must use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across each engine must not exceed that recommended below. Submit a letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified, stating the following values:

a. The maximum allowable inlet temperature of the coolant fluid.

b. The minimum allowable inlet temperature of the coolant fluid through the engine.

c. The maximum allowable temperature rise in the coolant fluid through the engine.

d. The minimum allowable inlet fuel temperature.

2.8.1 Coolant Pumps

Provide centrifugal coolant pumps. Each engine must have an engine-driven primary pump. Provide secondary pumps that are electric motor driven and have automatic controllers.

2.8.2 Heat Exchanger

Provide heat exchanger with the size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted for the maximum summer outdoor design temperature and site elevation. Submit manufacturer's data to quantify

heat rejected to the space with the engine generator set at rated capacity. Provide heat exchangers that are corrosion resistant, suitable for service in ambient conditions of application.

2.8.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosion resistant film, provided that corrective measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Provide internal surfaces that are compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Agency. Provide heat exchangers that are pressure type incorporating a pressure valve, vacuum valve and a cap. Design caps for pressure relief prior to removal. Provide heat exchanger and cooling system that is capable of withstanding a minimum pressure of 7 psi and protect with a strong grille or screen guard. Provide heat exchanger with at least two tapped holes; equip one tapped hole with a drain cock, and plug the rest.

Provide for each engine-generator set, as standard with the manufacturer.

a. Design Conditions: Each radiator unit must have ample capacity to remove not less than the total Btu per hour of heat rejected by its respective engine at 100 percent full-rated load to the jacket water, fuel oil, and lubricating oil system, and intercooler. Radiator capacity must be rated at optimum temperature of coolant leaving the engine and intercooler as recommended by the engine manufacturer with an ambient dry bulb air temperature outside the enclosure of 80 degrees F maximum, and 10 degrees F minimum at the site elevation specified in the paragraph SITE CONDITIONS, and with the coolant mixture specified in the paragraph ENGINE CAPACITY. Pressure drop through the radiator must not exceed 6 psi when circulating the maximum required coolant flow. Radiator air velocity must be a maximum of 1500 feet per minute.

b. Engine Mounted Radiator Construction: Radiator fan must direct airflow from the engine outward through the radiator. Fan must be V-belt driven directly from the engine crankshaft. Fan static capacity must be adjusted to suit the ductwork furnished. Cooling section must have a tube and fin-type core consisting of copper or copper base alloy tubes with nonferrous fins. Select engine-driven fans for quiet vibration-free operation. Make provision for coolant expansion either by self-contained expansion tanks or separately mounted expansion tanks, as standard with the manufacturer. Provide suitable guards for each fan and drive.

c. Coolant solution must be a mixture of clean water and ethylene glycol, 50 percent by volume each. Provide an anti-freeze solution tester suitable for the mixture.

d. Hangers and Supports: MSS SP-58.

2.8.3 Expansion Tank

The cooling system must include an air expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The tank must be suitable for operating temperature of 250

degrees F and a working pressure of 125 psi. Provide welded steel tank , tested and stamped in accordance with ASME BPVC SEC VIII D1 for the stated working pressure. Do not use a bladder type tank. Support the tank by steel legs or bases for vertical or steel saddles for horizontal installation.

2.8.4 Thermostatic Control Valve

Provide a modulating type, thermostatic control valve in the coolant system to maintain the coolant temperature range submitted in paragraph SUBMITTALS.

2.8.5 Ductwork

Use a flexible connection to connect the duct to the engine radiator. Material for the connection must be wire-reinforced glass. Provide airtight connection.

2.8.6 Temperature Sensors

Equip each engine with coolant temperature sensors. Provide temperature sensors with signals for pre-high and high indication and alarms.

2.9 SOUND LIMITATIONS

Submit sound power level data for the packaged unit operating at 100 percent load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of less than 85 decibels at 7 meters with an arctic enclosure.

2.10 AIR INTAKE EQUIPMENT

Locate filters and silencers in locations that are convenient for servicing. Provide high-frequency filter type silencers and locate in the air intake system as recommended by the engine manufacturer. Provide silencer to reduce the noise level at the air intake so that the indicated pressure levels specified in paragraph SOUND LIMITATIONS will not be exceeded. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Provide copper or rubber expansion elements in air-intake lines.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.11 EXHAUST SYSTEM

Provide a separate and complete system for each engine. Support piping to minimize vibration.

2.11.1 Flexible Sections and Expansion Joints

Provide a flexible section at each engine and an expansion joint at each muffler. Provide flexible sections and expansion joints that have flanged connections. Provide flexible sections made of convoluted seamless tube without joints or packing. Provide bellows type expansion joints. Provide stainless steel expansion and flexible elements suitable for

engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Provide expansion and flexible elements that are capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.11.2 Exhaust Muffler

Provide a chamber type exhaust muffler. Provide welded steel muffler. Provide eyebolts, lugs, flanges, or other items as necessary for support in the location and position indicated. Do not exceed the engine manufacturer's recommended pressure drop. Outside mufflers must be zinc coated or painted with high temperature 400 degrees F resisting paint. The muffler and exhaust piping together must reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. Provide muffler with a drain valve, nipple, and cap at the low-point of the muffler.

2.12 PYROMETER

Provide a pyrometer and thermocouple with calibrated leads to show the temperature in each engine cylinder and the combined exhaust. For a supercharged engine, provide additional points, thermocouples and leads to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. Graduated scale length less than 6 inches is not acceptable. Provide double pole selector switch with an "off" position, one set of points for each thermocouple, and suitable indicating dial. Calibrate the pyrometer, thermocouples, leads and compensating devices to show true exhaust temperature within plus or minus 1 percent above the highest temperature encountered at 110 percent load conditions.

2.13 EMISSIONS

The finished installation must comply with Federal, state, and local regulations and restrictions regarding the limits of emissions. Submit certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification must include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HAPs).

2.14 STARTING SYSTEM

Provide starting system for standby engine generator sets used in non emergency applications in accordance with NFPA 99 and NFPA 110.

2.14.1 Controls

Provide an engine control switch with functions including: run/start (manual), off/reset, and, automatic mode. Provide start-stop logic for adjustable cycle cranking and cool-down operation. Arrange the logic for manual starting and fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION. Provide electrical starting systems with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.14.2 Capacity

Provide starting system with sufficient capacity, at the maximum outdoor

summer temperature specified to crank the engine without damage or overheating. The system must provide a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period must have a maximum duration of 15 seconds. Starting must be accomplished using an adequately sized dc starter system with a positive shift solenoid to engage the starter motor and to crank the engine continuously for 60 seconds without overheating.

2.14.3 Electrical Starting

Manufacturers recommended dc system.

2.14.3.1 Battery

Provide a starting battery system including the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. Provide battery in accordance with SAE J537. Size critical system components (rack, protection, etc.) to withstand the seismic acceleration forces specified.

Provide maintenance free, sealed, lead-acid, SAE Type D engine starting batteries. Batteries must have sufficient capacity to provide 60 seconds of continuous cranking of the engine in an ambient temperature of 10 degrees F.

2.14.3.2 Battery Charger

Provide 120 volt ac, enclosed, automatic equalizing, dual-rate, solid-state, constant voltage type battery charger with automatic ac line compensation. DC output must be voltage regulated and current limited. Charger must have two ranges, float and equalize, and must provide continuous taper charging. The charger must have a continuous output rating of not less than 10 amperes and must be sized to recharge the engine starting batteries in a minimum of 8 hours while providing the control power needs of the engine-generator set. Enclosure must be NEMA ICS 6, Type 4X. The following accessories must be included:

a. DC ammeter

b. DC voltmeter

c. Equalize light

d. AC on light

e. Low voltage light

f. High voltage light

g. Equalize test button/switch

h. AC circuit breaker

i. Low dc voltage alarm relay

j. High dc voltage alarm relay

k. Current failure relay

l. AC power failure relay

2.14.4 Starting Aids

Provide the following methods to assist engine starting.

2.14.4.1 Glow Plugs

Design glow plugs to provide sufficient heat for combustion of fuel within the cylinders to guarantee starting at an ambient temperature of -25 degrees F.

2.14.4.2 Jacket-Coolant Heaters

Mount a thermostatically controlled electric heater in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees F of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 208 volts ac. Include necessary equipment, piping, controls, wiring, and accessories.

2.14.4.2.1 Standby Rated Sets

The control temperature must be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.14.4.3 Lubricating-Oil Heaters

Mount a thermostatically controlled electric heater in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus 3 degrees F of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 208 volts ac.

2.14.5 Auxiliary Power Supply

Provide on the Generator Skid Power Distribution for all auxiliary electrical loads. Provide a single circuit breaker for termination of power supply conductors for all auxiliary loads.

2.15 GOVERNOR

Provide engine with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. Configure the governor for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without special tools, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of 0 to 100 percent or rated capacity. Submit two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. Provide a suitable tool box for tools. Provide one handset for each electronic governor when required to indicate and/or change governor response settings. Maintain the midpoint of the frequency bandwidth at the same value for steady-state loads over the range of zero to 100 percent of rated output capacity for isochronous governors.

2.16 GENERATOR

Provide synchronous type, one or two bearing, generator conforming to the performance criteria in NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Submit calculations of the engine and generator output power capability, including efficiency and parasitic load data. Provide Class F insulation.

a. Provide vacuum pressure impregnation (VPI) insulated coils.

b. Provide salient-pole type, ac, brushless-excited, revolving field, air-cooled, self-ventilated, coupled type, synchronous generator conforming to NEMA MG 1, Part 16 or 22, and IEEE C50.12. Generator must be rated for standby duty at 100 percent of the power rating of the engine-generator set as specified in paragraph ENGINE-GENERATOR SET RATINGS AND PERFORMANCE. Temperature rise of each of the various parts of the generator must not exceed 130 degrees C as measured by resistance, based on a maximum ambient temperature of 40 degrees C.

c. Stator: Stator windings must be 2/3 pitch design with VPI insulated coils.

d. Rotor: The rotor must have connected amortisseur windings.

e. Generator Space Heater: Provide 120 volt ac heaters. Heater capacity must be as recommended by the generator manufacturer to aid in keeping the generator insulation dry.

f. Grounding: Provide non-corrosive steel grounding pads located at two opposite mounting legs.

g. Filters: Provide manufacturer's standard generator cooling air filter assembly.

h. Design generator to protect against mechanical, electrical and thermal damage due to vibration, 25 percent overspeeds, or voltages and temperatures at a rated output capacity of 110 percent for prime applications and 100 percent for standby applications.

i. Provide generator ancillary equipment meeting the short circuit requirements of NEMA MG 1. Select drip-proof guarded option for generators without weatherproof enclosures.

j. Submit manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:

(1) Direct-Axis sub-transient reactance (per unit).

(2) The generator kW rating and short circuit current capacity (both symmetric and asymmetric).

2.16.1 Current Balance

At 100 percent rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases must not exceed 2 percent of the largest current on either of the 2 phases. Submit certification stating that the flywheel has been statically and

dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

2.16.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated output capacity, the difference in line-to-neutral voltage among the 3 phases must not exceed 1 percent of the average line-to-neutral voltage. For a single phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage between the phases must not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement must be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.16.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity must not exceed 10 percent. The RMS of all harmonics must be less than 5.0 percent and that of any one harmonic less than 3.0 percent of the fundamental at rated output capacity. Design and configure engine-generator to meet the total harmonic distortion limits of IEEE 519.

2.17 EXCITER

Provide brushless generator exciter. Provide semiconductor rectifiers that have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 110 percent generator output at 104 degrees F ambient. The exciter and regulator in combination must maintain generator-output voltage within the limits specified.

Provide a brushless excitation system consisting of an exciter and rotating rectifier assembly integral with the generator and a voltage regulator. Insulation class for parts integral with the generator must be as specified in paragraph GENERATOR. System must provide a minimum short circuit of 300 percent rated engine-generator set current for at least 10 seconds. Steady state voltage regulation must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

a. Exciter and Rotating Rectifier Assembly: Rectifiers must be provided with surge voltage protection.

b. Voltage Regulator: Voltage regulator must be solid state or digital, automatic, three-phase sensing, volts per hertz type regulator. Regulator must receive its input power from a PMG. Voltage variation for any 40 degree C change over the operating temperature range must be less than plus or minus 1.0 percent. Operating temperature must be minus 40 degree C to plus 70 degree C. Voltage adjust range must be plus to minus 5.0 percent of nominal. Inherent regulator features must include over excitation shutdown.

2.18 VOLTAGE REGULATOR

Provide a solid-state voltage regulator, separate from the exciter, for

each generator. Maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Configure regulator for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110 percent of the rated voltage over the steady state load range of 0 to 100 percent of rated output capacity. Regulation drift exceeding plus or minus 0.5 percent for an ambient temperature change of 68 degrees F is not acceptable. Reactive droop compensation or reactive differential compensation must load share the reactive load proportionally between sets during parallel operation. Provide voltage regulator with a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.19 SAFETY SYSTEM

Provide and install devices, wiring, remote panels, and local panels, etc., as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. Provide a safety system with a self-test method to verify its operability. Provide alarm signals that have manual acknowledgment and reset devices. The alarm signal systems must reactivate for new signals after acknowledgment is given to any signal. Configure the systems so that loss of any monitoring device will be dealt with as an alarm on that system element.

2.19.1 Audible Signal

Provide audible alarm signal sound at a volume of 75 dB at 10 feet. The sound must be continuously activated upon alarm and silenced upon acknowledgment.

2.19.2 Visual Signal

The visual alarm signal must be a panel light. The light must be normally off, activated to be blinking upon alarm. The light must change to continuously lit upon acknowledgement. If automatic shutdown occurs, the display must maintain activated status to indicate the cause of failure and must not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms must be red; all other alarms must be amber.

2.19.3 Alarms and Action Logic

2.19.3.1 Shutdown

Accomplish simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers.

2.19.4 Safety Indications and Shutdowns

Provide a local alarm panel with the shutdown and alarm functions in accordance with NFPA 110 level 2 mounted either on or adjacent to the engine generator set.

Provide common generator alarm output relay for connection to plant SCADA system.

2.19.5 Time-Delay on Alarms

For startup of the engine-generator set, install time-delay devices bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. Submit the magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels. The lube-oil time-delay device must return its alarm to normal status after the engine starts. The coolant time-delay device must return its alarm to normal status 5 minutes after the engine starts.

2.20 PANELS

Each panel must be of the type and kind necessary to provide specified functions. Mount panels on the engine-generator set base by vibration/shock absorbing type mountings. Mount instruments flush or semiflush. Provide convenient access to the back of panels to facilitate maintenance. Calibrate instruments using recognized industry calibration standards. Provide a panel identification plate identifying the panel function. Provide a plate identifying the device and its function for each instrument and device on the panel. Provide switch plates identifying the switch-position function.

2.20.1 Enclosures

Provide insulated enclosure suitable for marine environment. Provide data to prove enclosures are suitable for marine or saltwater environment.

Design enclosures for the application and environment, conforming to NEMA ICS 6. Locking mechanisms must be keyed alike.

Provide for each engine-generator set and fabricate from zinc coated or phosphatized and shop primed 16 gage minimum sheet steel in accordance with the manufacturer's standard design. Provide a complete, weatherproof enclosure for the engine, generator, and auxiliary systems and equipment. Support exhaust piping and silencer so that the turbocharger is not subjected to exhaust system weight or lateral forces generated in connecting piping that exceed the engine manufacturer's maximum allowed forces and moments. The housing must have sufficient louvered openings to allow entrance of outside air for engine and generator cooling at full load. Design louvered openings to exclude driving rain and snow. Provide properly arranged and sized, hinged panels in the enclosure to allow convenient access to the engine, generator, and control equipment for maintenance and operational procedures. Provide hinged panels with spring type latches which must hold the panels closed securely and will not allow them to vibrate. Brace the housing internally to prevent excessive vibration when the set is in operation

2.20.2 Electronic

Electronic indicating instruments must be true RMS indicating instruments, 100 percent solid state, state-of-the-art, microprocessor controlled to provide specified functions. Provide control, logic, and function devices that are compatible as a system, sealed, dust and water tight, and that utilize modular components with metal housings and digital instrumentation. Provide an interface module to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy less than 98 percent for

unit mounted devices and 99 percent for control room, panel mounted devices, throughout a temperature range of minus 4 to 158 degrees F is not acceptable. Provide LED or back lit LCD data display. Additionally, the display must provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height must be 0.5 inch.

2.20.3 Parameter Display

Provide indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters.

2.21 SURGE PROTECTION

Electrical and electronic components must be protected from, or designed to withstand the effects of surges from switching and lightning.

2.22 MANUAL ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide complete facilities for manual starting and testing of each set without load, loading and unloading of each set, and synchronization of each set with an energized bus.

2.23 BASE

Provide a corrosion-proof base suitable for marine environment. Design the base to rigidly support the engine-generator set, ensure permanent alignment of rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base must permit skidding in any direction during installation and must withstand and mitigate the affects of synchronous vibration of the engine and generator. Provide base with suitable holes for anchor bolts and jacking screws for leveling.

2.24 FOUNDATION

Provide a single concrete foundation sized to accommodate both generators supplied with adequate working space between the units. Contractor will provide foundation design based on the packaged engine-generator sets provided. Foundation designs will be engineered and stamped by an engineer licensed in the State of Alaska.

Submit foundation design under SECTION 03 60 00CONCRETE DEMOLITION, REPAIR OF CONCRETE SURFACES, AND EQUIPMENT FOUNDATIONS.

2.25 PAINTING AND FINISHING

Clean, prime and paint the engine-generator set in accordance with the manufacturer's standard color and practice for generators located in a marine saltwater environment.

2.26 FACTORY INSPECTION AND TESTS

Submit one electronic copy of the factory inspection result on the checklist format specified below. Perform the factory tests on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Run each engine-generator set for at least 1 hour at rated output capacity prior to inspections. Complete inspections and make all necessary repairs prior to testing. Use engine generator

controls and protective devices that are provided by the generator set manufacturer as part of the standard package for factory tests. The Agency may provide one or more representatives to witness inspections and tests.

2.26.1 Factory Inspection

Perform inspections prior to beginning and after completion of testing of the assembled engine-generator set. Look for leaks, looseness, defects in components, proper assembly, etc. and note any item found to be in need of correction as a necessary repair. Use the following checklist for the inspection:

INSPECTION ITEM	GOOD	BAD	NOTES
Drive belts			
Governor and adjustments			
Engine timing mark			
Starting motor			
Starting aids			
Coolant type and concentration			
Radiator drains			
Block coolant drains			
Coolant fill level			
All coolant line connections			
All coolant hoses			
Combustion air filter			
Combustion air silencer			
Lube oil type			
Lube oil sump drain			
Lube-oil filter			
Lube-oil-level indicator			
Lube-oil-fill level			
All lube-oil line connections			
All lube-oil lines			
Fuel type and amount			

INSPECTION ITEM	GOOD	BAD	NOTES
All fuel-line connections			
All fuel lines			
Fuel filter			
Coupling and shaft alignment			
Voltage regulators			
Battery-charger connections			
All wiring connections			
Instrumentation			
Hazards to personnel			
Base			
Nameplates			
Paint			
Exhaust-heat recovery unit			

2.26.2 Factory Tests

Submit a letter giving notice of the proposed dates of factory inspections and tests at least 21 days prior to beginning tests, including:

a. A detailed description of the manufacturer's procedures for factory tests at least 14 days prior to beginning tests.

b. One electronic copy of the Factory Test data described below.

(1) A detailed description of the procedures for factory tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.

On engine-generator set tests where the engine and generator are required to be connected and operated together, the load power factor must be 0.8 power factor. Perform electrical measurements in accordance with IEEE 120. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation must be in accordance with IEEE 1. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Tests specifically for the generator may be performed utilizing any prime mover.

a. Insulation Resistance for Stator and Exciter Test, IEEE 115 and IEEE 43, to the performance criteria in NEMA MG 1, Part 22. Generator manufacturer's production line test is acceptable.

b. High Potential Test, in accordance with IEEE 115 and NEMA MG 1, test voltage in accordance with NEMA MG 1. Generator manufacturer's production line test is acceptable.

c. Winding Resistance Test, Stator and Exciter, in accordance with IEEE 115. Generator manufacturer's production line test is acceptable.

d. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.

    (1) Start and operate the generator at no load.

    (2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

    (3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

    (4) Apply 75 percent rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

    (5) Apply rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

    (6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.

e. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 percent of Rated Output Capacity, with the load impedance equal for each of the three phases: to the performance criteria specified in paragraph GENERATOR.

f. Voltage Waveform Deviation and Distortion Test in accordance with IEEE 115 to the performance criteria specified in paragraph GENERATOR. Use high-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion. Include appropriate scales to provide a means to measure and interpret results.

g. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:

(1) With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.

(2) Increase load to Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

(3) Calculate the percent droop for voltage and frequency with the following equations:

$$\text{Voltage droop percent} = \frac{(\text{No-Load Volts}) - (\text{Rated Capacity Volts})}{(\text{Service-Load Volts})} \times 100$$

$$\text{Frequency droop percent} = \frac{(\text{No-Load Hertz}) - (\text{Rated Capacity Hertz})}{(\text{Service-Load Hertz})} \times 100$$

(4) Repeat steps 1 through 3 two additional times without making any adjustments.

h. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Agency. Include the following tabular data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes).

(6) Graphic representations must include the actual instrument trace of voltage and frequency showing: charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

(a) Perform and record engine manufacturer's recommended pre-starting checks and inspections.

(b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

(c) With the unit at no load, apply the Maximum Step Load Increase.

(d) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

(e) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

(f) Apply the Maximum Step Load Increase.

(g) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(h) Repeat steps (c) through (g).

j. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. Prototype test data is acceptable in lieu of the actual test. Submit manufacturer's standard certification that prototype tests were performed for the generator model proposed. This test may be performed using any prime mover.

(1) Start and operate the generator set at rate voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(2) Apply the specified load between terminals L_1-L_2, L_2-L_0, and L_3-L_0 in turn. Record all instrument readings at each line-neutral condition.

(3) Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.

(4) Compare the largest differences expressed in percent with the maximum allowable difference specified.

PART 3 EXECUTION

3.1 EXAMINATION

The general area for installation of the generators is shown on the drawings. The Contractor will inspect the site and confirm the exact location for installation of the generators.

3.2 GENERAL INSTALLATION

Provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Submit a copy of the manufacturer's installation

procedures and a detailed description of the manufacturer's recommended break-in procedure. Install pipe, duct, conduit, and ancillary equipment to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 ELECTRICAL INSTALLATION

Perform electrical installation in compliance with NFPA 70, IEEE C2. For vibration isolation, provide flexible fittings for conduit, cable trays, and raceways attached to engine-generator sets; provide flexible stranded conductor for metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set; and provide crimp-type terminals or lugs for terminations of conductors on the engine generator set.

3.4 ONSITE INSPECTION AND TESTS

Perform and report on factory tests and inspections prior to shipment. Provide certified copies of manufacturer's test data and results. Test procedures must conform to ASME, IEEE, and ANSI standards, and to ISO requirements on testing, as appropriate and applicable. The manufacturer performing the tests must provide equipment, labor, and consumables necessary for tests and measuring and indicating devices must be certified to be within calibration. Tests must indicate satisfactory operation and attainment of specified performance. If satisfactory, equipment tested will be given a tentative approval. Equipment must not be shipped before approval of the factory test reports for the following tests.

Submit a letter giving notice of the proposed dates of onsite inspections and tests at least 14 days prior to beginning tests.

a. Submit a detailed description of the Contractor's procedures for onsite tests including the test plan and a listing of equipment necessary to perform the tests at least 14 days prior to beginning tests.

b. Submit one electronic copy of the onsite test data described below. Provide full size (8-1/2 by 11 inch minimum) data plots showing grid lines, with full resolution.

    (1) A detailed description of the procedures for onsite tests.

    (2) A list of equipment used, with calibration certifications.

    (3) A copy of measurements taken, with required plots and graphs.

    (4) The date of testing.

    (5) A list of the parameters verified.

    (6) The condition specified for the parameter.

    (7) The test results, signed and dated.

    (8) A description of adjustments made.

3.4.1 Test Conditions

3.4.1.1 Data

Make and record measurements of all parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, make adjustments, replacements, or repairs and repeat the step until satisfactory results are obtained. Unless otherwise indicated, record data in 15 minute intervals during engine-generator set operation and include: readings of all engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set. Perform electrical measurements in accordance with IEEE 120. Definitions of terms are in accordance with IEEE 100. Provide temperature limits in the rating of electrical equipment and for the evaluation of electrical insulations in accordance with IEEE 1.

3.4.1.2 Power Factor

Submit the generator capability curve showing generator kVA output capability (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0. For all engine-generator set operating tests the load power factor must be 0.8 power factor.

3.4.1.3 Contractor Supplied Items

Provide equipment and supplies required for inspections and tests including fuel, test instruments, and loadbanks at the specified power factors and rated capacity of the generator.

3.4.1.4 Instruments

Verify readings of panel gauges, meters, displays, and instruments provided as permanent equipment during test runs, using test instruments of greater precision and accuracy. Test instrument accuracy must be within the following: current plus or minus 1.5 percent, voltage plus or minus 1.5 percent, real power plus or minus 1.5 percent, reactive power plus or minus 1.5 percent, power factor plus or minus 3 percent, frequency plus or minus 0.5 percent. Calibrate test instruments by a recognized standards laboratory within 30 days prior to testing.

3.4.1.5 Sequence

Provide the sequence of testing as specified in the approved testing plan unless variance is authorized by the Agency. Perform field testing in the presence of the Agency representative. Schedule and sequence tests in order to optimize run-time periods; however, follow the general order of testing: Construction Tests; Inspections; Pre-operational Tests; Safety Run Tests; Performance Tests; and Final Inspection.

3.4.2 Construction Tests

Perform individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer prior to connection to the engine-generator set.

3.4.2.1 Piping Test

a. Flush lube-oil and fuel-oil piping with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

b. Test fuel piping which is external to the engine-generator set in accordance with NFPA 30. Pressure all remaining piping which is external to the engine-generator set with air pressure at 150 percent of the maximum anticipated working pressure, but not less than 150 psi, for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, perform the test before the insulation is applied.

3.4.2.2 Electrical Equipment Tests

a. Perform low-voltage cable insulation integrity tests for cables connecting the generator breaker to the 480-volt switchgear circuit breaker for each generator. Test low-voltage cable, complete with splices, for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. Apply a test voltage of 500 volts dc for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. Provide the minimum value of insulation as follows:

(1) R in meg-ohms = (rated voltage in kV plus 1) x 304.8/(length of cable in meters)

(2) R in meg-ohms = (rated voltage in kV plus 1) x 1000/(length of cable in feet)

(3) Each cable failing this test must be repaired or replaced. The repair cable must be retested until failures have been eliminated.

b. Examine and test circuit breakers in accordance with the manufacturer's published instructions for functional testing.

3.4.3 Inspections

Perform the following inspections jointly by the Agency and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Submit a letter certifying that all facilities are complete and functional; that each system is fully functional; and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use. Perform checks applicable to the installation. Document and submit the results of those which are physical inspections (I) in accordance with paragraph SUBMITTALS. Present manufacturer's data for the inspections designated (D) at the time of inspection. Verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Provide manufacturer's statements to certify provision of features which cannot be verified visually.

Drive belts	I

Governor type and features	I
Engine timing mark	I
Starting motor	I
Starting aids	I
Coolant type and concentration	D
Radiator drains	I
Block coolant drains	I
Coolant fill level	I
Coolant line connections	I
Coolant hoses	I
Combustion air filter	I
Intake air silencer	I
Lube oil type	D
Lube oil sump drain	I
Lube-oil filter	I
Lube-oil level indicator	I
Lube-oil fill level	I
Lube-oil line connections	I
Lube-oil lines	I
Fuel type	D
Fuel level	I
Fuel-line connections	I
Fuel lines	I
Fuel filter	I
Access for maintenance	I
Voltage regulator	I
Battery-charger connections	I
Wiring and terminations	I

Instrumentation	I
Hazards to personnel	I
Base	I
Nameplates	I
Paint	I
Exhaust-heat system	I
Exhaust muffler	I
Access provided to controls	I
Enclosure is weather resistant	I
Engine and generator mounting bolts (application)	I

3.4.4 Engine Tests

Perform customary commercial factory tests in accordance with ISO 3046 on each engine and associated engine protective device, including, but not limited to the following:

a. Perform dynamometer test at rated power. Record horsepower at rated speed and nominal characteristics such as lubricating oil pressure, jacket water temperature, and ambient temperature.

b. Test and record the values that the low oil pressure alarm and protective shutdown devices actuate prior to assembly on the engine.

c. Test and record values that the high jacket water temperature alarm and protective shutdown devices actuate prior to assembly on the engine.

3.4.5 Generator Tests

Tests must be performed on the complete factory assembled generator prior to shipment. Conduct tests in accordance with IEEE 115, IEC 60034-2A, and NEMA MG 1.

3.4.5.1 Routine Tests

Perform the following routine tests on the generators and their exciters:

a. Resistance of armature and field windings.

b. Mechanical balance.

c. Phases sequence.

d. Open circuit saturation curve and phase (voltage) balance test.

e. Insulation resistance of armature and field windings.

f. High potential test.

3.4.5.2 Design Tests

Submit the following design tests made on prototype machines that are physically and electrically identical to the generators specified.

a. Temperature rise test

b. Short circuit saturation curve and current balance test

3.4.6 Assembled Engine-Generator Set Tests

Submit the following tests made on prototype machines that are physically and electrically identical to the engine-generator set specified.

3.4.6.1 Initial Stabilization Readings

Operate the engine-generator set and allow the set to stabilize at rated kW at rated power factor, rated voltage, and rated frequency. During this period record instrument readings for output power (kW), terminal voltage, line current, power factor, frequency (rpm) generator (exciter) field voltage and current, lubricating oil pressure, jacket water temperature, and ambient temperature at minimum intervals of 15 minutes. Adjust the load, voltage, and frequency to maintain rated load at rated voltage and frequency. Adjustments to load, voltage, or frequency controls must be recorded on the data sheet at the time of adjustment. Stabilization must be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

3.4.6.2 Regulator Range Test

Remove load and record instrument readings (after transients have subsided). Adjust voltage to the maximum attainable value or to a value just prior to actuation of the overvoltage protection device. Apply rated load and adjust voltage to the minimum attainable value or a value just prior to activation of the under-voltage protection device. The data sheets must indicate the voltage regulation as a percent of rated voltage and the maximum and minimum voltages attainable. Voltage regulation must be defined as follows:

$$\text{Percent Regulation} = \frac{(\text{No-Load Voltage}) - (\text{Rated-Load Voltage})}{(\text{Rated-Load Voltage})} \times 100$$

3.4.6.3 Frequency Range Test

Adjust the engine-generator set frequency for the maximum attainable frequency at rated load. Record instrument readings. Adjust the engine-generator set frequency for the specified minimum attainable frequency at rated load. Record instrument readings. Reduce the load to zero and adjust the engine-generator set frequency for the maximum

attainable frequency. Record instrument readings. Adjust the engine-generator set frequency for the minimum attainable frequency. Record instrument readings. The data sheet must show the maximum and minimum frequencies attained at rated load, and at no load.

3.4.6.4 Transient Response Test

Drop the load to no load and re-apply rated load three times to ensure that the no load and rated load voltage and frequency values are repeatable and that the frequency and voltage regulation is within the limits specified. Record generator terminal voltage and frequency using a high speed strip chart recorder. The data sheet must show the following results:

a. Frequency

(1) Stability bandwidth or deviation in percent of rated frequency.

(2) Recovery time.

(3) Overshoot and undershoot.

b. Voltage

(1) Stability bandwidth or deviation in percent of rated voltage.

(2) Recovery time.

(3) Overshoot and undershoot.

3.4.7 Pre-operational Tests

3.4.7.1 Protective Relays

Visually and mechanically inspect, adjust, test, and calibrate protective relays in accordance with the manufacturer's published instructions. Include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Implement relay settings in accordance with the installation coordination study. Manually or electrically operate relay contacts to verify that the proper breakers and alarms initiate. Field test relaying current transformers in accordance with IEEE C57.13.1.

3.4.7.2 Insulation Test

Test generator and exciter circuits insulation resistance in accordance with IEEE 43. Take stator readings including generator leads to the circuit breaker. Record results of insulation resistance tests. Readings must be within limits specified by the manufacturer. Verify mechanical operation, insulation resistance, protective relay calibration and operation, and wiring continuity of assembly. Do not damage generator components during test.

3.4.8 Safety Run Test

For the following tests, repeat the associated safety tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

c. Activate the manual emergency stop switch and verify that the engine stops.

d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine-generator set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If either temperature reading exceeds the value required for an alarm condition, activate the manual emergency stop switch.

f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine generator-set at no load until the output voltage and frequency stabilize.

i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

k. Operate the engine generator-set for at least 2 hours at 75 percent of Service Load.

l. Verify proper operation and set-points of gauges and instruments.

m. Verify proper operation of ancillary equipment.

n. Manually adjust the governor to increase engine speed past the

over-speed limit. Record the RPM at which the engine shuts down.

o. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

p. Manually adjust the governor to increase engine speed to within 2 percent of the over-speed trip speed previously determined and operate at that point for 5 minutes. Manually adjust the governor to the rated frequency.

q. Manually fill the fuel tank to a level above the overfill limit. Record the level at which the overfill alarm sounds. Drain the day tank down below the overfill limit.

r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine.

s. Attach a manifold to the engine oil system (at the oil pressure sensor port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. Move the engine's oil pressure sensor from the engine to the manifold. Open the manifold shutoff valve and close the bleed valve.

t. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

v. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100 percent of Service Load. Record the maximum sound level in each frequency band at a radius of 75 feet from the engine at 45 degrees apart in all directions for vertical piping. If a sound limiting enclosure is not provided, the muffler and air intake silencer as required to meet the sound limitations of this specification. If the sound limitations can not be obtained by modifying or replacing the muffler and air intake silencer, notify the Agency Representative and provide a recommendation for meeting the sound limitations.

w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.4.9 Performance Tests

In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency,

current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, repeat the associated tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

3.4.9.1 Continuous Engine Load Run Test

Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, repeat the entire test. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Take data taken at 15 minute intervals and include the following:

Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

Pressure: Lube-oil.

Temperature: Coolant, Lube-oil, Exhaust, Ambient.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warmup period.

c. Operate the engine generator-set for 4 hours at 75 percent of generator rating.

3.4.9.2 Voltage and Frequency Droop Test

For the following steps, verify that the output voltage and frequency return to and stabilize within the specified bandwidth values following each load change. Record the generator output frequency and line-line and line-neutral voltages following each load change.

a. With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency.

b. Increase load to 100 percent of Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

c. Calculate the percent droop for voltage and frequency with the following equations.

$$\text{Voltage droop percent} = \frac{\text{No-load volts - rated output capacity volts}}{\text{Rated output capacity volts}} \times 100$$

$$\text{Frequency droop percent} = \frac{\text{No load hertz - rated output capacity hertz}}{\text{Rated output capacity volts}} \times 100$$

d. Repeat steps a. through c. two additional times without making any adjustments.

3.4.9.3 Voltage Regulator Range Test

a. While operating at no load, verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

3.4.9.4 Governor Adjustment Range Test

a. While operating at no load, verify that the governor adjusts from 90 to 110 percent of rated frequency.

b. Increase load to 100 percent of Rated Output Capacity. Verify that the governor adjusts from 90 to 110 percent of rated frequency.

3.4.9.5 Frequency and Voltage Stability and Transient Response

Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Agency. Include the following tabular data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes.

(6) Include the actual instrument trace of voltage and frequency in graphic representations showing:

Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

c. With the unit at no load, apply the Maximum Step Load Increase.

d. Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

e. Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

f. Apply the Maximum Step Load Increase.

g. Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

h. Repeat steps c. through g.

3.4.10 Parallel Operation Tests

Test the capability of each engine generator set to parallel and share load with the 480-volt switchgear normal power bus. The commissioning engineer shall determine the testing procedures required to test parallel operation of each generator set with its associated bus and normal power, automatic operation upon loss of normal power through SCADA control, parallel operation with the other generator when both normal power sources are lost and gensets are paralleled with the bus tie closed.

3.4.11 Automatic Operation Tests

Test the automatic operating system. Utilize actual loads to be served for this test, and the loading sequence is the indicated sequence. Record load-sharing characteristics during all operations. Perform this test for a minimum of two successive, successful tests. Include the following data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Generator output frequency (before and after load changes).

(5) Power division and exchange between generator sets.

(6) Real and reactive power on each set.

a. Initiate loss of the preferred power source and verify the specified sequence of operation.

b. Verify resetting of automatic starting and transfer logic.

3.5 GROUNDING

NFPA 70 and IEEE C2, except that grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

3.5.1 Grounding Electrodes

Provide a #4 bare copper connection to the generator foundation rebar. Provide connection to rebar in two locations for each generator set.

Provide listed compression fitting for connection to rebar. Inspect and photograph connections prior to concrete placement. Submit photographs with closeout documents.

3.5.2 Connections

Make joints in grounding conductors by exothermic weld or compression connector.

3.5.3 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.6 START-UP ENGINEER

Provide the services of a qualified factory trained start-up engineer, regularly employed by the engine-generator set manufacturer. The start-up services must include conducting preliminary operations and functional acceptance tests. The start-up engineer must be present at the engine generator set installation-site, full-time, while preliminary operations and functional acceptance tests are being conducted.

3.7 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the engine-generator set and auxiliary equipment.

3.7.1 Performance of Acceptance Checks and Tests

The acceptance checks and tests must be accomplished by the testing organization as described in Section 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING.

3.7.2 Generator Sets

Complete as specified in the paragraph ACCEPTANCE CHECKS AND TESTS.

3.7.3 Preliminary Operations

The start-up engineer must conduct manufacturer recommended start-up procedures and tests to verify that the engine-generator set and auxiliary equipment are ready for functional acceptance tests. Give the Agency 15 days' advance notice that preliminary operations will be conducted. After preliminary operation has been successfully conducted, the start-up engineer will notify the Agency in writing stating the engine-generator set and auxiliary equipment are ready for functional acceptance tests.

3.7.4 Preliminary Assembled Operation and Maintenance Manuals

Preliminary assembled operation and maintenance manuals must have been submitted to and approved by the Agency.

3.7.5 Functional Acceptance Test Procedure

Test procedure must be prepared by the manufacturers start-up engineer and the Contractors commissioning engineer specifically for the engine-generator set and auxiliary equipment. The test agenda must cover the requirements specified in the paragraph FUNCTIONAL ACCEPTANCE TESTS.

The test procedure must indicate in detail how tests are to be conducted. A statement of the tests that are to be performed without indicating how the tests are to be performed is not acceptable. Indicate what work is planned on each workday and identify the calendar dates of the planned workdays. Specify what additional technical support personnel is needed such as factory representatives for major equipment. Specify on which testing workday each technical support personnel is needed. Data recording forms to be used to document test results are to be submitted with the proposed test procedure. A list of test equipment and instruments must also be included in the test procedure.

3.7.6 Test Equipment

Test equipment and instruments must be on hand prior to scheduling field tests or, subject to Contracting Officer approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on-site prior to field testing.

3.8 FIELD QUALITY CONTROL

Give Contracting Officer 30 days' notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will schedule a time that will eliminate or minimize interruptions and interference with the Plant operations. The Contractor must be responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The Contractor must provide labor, equipment, fuel, test load, and consumables required for the specified tests. Calibration of measuring devices and indicating devices must be certified. Perform the following field tests.

3.8.1 Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.8.1.1 Circuit Breakers - Low Voltage Insulated Case/Molded Case

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect circuit breaker for correct mounting.

(3) Operate circuit breaker to ensure smooth operation.

(4) Inspect case for cracks or other defects.

(5) Verify tightness of accessible bolted connections and cable connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Adjust breaker(s) for final settings in accordance with engine-generator set manufacturer's requirements.

3.8.1.2 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform polarity tests.

(3) Perform ratio-verification tests.

3.8.1.3 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watt-hour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer secondary circuits are intact.

3.8.1.4 Battery Systems

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(4) Measure electrolyte specific gravity and temperature and visually check fill level.

(5) Verify adequacy of battery support racks, mounting, anchorage, and clearances.

b. Electrical Tests

(1) Set charger float and equalizing voltage levels.

(2) Verify all charger functions and alarms.

(3) Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.

(4) Perform a capacity load test.

3.8.1.5 Engine-Generator Set

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect for correct anchorage and grounding.

b. Electrical and Mechanical Tests

(1) Perform an insulation-resistance test on generator winding with respect to ground. Calculate polarization index.

(2) Perform phase rotation test to determine compatibility with load requirements.

3.8.1.6 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

3.8.2 Functional Acceptance Tests

The tests must be performed by the start-up engineer. Upon successful

test completion, the start-up engineer must provide the Contracting Officer with a written test report within 15 calendar days showing the tests performed and the results of each test. The report must include the completed approved test data forms and certification from the start-up engineer that the test results fall within the manufacturer's recommended limits and meet the specified requirements performance. The report must be dated and signed by the start-up engineer, and submitted for approval by the Agency Representative. The Agency Representative will witness final acceptance tests. Testing must include, but not be limited to, the following:

a. Verify proper functioning of each engine protective shutdown device and pre-shutdown alarm device. Testing of the devices must be accomplished by simulating device actuation and observing proper alarm and engine shutdown operation.

b. Verify proper functioning of the engine over-speed trip device. Testing of the over-speed trip device must be accomplished by raising the speed of the engine-generator set until an over-speed trip is experienced.

c. Verify proper functioning of the crank cycle/terminate relay. Testing of the relay must be accomplished by engaging the starter motor with the engine being prevented from running. Observe the complete crank/rest cycle as described in the paragraph STARTING SYSTEM.

d. Verify proper functioning of the following automatic and manual operations. Testing must include, but not be limited to, the following:

   (1) Loss of Utility: Initiate a normal power failure with connected test load of rated kW at 1.0 power factor. Record time delay on start, cranking time until engine starts and runs, time to come up to operating speed, voltage and frequency overshoot, and time to achieve steady state conditions with all switches transferred to emergency position.

   (2) Return of Utility: Return normal power and record time delay on retransfer for each automatic transfer switch, and time delay on engine cool-down and shutdown.

   (3) Manual starting.

   (4) Emergency stop.

e. Operate the engine-generator set at rated current (amperes) until the jacket water temperature stabilizes. Stabilization will be considered to have occurred when three consecutive temperature readings remain unchanged. Continue to operate the generator set for an additional 2 hours. Record instrument readings for terminal voltage, line current, frequency (Hz), engine speed rpm, lubricating oil pressure, jacket water temperature, and ambient temperature at 5 minute intervals for first 15 minutes and at 15 minute intervals thereafter.

3.9 DEMONSTRATION

Upon completion of the work and at a time approved by the Agency Representative, the Contractor must provide instructions by a qualified instructor to the Agency personnel in the proper operation and maintenance

of the equipment. Site personnel must receive training comparable to the equipment manufacturer's factory training. The duration of instruction must be for not less than one 8 hour working day for instruction of operating personnel and not less than one 8 hour working day for instruction of maintenance personnel.

3.9.1 Instructor's Qualification Resume

Instructors must be regular employees of the engine-generator set manufacturer. The instruction personnel provided to satisfy the requirements above must be factory certified by the related equipment manufacturer to provide instruction services. Submit the name and qualification resume of instructor to the Agency Representative for approval.

3.9.2 Training Plan

Submit training plan 30 calendar days prior to training sessions. Training plan must include scheduling, content, outline, and training material (handouts). Content must include, but not be limited to, the following:

3.9.2.1 Operating Personnel Training

This instruction includes operating the engine-generator set, auxiliary equipment including automatic transfer switches in all modes, and the use of all functions and features specified.

3.9.2.2 Maintenance Personnel Training

Training must include mechanical, hydraulic, electrical, and electronic instructions for the engine-generator set and auxiliary equipment including automatic transfer switches.

a. Mechanical Training: Must include at least the following:

(1) A review of mechanical diagrams and drawings.

(2) Component location and functions.

(3) Troubleshooting procedures and techniques.

(4) Repair procedures.

(5) Assembly/disassembly procedures.

(6) Adjustments (how, when, and where).

(7) Preventive maintenance procedures.

(8) Review of flow diagram.

(9) Valve locations and function.

(10) Valve and hydraulic equipment adjustment and maintenance procedures.

(11) Hydraulic system maintenance and servicing.

(12) Lubrication points, type, and recommended procedures and frequency.

b. Electrical and Electronic Maintenance Training: Must include at least the following:

(1) A review of electrical and electronic systems including wiring diagrams and drawings.

(2) Troubleshooting procedures for the machine and control systems.

(3) Electrical and electronic equipment servicing and care.

(4) Use of diagnostics to locate the causes of malfunction.

(5) Procedures for adjustments (locating components, adjustments to be made, values to be measured, and equipment required for making adjustments).

(6) Maintenance and troubleshooting procedures for microprocessor.

(7) Recommended maintenance servicing and repair for motors, switches, relays, solenoids, and other auxiliary equipment and devices.

3.10 ONSITE TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period must start after the system is functionally completed but prior to final acceptance.

a. Submit a letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the digital video recording to be provided. The course instructions must cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions must demonstrate routine maintenance procedures as described in the operation and maintenance manuals.

b. Provide approved operation and maintenance manuals for the training course. Post approved instructions prior to the beginning date of the training course. Coordinate the training course schedule with the using service's work schedule, and submit for approval 14 days prior to beginning date of proposed beginning date of training.

3.11 INSTALLATION

Installation must conform to the applicable requirements of IEEE C2, NFPA 30, NFPA 37, and NFPA 70.

3.12 FINAL TESTING AND INSPECTION

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the Maximum Step Load Increase to 100 percent of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration

at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Verify any corrective action for effectiveness by running the engine for 8 hours at Service Load, then re-examine the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.

f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

g. Replace air, oil, and fuel filters with new filters.

3.13 MANUFACTURER'S FIELD SERVICE

The engine generator-set manufacturer must furnish a qualified representative to supervise the installation of the engine generator-set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment.

3.14 INSTRUCTIONS

Submit instructions including: the manufacturers pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode; running checks, procedures, and precautions; and shutdown procedures, checks, and precautions.

3.15 ACCEPTANCE

Submit drawings which accurately depict the as-built configuration of the installation, upon acceptance of the engine-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings. Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

-- End of Section --

SECTION 31 00 00

EARTHWORK

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D4253	(2016; E 2019) Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	(2016) Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D4829	(2021) Standard Test Method for Expansion Index of Soils

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

1.2 DEFINITIONS

1.2.1 Structural Fill

Soil material placed to support buildings, walls, pads, and other similar facilities.

1.2.2 Embankment Fill

Soil material placed to construct embankment.

1.2.3 Topsoil

Surface layer of primarily organic soil capable of supporting vegetation growth.

1.2.4 Utility Bedding Material

Fill placed to directly support pipes, conduits, cables, and appurtenant structures. Bedding may also be used to provide a cushion between utilities and bedrock, obstacles, obstructions and other unyielding materials.

1.2.5 Satisfactory Materials

Satisfactory materials for fill, backfill, and/or any in-situ soils to remain in place comprise any materials classified State of Alaska DOT.

1.2.6 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; roots and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.2.7 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 1 inch in any dimension. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.8 Unstable Material

Unstable materials are too weak to adequately support the utility pipe, conduit, equipment, or appurtenant structure. Satisfactory material may become unstable due to ineffective drainage, dewatering, becoming frozen, excessive loading.

1.2.9 Expansive Soils

Expansive soils are defined as soils that have an expansion index greater than 20 when tested in accordance with ASTM D4829.

1.2.10 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume.

1.2.11 Capillary Water Barrier

A layer of clean, poorly graded crushed rock, stone, or natural sand or gravel having a high porosity which is placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below a slab.

1.2.12 Degree of Compaction (Proctor)

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557or ASTM D698 abbreviated as a percent of laboratory maximum density.

1.2.13 Degree of Compaction (Relative Density)

Degree of compaction required for soils with less than 5 percent passing the No. 200 sieve, is expressed as a relative percentage of the maximum index density/dry unit weight and minimum index density/dry unit weight, obtained by the test procedures in accordance with ASTM D4253 and ASTM D4254, respectively, abbreviated as a percent of laboratory relative density.

1.2.14 Borrow

Soil brought to the project site from an external location for the purposes of project construction.

1.2.15 Subgrade

Earth materials directly below foundations and directly below granular base materials in building slab and pavement areas including shoulders.

1.3 SUBMITTALS

Agency approval is required for submittals. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Excavation and Trenching Plan;

Borrow Plan;

Disposition of Surplus Materials;

Preconstruction Meeting;

1.4 QUALITY CONTROL

1.4.1 Preconstruction Meeting

Conduct a preconstruction meeting at the jobsite at least five business days prior to the start of earthwork operations on the project. The preconstruction meeting is to be arranged by the Contractor and is to follow the written agenda submitted prior to the meeting. The purpose of this meeting is to review the requirements of this specification and the associated plans. The following individuals must be in attendance at this meeting: Contractor's Project Manager and Project Superintendent, earthwork subcontractor's Project Manager and Site Foreman, Agency Construction Manager.

The minutes of this meeting are to be recorded by the Contractor and published via email within 48 hours to all attendees. The minutes must be re-published within 48 hours via email pending any subsequent comments from the attendees.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Structural Fill

Provide type A fill as defined by State of ALASKA DOT.

2.1.2 Topsoil

Material suitable for topsoil obtained from is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth.

2.1.3 Utility Bedding Material

Provide bedding for buried conduit. Utility bedding material may include the following:

2.1.3.1 Class B

Type B bedding material as defined by the State of Alaska DOT

2.1.3.2 Sand

Clean, coarse-grained sand as defined by the State of Alaska DOT.

2.2 BURIED WARNING AND IDENTIFICATION MARKERS

Provide polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width. Provide Red tape imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED ELECTRIC LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

2.3 BORROW

Provide borrow materials from sources located outside of Agency property meeting the requirements of paragraph STRUCTURAL FILL or Utility Bedding Material.

PART 3 EXECUTION

3.1 PROTECTION

Perform all work specified in accordance with applicable requirements of the Corps of Engineers publication EM 385-1-1 Safety and Health Requirements Manual.

Use equipment of type and size appropriate for the site conditions (soil character and moisture content). Maintenance of exposed subgrades and fills is the responsibility of the Contractor. The Contractor is required to prevent damage by ineffective drainage, dewatering, and heavy loads and equipment by implementing precautionary measures. Repair or replace any defects or damage.

3.1.1 Underground Utilities

Location of the existing utilities indicated is approximate. Physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor is responsible for protecting utilities from damage during construction.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity or provide temporary ditches, swales, and other drainage features and equipment as required to keep soils from becoming unstable, prevent erosion, or undermining of foundations. Remove unstable material from working platforms for equipment operation and soil support for subsequent construction features and provide new material as specified herein. It is the responsibility of the Contractor to assess the site conditions to employ necessary measures to permit construction to proceed.

3.1.2.2 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction.

3.1.3 Protection of Graded Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.2 BORROW

Select borrow material to meet the requirements and conditions of the fill or embankment for which it is to be used. Obtain borrow material from from approved private sources. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval.

3.3 SURFACE PREPARATION

3.3.1 Stockpiling Operations

Place and grade stockpiles of satisfactory and unsatisfactory and wasted materials. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Sseparately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles

of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. Do not create stockpiles that could obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.4 EXCAVATION

Excavate to contours, elevation, and dimensions required. Excavate soil disturbed or weakened by Contractor's operations, and soils softened or made unstable for subsequent construction due to exposure to weather. Use material removed from excavations meeting the specified requirements in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes to minimize surplus material and to minimize additional material to brought on site. Remove and replace excavations below the grades shown with appropriate materials as directed by the Contracting Officer.

If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock or as hard/unyielding material, uncover such material, and notify the Agency. Do not proceed with the excavation of this material until the Contracting Officer has classified the materials as common excavation or rock excavation.

3.4.1 Trench Excavation Requirements

Excavate the trench as required for required conduit burial depths. Provide vertical or sloped trench walls as required for safe operations. Do not overexcavate.

3.4.1.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Remove stones of 1" inch or greater in any dimension to avoid point bearing.

3.4.1.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, notify the Agency. Following approval, remove such material inch below the required grade and replaced with suitable materials as provided in paragraph FILLING AND COMPACTION.

3.4.1.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with suitable material as provided in paragraph FILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Agency.

3.4.2 Underground Utilities

Perform work adjacent to utilities in accordance with procedures outlined

by utility owner. Excavation made with power-driven equipment is not permitted within 2 feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.5 SUBGRADE PREPARATION

3.5.1 General Requirements

Shape subgrade to line, grade, and cross section as indicated. Remove unsatisfactory and unstable material in surfaces to receive fill or in excavated areas, and replaced with satisfactory materials. Do not place material on surfaces that are muddy, frozen, contain frost, or otherwise containing unstable material. Scarify the surface to a depth of 4 inches prior to placing fill.

3.5.2 Subgrade for Structures, Spread Footings, and Concrete Slabs

Do not excavate below depth shown for structures, spread footings, and concrete slabs. If over excavation occurs, notify the Contracting Officer and remove, replace, and compact as directed. Compact disturbed material to 95 percent of ASTM D698 or ASTM D1557.

3.6 FILLING AND COMPACTION

Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs for SUBGRADE PREPARATION. Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Fill and backfill to contours, elevations, and dimensions indicated. Compact and test each lift before placing overlaying lift.

3.6.1 Trench Backfill

Backfill trenches to match existing grade.

3.6.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with satisfactory material or initial backfill material.

3.6.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with satisfactory material placed in layers not exceeding 6 inches loose thickness.

3.6.1.3 Bedding and Initial Backfill

Provide 3" of bedding material above and below for all conduit installations. Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Provide bedding for buried piping in accordance with PART 2 paragraph UTILITY BEDDING MATERIAL. Compact backfill to top of pipe to 85 percent of ASTM D1557.

3.6.1.4 Final Backfill

Do not begin backfill until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Bring backfill to indicated finish grade. The backfill material up to an elevation one foot above utility lines need to be free from stones larger than one inch in any dimension. Heavy equipment for spreading and compacting backfill are not to be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; compact remaining area in layers not more than 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Place backfill carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Do not place backfill against foundation walls prior to 7 days after completion of the walls. As far as practicable, bring backfill up evenly on each side of the wall and sloped to drain away from the wall.

Fill the remainder of the trench, except for special materials for buildings and pavements with satisfactory material. Place backfill material and compact as follows:

3.6.1.5 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.6.1.6 Buried Tape And Detection Wire

3.6.1.6.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade.

3.6.2 Structural Fill Placement

Place fill and backfill beneath and adjacent to structures in successive horizontal layers of loose material not more than 8 inches in depth, or in loose layers not more than 4 inches in depth when using hand-operated compaction equipment. Do not place over wet or frozen materials. Compact to at least 90 percent of laboratory maximum density for cohesive materials or 95 percent of laboratory maximum density for cohesionless materials, except as otherwise specified. Perform compaction in such a manner as to prevent wedging action or eccentric loading upon or other damage to the structure. Moisture condition fill and backfill material to a moisture content that will readily facilitate obtaining the specified compaction.

3.6.3 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.6.4 Compaction

3.6.4.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 85 percent of ASTM D1557.

3.7 DISPOSITION OF SURPLUS MATERIAL

Remove from Agency property all surplus or other soil material not required or not suitable for filling or backfilling. Properly disposed of in accordance with all applicable laws and regulations. Prepare plan for Disposition of Surplus Materials to include permissions document to dispose of nonsalable products.

-- End of Section --

SECTION 33 71 02

UNDERGROUND CONDUITS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2023) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 9	(2020) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 4 2023) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 94	(2023; Reprint May 2023) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and

	Rubber Insulating Tape
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

1.3 SUBMITTALS

Agency approval is required for submittals. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Conduits and fittings;

Field Acceptance Checks and Tests;

Cable Installation Plan and Procedure;

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

1.4 QUALITY ASSURANCE

1.4.1 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. Cable installer must demonstrate experience with a minimum of three medium voltage cable installations. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for an alternate qualified cable installer.

1.4.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.4.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.2 Plastic Conduit for Direct Burial and Riser Applications

UL 651 and NEMA TC 2, EPC-80.

2.1.3 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that expands and hardens to form a closed, chemically and water resistant, rigid structure. Sealant must be compatible with common cable and wire jackets and capable of adhering to metals, plastics and concrete. Sealant must be capable of curing in temperature ranges of 35 degrees F to 95 degrees F. Cured sealant must withstand temperature ranges of -20 degrees F to 200 degrees F without loss of function.

2.1.4 Fittings

2.1.4.1 Metal Fittings

UL 514B.

2.1.4.2 PVC Conduit Fittings

UL 514B, UL 651.

2.1.4.3 PVC Duct Fittings

NEMA TC 9.

2.2 TAPE

2.2.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.2.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK.

2.3 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2.

3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

Obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. Perform pulling calculations and prepare a pulling plan and submit along with the manufacturer's instructions in accordance with SUBMITTALS. Install cable strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan must include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.4 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.4.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 3 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Terminate all PVC conduit end points in utility holes, switching cabinets, transform handholes and buildings with end bells. The bell end of the conduits that enter manholes and handholes must be flush with the wall.

Perform changes in ductbank direction as follows:

a. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable.

b. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater in diameter.

c. As an exception to the bend radius required above, provide field manufactured longsweep bends having a minimum radius of 25 feet for a change of direction of more than 5 degrees, either horizontally or vertically, using a combination of curved and straight sections. Maximum manufactured curved sections allowed for use in field manufactured longsweep bend: 30 degrees.

3.4.2 Treatment

Keep ducts clean of concrete, dirt, or foreign substances during

construction. Make field cuts requiring tapers with proper tools and match factory tapers. Use a coupling recommended by the duct manufacturer whenever an existing duct is connected to a duct of different material or shape. Store ducts to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Thoroughly clean ducts before being laid. Store plastic ducts on a flat surface and protected from the direct rays of the sun.

3.4.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.4.4 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations must be PVC coated and extend from at least 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches from penetration).

3.4.5 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.4.6 Conduit Plugs and Pull Rope

Provide new conduit indicated as being unused or empty with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.4.7 Conduit and Duct Without Concrete Encasement

Depths to top of the conduit must be not less than 24 inches below finished grade. Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation must be backfilled and compacted in 3 to 6 inch layers. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.5 CABLE PULLING

Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into generators, switchboards, and other enclosures. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.5.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.6 LOW VOLTAGE CABLE SPLICING AND TERMINATING

When specifically approved by the Agency, Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination pedestals.

3.7 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

3.7.1 Reconditioning of Surfaces

3.7.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.8 FIELD QUALITY CONTROL

3.8.1 Performance of Field Acceptance Checks and Tests

Coordinate testing requirement of this section with 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING.

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.8.1.1 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Verify tightness of accessible bolted electrical connections.

(4) Inspect compression-applied connectors for correct cable match and indentation.

(5) Visually inspect jacket and insulation condition.

(6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

(2) Perform continuity tests to insure correct cable connection.

3.8.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

SECTION 33 72 33.14 26

POWER SYSTEM RELAY PROTECTION

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

TIA-232-F	(1997; R 2002) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61810-2	(2005) Electromechanical Elementary Relays - Part 2: Reliability
IEC 60255-5	(2002)Insulation Tests for Electrical Relays

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007) National Electrical Safety Code
IEEE C37.90	(2005) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C37.90.1	(2002) Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C37.90.2	(2004) Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011) National Electrical Code - 2011 Edition

1.2 SUBMITTALS

The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Submit within 45 days after Notice To Proceed:

Protective Relays;

Data consisting of manufacturer's Relay Descriptive Literature and Instruction Manuals. Include IEEE Device Number Protection Functions available in the relays provided, testing procedures and instructions pertaining to the frequency of calibration, inspection, adjustment, and cleaning.

Installation;

Procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the relays and associated equipment provided.

SD-06 Test Reports

Submit testing plans and procedures 30 days prior to tests:

Field Tests

The Contractor's final field test report based on the relay manufacturer's recommended test procedure.

Manufacturer's Test Reports;

SD-07 Certificates

Submit within 90 days after Notice To Proceed:

Devices and Equipment;

Certificates certifying that all devices or equipment meet the requirements of the contract documents.

1.3 SYSTEM DESCRIPTION

The power system covered by this specification consists of: 480 volt station service switchgear and the 15kV generator switchgear.

1.4 QUALIFICATIONS

1.4.1 System Coordinator

System coordination will be done by the Agency.

1.4.2 System Installer

Contractor shall install the relays, perform preliminary tests, and ready them for commissioning. Calibration, final testing, adjustment, and placing into service of the protective relays will be accomplished by the Agency.

1.5 DELIVERY, STORAGE, AND HANDLING

Contractor shall visually inspect Protective Relays and associated equipment when received at the Tyee Lake Project and prior to acceptance from conveyance. Contractor shall protect stored items from the environment in accordance with the manufacturer's published instructions.

Contractor shall replace any damaged items.

1.6 PROJECT/SITE CONDITIONS

Devices and equipment furnished under this section shall be suitable for the following site conditions:

1.6.1 Altitude

Altitude: 20 ftmsl

1.6.2 Ambient Temperature

Ambient Temperature: 30 degrees F to 80 degrees F

1.6.3 Frequency

Frequency: 20 to 70 Hertz

1.6.4 Battery Voltage

Project battery voltage range: 105 Volts DC to 140 Volts DC

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Protective relays and associated equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product.

2.2 STATION SERVICE HIGH-SPEED BUS PROTECTIVE RELAYS

2.2.1 General

Protective relays provided for protection of 480 volt buses shall be functionally similar to the SEL-751.

2.2.2 Protective Relay Characteristics

2.2.2.1 General

The protective relay protection, control, and monitoring of the Station Service Bus shall be provided by a microprocessor based package with fiber optic arc sensing along the buses. Each relay shall have a front panel display that will display quantities and messages selectable by Agency programming, and indicators that display the relay state and fault type. See IEEE C37.90, IEEE C37.90.1, IEEE C37.90.2, and IEC 60255-5.

2.2.2.2 AC Current Inputs from Metering Current Transformers

The relays shall be rated for 5 amps nominal current input, 15 Amps continuous duty, 500 Amps for one second, 1250A for 1 cycle. Burden on current circuit shall not exceed 0.27 Volt Amps at 5 amps and 2.51 Volt Amps at 15 Amps.

2.2.2.3 AC Voltage Inputs from Metering Potential Transformers

The relays shall accept Voltage inputs of 300 Volts line to neutral, from three phase four wire connected metering transformers, 300 Volts

continuous duty, and 600 Volts for ten seconds. Burden on the Voltage supply shall not exceed 0.03 Volt Amps at 67 Volts, 0.06 Volt Amps at 120 Volts, and 0.8 Volt Amps at 300 Volts. The relay shall include three phase voltage inputs for independent enabling of 24 over/under voltage elements and 6 over/under frequency elements. These are IEEE functions 27, 59 and 81. See IEEE C37.2.

2.2.2.4 Relay Power Supply

Power to operate the relays shall be nominally 125 Volts Direct Current (VDC) from the Station Battery, with a range of 105 VDC to 140 VDC.

2.2.2.5 Output Contacts

Each relay shall have not less than 8 output contacts configurable as normally opened or normally closed. Relay Contacts shall be rated for the Project operating power supply from the Station Battery, which can range from 105 VDC to 140 VDC. Output contacts on the relays provided shall be capable of a 'make' current of 30 Amps DC, carrying 6 Amps DC, with a one second rating of 100 Amps DC. Current break capability shall be not less than 0.3 Amps DC. See IEC 61810-2; IEEE C37.90.

2.2.2.6 Contact Inputs

Each relay shall have not less than two Contact Input points. Contact inputs shall be assignable to functions by Agency programming. Contact inputs shall be optically isolated and rated to accept a "closed contact" sensing voltage of 125 VDC nominal, with a pickup range of not less than 105 VDC to 140 VDC.

2.2.2.7 Event Reporting and Sequential Events Recorder (SER)

The relay shall provide automatic recording of disturbances events of 15, 29, or 60 cycles with settable pre-fault duration and user-defined triggering. The relay shall store events in nonvolatile memory. The relay shall also include a sequential events recorder (SER) feature that stores the latest 512 events.

2.2.2.8 Through Fault Event Monitor

The relay shall provide the capability of monitoring and reporting fault current level, duration, and the date and time for over-current events through the differential protection zone. A settable I squared t (current squared times time duration) alarm shall provide indication of an excess of accumulated through-fault energy.

2.2.2.9 Over-current Fault Protection

Independent enabling of each of the three phase current input groups for over-current protection shall be possible. The relay shall provide adaptive phase over-current elements which perform reliably in the presence of current transformer saturation, dc offset, and off-frequency harmonics. The relay shall incorporate directional, instantaneous, definite time, and inverse time over-current elements. These are IEEE functions 67, 50, and 51. See IEEE C37.2.

2.2.2.10 Mounting Options

The relay shall be of the flush panel-mount type.

2.2.2.11 Relay Communication Provisions

The relay shall be fully compatible with SEL networking equipment without additional software or hardware. The relay shall include one EIA-232 serial port to provide communication to external computers and control systems. The relay shall operate at a speed of 300-19200 baud. See TIA-232-F.

2.3 FEEDER PROTECTIVE RELAYING

2.3.1 General

Protective Relays shall be functionally similar to the Cutler-Hammer Digitrip.

2.3.2 Feeder Protective Relay Characteristics

2.3.2.1 General

The protective relay protection, control, and monitoring of the feeder breakers shall be provided by a microprocessor based package. Each relay shall have a front panel display that will display quantities and messages selectable by Agency programming, and indicators that display the relay state, fault type, as well as indicating status of the relay function elements. See IEEE C37.90; IEEE C37.90.1; IEEE C37.90.2; and IEC 60255-5.

2.3.2.2 Relay Power Supply

Power to operate the Station Service Breaker Protection relays shall be nominally 125 Volts Direct Current (VDC) from the Station Battery, with a range of 105 VDC to 140 VDC. Power consumption shall be not more than 25 Watts.

2.3.2.3 Mounting Options

The relay shall be of the flush panel-mount type.

2.4 GENERATOR PROTECTIVE RELAYING

Provide Schweitzer SEL-700G Generator Protection Relays. Provide with the following generator protection features:

a. Ground differential.
b. Sensitive restricted earth fault.
c. Thermal overload.
d. Phase, negative-sequence, residual-ground, and neutral-ground overcurrent elements for backup.
e. Residual-ground and neutral-ground time-overcurrent elements.
f. Directional residual-ground and neutral ground overcurrent elements.
g. Current imbalance element.
h. Voltage-controlled, voltage-restrained time-overcurrent element for backup protection.
i. Breaker failure protection for three-pole breaker.
j. Under- and overvoltage elements.
k. Inverse-time under- and overvoltage elements.
l. Loss-of-potential element.
m. Volts/hertz or overexcitation protection.
n. Directional power elements.

o. Loss-of-field.
p. Under- and overfrequency protection elements.
q. Rate-of-change-of-frequency elements.
r. Vector shift elements for islanding detection.
s. Inadverdent energization protection.

PART 3 EXECUTION

3.1 VERIFICATION OF DIMENSIONS

After becoming familiar with details of the work, the Contractor shall verify dimensions in the field, and shall advise the Agency Representative of any discrepancy discovered before performing any work.

3.2 INSTALLATION

Install protective devices in accordance with the manufacturer's published Instruction Manual and in accordance with the requirements of NFPA 70 and IEEE C2.

3.2.1 Panel Mounting

The relays shall be protected from shock and excessive force, torque, or distortion during the mounting process.

3.2.2 Panel Cutouts

All of the relays provided shall be mounted in panel cutouts of the dimensions shown in the Manufacturer's Instruction Manuals installation sections.

3.2.3 Connector Wiring

Wire the connectors in accordance with the manufacturer's Instruction Manual and as required to interface with existing external wiring and functions for the equipment being replaced.

3.2.4 Relay Instruction Manuals

Procure and read the Instruction Manual for the relays before beginning installation of the relays.

3.3 FIELD TESTING

3.3.1 General

Field testing for relays installed under this Contract shall include 'ringing out' all relay connections to ensure correct wire terminations and continuity from end to end of the conductors, including the relay connectors. The Contractor shall furnish all materials, labor, and equipment necessary to conduct further field tests. The Contractor shall perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all field tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Update as-built drawing redlines with any field changes.

3.3.1.1 Commissioning

The Contractor shall be responsible for performing all equipment commissioning required by the equipment manufacturers and as noted in SECTION 26 08 01.00 26 SYSTEMS TESTING AND COMMISSIONING of this contract.

3.3.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Protective Relays

Protective relay shall be factory tested prior to shipment, and visually and mechanically inspected once received at the project. Manufacturer's Test Reports shall be submitted after shipment to the project. Relay settings (programming) will be provided by the Agency and the relays will be operationally tested by the Agency.

3.3.4 Spare Parts

a. One - Station Service High-Impedance Bus Differential Protective Relay identical in manufacturer and model as supplied to fulfill the requirements of paragraph STATION SERVICE HIGH-SPEED BUS PROTECTIVE RELAYS.

b. Two - Station Service Feeder Protective Relays identical in manufacturer and model as supplied to fulfill the requirements of paragraph FEEDER PROTECTIVE RELAYING.

-- End of Section --