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CLASS II GSU POWER TRANSFORMER (T2)

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

This Section covers the manufacturing and factory testing of Two (2) single-phase generator step-up (GSU) power transformers rated 82,000 / 109,334 kVA, 500 kV high-voltage (H), 13.2 kV low-voltage (X & Y), Class ONAN/ONAF cooling, for delivery f.o.b. to Little Goose Lock & Dam storage yard. The transformer design can be a core-form or a shell-form transformer design as long as the transformer meets the critical dimensions identified on the contract drawings. Each transformer shipment, hauling, site reassembly, field testing are as required in SECTION 48 20 00.04 26, TRANSFORMER SHIPMENT, HAULING AND SITE ASSEMBLY. Throughout this Section, the transformer tank layout is identified ~~on~~ by Segments 1 through 4, as defined in IEEE C57.12.10, Figure 1, and indicated on the contract drawings.

1.2 GENERAL INFORMATION

1.2.1 Transformer Location

The single-phase transformers specified in this section will be spare transformers for Little Goose, Lower Granite, and Lower Monumental dams. These transformers are meant to be a spare for the single-phase T2 Bank transformers at the three Projects. Contract Drawing G-003 of Volume, shows the site map and the storage yard where the spare transformers will be placed. The spare transformers will placed on concrete pads in the storage yard. See supplemental drawing LMP-5-6-1A5/1 for details on the existing transformer mounting pads.

1.2.2 Ratings

Size the new single-phase power transformers per the requirements of paragraph, "Ratings and Electrical Characteristics", to match the impedance, capacitance, and ratings of the existing single phase transformers.

1.3 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 CIVIL ENGINEERS (ASCE)

ASCE 7-22	(2022; Supp 1 2023; Supp 2 2023) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2024) Unified Inch Screw Threads (UN, UNR, and UNJ Thread Form)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.24	(2022) Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500
ASME B31.1	(2024) Power Piping
ASME BPVC SEC IX	(2023) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ANSI/ASNT CP-189	(2020) ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A343/A343M	(2014; R 2019) Standard Test Method for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame
ASTM A664	(2015; R 2022) Standard Practice for Identification of Standard Electrical Steel Grades in ASTM Specifications
ASTM A717/A717M	(2012; R 2022) Standard Test Method for Surface Insulation Resistivity of Single-Strip Specimens
ASTM A876	(2017; E 2017) Standard Specification for Flat-Rolled, Grain-Oriented, Silicon-Iron, Electrical Steel, Fully Processed Types
ASTM D923	(2015; R 2023) Standard Practices for Sampling Electrical Insulating Liquids
ASTM D1535	(2014; R 2023) Standard Practice for Specifying Color by the Munsell System

ASTM D3487	(2024) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(2020) Standard Symbols for Welding, Brazing, and Nondestructive Examination
AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D1.6/D1.6M	(2017) Structural Welding Code - Stainless Steel

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 693	(2018) Recommended Practice for Seismic Design of Substations
IEEE 1427	(2020) Guide for Recommended Electrical Clearances and Insulation Levels in Air Insulated Electrical Power Substations
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.10	(2017) Requirements for Liquid-Immersed Power Transformers
IEEE C57.12.70	(2020) Standard Terminal Markings and Connections for Distribution and Power Transformers
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.19.00	(2023) Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings
IEEE C57.19.01	(2017) Performance Characteristics and Dimensions for Power Transformer and Reactor Bushings
IEEE C57.104	(2019; E 2019) Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers
IEEE C57.113	(2023) Recommended Practice for Partial Discharge Measurement in Liquid-Filled

	Power Transformers and Shunt Reactors
IEEE C57.116	(2022) Guide for Transformers Directly Connected to Generators
IEEE C57.149	(2012) Guide for the Application and Interpretation of Frequency Response Analysis for Oil-Immersed Transformers
IEEE C57.152	(2013) Guide for Diagnostic Field Testing of Fluid-Filled Power Transformers, Regulators, and Reactors

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA MW 1000	(2023) Magnet Wire
NEMA SG 4	(2009; R 2013) AC High-Voltage Circuit Breakers

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 1 2024; TIA 24-1) National Electrical Code

UL SOLUTIONS (UL)

UL 248-8	(2011; Reprint Aug 2020) Low-Voltage Fuses - Part 8: Class J Fuses
UL 360	(2013; Reprint Jan 2024) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 489	(2025) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2024) Industrial Control Equipment

UL 508A	(2018; Reprint Jul 2022) UL Standard for Safety Industrial Control Panels
UL 514B	(2012; Reprint Mar 2024) UL Standard for Safety Conduit, Tubing and Cable Fittings
UL 969	(2017; Reprint May 2023) UL Standard for Safety Marking and Labeling Systems
UL 1203	(2023; Reprint May 2024) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 4248-8	(2024) Fuseholders - Part 8: Class J

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with SECTION 01 33 00, "SUBMITTAL PROCEDURES", unless otherwise indicated below:

SD-01 Preconstruction Submittals

Welding Quality Control Plan; G, HDC

Submit for approval the welding quality control plan a minimum of 60 calendar days prior to the start of tank manufacturing. (see paragraph "Welding Quality Control Plan").

SD-02 Shop Drawings

a. Outline and Assembly Drawings; G, HDC

Submit outline and assembly drawings of the transformer for approval no later than 240 calendar days prior to the start of transformer fabrication to demonstrate that the equipment will conform to the requirements and intent of the specifications.

b. Detail Drawings; G, HDC

Submit detail drawings for approval not later than 180 calendar days prior to the start of transformer fabrication to demonstrate that the equipment will conform to the requirements of the specifications.

SD-03 Product Data

Submit for approval the product data no later than 120 calendar days prior to the start of transformer fabrication to demonstrate that the welding materials will conform to the requirements of the specifications.

a. Welding Electrodes and Rods; G, HDC

b. Shielding Gas; G, HDC

SD-05 Design Data

a. Transformer Design Data Review Report; G, HDC

Submit for approval a transformer design data review report within 14 calendar days of the design data review meeting, to demonstrate fully that all parts of the equipment will conform to the requirements and intent of the specifications.

b. Descriptive Data; G, HDC

Submit for approval the descriptive data and catalog data of all accessory devices, ancillary equipment and gaskets to be provided with the transformer within 210 calendar days after date of award, to demonstrate fully that all parts of the equipment will conform to the requirements and intent of the specifications. (see paragraph "Descriptive Data")

c. Spare Parts List; G, HDC

Submit for approval a listing of all required spare parts to be provided with the transformer within 210 calendar days after date of award. (see paragraph "SPARE PARTS")

d. Structural Design Criteria and Seismic Calculations; G, HDC

Submit for approval the structural design criteria and seismic calculations within 45 calendar days after outline and assembly drawing approval. Perform design criteria and calculations utilizing civil or structural engineers who are presently registered professional engineers (PE) in any state or territory of the United States, and provide a cover sheet for the submittal which is stamped or sealed and signed by a PE.

e. Cabinet Heater Sizing Calculations; G, HDC

Submit for approval the calculations not later than 180 calendar days prior to the start of transformer fabrication to verify the ratings of the transformer control and power cabinet heaters, based upon the cabinet sizes, cabinet material, and the regional ambient temperature conditions as shown in Contract Drawing G-005. See paragraph "Lighting, Convenience Receptacle, and Cabinet Heaters" for information.

SD-06 Test Reports

a. Transformer Factory Acceptance Test Report; G, HDC

Submit for approval the transformer factory acceptance test report not later than 14 calendar days following completion of the factory acceptance tests. (see paragraph "Factory Acceptance Test Report").

b. Bushing Design Tests; G, HDC

Submit for approval the transformer bushing design test reports not later than 30 calendar days following completion of the tests (see paragraph "Bushing Design Tests"). If certified copies of

bushing design tests previously conducted within ten (10) years are submitted in-lieu of new test results, submit them when the bushing selection is made, but not later than 60 calendar days prior to the performance of transformer factory acceptance tests.

c. Bushing Routine Tests; G, HDC

Submit for approval the transformer bushing routine test reports not later than 30 calendar days following completion of the tests. (see paragraph "Bushing Routine Tests").

d. Bushing Current Transformer Tests; G, HDC

Submit for approval the transformer bushing current transformer test reports not later than 30 calendar days following completion of the tests. (see paragraph "Bushing Current Transformer Tests").

g. Weld Inspection and Test Report; G, HDC

Submit for approval the weld inspection and test report not later than 14 calendar days following completion of the weld inspections and tests. (see paragraph "Weld Inspections, Tests and Weld Inspector Qualifications").

SD-07 Certificates

a. Transformer Oil Certification; G, HDC

Submit for approval the transformer oil certification documents a minimum of 7 calendar days prior to the delivery of transformer oil to the Little Goose Lock & Dam "Storage Yard". (see paragraph "Quantity and Transformer Oil Certification").

b. Notification of the Date of the Transformer Design Data Review Meeting; G, HDC

Notify the COR 30 calendar days in advance of when the transformer manufacturer will be ready for performance of a design data review meeting, to be held at the manufacturer's facility. If the meeting is to be held in a foreign country, notify the COR in writing of the meeting dates a minimum of 60 days prior to the proposed meeting date.(see paragraph "TRANSFORMER DESIGN DATA REVIEW MEETING").

c. Notification of the Date of Factory Tests; G, HDC

For transformer manufacturers located in the United States, notify the COR 30 calendar days in advance of when the transformer manufacturer will be ready for factory acceptance tests, so that the tests may be witnessed by a Government Representative at the manufacturer's facility.(see paragraph "TRANSFORMER FACTORY ACCEPTANCE TESTS").

For transformer manufacturers located in foreign countries, notify the COR 60 calendar days in advance of when the transformer manufacturer will be ready for factory acceptance tests, so that the tests may be witnessed by a Government Representative at the manufacturer's facility.(see paragraph "TRANSFORMER FACTORY ACCEPTANCE TESTS").

d. Welder Qualifications; G, HDC

Submit for approval the welding operators and welders qualifications a minimum of 60 calendar days prior to their performance of work. (see paragraph "Welder Qualifications").

e. Weld Inspector Qualifications; G, HDC

Submit for approval the qualifications for the Contractor's Quality Assurance personnel responsible for performing weld inspections a minimum of 60 calendar days prior to the performance of weld inspections. (see paragraph "Inspection and Weld Inspector Qualifications").

SD-08 Manufacturer's Instructions

a. Factory Test Procedures; G, HDC

Submit for approval the transformer factory test procedures a minimum of 60 calendar days prior to the performance of the factory acceptance tests. (see paragraph "TRANSFORMER FACTORY ACCEPTANCE TESTS").

b. Welding Procedures; G, HDC

Submit for approval the welding procedures and specifications, and copies of test reports, a minimum of 60 calendar days prior to the performance of work. (see paragraph "Welding Procedure").

c. Prequalified Weld Procedures; G, HDC

Submit for approval the applicable prequalified weld procedures per the requirements of AWS a minimum of 60 calendar days prior to the performance of work. (see paragraph "Welding Procedure").

1.5 TRANSFORMER WARRANTY REQUIREMENTS

1.5.1 General Warranty Requirements

In addition to the requirements outlined in FAR 52.246-18, provide a manufacturer’s warranty for the power transformers for a period of 5 years from the date of final acceptance of the work. Provide a warranty certificate for each transformer indicating the date of expiry, to be included in the final Operations and Maintenance Instructions. The following transformer issues will also be considered warranty repair items:

a. Transformer gassing quantities or rates exceeding the DGA Status 1 level as defined in Figure 2 Tables 1 through 4 of IEEE C57.104.

b. Transformer oil leaks, at welded joints as well as gasketed connections and valve stem packing.

c. Paint failures resulting in visible loss of adhesion through bubbling, flaking, peeling, or any visible rust due to paint failure.

d. Transformer bushing dielectric integrity and oil leaks.

e. Transformer control cabinet heater functionality.

1.5.2 Devices Exempt from the Transformer Full Warranty Period

Transformer ancillary devices which are not manufactured by the transformer manufacturer are subject to the device manufacturer's standard warranty period, and are exempt from the 5 year duration of the transformer warranty period. All ancillary devices which are not manufactured by the transformer manufacturer, such as gauges, have a minimum 1-year warranty or the part's manufacturer's guaranteed warranty, whichever is higher of the two.

PART 2 PRODUCTS

2.1 TYPE AND RATING

2.1.1 General

The transformers to be furnished under these specifications must be single-phase, three-winding, with one high-voltage and dual low-voltage windings, oil-immersed type suitable for outdoor operation. The transformers must be self-cooled/forced air-cooled type, Class ONAN/ONAF, and must be of a design that has an established record of satisfactory operation with the type of oil preservation system specified, and manufactured suitable for shipment by sea transportation, railcar, and trucking by heavy hauler. The transformers are a step-up transformer to be used in direct connection with electrical power generators and will be subject to backfeed mode as defined in IEEE C57.116. The transformer design must be of a design that has an established record of satisfactory operation in this type of configuration.

2.1.2 Transformer Limiting Dimensions and Equipment Arrangement

Provide transformers with the layout, equipment arrangement and dimensional requirements as indicated on contract drawings.

2.1.3 Requirements

Except as otherwise specified herein, the transformers, accessories, and spare parts must conform to the applicable requirements of IEEE C57.12.00, IEEE C57.12.10, IEEE C57.12.70, IEEE C57.12.80 and IEEE C57.12.90, and IEEE C57.116.

2.1.4 Standard Products

Provide material and equipment which are standard products from a manufacturer that is regularly engaged in their production, and are items that have been commercially available for at least 3 years prior to bid opening, unless otherwise specifically approved. All materials must conform to the requirements of these specifications. Materials must be of industrial quality, free from defects and imperfections, presently being manufactured, and of the classification and grades designated. If the Contractor desires for any reason to deviate from the standards designated in these specifications, submit for approval a statement describing the exact nature of the deviation, including complete specifications for the materials that are being proposed for use.

2.1.5 Descriptive Data

Submit for approval descriptive data for all transformer equipment, which

includes catalog and technical data of sufficient detail to verify conformance with the requirements, herein. Highlight or circle the catalog and technical data for the specific device and model, and provide ordering information and cut sheets. The descriptive data is to include the following at a minimum:

1. Electrical core steel, including country of origin
2. Winding conductors, including country of origin
3. Gasket type and material
4. Valves (each type)
5. Oil sampling device
6. Radiators
7. Cooling fans (including wiring connection methods)
8. Nitrogen regulator cabinet and nitrogen bottles if providing a nitrogen gas pressure system of oil preservation
9. Bushings (each type and rating)
10. Core ground bushings
11. Bushing current transformers
12. Bushing current transformer terminal boxes
13. Thermowells
14. Oil level indicator
15. Oil temperature indicator
16. Winding temperature indicator, including associated equipment
17. Pressure relief device, including discharge piping
18. De-energized tap changer, including operating handwheel
19. Rapid Pressure Rise Relay and Seal-in
20. Personal fall arrest system
21. Insulating oil, including vendor and inhibitor
22. Control and power cabinet vibration isolators
23. Fiber-optic probes
24. Fiber-optic tank feed-through plate and connectors
25. Auxiliary power transformer and mounting cabinet
26. Magnetic contactors
27. Molded-case circuit breakers (each type and rating)
28. 480 VAC circuit breaker locking provisions
29. Auxiliary relays
30. Undervoltage relays
31. Control and instrument switches
32. Terminal blocks (each type)
33. Fuses
34. Fuse holders
35. Wire duct
36. Cabinet lighting
37. GFCI receptacle
38. Cabinet heaters
39. Cabinet grounding busbar
40. Cabinet ventilation
41. Thermostat / humidistat
42. Insulated wire and cable (each type) and signal cable
43. Wire labeling method
44. Device nameplate method
45. Conduit and fittings
46. Junction boxes
47. Impact recorders for shipment (analog & digital)

If providing a conservator tank system of oil preservation include descriptive data of the following:

48. Conservator tank bladder

49. Dehydrating breather
50. Buchholz relay

2.1.6 Ratings and Electrical Characteristics

The ratings and electrical characteristics of the transformers must be as follows:

a. Continuous rating, at the 65 degrees-C temperature rise, of the high-voltage winding at all taps, kVA:

(1) ONAN Rating: 82,000
(2) ONAF Rating: 109,334

b. Continuous rating, at the 65 degrees-C temperature rise, of each low-voltage winding, kVA:

(1) ONAN Rating: 41,000
(2) ONAF Rating: 54,667

b. Frequency, Hz: 60

c. Number of phases: 1

d. Rated voltage, kV:

(1) High-voltage windings: 500
(2) Low-voltage winding X: 13.2
(3) Low-voltage winding Y: 13.2

e. Winding connections (external to the transformer):

(1) High-voltage windings: Grounded-Wye
(2) Low-voltage windings: Ungrounded Delta

f. Impedance, at ONAN rated current between the high-voltage winding and each low-voltage winding, subject to IEEE tolerances, percent:
9.2% (H-X)
9.2% (H-Y)

g. Impedance, at ONAN rated current, between the low-voltage windings (X-Y), as high as feasible for an economic design, but not less than, percent: 20.9%

g. Polarity: Subtractive

h. Basic impulse insulation levels (BIL), kV:

(1) Line ends of the high-voltage windings, not less than: 1425
(2) Neutral ends of the high-voltage windings, not less than: 150
(3) Low-voltage windings, not less than: 110

i. Taps in low voltage windings: None

j. Taps (full capacity) in high voltage winding

(1) Tap 1, percent of high-voltage rating: 107.5
(2) Tap 2, percent of high-voltage rating: 105.0
(3) Tap 3, percent of high-voltage rating: 102.5

(4) Tap 4, percent of high-voltage rating: 100.0
(5) Tap 5, percent of high-voltage rating: 97.5

k. Maximum no-load losses at rated voltage and frequency, kW: 52

l. Maximum load losses at maximum ONAN rated kVA and 1.0 power factor, with each low-voltage winding equally loaded, kW: 175

m. Maximum average sound level at rated voltage and frequency, with all cooling groups in operation, dB: 74

n. ~~Maximum~~Existing Oil Volume, GAL: 10,667

o. Maximum transformer total weight, completely assembled and oil filled with all accessories installed, pounds: ~~355,000~~360,000

p. The transformers' capacitances must match those of the existing transformers and be designed to be compatible with bank of single-phase shell-type transformers. See the T2 Doble Report attachment at the end of the specifications.

2.1.7 Transformer Type

The existing transformers in T2 Bank are shell-type transformers. A shell-form or core-form type transformer design is acceptable and must meet requirements described in these specifications. The transformers design must fit each existing Project connections without modifications to existing equipment and the weight must fit the intake deck loading limitations and any oil quantity restrictions if any. The new transformers must fit within the allowable space and for example, without extending into space for gantry crane. The transformers must be designed to be compatible for operation with the existing single phase shell-type transformers in T2 Bank. The transformers must be able to be transported from manufacturer's location to Little Goose Lock & Dam Storage Yard.

2.1.8 Unusual Service Conditions

2.1.8.1 Magnetic Fields

The transformers will be subject to the following unusual service conditions, as defined by IEEE C57.12.00, paragraph 4.3:

The transformers' high-current low-voltage bushings will be connected to isolated-phase bus ducts and will exhibit strong magnetic fields during operation, which may cause circulating currents in the transformer tank covers and bus duct housings. Corrective measures must be taken during manufacturing to utilize non-magnetic metals in the cover around the bushings and the bushing housing flanges.

2.1.8.2 Backfeed Mode

The transformers must be designed to operate under IEEE C57.116 related service conditions with the transformers being used as a generator step-up transformer and will be subject to periods of backfeed operation.

2.1.9 Impedance Tolerance

The impedance tolerance between the supplied single-phase transformers and the specified impedance must be limited to a maximum of 3 percent, at the

ONAN self-cooled rating, to reduce circulating currents when wye-connected and assure proper operation of the transformers differential relaying.

2.2 STRUCTURAL DESIGN CRITERIA AND SEISMIC CALCULATIONS

Provide Structural design criteria and seismic calculations for the transformer, to include the main tank and all major components such as bushings, cooling equipment, oil preservation equipment, and cabinets.

2.2.1 Structural Design Criteria

Structural design criteria must include the following:

a. Indicate the industry design standards (ASCE or IEEE) and allowable stresses or capacities to which steel plate, structural steel shapes, welds, bolts and studs must conform.

b. Indicate the industry standards (ASCE or IEEE) used in developing the seismic forces and analysis techniques used in the design of the transformer and transformer components.

c. Provide the seismic design for equipment restraint in accordance with Chapter 13, "Seismic Design Requirements for Nonstructural Components," of ASCE 7-22 with the seismic design force computed as per Section 13.3 "Seismic Demands on Nonstructural Components". Provide electrical equipment restraint in accordance with the provisions in IEEE 693 Annex D, or Section 13.3 of ASCE 7-22 whichever produces the more adverse seismic effects. For ASCE 7-22, use a spectral acceleration S_{DS} = 0.32, I_P = 1.5 and z=h=1. Use a moderate seismic qualification level For IEEE 693.

d. Provide wind load calculations based upon Exposure Category "D" of ASCE 7-22. Base the effect of wind load forces upon ASCE 7-22, or 40 psf, whichever is greater.

2.2.2 Transformer Mounting

The transformers must be manufactured with structural bases that meets the requirements of paragraph "Transformer Steel Base, and that rests on the existing concrete pedestals with a steel plate cap as shown in supplemental drawing LMP-5-6-1A5/1.

2.3 THERMAL DESIGN

The temperature rise above ambient temperature of the transformers or parts thereof, when tested in accordance with its ratings, must not exceed the limits of observable temperature rise for oil immersed apparatus as stated in IEEE C57.12.00 (paragraph 5.11.1). The winding temperature rise by resistance must not exceed 65 degrees-C, and the hottest spot winding temperature rise must not exceed 80 degrees-C on the tap connections that give the highest losses, at all self-cooled and forced-air cooled ratings. The transformers must be designed for satisfactory continuous operation with any combination of simultaneous loads on the low-voltage windings within their ratings, and also for the case where either low-voltage winding carries maximum rated load and the other low-voltage winding carries no load.

2.4 CORE

The transformers' core steel laminations must be high-quality, non-aging, cold-rolled, grain-oriented steel especially suitable for the purpose, meeting the requirements of ASTM A664 and ASTM A876, and the following:

a. Lamination maximum thickness of 0.270 mm, and the design flux density less than 1.75 Tesla.

b. Electrical core steel core loss, rms exciting power, rms and peak exciting current, and ac permeability design tested in accordance with ASTM A343/A343M, with the design test reports included with the descriptive data.

c. Each roll of sheet steel used must have the surface insulation resistivity tested in accordance with ASTM A717/A717M.

d. The core must be assembled with interleaved joints, and rigidly clamped to ensure mechanical strength to support the windings and to prevent shifting of the laminations during shipment, and also to reduce vibration during operation.

2.5 WINDINGS

The single-phase transformers must be manufactured with windings meeting the requirements of paragraph "Ratings and Electrical Characteristics", consisting of one high-voltage winding (H) and two low-voltage windings (X and Y). Consideration must be given to all factors of service, such as high dielectric and mechanical strength of insulation, coil characteristics, and minimum restrictions to free circulation of oil. Coils must be made up, shaped, and braced to provide for expansion, contraction, and shrinkage due to temperature changes and aging in service in order to avoid abrasion of insulation and to provide resistance to movement and distortion caused by abnormal operating conditions.
The insulation of the coils must be designed to withstand possible transient voltages that occur when the transformers are operated in backfeed mode and the secondary windings (hi side) are exposed to typical system transients as described in IEEE C57.116, clause 11. Barriers must be provided between windings and core and between high-voltage and low-voltage windings. End coils must have additional protection against normal line disturbances. The windings must meet the following requirements:

a. Winding conductors manufactured from high-conductivity copper magnet wire meeting the applicable requirements of NEMA MW 1000.

b. Winding assembly of a circular coil fabrication if the transformers are a core-form design.

c. Conductor insulation consisting of thermally upgraded Kraft paper.

d. A de-energized tap changer with taps located in the high-voltage windings. The tap changer contacts must be silvered, and capable of withstanding the full short circuit current of the transformers without injury.

e. Basic impulse insulation level (BIL) of the windings as specified in paragraph "Ratings and Electrical Characteristics", and capable of withstanding IEEE Standard dielectric tests, in accordance with

paragraph "Power Transformer Tests", corresponding to the specified winding insulation levels.

f. Capable of withstanding without injury the mechanical and thermal stresses caused by short circuits on the external terminals of any winding or windings, with rated voltages maintained across the terminals of all other windings intended for connection to sources of energy, under the conditions listed in IEEE C57.12.00 (paragraph 7.1.1).

g. Fiber-optic probes embedded in the calculated hottest spot for each high and low-voltage winding duct spacers for direct winding temperature measurement, with quantities and distribution as required in paragraph "Transformer Fiber-Optic Winding Temperature Measurement."

2.6 TANK

2.6.1 FABRICATION

The transformers must be manufactured with an oil-tight steel tank, with oil-tight covers per the requirements of IEEE C57.12.10 (paragraph 5.8), with the following features:

a. The main transformer tanks and any attached compartment that is subjected to operating pressures designed and manufactured to withstand, without leakage or permanent deformation, an internal maximum operating pressure not less than 10 psi.

b. Manufactured for vacuum filling (essentially full vacuum) in the field, with all valves, fittings and piping affected by vacuum filling rated for such filling.

c. Welded joints between the tank and cover, and between tank sections, designed to prevent weld splatter from entering the inside of the tank during the welding process.

d. Positioning guides inside the tank to assure the core and windings are in the correct position during the assembly process, and provide additional rigidity during transportation.

e. One or more unobstructed manholes in the cover with minimum dimensions of 24 inches by 24 inches, or 24 inches minimum diameter, to afford easy personnel access to the inside of the tank and the upper portions of the core and coils.

f. Handhole access covers in the tank sidewall for access to low-voltage bushing bottom connection, and the de-energized tap changer switch mechanism for future maintenance.

g. If providing a conservator tank oil preservation system, the tank must include the necessary pressure equalizing valves to allow for oil-filling under vacuum.

2.6.2 Lifting, Moving and Jacking Facilities

2.6.2.1 Lifting Facilities

Design loads for lifting facilities must have a safety factor of five in accordance with IEEE C57.12.10 (paragraph 5.3.1). Lifting facilities must

positively keep the lifting cable in place even when the cable is slack. Provide transformers with the following lifting facilities:

a. Lifting attachments on the tank cover.

b. Adequate means for lifting the core and coil assembly from the tanks for a core-form design.

c. Lifting facilities and pivot points on the tanks adequate for lifting and pivoting the transformers from the shipping position to the upright position for a shell-form design.

d. Lifting facilities on the tanks adequate for lifting the complete transformer filled with oil. The lifting facilities will also be used for securing of the transformers during shipment.

2.6.2.2 Moving Facilities

Furnish moving facilities in accordance with IEEE C57.12.10 (paragraph 5.3.3).

2.6.2.3 Jacking Facilities

Provide transformers manufactured with jacking facilities to permit jacking the fully assembled transformer filled with oil per the requirements of IEEE C57.12.10 (paragraph 5.3.4). The design loads for jacking facilities must be a minimum of five times the actual loads to allow for possible unequal jacking forces.

2.6.3 Gasketing

2.6.3.1 General

Gaskets between metal surfaces must be set in expansion-limiting grooves so that all contact surfaces are metal-to-metal when tightened. The gaskets must be made of Nitrile NBR (Buna N), with the exception that gaskets for the low-voltage bushings must be fluoroelastomeric rubber, with a Durometer rating between 50 and 70. Circular cross-section gaskets are not acceptable for use in gasket grooves of rectangular cross-section.

2.6.3.1.1 Low-voltage Bushings

The low-voltage bushing gaskets but meet the following requirements:

a. Meets the requirements of ASTM D-1418, designation FKM, Type 2.
b. Must be manufactured with 100% virgin FKM Fluoroelastomer polymer
c. Rated for application in temperature range of -20F to +400F
d. Durometer hardness of 70 (+/- 2)
e. Minimum fluorine content: 66%

2.6.3.2 Sizing

Gasket sizing for rectangular cross-section grooves must be accomplished as follows:

a. Gasket thickness is chosen so that approximately 25-percent of the gasket cross-section protrudes above the depth of the groove, referred to as the 'gasket compression area'.

b. The width of the groove minus the width of the gasket determines the space available for gasket expansion during compression. The amount of groove space available for gasket expansion during the compression process is referred to as the 'gasket expansion area', which must be greater than the gasket compression area to avoid pinching of the gasket between the metal surfaces when tightened.

c. Proper sizing coordination between the gasket groove and the gasket cross-sections results in 25-percent gasket compression, with a remaining gasket expansion area after tightening of between 5 and 10-percent.

2.6.4 Valves

Provide valves that conform with IEEE C57.12.10 (paragraph 5.1.8), are of ball-type stainless steel construction conforming to MSS SP-72, circular flanged mounting, with reinforced PTFE valve seats, unless otherwise specifically indicated. The valves must be of full-port design, designed for use with insulating oil with a 120 degrees Celsius minimum temperature rating and include hasps for locking the handle. Provide the following valves:

a. Upper filter connection. A 1.5-inch valve with a 1.5-inch female NPT threaded open-end connection and a threaded plug, located on the tank sidewall such that it can be used to fill the transformers with oil while the transformers are under vacuum.

b. Vacuum pump connection. A 3-inch valve with a 3-inch circular-flanged open-end connection, located on the tank cover for use in connecting a vacuum pump during the vacuum filling process. Provide a gasketed blind flange cover with an integral 3-inch NPT female connection and threaded plug for the valve open-end connection.

c. Main drain. A 3-inch valve with a 3-inch circular-flanged open-end connection, located at the extreme bottom of the tank for use in gravity draining of the transformer. Provide a gasketed blind flange cover with an integral 3-inch NPT female connection and threaded plug for the valve open-end connection.

d. Oil sampling valve. A 1-inch valve, with a 1/2-inch NPT threaded open-end connection and a 1/2-inch threaded sampling device, complete with protective cover. This valve may be located at the main drain valve location..

e. Lower filter connection. A 1.5-inch valve with a 1.5-inch female NPT thread open-end connection and a threaded plug, located at the extreme bottom of the tank.

f. Tank air vents. Threaded plugs for venting the radiators. If providing a conservator tank oil preservation system, valves must be provided for venting of the conservator tank. Schrader valves are not acceptable for use as vent valves.

g. If providing a conservator tank system of oil preservation provide a conservator tank drain valve. A valve must be located at the bottom of the conservator tank for use in gravity draining.

h. If providing a nitrogen gas pressure system of oil preservation provide a nitrogen gas connection. Two 1/2-inch valves for connection

of the nitrogen generator system tubing.

i. Radiator drain. A 1/4-turn valve at the lowest point of each radiator to permit draining, with an NPT threaded open-end connection and threaded plug.

j. Isolation valves.

(1) Radiators. At the inlet and outlet of each radiator to permit removal without draining the oil from the tank. Radiator isolation valves at the transformer tanks may be of a butterfly type.

(2) Rapid pressure rise relay. 1.5-inch isolating valve for the rapid pressure rise relay.

(3) Gas-in-oil monitor interface valve. Two 2-inch valves for future connection to the gas-in-oil monitor

(4) Conservator tank. If providing a conservator tank system, provide a valve isolating the conservator tank from the main transformer tanks, and isolating the Buchholz relay. Isolation valves adjacent to the Buchholz relay may be of a butterfly design.

2.6.5 Connections

2.6.5.1 General

All bolts, studs, machine screws, nuts, and tapped holes designed for customer connection must be in accordance with ASME B1.1 (inch fasteners). Bolting hardware must be Grade 8 minimum, or equivalent, and and all hardware not internal to the tank must be galvanized. Threads for sizes 1/4-inch to 1-inch, inclusive, must be NC or UN series. The sizes and threads of all valves, pipe and fittings, conduit and fittings, tubing and fittings, and connecting equipment, must be in accordance with ASME B1.20.1. Manufacturers' standard threads and construction may be used on small items which are integrally replaceable, except that threads for external connections to these items must meet the above requirements.

2.6.5.2 Stainless Steel

All stainless steel connecting hardware must be installed using an anti-galling compound such as molybdenum disulfide on the threads prior to connection, or the nuts may be of a Nitronic 60 grade material.

2.6.6 Steel Pipe and Fittings

Steel pipe must conform to ASTM A53/A53M, Grade A, Weight Class XS. Dimensions of terminating flanges must conform to ASME B16.1 and ASME B16.24. For a conservator tank system, if the bushing turret design is such that any gasses generated may accumulate within the turret enclosure, piping must be provided for the purposes of venting these gases to the conservator tank piping, passing through the Buchholz relay.

2.6.7 Grounding

The transformer tanks must include four ground pads, with grounding provisions in accordance with IEEE C57.12.10 (paragraph 5.5).

2.6.8 Portable Fall Arrest System

2.6.8.1 Portable Fall Arrest System Anchor Post

Provide one portable fall arrest system anchor post. The anchor post must have the following features:

a. Three-stage, four-position telescoping design of aluminum construction.

b. Provision of three independent swivel tie-off points, with horizontal lifeline attachment.

c. Base leveling screws allowing the system to be plumbed to vertical for working stability on inclines up to 15-degrees.

d. Designed for attachment to a uni-anchor mounting plate.

2.6.8.2 Anchor Post Accessories

Provide the following accessories with the portable fall arrest system anchor post:

a. Rescue Davit Arm, with quick mount winch and cable.

b. Carrying bag for the anchor post assembly.

c. Carrying bag for the Davit Arm with mounted winch.

2.6.8.3 Mounting Plates

Provide two portable fall arrest system anchor post mounting plates welded on the transformer covers, located so that the center of each manhole access cover is 36-inches from the mounting plate. The mounting plates must be designed for use with the portable fall arrest system anchor post indicated above.

2.6.9 Transformer Steel Base

The transformers must be manufactured with an integral structural steel base designed for meeting the following requirements:

a. Suitable for resting on the existing concrete pedestals with steel caps as shown on supplemental drawings LMP-5-6-1A5/1, and LGB-I-003, Volume 1.

b. Capable of supporting the weight of the assembled and oil filled transformers on the existing concrete pedestals with steel caps.

c. Manufactured to be suitable for moving on rollers or skids when the transformers are completely assembled and filled with oil, permitting moving the transformers in a direction parallel to either centerline, with suitable pulling eyes provided.

d. Spare must directly bear on steel bearing plates of the storage structure and on the foundation plates in operating locations. Provide at minimum provisions for six (6) 1-inch diameter anchors to be installed in the locations shown in resource drawings and adequate clearance to install the anchors.

2.7 COOLING EQUIPMENT

2.7.1 Radiators

Provide transformers manufactured with radiators to cool the oil at a 82,000 kVA continuous load, without any cooling groups in operation. The radiators must meet the following requirements:

a. Located on the tanks to ensure uniform circulation of the oil through the windings, with valves installed on each connection to the main tanks so that the radiators may be removed for repairs without taking the transformers out of service.

b. Fully hot-dip galvanized on the outside and remain unpainted.

c. Designed and manufactured to withstand essentially full vacuum to permit filling of the transformers under vacuum with the radiators in-place and radiator valves open.

d. Provisions for draining and venting each radiator, 1/4-turn ball valve for draining each radiator, and lifting eyes for handling.

e. The welding and fittings must be smooth, both inside and out, so as to present no obstruction to the flow of oil inside, with full penetration welds on the outside of the radiators such that there will be no crevices in which water might collect.

2.7.2 Cooling Fans

Horizontal-draft cooling fans must be provided so that the continuous forced-air-cooled capacity of the transformers will be at least 109,334 kVA without exceeding the allowable temperature rise specified in paragraph "Ratings and Electrical Characteristics". Locate the cooling fans to direct the air stream against the radiator and to prevent recirculation of discharged air. Provide cooling fans that meet the following requirements:

a. Balanced cast aluminum fan blades.

b. Hot-dip galvanized steel basket-type fan blade guards.

c. Fan motors to have IP55 enclosure rating.

d. Fan motor housing painted with epoxy primer and aliphatic urethane top-coat.

e. Individual thermal overload protection with automatic-reset.

f. Fan motors with permanently lubricated, double-sealed ball bearings.

g. Fan motors with Class F insulation, Class B temperature rise.

2.7.3 Power Supply Equipment

The power supply for fan motors will be Government-furnished, 480 V, three-wire, 3 phase, 60 Hz, as indicated on the contract drawings. One 3-pole, 600 V, molded case circuit breaker of proper current rating must be provided in the power cabinet for the supply circuit.

2.7.4 Cooling Control Equipment

All necessary protective and control equipment for the fan motors must be furnished and installed in the control and power cabinets for each transformer (see paragraph "CONTROL AND POWER CABINET EQUIPMENT").

2.8 BUSHINGS

2.8.1 General Bushing Requirements

Provide transformers with one high-voltage, four low-voltage, and one neutral leads brought out from the tank through bushings as specified below. Bushings of the same voltage and current rating must be interchangeable and as applicable, conform to IEEE C57.19.00 and IEEE C57.19.01. All bushings must meet the following requirements:

a. Of recent manufacture and of a type and style currently being manufactured.

b. Nameplate rated and tested for use at 60 Hz rated frequency.

c. Rated for outdoor service, with UV resistant insulating sheds for bushings which will be exposed to direct sunlight.

d. Manufactured so that there will be no stressing of any parts due to temperature changes, and means provided to accommodate conductor expansion.

e. Gastight and oiltight when installed on the transformer tanks.

f. The power factor of each bushing must meet the requirements of IEEE C57.19.01, Table 6, or as otherwise specifically required herein.

2.8.2 High-Voltage and High-Voltage Neutral Bushings

The high-voltage and neutral bushings must be designed to withstand the standard withstand test voltages as indicated in Table 1 of IEEE C57.19.01, and tested in accordance with paragraph "Bushing Tests". The bushings must be ABB Type O Plus C Type and meet the following requirements:

a. Designed for use in an air-to-oil power transformer applications.

b. Constructed with a normally grounded test tap.

2.8.2.1 High-Voltage Bushing Ratings

a. Insulation class, kV: 500

b. BIL rating, kV: 1,550

c. Minimum current rating, Amperes: 1,600

d. Creepage distance: Light contamination

e. Drawing number: T550W2000VV

2.8.2.2 High-Voltage Neutral Bushing Ratings

a. Insulation class, kV: 25

b. BIL rating, kV: 150

c. Minimum current rating, Amperes: 1,200

d. Creepage distance: Light contamination

e. Drawing number: T025W0412AT

2.8.3 Low-Voltage Bushings

Low-voltage bushings must meet the requirements of IEEE C57.19.01 (1991), and must be tested in accordance with paragraph "Bushing Tests". The bushings must be of solid bulk construction of a low-corona design for vertical mounting, and the exterior shell above the mounting flange must be of porcelain construction and formed in one piece. Viton gaskets must be used for the installation of all low-voltage bushings. All low-voltage bushings must be rated as follows:

a. Insulation class, kV: 25

b. BIL rating, kV: 150

c. Minimum current rating, Amperes: 7,500

d. Thermal rating, degrees Celsius temperature rise: 125

e. Drawing number: T025B0750EC

2.8.4 High-Voltage and Neutral Bushing Terminals and Connections

The high-voltage and neutral bushings must have threaded copper terminal stud with dimensions in compliance with IEEE C57.19.01.

2.8.5 Core Ground Bushings

The transformers must be manufactured with two external bushings for core grounding; one for the main core connection to ground, and one for the core frame connection to ground. The bushings must be mounted adjacent to each other and located on the transformer tank covers, protected with a removable weatherproof metal cover with device nameplates. The bushings must be manufactured with an integral cast copper stud, with an insulating body of either epoxy or solid porcelain, and include a bolted-flange so that they can be removed for maintenance without having to enter the tank. The stud must be silver plated, with tapped holes for connection of removable grounding straps between the bushing bottom terminal and the core and tank wall. The minimum ground wire size from each bushing top terminal to the tank must be #4 AWG equivalent. The core ground bushings must have the following minimum nameplate ratings:

a. Insulation class, kV: 2.5

b. BIL rating, kV: 45

c. Minimum current rating, Amperes: 100

2.8.6 SFRA Test Shipping Bushings

For the purposes of performing SFRA testing with the transformers in the shipping configuration, each shipping cover installed after the bushings have been removed for shipment must include a bushing that is connected to the winding leads, so that the SFRA tests can be performed just prior to each transformer shipment and immediately after each transformer delivery to the Little Goose Lock & Dam "Storage Yard" for each transformer. This assembly permits the SFRA testing on the transformers without having to gain entrance into, or modifying the transformer shipping assembly. The winding leads must be appropriately braced inside the transformer tanks to assure there is no movement during shipment which could damage the bushings, or potentially alter the SFRA test results. During shipment, the external terminals of these bushings must be grounded to the tank. Testing must be performed per the requirements of paragraph "Sweep Frequency Response Analysis Tests". Each temporary SFRA Test Shipping Bushings must be of the same manufacture and rating as the core ground bushings.

2.8.7 Shipment and Storage

2.8.7.1 Shipment

For bushings shipped separate from the transformers, each bushing must be crated and packed per the manufacturer's requirements in such a manner to protect the bushing from damage due to moisture, breakage and vibration damage during transit.

2.9 BUSHING-TYPE CURRENT TRANSFORMERS

All bushing-type current transformers must conform to the requirements of IEEE C57.13 and additional requirements in NEMA SG 4, and have revenue metering accuracy classifications as required in Table 6 of IEEE C57.12.10, unless otherwise specifically indicated. The continuous thermal rating factor must be a minimum of 1.33, based upon a 30 degree Celsius average ambient air temperature.

2.9.1 High-Voltage Bushing Current Transformers

Provide two 1200:5, multi-ratio bushing-type current transformers for each transformer high-voltage bushings.

2.9.2 Low-Voltage Bushing Transformers

Provide bushing current transformers on the low-voltage bushings as required for the winding temperature monitoring equipment.

2.10 LOW-VOLTAGE BUSHING THROAT ENCLOSURE

Provide transformers with circular flanged connections that are at same location and height to bolt to the existing bus housings and bushing enclosures.

2.11 TRANSFORMER MOUNTED ACCESSORIES

2.11.1 General

Dials, indicators, and gages installed on the transformers must have glass faces, and be mounted at a height of approximately 60 inches above the

base of the transformers, unless otherwise indicated, and arranged for convenient reading standing at the level of the base. The following accessory devices must be included in the price for the transformers, and meet the requirements of IEEE C57.12.10 (paragraph 5.1), unless otherwise indicated.

2.11.2 Liquid Level Indicator

Provide one magnetic-type liquid level indicator located on the tank sidewall or on the constant-pressure, reservoir tank if a conservator tank system is provided. The liquid level indicator must be equipped with three circuit-closing low-level alarm contacts suitable for use with an ungrounded 125 V dc circuit. The indicator must have a 6-inch dial face with a field-replaceable case, with the dial marked to indicate the 25 degrees Celsius oil level and the maximum and minimum oil levels.

2.11.3 Thermowells

Provide a total of five top oil thermowells and one bottom oil thermowell housed in weatherproof enclosures, with functionality as indicated on Contract drawing E-109 for each transformer. The thermowell locations must be designed such that they are always submerged in the insulating oil during transformer operation. Thermowells must be provided for the following:

a. One thermowell for use with the analog liquid temperature indicator, located on the tank sidewall near the top oil level in the path of the hottest oil.

b. Two thermowells for use with the analog winding temperature indicators, one for each low-voltage winding, located on the tank sidewall near the top oil level in the path of the hottest oil.

c. Three spare thermowells with NPT plugs. One must be for future use with the transformers temperature monitor for top oil temperature, located on the tank sidewall near the top oil level in the path of the hottest oil. One must be for future use with the transformer temperature monitor for bottom oil temperature, located on the tank sidewall.

2.11.4 Analog Temperature Indicating Equipment

The analog indicating equipment must be located on the tank sidewall as shown on the Contract drawings, with functionality as indicated on the control schematics.

2.11.4.1 Liquid Temperature Indicator

Provide one dial-type indicating thermometer for liquid temperature indication with a bourdon-tube sensing element for each transformer. The dial indicator must cover a range of 0 to 120 degrees Celsius and be equipped with two adjustable circuit closing alarm contacts suitable for use with an ungrounded 125 V dc circuit. One switch contact must be used for top oil over-temperature alarm set at 90 degrees Celsius.

2.11.4.2 Winding Temperature Equipment

a. General. Provide Two winding temperature indicators (WTI), with associated equipment, for use in remote indicating of the temperature

of each low-voltage winding (X and Y), and for use as an over-temperature trip backup to the future transformer temperature monitor for each transformer. The WTI equipment must be responsive to the current in the phase winding and to the top oil temperature, indicating the approximate hot-spot temperature of the winding, and provided with a means for calibration. Each WTI must include the following:

(1) A bourdon-tube sensing element located in the thermowell for operation of a dial indicator.

(2) A current transformer installed at each low-voltage winding which supplies current to a balancing autotransformer, proportional to the transformer load.

(3) A means for calibration connected each low-voltage winding current transformer and the thermowell heaters.

(4) Thermowell heating elements powered from the current balancing autotransformer, which simulates the winding temperature rise by adding the rise from the heating elements to the top oil temperature.

(5) An ungrounded three-wire 100-ohm platinum resistance temperature detector, which will be used with existing remote temperature recording or logging.

b. Dial Indicator and Switches. The WTI must have four electrically-independent, self-resetting contacts suitable for use on 125 V ungrounded dc circuits. Three switch contacts must be used as follows:

(1) One switch contact for cooling fan control. The setting of this contact is to be determined based on the results of the factory temperature rise tests.

(2) One switch contact for winding over-temperature alarm , set at 110 degrees Celsius.

(3) One switch contact for winding over-temperature trip set 117 degrees Celsius.

c. Leads. The leads from the WTI equipment must be routed through watertight and oiltight conduit fittings, and terminated in the transformer control cabinets. The connecting leads between the RTD elements and control cabinet terminal blocks must be soldered.

2.11.5 Rapid Pressure Rise Relay

Provide a rapid pressure rise relay and all connecting hardware required for each transformer. The rapid pressure rise relay must be designed for operation in oil space and have the following features:

a. Constructed of a die cast aluminum housing with ANSI 70 epoxy paint coating and an IP65 rating, designed for horizontal flange mounting.

b. Ambient operating range from -40 degrees Fahrenheit to 180 degrees Fahrenheit.

c. Rated pressure range of -14.7 to 20 pounds per square inch gauge.

d. A snap action, SPDT switch rated for 1/2 amp at 125V DC (resistive).

e. ANSI connector assembly with cable grip parts provided. Type SOOW, 16 gauge, 3 conductor cable to be provided and custom fit on-site at an estimated length of 40 feet (to be field verified by contractor).

2.11.6 Rapid Pressure Rise Seal-In Relay

Provide a rapid pressure rise seal-in relay rated for 125V DC operation to latch in the momentary switch actuation from the existing rapid pressure rise relay, to be installed in the transformer control cabinets, with the following features:

a. Designed specifically for use as a seal-in relay for the rapid pressure rise relay

b. LED Status indicating light and an LED Trip indicating light.

b. Two output relays with contacts rated for 8A at 250 Vac.

c. Reset button to unlatch the relays.

d. Redundant make/break circuit requirements that protect against false trips.

e. Surrounding air temperature range of -49 degrees Fahrenheit to 158 degrees Fahrenheit.

2.11.7 Pressure Relief Device

2.11.7.1 General

Provide each transformer tank with a self-resetting, mechanical-type high-flow pressure relief device mounted on the tank cover to automatically relieve internal pressure, and to protect the tank against rupture due to arcing below the surface of the oil. One pressure relief device must be provided for a volume of insulating oil contained within the main tank of less than 10,000 gallons, and two pressure relief devices must be provided for a volume of oil greater than 10,000 gallons. The relief device must be capable of withstanding full vacuum without rupture or loss of accuracy, constructed to minimize oil discharge during operation, and to exclude air and water after it opens. It must be equipped with a metal semaphore-type visual indicator and an alarm contact suitable for operation on a 125 V dc ungrounded circuit. The pressure relief device must have an oil-directed cover.

2.11.7.2 Oil Discharge Piping

Provide metal oil discharge piping for directing the oil discharged from the pressure relief device to the base of each transformer tank, of metal construction and sized to match the discharge outlet of the pressure relief device. The discharge piping must extend to approximately 24-inches above the base of the transformer, with mounting supports to the transformer tanks not spaced more than 36 inches apart, and the piping

outlet provided with a screen with a maximum hole size of 1/8-inch to discourage entry by animals, birds, and insects. The manufacturing details of the oil discharge piping must be included in the manufacturer's shop drawings.

2.11.8 Gas and Oil Actuated Relay (Buchholz)

If providing a conservator tank system of oil preservation, each transformer must be provided with a gas and oil actuated relay (Buchholz relay) located in the pipe connecting each transformer tank to the constant-pressure, reservoir tank. The relay must conform to the requirements in this paragraph. Pipe-work must be so arranged that all gas arising from the transformers must pass into the relay, and the size and arrangement of pipe-work must conform with the recommendations of the relay manufacturer. A flanged, flexible section of oil pipe must be provided between the Buchholz relay and the transformer tanks. The relay must have the following features:

a. The relay must be manufactured of a corrosion-resistant, oil-tight alloy casting, have flanged housing connections, and must have graduated inspection glass windows that enable the volume of gas and the contact system to be inspected.

b. Two floats (one for gas accumulation and one for low oil level) and one flap with counterbalance weight for the detection of oil speed.

c. A push-button for testing the relay electric circuits.

d. A pneumatic test device.

e. The relay must have independent alarm contacts wired back to the transformer control cabinets that close on collection of gas or at low oil level, and contacts that close following an oil surge. Mercury-based contacts will not be acceptable. The normally-open, electrically separate alarm and tripping contacts must not be exposed to oil, and must have a rated nominal current of 2A a.c./d.c. and a rated nominal voltage of 240V a.c./d.c.

f. Operation of the relay must be immune to seismic disturbances.

2.11.9 De-Energized Tap Changer Control

Provide each transformer with an external, manually operated tap changer for changing connections to the taps in the high-voltage windings when the transformers are de-energized. The tap changer control must have the following features:

a. Include an operating hand wheel, indicating pointer and dial, and means for locking the tap changer in any desired tap position.

b. The operating hand wheel must be mechanically interlocked with the tap mechanism to prevent its removal when the mechanism is not in a completed tap position.

c. Transmission of motion from the operating hand wheel shaft to taps by interaction of rigid members.

d. The tap changing mechanism must render it impossible to leave a winding open or short circuited when the operating wheel is placed in

a locked position.

2.11.10 Contacts and Devices

The contacts of all relays, gages, and thermometers must be insulated from ground and must be of a positive snap-action type. Alarm contacts must be suitable for operation on 125 V dc ungrounded circuits and rated 0.5 amperes (resistive) at 125 V dc.

2.12 INSULATING OIL

2.12.1 Quantity and Transformer Oil Certification

Provide all the oil required to fill the transformers to the proper operating levels at Little Goose as well as the oil required for factory tests. Submit for approval the transformer oil certification documents prior to prior to the factory tests and delivery of the transformer oil to the Little Goose Lock & Dam "Storage Yard", indicating that the oil furnished for placing the transformers in service will meet the requirements specified below.

2.12.2 Type of Oil

The grade of insulating oil furnished must be unused, produced from a naphthenic base crude petroleum specifically prepared and refined for use in electrical equipment as an insulating and cooling medium. Paraffinic and paraffinic-blends are not acceptable. Except for the oxidation inhibitor, the insulating oil must be free from additives of every kind, either natural or synthetic in any quantity, such as silicone or ester oil contamination from hoses or processing equipment.

2.12.3 Chemical, Physical and Electrical Characteristics

The insulating oil provided must have all tests performed per the requirements of ASTM D3487, Table 1, Type II, with an oxidation inhibitor content of between 0.25 and 0.30 percent by mass, prior to shipment.

2.12.4 Sampling

Samples for testing must be obtained as specified in ASTM D923.

2.12.5 Testing

Chemical, physical, and electrical tests must be conducted by the Contractor in accordance with the test methods listed in ASTM D3487, Table 1. A PDF copy of the test reports must be submitted for approval prior to shipment of the oil.

2.13 OIL PRESERVATION SYSTEM

2.13.1 General

Provide transformers with either an inert-gas pressure system or a constant oil pressure system. Any oil preservation system provided must meeting the dimensional requirements shown in the Contract drawings.

2.13.2 Inert-Gas Pressure System

2.13.2.1 General

An inert-gas pressure system is the preferred oil preservation system. If the transformers are provided with an inert-gas pressure system, the system must conform to all the requirements listed in section "Inert-Gas Pressure System." The system must consist of a nitrogen cylinder regulator enclosure that holds two cylinders, one of which is connected to the single regulator and supplies the blanket space and all associated stainless-steel piping and two 1/2-inch stainless-steel ball valves located at the top of the tank for connection of the nitrogen piping. The nitrogen gas must be supplied from the high-pressure cylinders through a pressure regulator, conforming to the requirements of IEEE C57.12.00 paragraph 6.6.3. Two cylinders of nitrogen gas must be furnished with the transformer for use with the regulating equipment and must remain the property of the Government.

2.13.2.2 Additional Gas Space

Use the vacuum bracing, and, if required, an additional external gas expansion tank to implement the inert-gas pressure system.

2.13.2.3 Pressure Regulating Equipment

The pressure regulator must be of a make and type which has been in successful operation with transformers for a period of not less than five years. All fittings and tubing for nitrogen connections between the pressure regulating equipment and transformer tanks must be furnished with the transformer, and must be stainless steel flex tubing manufactured at the correct length for the routing and application with integral screw-on fittings, and matching terminations. The tubing must be anchored to the transformer tanks along its length a maximum of every 36-inches. The pressure regulating equipment must maintain the transformers' nitrogen pressure as follows:

a. Low pressure regulator: 0.5 psi

b. High pressure regulator: 5.0 psi

c. Pressure relief valve: 6.5 psi

2.13.2.4 Alarm functions

Alarm contacts suitable for use on a 125 V dc ungrounded circuit, wired back to the control cabinet to indicate the following:

a. Empty cylinder alarm: 200 psi

b. Low pressure alarm: 0.25 psi

c. High pressure alarm: 8.5 psi

2.13.2.5 Enclosure

A NEMA 3R rated steel enclosure mounted as low as possible on the transformer tanks containing the gas cylinders and pressure regulating equipment, meeting the requirements of NEMA 250 with the following features:

a. A gasketed window permitting viewing of the gauges without opening the door.

b. A removable stainless steel floor with a 'lipless' threshold.

c. A means for locking of the door.

d. A door activated light.

e. A thermostatically controlled heater.

f. A GFCI outlet.

g. The enclosure must be grounded to the transformer tanks by means of a bonding jumper.

2.13.3 Air Cell, Constant-Pressure, Reservoir Tank System

2.13.3.1 General

If the transformers are provided with a conservator tank system of oil preservation, the system must conform to all the requirements listed in section "Air Cell, Constant-Pressure, Reservoir Tank System." The system must consist of one oil reservoir mounted on the transformer tanks, with the location and height coordinated with the high-voltage bushing turrets. The dimensions of the transformers must fit within the dimensional requirements shown in the Contract drawings. The tank must also meet all electrical clearances as required in IEEE 1427 from the high voltage equipment when installed in place. The reservoir tank must be designed for full vacuum during vacuum treatment and oil-filling, with valves provided for equalizing the pressure to the air bladder during these processes. The reservoir must be provided with a sump chamber to collect any impurities, and a minimum of two locations within the tank for suspending the air bladder, other than the flanged air vent connection. The reservoir liquid level indicator must be arranged to close the set of low-level alarm contacts when the oil level becomes too low or the air bladder sinks.

2.13.3.2 Air Bladder

The oil reservoir must contain an air bladder arranged to prevent direct contact between the oil and air. The air bladder material must be nylon-impregnated nitrile rubber designed for long life and for service in contact with hot oil, and must include a minimum of two integral straps used for suspending the air bladder from the inside top of the reservoir tank. The air bladder must be vented through a weather-tight maintenance-free electronic dehydrating breather provided with a suitable desiccant. Dimensions and drawings of the air bladder must be included in the descriptive data.

2.13.3.3 Dehydrating Breather

Provide one maintenance-free dehydrating breather for each conservator tank, utilized for removing atmospheric moisture from the air drawn into the reservoir tank air bladder, must be located on the transformer tanks at a height of approximately 48 inches above the base of the transformers. The hygroscopicity must be based upon a silica gel and sensor-controlled heated high-grade steel filter. During normal

operation, the silica gel dries the air entering the piping to the reservoir tank. When the relative humidity exceeds a selected value, the self-regulating heating element inside the dehydrating breather is activated, and extracts moisture from the silica gel, which condenses and drips out of the filter system. The vent piping connecting the oil reservoir air bladder to the maintenance free dehydrating breather must be metal, of 1-1/2-inch minimum diameter, and galvanized inside and out to help reduce corrosion. Provide a maintenance free dehydrating breather with the following characteristics:

a. Visual sight inspection glass.

b. Sealed control housing suitable for outdoor operation.

c. Designed for ambient temperature operation between -40 and 80 degrees C.

d. Status indicators for Power On, Heater On, and Device Malfunction, with one normally closed contact for Device Malfunction annunciation.

e. Supply voltage of 120 V AC - 240 V AC, 60 Hz

f. Filter heating system

g. Test button

h. Analog output: 4-20 mA

2.14 TRANSFORMER CONTROL AND POWER CABINETS

2.14.1 General

Provide the transformers with control and power cabinets, mounted on the transformer Segment 3 tank sidewall, as indicated. The fabrication of each cabinet must conform to the requirements of UL 508, UL 508A, and NEMA 250. The cabinets must be manufactured such that all 480 V ac wiring and equipment reside only in the power cabinet, and the control cabinet only includes wiring and equipment at maximum operating voltages of 125 V dc or 120 V ac. The cabinets must have the following features:

a. Environmental enclosure rating of NEMA Type 4.

b. Fabricated out of type 304 stainless steel that will remain unpainted on the exterior.

c. No. 12 Manufacturer's Standard Gage minimum thickness.

d. Rainproof enclosure vents of NEMA Type 3R construction, installed on the control cabinet enclosure back panel.

e. Bundled wire runs within the cabinet, routed through low-smoke, halogen-free wiring duct with slotted walls and interior corner guards to protect the wiring.

f. "Piano-hinges" will not be acceptable for cabinet doors.

g. Cabinet interiors powder-coated white.

h. Solar shielding provided on the top, front and side panels of the

enclosures, with cut-outs as required for the enclosure door viewing windows.

i. Door handles provided with provisions for locking, with all doors keyed the same.

j. Ground bonding jumper from each cabinet to the main transformer tanks.

2.14.2 Cabinet Mounting and Conduit Interface Provisions

The control and power cabinets must be configured as indicated on the contract drawings. A structural steel framework must be provided for mounting of the control and power cabinet assemblies to the transformer tanks' cabinet mounting frame rails, utilizing vibration isolation mounts. The vibration isolation mounts must be natural rubber with integral mounting stud provisions, sized for the maximum anticipated load of the cabinet assembly, and be a standard commercially available product for the purpose. Removable, gasketed plates must be provided in the bottom of the control and power cabinets, to which the external conduit connections to the Project will be installed. All wire and cable entering the control and power cabinets must be through conduit, and all conduit connections to the cabinets made through the base bottom plate of the cabinets.

2.14.3 Control Cabinet Requirements

Provide control cabinets with device layouts must be as indicated on contract drawings, and have the following features:

a. Devices mounted on the back of hinged panel doors that are not visible from the panel door fronts mounted such that device mounting screws do not penetrate the panel doors.

b. Provide windows in the control cabinet doors made of tempered glass, utilizing Claytonrite style rubber seals installed with silicone sealant so as to provide a waterproof installation.

c. Provide a 2-inch diameter wiring access hole between the power and control cabinets near the base of the cabinets, with protective bushings, for the routing of 120 V ac power from the control cabinet to the power cabinet for heaters and lights, and the permissive wiring to fan contactors.

d. Provide terminal blocks and wiring layouts such that all wiring for interconnection to the Project are located in the same vicinity near the base of the cabinet.

e. Provide two internal swing-panels for future installation of the transformers temperature monitor controls and annunciators.

f. Provide a 90-degree hinged, fold-down computer tray on the inside of the control cabinet door, with a means of securing the tray in the upright position.

2.14.4 Power Cabinet Requirements

Provide all 480 V ac protective and control equipment for the cooling fans, including the molded-case circuit breakers, contactors, and power

terminal blocks in each transformer's power cabinet, as indicated, conforming to the applicable requirements of NEMA ICS 2. The 480 V ac Government power supply will route through conduit connected directly from the Project to the base of the power cabinet, as indicated on contract drawings.

2.14.5 Device Nameplates

Provide an engraved nameplate for each item mounted in the transformer control and power cabinets that are comprised of anodized aluminum or stainless steel, engraved and provided with black lettering. Each nameplate must be fastened to the panels in proper locations, with either corrosion-resistant black finished round head screws, or on screw posts with corrosion-resistant black finished nuts. Nameplates must not be fastened to the wire ducts or duct covers. Labeling and marking must meet the requirements of UL 969, paragraph 7.3, "Marking and labeling systems for hazardous locations products".

2.15 CONTROL AND POWER CABINET EQUIPMENT

2.15.1 Cooling Control Equipment

2.15.1.1 General

The control equipment must be fully automatic, and manufactured to start and stop the fan motors as each transformer's winding temperature requires. The controls must de-energize all fans in the event of a transformer shutdown operation, as indicated. Provide additional circuit breakers for branch circuit protection of cooling circuits as required. All cooling control equipment must meet the applicable requirements of the NFPA 70.

2.15.1.2 Stages of Cooling

The cooling control circuits must provide for the following:

a. Provide transformers that are-self cooled through natural convection of the oil with no cooling fans in operation, capable of operation at the 100% base nameplate rating (ONAN) without exceeding the maximum allowable temperature rise.

b. Provide a winding temperature indicator fan contacts to activate the forced-air cooling group when the transformers are operating at a winding temperature corresponding to a load equal to the 100% self-cooled (ONAN) rated condition, as obtained during performance of the factory temperature rise testing.

c. When the maximum safe winding temperature for continuous operation has been reached, the winding temperature indicator alarm contact must provide an alarm for "Winding High Temperature" indication. This winding temperature setting must be at 110 degrees-C.

d. When the maximum allowable winding temperature has been reached, the analog winding temperature indicator must initiate a transformer shutdown utilizing the lockout relay in the powerhouse and set at a temperature of 117 degrees-C.

2.15.2 Transformer Fiber Optic Probes and Connectors

Fiber optic probes must be installed in each transformer's windings and terminated at the fiber-optic feed-through plate interface on the tank for future use with a temperature monitor. The fiber-optic probes must be made of non-conducting materials allowing for them to be immersed in oil and held in close contact to transformer windings for direct accurate measurement of temperature. The probes, connectors and their installation must meet the following requirements:

a. The probes must function based on the principles of Gallium Arsenide (GaAs), be capable of measuring transformer temperatures from -40 degrees Celsius to 200 degrees Celsius.

b. The fiber-optic jacket must feature a continuous slit to allow for complete oil immersion.

c. Utilize Fiber-optic feed-thru connectors at a tank wall plate, for connection of the internal fiber-optic probes to the fiber-optic extension cabling.

d. Feed-through connectors with internal sealing using glass metal soldering.

e. Stainless steel tank wall plate interface for the feed-thru connectors, including a removable, weatherproof cover.

f. Provide 2-inch conduit from the feed-through wall plate interface down to the control cabinets for routing of fiber-optic extension cables.

g. Provide the necessary extension cables from the wall plate to the control cabinets.

2.15.3 Auxiliary Power Transformer

The auxiliary power transformer must be 480 V AC primary - 120 V AC secondary, single-phase, conforming to the requirements for general purpose transformers in UL 508, and must be mounted on the transformer tanks adjacent to the power cabinet, as indicated. The auxiliary transformer will be used to power all AC circuits rated below 480 VAC as indicated. The Volt-Ampere capacity must be coordinated with the connected control circuits, and indicated on the shop drawings. The auxiliary power transformer must have the following characteristics:

a. Isolating transformer design, with an electrostatic shield

b. Housed in a NEMA Type 3R rated enclosure

c. Manufactured with all copper windings with a 200 degrees-C rated insulation system

d. Finger-safe terminals

2.15.4 Magnetic Contactors

The rating, performance and service characteristics must conform to the requirements of NEMA ICS 2 for contactors with continuous current ratings for the duty indicated. Contactors for motor control must be rated for

full-voltage starting (Class A controllers). Provide NEMA Size 2 contactors as a minimum, and must be rated for at least 200,000 complete operations under rated load without more than routine maintenance. The interruption arc and flame must be minimized by suitable arc chutes or other means so that no damage will be done to other portions of the device. The arc chutes, if provided, must be easily removable without removing or dismantling other parts. The contacts must be easily removable. All current-carrying contact surfaces must be silver-surfaced or of other approved material to prevent the formation of high resistance oxides. The contactor must operate without chatter or perceptible hum while energized. Coils must be rated for continuous operation for 120 V ac circuits. Alternating-current contactors must be three-pole, except where otherwise noted, and must be insulated for 600 V ac and of the electrically-operated, magnetically-held type.

2.15.5 Molded-Case Circuit Breakers

2.15.5.1 General

Provide Molded case circuit breakers that are listed to UL 489, and have voltage ratings and interrupting ratings hereinafter stated. They must be the manually-operated, quick-make, quick-break, automatic-trip, bolt-in, heavy-duty, industrial type. All poles of each breaker must be operated simultaneously by means of a common handle, and must be enclosed in a common molded plastic case. Single pole trip units with handle ties are not permitted. The operating handles must clearly indicate whether the breakers are in "On," "Off," or "Tripped" position. Miniature circuit breakers, circuit breakers listed for residential and commercial use, and plug-in type breakers are not acceptable.

2.15.5.2 Trip Units

The circuit breakers must be of the automatic type provided with combination thermal and instantaneous magnetic or solid state trip units, with instantaneous trip units set at approximately 10 times the continuous ratings of the circuit breakers. The Government reserves the right to change the indicated trip ratings, within frame limits, of the trip devices at the time the shop drawings are submitted for approval.

2.15.5.3 480 V ac Circuits

Circuit breakers for 480 V ac circuits must be rated 600 V ac, must have a minimum interrupting capacity of 18,000 Amperes at 480 V ac, and must come equipped with an integrated trip-handle padlocking provision.

2.15.5.4 120 V ac Circuits

Circuit breakers for 120 V ac circuits, must be rated not less than 250 V dc, and either 120/240 or 240 V ac, with a minimum NEMA interrupting capacity of 10,000 Amperes symmetrical.

2.15.5.5 125 V dc Circuits

Circuit breakers for 125 V dc circuits must be of the heavy duty type conforming to the applicable requirements of UL 489, rated for not less than 125/250 or 250 V dc operation with a minimum NEMA interrupting capacity of 10,000 A dc.

2.15.6 Control and Instrument Switches

Control and instrument switches must be of the rotary switchboard type with handles on the front and the operating mechanisms on the rear of the panels, and have the following features:

a. Suitable for operation on 600 V ac or 250 V dc circuits, capable of satisfactorily withstanding a life test of at least 10,000 operations at rated current, and capable of continuously carrying 20 Amperes without exceeding a temperature rise of more than 30 degrees Celsius above ambient.

b. Provided with ample contact stages to perform the functions of the control system.

c. Self-aligning contacts which operate with a wiping action.

d. A positive means of maintaining high-pressure on closed contacts.

e. Compression springs or pivoted joints must not be depended upon to carry current.

f. The covers or plates on the switches must be readily removable for inspection of contacts.

g. A single-breaking inductive load minimum interrupting rating of 1.5 Amperes for 125 V dc, or 10 Amperes for 120 V ac.

h. An escutcheon clearly marked to show each operating position, with the switch identifications engraved on the escutcheon plate and on a separate nameplate.

2.15.7 Terminal Blocks

Provide terminal blocks for control signal and current transformer secondaries with the following features:

a. Washer-head screw type, designed for connection of two No. 10 AWG conductors to each terminal.

b. Rated, at minimum, for 90 degree C terminations.

c. White or other light colored marking strips for circuit designation, with each connected terminal of each block having the circuit designation or wire number indicated on the marking strip with permanent marking fluid. One reversible or spare marking strip must be furnished with each terminal block.

d. Terminal blocks provided to terminate all external cables, containing at least two spare terminals, or 10 percent of total terminals as spares, whichever is greater, per terminal block.

2.15.7.1 Control Signal Type

Provide terminal blocks for control wiring, with a sliding link disconnect molded or fabricated type with barriers, rated not less than 600 volts with 30 Ampere capacity.

2.15.7.2 Short-Circuiting Type

Provide dedicated short-circuiting type terminal blocks for each current transformer's secondary leads, which will allow for shorting together the secondary leads of the current transformers without opening any circuit.

2.15.7.3 Power Distribution Blocks

Provide power distribution blocks to be used for branch circuits and feeders 600 volts and less with wire size #12 AWG and larger. Power distribution blocks must have lugs suitable for copper conductors, must be two-pole for single-phase circuits (phase and neutral conductors, or two phase conductors), and three-pole for three-phase circuits (three phase conductors).

2.15.8 Fuses and Fuseholders

Provide Class J fuses meeting the requirements of UL 248-8, rated for 600 V AC operation, and be dual-element with a 10 second time-delay at 500 percent overload. Provide Class J fuseholders, meeting the requirements of UL 4248-8, and be of a finger-safe modular type, consisting of a removable fuse carrier which allows fuse replacement away from the base.

2.15.9 Lighting, Convenience Receptacle, and Cabinet Heaters

Provide cabinet lighting, convenience receptacle and heaters that have the following features:

a. Lighting consisting of 120 V ac Size A19 LED bulbs with a medium E26 base, each with integral heat sink and 800 Lumens minimum output, complete with industrial grade socket with bulb safety cage, wiring, and door-activated switches.

b. Provide a 125 V ac, 3-wire, 20 Ampere, hospital grade GFCI type receptacle, inside the control cabinet.

c. Provide industrial grade enclosure heaters in each cabinet to prevent condensation when the outside temperature is as low as -25 degrees Celsius, while maintaining a minimum interior cabinet temperature of 10 degrees Celsius. The enclosure heaters must be mounted on the cabinet side panels towards the bottom, and be of a touch-safe, positive temperature coefficient (PTC) resistor type with an integral fan. The heaters must have a rated operating voltage of 120 V ac, and be thermally sized for the cabinet volume in which they are installed. Submit for approval the Cabinet heater sizing calculations, with considerations given to cabinet sizing and material. Provide a separate humidity and temperature control device which controls the cabinet heaters and independently monitors the relative humidity and enclosure temperature, having the following characteristics:

1) Temperature setting range: 0C - 60C
2) Relative humidity setting range: 50% - 90%
3) Operating voltage: 100 VAC - 240 VAC
4) Switching relay output (minimum): 10A resistive, 1.6A inductive @ 240 VAC
5) Inrush current (minimum): 30A for 10 sec
6) Heaters set at 20 C
7) Humidistat set to 20% relative humidity

2.16 INSULATED WIRE AND CABLE

Provide all insulated wire and cable that conforms to the requirements of Section 26 05 19.00 26 INSULATED WIRE AND CABLE.

2.17 CONDUIT SYSTEMS

2.17.1 General

Run all wiring from the transformer devices and accessories listed below in rigid galvanized steel conduit greater than 1-inch in diameter, installed plumb and level, and terminated at devices, connection boxes and at the control cabinet using fittings suitable for wet locations. Conduit runs used on the transformer tanks' cover must be installed so as to help maintain an obstruction-free walking surface. The conduit systems must be electrically continuous and all threaded joints must have the threads coated with an approved high temperature lithium based, anti-galling conductive joint compound, rated for -70 degrees-C 1800 degrees-C, such as Crouse-Hinds Type HTL high temperature thread lubricant. The use of PTFE (polytetrafluoroethylene) tape at conduit threaded joint connections will not be allowed. Conduit threads must be tapered, and no running threads will be allowed. Conduit runs must be deburred and cleaned of shavings and debris prior to the routing of wire and cable.

2.17.2 Corrosion Protection

Provide conduit, conduit fittings, conduit bodies, and conduit outlet boxes made of ferrous metal materials that is hot-dip galvanized in accordance with ASTM A123/A123M and ASTM A153/A153M.

2.17.3 Conduit and Fittings

a. Rigid Metal Conduit. Provide rigid metal conduit that is zinc-coated both inside and outside by the hot-dip galvanizing method, conforming to the requirements of ANSI C80.1.

b. Rigid Metal Conduit Fittings. Provide threaded fittings for rigid conduit that is made of solid zinc or malleable iron conforming to the requirements of UL 514B and/or NEMA FB 1. Malleable iron fittings must be zinc-coated both inside and outside by hot-dip galvanizing method, with hubs having a grounding screw on the locknut.

c. Liquid-Tight Flexible Metal Conduit. Provide liquid-tight flexible metal conduit that is made from steel strip that is zinc-coated by the hot-dip galvanizing method with a water-proof extruded PVC cover conforming to the requirements of UL 360. The liquid-tight flexible metal conduit must have either have an integral bond wire or be an interlocked design with no bonding wire. Lengths of liquid-tight flexible metal conduit connections to equipment must not exceed 36-inches, and must be securely fastened to the transformer tanks.

d. Liquid-Tight Flexible Metal Conduit Fittings. Provide fittings for liquid-tight flexible metal conduit that is made from steel or malleable iron with a zinc coating and positive bonding, conforming to the requirements of UL 514B.

2.17.4 Conduit Bodies

provide conduit bodies and covers that meet the following requirements:

a. Be made from malleable cast iron, be corrosion resistant and UL listed.

b. For the purposes of mechanical and environmental integrity, all conduit bodies must be raintight and suitable for use in hazardous locations, conforming to UL 1203 installed in outdoor locations subject to adverse environmental conditions.

c. Conduit body covers must attach to the conduit bodies by screw connections and neoprene gaskets.

d. Provide conduit bodies for use in locations to provide for change in conduit direction, access to conductors, and as pull boxes.

2.17.5 Conduit Outlet Boxes

Provide conduit outlet boxes and covers that meet the following requirements:

a. Be made from malleable cast iron, be corrosion resistant and UL listed.

b. For the purposes of mechanical and environmental integrity, all conduit outlet boxes must be raintight and suitable for use in hazardous locations, conforming to UL 1203 installed in outdoor locations subject to adverse environmental conditions.

c. Provide conduit outlet boxes and covers made from malleable cast iron with externally threaded body and internally threaded cover. All conduit entrances must be bossed, drilled, and tapped with tapered NPT threads. Conduit entrances must be located on the bottom or sides of the box to the greatest extent possible to prevent the ingress of water. If required, outlet and junction boxes must be equipped with external mounting lugs.

2.18 SPARE PARTS

Provide all spare parts that are duplicates of the original parts furnished and interchangeable therewith. Furnish the following spare parts, and submit for approval a spare parts list, indicating the quantity furnished, manufacturer, catalog or model number, and the retail cost of each item in US Dollars.

a. One complete set of all gaskets needed to seal all openings into the transformer tanks at the cover, manholes, handholes, openings for accessory devices, openings for each type bushing, and pipe connections for radiators.

b. One complete set of all gaskets required to replace the shipping gaskets, for use during final assembly of the transformer.

c. One complete relay and contactor of each type and rating

d. One pressure relief device (Qty. 1)

e. One liquid level indicator (Qty. 1)

f. One winding temperature indicator (Qty. 1)

g. One oil temperature indicator (Qty. 1)

h. One bushing current transformer, of each type and rating

i. One rapid pressure rise relay and seal in relay (Qty 1)

j. Two fans, complete with motors, cables and connections (Qty. 2)

k. One crated radiator complete with inlet and outlet isolating valves, vent and drain valves, and blank flanges (Qty. 1)

l. Three fiber-optic extension cables that connect from the feed-through wall plate to the control cabinet (Qty. 3)

m. One fuse of each type and rating

n. One pressure regulator for nitrogen-gas equipment (Qty. 1) (if supplying nitrogen blanket type oil preservation system)

o. One Buchholz Relay (Qty.1) (if supplying a COPS type oil Preservation system)

p. One spare valve of each type and size

2.19 NAMEPLATES

Transformer nameplates must be Type 316 stainless steel, with the information chemically etched then filled with baked enamel paint.

2.19.1 Transformer Nameplate

Each transformer nameplate must conform to the requirements of IEEE C57.12.00, Table 6, and also include the following information:

a. Government contract number

b. Transformer X/R ratio

c. Estimated weight of the insulation system

d. The nameplate or an adjacent nameplate must also include the following information for each current transformer furnished: the accuracy class, the primary and all secondary ampere ratings, the thermal rating, and identification of the terminals to which the current rating applies.

2.19.2 Lifting Nameplate

Provide a lifting diagram nameplate mounted on each transformer, adjacent to the transformer nameplate showing the following:

a. Various sling and lift positions required for proper lifting of the core and coil assembly.

b. Lifting or jacking the completely assembled transformer.

c. The overall height required for untanking.

d. Indication that the transformers can be lifted or jacked when filled with oil.

2.19.3 Device Nameplates

Provide nameplates for the following devices that are mounted on each transformer. The nameplate must be permanently affixed onto a bracket adjacent to the device.

a. High-voltage bushings (H1, H0)

b. Low-voltage bushings (X & Y)

c. Core ground bushings

d. Center of gravity markers

e. Winding temperature indicator

f. Oil temperature indicator

g. Thermowells

h. Valves

2.19.4 Additional Transformer Identification

Provide the following additional transformer identification for each transformer:

a. The transformer serial number welded onto the tank, or on the face of the jacking pad nearest the main drain valve, with letters approximately 1-inch in size.

b. The location of the centers of gravity (c.g.) of the completely assembled transformer filled with oil, and for the shipping configuration without oil, permanently marked with weld-on nameplates or tags on two adjacent sides of the transformer tank and identified "c.g. complete" and "c.g. for shipment".

c. Stamping of the serial number on the core frame structure or into the tank immediately adjacent to the transformer nameplate.

d. If the oil level gauge is mounted on the tank sidewall, the 25 degree-C operational oil level must be indicated by either a raised surface weld bead with contrasting paint color, or with an etched nameplate permanently affixed to the tank wall.

PART 3 EXECUTION

3.1 TRANSFORMER DESIGN DATA REVIEW MEETING

3.1.1 General

Conduct a transformer design data review meeting at the transformer manufacturing facility, with representatives of the Contractor,

transformer manufacturer, and the Government representative in attendance, not later than 120 days after contract award. Provide the notification of the date of the transformer design data review meeting, the location, the duration, and the proposed agenda. Notification must be no less than 30 days in advance for domestic travel in the US and 60 days in advance for travel outside the continental US. The intent of the design data review meeting is to:

a. Meet with the manufacturing personnel and tour the manufacturing facility.

b. Discuss the technical specifications which address transformer manufacturing, testing, and shipment.

c. Perform a design data review with transformer manufacturing engineers and key personnel.

3.1.2 Design Data Review Meeting Requirements

The purpose of the design data review portion of the meeting is to help assure prior to official submittals that the key elements of the transformer specification requirements are being met, and to describe the transformer manufacturing and design data features. In preparation for the design data review meeting, the transformer manufacturer must have prepared a transformer design data review report in PDF format for the transformer design, which includes the following elements as a minimum:

a. Transformer nameplate data and ratings

b. Preliminary transformer layout drawing

c. Winding connection diagram

d. Winding design information, including:

(1) Proposed winding material supplier.
(2) Winding manufacturing details, including the turn design, dimensions and weight.
(3) Block diagram of the winding arrangement.
(4) Conductor type
(5) Insulation type
(6) Tabular listing of the calculated and maximum allowable voltage stresses within the windings for chopped-wave and full-wave conditions, including the factory design factor of safety margins.
(7) Block diagram of the windings indicating the various voltage stresses.
(8) Calculated resistance (@ 85 degrees-C reference)
(9) Drying and clamping methods.
(10) Design features added to assure reliable operation in back feed mode.

e. Thermal calculations and distribution throughout the windings, including proposed locations for the fiber-optic temperature probes.

f. Core design information, including:

(1) Proposed core lamination steel supplier
(2) Core manufacturing details, including the number of limbs,

dimensions and weights
(3) Core material type
(4) Joint construction
(5) Banding
(6) Acceptable gap/burrs
(7) Cooling ducts
(8) Rated flux density
(9) Calculated exciting current

g. Calculated short-circuit currents and forces

h. Loss calculations

i. Impedance calculations

j. Accessories, including:

(1) Bushings
(2) Cooling equipment
(3) De-energized tap changer

3.2 TRANSFORMER DRAWINGS

3.2.1 Outline and Assembly Drawings

Submit for approval the transformer outline and assembly drawings to demonstrate that the equipment will conform to the requirements and intent of the specifications, to include the following at a minimum:

a. Transformer nameplate information, for both the main and lifting nameplates as required in paragraph "NAMEPLATES".

b. Outline drawings, indicating the following:

(1) Layout and dimensions of the assembled transformer, including an elevation view for each side of the transformer, a plan view, and details of the tank structural base with the centers of gravity indicated with the transformer empty and filled with oil.

(2) Jacking, lifting and pulling-eye locations.

(3) Locations of all ancillary equipment, dimensioned to the transformer centerlines or edges, as appropriate, including bushings, control and power cabinets, valves, gauges, relays, nitrogen regulator cabinet or conservator tank, radiators and fans, and grounding pads.

(4) Drawing legend and transformer weight information.

(5) A transformer elevation view indicating clearances required for untanking or disassembling.

(6) Information for the transformer oil levels, including: the minimum oil level in the tank without exposing the core and coil assembly, and the corresponding volume of oil to remove at 25 degrees Celsius; the maximum oil level in the tank to allow access to any bottom connected bushings utilizing handhole access covers, and the corresponding volume of oil to remove at 25 degrees Celsius.

c. Transformer winding layout and configuration diagram, consisting of a physical representation of the active assembly installed in the transformer tank, including a sectional elevation view of sufficient detail to identify the following basic features of the core/coil fabrication:

(1) Core legs
(2) High-voltage winding
(3) Low-voltage winding
(4) Winding taps
(5) De-energized tap changer and lead support structure
(6) Bushing configuration and connections
(7) Shielding (if present)
(8) Pressboard
(9) Tank wall surface

d. Control and power cabinets layout, including internal device layouts and component lists.

e. Electrical schematic diagrams which reference the associated detailed wiring connection diagrams, including:

(1) Cooling power schematic diagrams
(2) 120 V ac and 125 V dc control schematic diagrams
(3) Annunciation schematic diagrams
(4) Transformer accessories block schematic diagrams

f. General electrical drawings including:

(1) Wiring and ferruling methods
(2) Wire types, sizes and color coding
(3) Graphic symbols
(4) Device nameplates and marking methods

3.2.2 Detail Drawings

Submit for approval the transformer detail drawings, to include the following at a minimum:

a. Further refinement of the outline and assembly drawings, including the routing of conduit, piping, and locations of junction boxes and external devices.

b. Shipping drawing showing the outline of the transformers disassembled as required for shipment, including the following:

(1) Overall shipping dimensions, including indication of centers of gravity for the transformer in the shipping configuration. All devices remaining installed on the transformer during shipment must be indicated.

(2) Lifting details and overall height required for the slings and crane hook, including recommended sling length and ratings.

(3) Location of temporary covers for bushings, valves and control and power cabinets left installed during shipment.

(4) Method and locations for securing the transformer during

shipment.

(5) Detail indicating the method of installing the SFRA test shipping bushings, their locations, and a description of the method of bracing the winding leads to these bushings during shipment.

(6) Location of impact recorders, shipping gas pressure gauge and pressure regulator system.

(7) A note indicating the requirement for shrink-wrapping of the transformer for shipment, and the type of material used.

c. Wiring connection diagrams showing terminal block and conductor designations, including detailed control and power cabinet interconnections and device locations, based upon the actual equipment arrangement.

d. Seismic anchoring location details.

e. A transformer outline drawing indicating the locations of all gaskets on the transformer, a schedule of each gasket type and size cross-referenced to the location on the outline drawing, and a detail for each design of gasket showing the gasket dimensions, groove dimensions and compression requirements.

f. A transformer outline drawing indicating the locations of typical welds, with structural weldment details for each type of weld.

3.3 TRANSFORMER FACTORY ASSEMBLY

3.3.1 General

Each transformer must be completely assembled and adjusted at the factory, and be subjected to the manufacturer's routine shop tests and other tests as specified below. All parts and accessories must be properly match-marked and identified for ease of re-assembly after delivery to Little Goose Lock & Dam "Storage Yard". After the transformers has been completely assembled and oil-filled, the overall weight of the transformers must be measured using a load cell when lifted with a crane or moved with an air pallet, and the measured weight included in the factory test report, the as-built drawings, and on the final nameplate information.

3.3.2 Welding

3.3.2.1 General

Welding will not be accepted if the welding does not conform to the requirements of this specification, unless otherwise approved by the Government. Develop procedures for the welding all metals included in the work. Do not start welding until welding procedures, welders, and welding operators have been qualified and approved. Weld symbols must be in accordance with AWS A2.4. In all instances requiring adherence with AWS specifications, equivalent country of origin standards will also be accepted. If using equivalent country standard, welding submittals must provide table showing equivalency with AWS standards.

3.3.2.2 Welding Quality Control Plan

Before the start of tank manufacturing, submit for approval a welding quality control plan which describes the methods, equipment, and procedures utilized to ensure quality control including but not limited to material tracking, weld tracking, NDT equipment calibration, non-conformance reports, weld repair, and inspection witness points. Indicate any manufacturer specific requirements used to verify the tank is oil-tight in addition to those required herein.

3.3.2.3 Welder Qualifications

Welding operators and welders must be qualified and, as necessary, requalified for the particular type of weld to be performed. Qualification must be in accordance with AWS D1.1/D1.1M. The welder record of qualification must be submitted and approved. The Contractor must certify by name, the welders and welding operators so qualified including the date of qualification, code, and procedures under which qualified. Certification and testing of welders and operators must be performed by an independent testing company. Prior qualification may be accepted provided the welder has performed satisfactory work within the preceding three months under the code for which qualified, documentation of continuous welding in process and certification of prior qualification from an independent testing company is furnished. If at any time, the work of an operator appears questionable, such operator will be required to pass additional qualification tests to determine their ability to perform the type of welding on which they are engaged. All such additional qualification tests for welding operators and the physical tests of the welded specimens must be witnessed by the Government, unless waived in writing.

3.3.2.4 Welding Materials

Welding materials must comply with AWS specifications. Welding equipment, electrodes, welding wire, and fluxes must be capable of producing satisfactory welds when used by a qualified welder or welding operator using qualified welding procedures.

3.3.2.5 Welding Procedures

Submit for approval a complete schedule of welding procedures including certified copies of reports of test results, consisting of detailed procedure specifications for each structure to be welded, and tables or diagrams showing the procedure to be used for each required joint. Do not perform welding without an approved procedure. Applicable prequalified weld procedures in AWS D1.1/D1.1M may be submitted for approval. Weld procedures not meeting the requirements of prequalified weld procedures in AWS D1.1/D1.1M may be submitted and qualified through testing under AWS D1.1/D1.1M or ASME BPVC SEC IX. All welds must be made using low-hydrogen welding rods or electrodes/electrode-flux combinations capable of depositing weld metal with a maximum diffusible hydrogen content of 8 mL/100g (H8). If the use of other filler metals is preferred, submit for approval a written justification of why an alternative is preferred and indicate where these welds will be utilized. Perform all welding using the electric-arc method, by a process which will exclude the atmosphere from the molten metal. Submit for approval the product data on welding electrodes and rods and shielding gas. All welded joints must conform to AWS publications, or as otherwise specified or approved, and the qualification plates representing those joints must be tested in

accordance with AWS D1.1/D1.1M or AWS D1.6/D1.6M. All oil piping welds must meet the requirements of ASME B31.1.

3.3.2.6 Preheat and Interpass Temperature

Preheating must be performed as required by Section 3 of AWS D1.1/D1.1M, or as otherwise specified except that the temperature of the base metal must be at least 70 degrees Fahrenheit.

3.3.2.7 Weld Inspections, Tests and Weld Inspector Qualifications

a. All welds must be visually inspected to ensure conformance to the requirements of this specification, the appropriate section of AWS D1.1/D1.1M, and the approved welding procedure. Submit for approval the weld inspector qualifications, meeting the requirements of AWS D1.1/D1.1M and ANSI/ASNT CP-189, for the personnel responsible for inspections. Inspections must be performed visually, and during the transformer leak tests per the requirements of paragraph "Pressure Test". If the weldment is determined to be the cause of failure to pass the pressure test, the Government reserves the right to either a Non-Destructive Examination or Destructive Examination of any welds with the cost borne by the Contractor.

b. The following tests must be performed on all welds, and the results included in a Weld Inspection and Test Report:

(1) Dye penetrant test performed on all welds.

(2) Magnetic particle test performed on all lifting lug welds.

(3) Ultrasonic test performed on 25-percent of all full penetration welds.

3.3.3 Manufacturing Inspection by Government Personnel

Manufacturing inspections of each transformer may be performed by a representative of the Contracting Officer, at the option of the Government. These inspections would be performed at, but not necessarily limited to, the following manufacturing hold points:

a. Manufacturing facility inspection during the Design Data Review Meeting.

b. Weld inspection during tank manufacturing, to include dye penetrant, magnetic particle and ultrasonic testing.

c. Inspection of the windings after completed, but prior to being landed on the core. During this inspection, winding and core material bill of material information must be provided, and the materials inspected, for comparison with the manufacturer's design data to assure conformance.

d. Inspection of the completed core and coil assembly prior to tanking. Winding and core assembly drawings, including the lead support structure, must be made available during performance of these inspections.

e. Completely assembled transformers during performance of the factory acceptance tests.

3.4 FACTORY CLEANING AND PAINTING

3.4.1 General

All interiors and exteriors of the tanks, enclosures, cabinets, and other metal parts which are not galvanized or of corrosion resistant material and are exposed to oil or weather must be thoroughly cleaned and painted. Cleaning must be by degreasing and abrasive blasting or other means to remove all grease, scale, corrosion, and foreign substances. All paint must be lead-free.

3.4.2 Interior Surfaces

All interior surfaces of the main tanks must be given at least one priming coat and one finish coat of oil-resistant paint or enamel. The interior tank color must be white. After painting of the tank interiors, the surfaces must be allowed to cure for one week prior to the introduction of insulating oil.

3.4.3 Exterior Surfaces

All exterior surfaces of the transformers, except as otherwise indicated, must be given a primer and two finish coats of paint in the factory. The paint color must be Munsell 5BG 7/0.4 high gloss (ANSI No. 70 gray), per the requirements of ASTM D1535, and must consist of a polyurethane top coat over an epoxy base coat. The dry film thickness of the primer must be a minimum of 1.5 mils, and that of the top and base finish coats a minimum of 3.5 mils. At minimum, supply one gallon of primer and one gallon of the polyurethane paint, from the same batch used on the transformer, for transformer field paint repairs. All SDS information must be provided with the touch-up paint, in the English language, and included in the Operations and Maintenance Manual. With prior approval of the Contracting Officer, other comparable paint types may be used. The cover surface of the transformer tanks must have a non-slip additive added to the paint, so that the color is the same as the tank color.

3.4.4 Machined Surfaces

All machine finished or corrosion-resistant surfaces must remain unpainted, and be thoroughly cleaned, coated with a suitable, easily removed, corrosion resistant compound, and wrapped or otherwise protected from damage in shipment.

3.5 TRANSFORMER FACTORY ACCEPTANCE TESTS

3.5.1 General

Perform all routine power transformer tests as indicated in IEEE C57.12.00, Table 17 on each transformer, fully assembled with all components installed which are being provided for the final assembled transformer. In addition to the required routine tests, the following design tests and specific test requirements must be performed, unless otherwise specifically indicated. Do not perform any power transformer acceptance tests until all submittals required up to the point of factory testing have been reviewed by the Government and given an Action Code 'A' or 'B' approval. The factory acceptance tests, including test equipment, test methods, measurements, and computations, must be in accordance with the applicable requirements of IEEE C57.12.00, IEEE C57.12.80 and

IEEE C57.12.90, unless otherwise specified, and submit for approval the Factory Test Procedures. Except where otherwise specified in the Standards, all measurements and tests involving alternating voltage must be made with 60 Hz sine wave voltage. The cost of performing all tests must be borne by the Contractor and must be included in the unit prices for the items of the Schedule. The Government representative will witness all tests required herein unless waived in writing, and do not ship any transformer, or parts until it has been released for shipment by the COR. Submit the notification of the date of factory tests as follows so that arrangements can be made for the Government representative to be present at the tests:

a. **For transformer manufacturers located in the United States**, notify the COR 30 calendar days in advance of when the transformer manufacturer will be ready for factory acceptance tests, so that the tests may be witnessed by a Government Representative at the manufacturer's facility.

b. **For transformer manufacturers located in foreign countries**, notify the COR 60 calendar days in advance of when the transformer manufacturer will be ready for factory acceptance tests, so that the tests may be witnessed by a Government Representative at the manufacturer's facility.

3.5.2 Factory Acceptance Test Report

Submit for approval an electronic PDF copy of the Transformer Factory Acceptance Test Report for each transformer tested, including digital waveform printouts, data files for the SFRA, insulation power factor, and leakage reactance tests, and complete data on all tests performed. The witnessing representatives of the Contractor and the Government must sign reports of all witnessed tests. The certified test reports must include the information as listed in IEEE C57.12.00, paragraph 8.7, and include all additional required tests results with the corresponding digital waveform and color thermal imaging printouts.

3.5.3 Dissolved Gas-In-Oil Analysis

Samples of the transformer insulating oil must be taken from each transformer, and dissolved gas-in-oil analysis tests performed as indicated, herein. Identity of samples and results of analyses must be included in the certified test reports, and the results of all insulating oil tests made available for inspection by the Government representative during the transformer factory acceptance testing.

a. After oil-filling of each transformer, and prior to the performance of any transformer factory acceptance tests.

b. After performance of dielectric tests.

c. After performance of temperature rise tests at each cooling rating.

d. Eight hours after performance of all transformer factory acceptance tests, to allow any possible generated gases to fully disperse within the oil.

3.5.4 Temperature Rise Test

Perform a temperature rise test on one transformer with measurements made

at each cooling rating (ONAN, ONAF). During the temperature rise tests use temporary fiber leads and temporary multi-channel fiber-optic temperature monitor to monitor and record the temperatures on all of the embedded winding fibers. During the temperature rise tests, obtain thermal images of all parts of the transformer utilizing a color infrared camera, and include the thermal images with corresponding temperatures indicating the ambient and hottest temperatures, including loading conditions, in the transformer's factory acceptance test report. The tank wall hot-spot temperature rise must not exceed 70 degrees-C while operating at 100 percent of its forced-air cooled rating.

3.5.5 Core Insulation Resistance

In the case of a core type transformers, the transformer core insulation resistance test must be performed on each transformer at each core ground bushing, for the main core connection to ground, and the core frame connection to ground.

3.5.6 Impulse Tests

All transformer impulse tests must be completed on a winding connection (bushing) before performing tests on a different winding connection. The impulse tests must be made by direct application without 60-Hz excitation. Computer-based waveform recordings must be taken of surge voltages during all impulse tests and of neutral current during the reduced full-wave and full-wave impulse tests, with the digital waveforms adjusted to give the same deflection on reduced-voltage and full-voltage impulse waves to facilitate comparison. Comparisons must also be made of the consecutive chopped-wave impulse waveforms. Waveform comparisons must be printed, and provided in the certified test report. Any deviation in voltage or neutral current wave shape between reduced-voltage and full-voltage full-wave tests, must be explained to the satisfaction of the COR or it may be considered cause for rejection of the transformer.

3.5.7 Induced Voltage Test With Partial Discharge Measurements

3.5.7.1 General

Partial discharge measurements during the induced voltage test must be per the requirements of IEEE C57.12.90, paragraph 10.8, and IEEE C57.113. It is recognized that sizable partial discharge readings during tests are likely to occur from causes external to the transformer, such as partial discharge in the high-voltage test circuit, noise from shop equipment, other tests being performed, and radiation or induction pickup through air between the measuring circuit and the high-voltage test equipment. All reasonable precautions must be taken to minimize such external interference, and if necessary, the manufacturer must demonstrate that this partial discharge is not internal to the transformer. It is permissible to utilize special bushing corona shields during performance of the tests.

3.5.7.2 7,200 Cycle Enhancement Level

During the 7,200-cycle test, the partial discharge level, excluding background noise, must not exceed 500 pico-coulombs. Any variation in corona intensity before and after application of full 7,200-cycle test voltage must be explained to the satisfaction of the Contracting Officer.

3.5.7.3 One-Hour Level

During the one-hour test, the partial discharge level must not exceed 300 pico-coulombs, and the increase in partial discharge levels must not exceed 100 pico-coulombs.

3.5.7.4 Data Reporting

All records, meter readings, and data taken during the above described tests, together with a diagram of the circuit employed, must be incorporated in the certified test report. The measurement of partial discharge using the apparent charge (pico-coulomb) method must be performed during the induced voltage test, and the measurements included with the test report.

3.5.8 Audible Sound Level Test

Perform an audible sound level test and it must not exceed the manufacturer's guaranteed sound level included in the proposal documents. The sound level tests must be performed at the ONAN rating, and at the ONAF rating with all cooling fans in operation. If the sound level exceeds the manufacturer's guaranteed level, the transformers must be modified as required to reduce the sound level and the test repeated. The abatement technique used to reduce the tested sound level to the guaranteed sound level must be subject to approval of the Contracting Officer. All data records taken during the sound level test, including a diagram of the transformer and how the measurements were taken, must be included in the certified test report. The data reporting format must be similar to that indicated in Figures 30 and 31 of IEEE C57.12.90.

3.5.9 Leak Test

Perform a leak test on each transformer tank and radiators when filled with oil. The test pressure must be a minimum of 4 psi, maintained for a minimum of 24 hours with no loss in gas pressure during the test period. The dial gauge used for this test must have a scale of 0 - 10 psi. During the pressure test, an alcohol-based industrial marking chalk, or another similar method of oil leak detection, must be applied to the tank welded seams and all gasketed connections and monitored for oil leaks. After the leak test is completed, all chalk must be cleaned off each transformer.

3.5.10 Leakage Reactance Measurement Test

Perform a leakage reactance measurement tests per the requirements of IEEE C57.152, paragraph 7.2.12, between the high-voltage winding and the low-voltage winding, for use as baseline data for future testing. Voltage, current, and phase angle measurements must be recorded, and the corresponding impedance calculated. Use standard equipment for performance of the leakage reactance test. The proposed test setup and procedures must be included in the factory test procedures submittal.

3.5.11 Sweep Frequency Response Analysis Tests

3.5.11.1 Required Tests

Perform two Sweep Frequency Response Analysis (SFRA) tests at the manufacturing facility on each transformer, per the requirements of IEEE C57.149, at the following manufacturing stages for use as baseline data for future testing and for shipping purposes.

a. After all factory tests have been performed, and while each transformer is still fully assembled and filled with oil.

b. After each transformer has been drained of oil and disassembled for shipment, and in its shipping configuration (see paragraph "SFRA Test Shipping Bushing). The test equipment and connections must be as indicated in paragraph "Test Equipment and Test Parameters", below, with the tests performed at the rated tap position.

3.5.11.2 Test Equipment and Test Parameters

Use a Sweep Frequency Response Analyzer for performance of the SFRA test. The proposed SFRA setup and procedures must be included in the factory test procedures submittal. The excitation source must be capable of providing consistent and controlled peak to peak voltage over the entire frequency range, with the test equipment parameters as follows:

a. A test voltage of 20V peak-to-peak minimum.

b. Testing performed over the 20 Hz to 2 MHz frequency range as a minimum.

c. Frequency response measurements made using a log-based scale for frequency.

d. An interference bandwidth (IBW), or equivalent, of less than 1 Hz at 10Hz used for each measurement frequency.

e. Record the magnitude of the response on a decibel (dB) scale for each measurement point.

f. The dB accuracy within 1 dB at every measurement point, using calibrated equipment.

g. A test set with a dynamic range better than 100 dB.

h. Record the phase, in degrees, for each measurement point, with an accuracy within 1 degree at every measurement point, using calibrated equipment.

i. High frequency coaxial test cables, with a 50 ohm matched impedance.

j. A three lead system, which consists of a signal, a reference and a test measurement lead.

k. All cables of the same length. A consistent ground connection should be available at the bushing end of the leads and be the same length for each cable.

l. The size and type of all temporary grounding leads identified.

3.5.11.3 Test Cable Integrity

Prior to the performance of any SFRA tests, the integrity of the test cables must be tested by a short-circuit test. Each coaxial test cable must be laid together, side-by-side on the floor, with the measurement clips connected together and the ground clips connected together. The

frequency response of the test cables when connected in this fashion should be "flat", with the exception of a gradual "roll-off" above 100 kHz due to pre-fitted cable grounds, and any variation could indicate damage within the coaxial cables. Any anomalies in the cable test results must be brought to the attention of the COR.

3.5.11.4 Test Connections

During performance of the SFRA tests, the test coaxial cables must be directly connected to the transformer bushings. For tall bushings, ground jumpers may be used to facilitate connection of the coaxial cable ground shield to the base of the bushing. All windings must be tested as indicated below, for the 'neutral' (or rated kV) tap position, and for the tap position that includes all of the windings, with each SFRA result identified by the applied and measured terminals. The SFRA tests must be per the requirements of IEEE C57.149, Table 5, Group 2, second column).

3.5.11.5 Data Reporting

Test equipment must be capable of producing a test report file which is in the Extensible Markup Language (XML) format. Test data must be able to be viewed without the editing, reorganizing or reformatting of the data. A simple format of separate measurements being in separate spreadsheet columns is required. The test data must show all waveforms in graphical form with the response in linear scale dB units on the Y-axis and the Frequency in logarithmic scale Hz on the X-axis. The Y-axis must auto-scale and the X-axis must display the range from 20 Hz to 2 MHz, as a minimum. The electronic version of the test report must include the complete data on a CD in the format and organization that will permit the file to be viewed completely using standard spreadsheet software. Data reporting must meet the requirements of IEEE C57.149, paragraph 5.

3.5.11.6 Data Interpretation

SFRA testing produces traces which provides information related to the physical geometry of the test specimen. The factory SFRA tests performed creates baseline data for use in future testing, and helps in recognizing obvious manufacturing defects, such as open circuits, short circuits, and winding deformations.

3.5.12 De-Energized Tap Changer Test

Each transformers' completely assembled de-energized tap changer (DETC) must be subjected to five complete tap changing cycles (end-tap to end-tap) during the process of transformer testing to demonstrate that all linkages, contacts, and indicating mechanisms are properly assembled and aligned and free from excessive slack, deformation, or fragility.

3.5.13 Transformer Turns Ratio Test

For Each transformer perform a transformer turns ratio (TTR) test on each tap in accordance with "Ratio Tests" paragraph of IEEE C57.152 after the completion of the DETC testing.

3.5.14 Insulated Wire and Cable

Perform testing on all insulated wire and cable within each transformer's control and power cabinets, extending to all transformer mounted equipment per the requirements of SECTION 26 05 19.00 26, INSULATED WIRE AND CABLE.

3.6 BUSHING TESTS

3.6.1 General

Bushing tests must be performed in accordance with IEEE C57.19.00 and IEEE C57.19.01. Any bushing that fails to pass all tests to which it is subjected will be rejected. Provide electronic PDF copies of all bushing and bushing current transformer test reports for each transformer.

3.6.2 Bushing Design Tests

Bushing design tests must be performed on one bushing of each type provided in accordance with IEEE C57.19.00, unless these tests have previously been performed on bushings of the same manufacture, design, type, and rating as those being provided within 10 years of the date of this contract, in which case the requirements for repeating these design tests will be waived and certified copies of the test results of satisfactory tests of this kind must be furnished to the Contracting Officer. If any bushing given the impulse tests fails to pass any of the tests, than all bushings of the same type and rating must be subjected to the impulse tests at no additional cost to the Government.

3.6.3 Bushing Withstand Test Voltages

The bushings must be tested per the applicable requirements of IEEE C57.19.01, Table 1.

3.6.4 Bushing Routine Tests

Each new bushing provided must be subjected to routine tests by the bushing manufacturer in accordance with IEEE C57.19.00, Table 3. Power factor tests must be performed on each design bushing per the following requirements:

a. Perform a power factor test at 10 kV for C1. The power factor must not exceed 0.35 percent.

3.6.5 Bushing Current Transformer Tests

Provide electronic PDF copies of all bushing current transformer test data.

3.6.5.1 Routine Tests

Each bushing current transformer is to be given bushing current transformer manufacturer routine tests, including an applied voltage test, in accordance with IEEE C57.13, Annex B.8.

3.6.5.2 Tests Performed After Installation

Each current transformer is to be checked for proper nameplate and polarity markings prior to installation on the transformers, and be given a polarity and ratio check after installation and prior to the performance of the factory acceptance tests to ensure correct installation. The following bushing current transformer tests are to be performed after all other transformer acceptance tests have been completed, and the test results included in the factory acceptance test report:

a. Excitation curves for each turn ratio.

b. Ratio correction factor curves for each turn ratio.

c. The resistance of the secondary winding at 75 degrees Celsius, including the resistance of the secondary leads from the bushing current transformer to the terminal blocks in the control cabinet.

3.7 TRANSFORMER SHIPMENT, HAULING AND SITE ASSEMBLY

Each transformer and it's equipment, accessories, and spare parts must be prepared for shipment f.o.b. Little Goose Lock & Dam, transported, inspected, unloaded, moved into its storage location in the storage yard, re-assembled, oil-filled, and tested per the requirements of SECTION 48 20 00.04 26.

-- End of Section --

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T1 Doble Report

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SECTION 48 19 23.08 26

CLASS II GSU POWER TRANSFORMER (T1)

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

This Section covers the manufacturing and factory testing of three (3), single-phase generator step-up (GSU) power transformers rated 164,000 / 218,666 kVA, 500 kV high-voltage (H), 13.2 kV low-voltage (X & Y), Class ONAN/ONAF cooling, for delivery f.o.b. to Little Goose Lock & Dam storage yard. The transformer design can be a core-form or a shell-form transformer design as long as the transformer meets the critical dimensions identified on the contract drawings. Each transformer shipment, hauling, site reassembly, field testing are as required in SECTION 48 20 00.04 26 TRANSFORMER SHIPMENT, HAULING AND SITE ASSEMBLY. Throughout this Section, the transformer tank layout is identified by Segments 1 through 4, as defined in IEEE C57.12.10, Figure 1, and indicated on the contract drawings.

1.2 GENERAL INFORMATION

1.2.1 Transformer Location

The single-phase transformers specified in this section will be spare transformers for Little Goose, Lower Granite, and Lower Monumental dams. These transformers are meant to be spares for the single-phase T1 Bank transformers at the three Projects. Contract Drawing G-003, shows the site map and the storage yard where the spare T1 transformers will be placed. The spare transformers will be placed on concrete pads in the storage yard. Supplemental drawings LGP-1-4-2/40 and LGP-1-5-0/21 shows the details on the existing transformer mounting pads.

1.2.2 Ratings

Size the new single-phase power transformers per the requirements of paragraph, "Ratings and Electrical Characteristics", to match the impedance, capacitance, and ratings of the existing single phase transformers.

1.3 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 CIVIL ENGINEERS (ASCE)

ASCE 7-22	(2022; Supp 1 2023; Supp 2 2023) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2024) Unified Inch Screw Threads (UN, UNR, and UNJ Thread Form)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.24	(2022) Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500
ASME B31.1	(2024) Power Piping
ASME BPVC SEC IX	(2023) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ANSI/ASNT CP-189	(2020) ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A343/A343M	(2014; R 2019) Standard Test Method for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame
ASTM A664	(2015; R 2022) Standard Practice for Identification of Standard Electrical Steel Grades in ASTM Specifications
ASTM A717/717M	(2012; R 2022) Standard Test Method for Surface Insulation Resistivity of Single-Strip Specimens
ASTM A876	(2017; E 2017) Standard Specification for Flat-Rolled, Grain-Oriented, Silicon-Iron, Electrical Steel, Fully Processed Types
ASTM D923	(2015; R 2023) Standard Practices for Sampling Electrical Insulating Liquids
ASTM D1535	(2014; R 2023) Standard Practice for Specifying Color by the Munsell System

ASTM D3487	(2024) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(2020) Standard Symbols for Welding, Brazing, and Nondestructive Examination
AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D1.6/D1.6M	(2017) Structural Welding Code - Stainless Steel

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 693	(2018) Recommended Practice for Seismic Design of Substations
IEEE 1427	(2020) Guide for Recommended Electrical Clearances and Insulation Levels in Air Insulated Electrical Power Substations
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.10	(2017) Requirements for Liquid-Immersed Power Transformers
IEEE C57.12.70	(2020) Standard Terminal Markings and Connections for Distribution and Power Transformers
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.19.00	(2023) Standard General Requirements and Test Procedures for Outdoor Power Apparatus Bushings
IEEE C57.19.01	(2017) Performance Characteristics and Dimensions for Power Transformer and Reactor Bushings
IEEE C57.104	(2019; E 2019) Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers
IEEE C57.113	(2023) Recommended Practice for Partial Discharge Measurement in Liquid-Filled

	Power Transformers and Shunt Reactors
IEEE C57.116	(2022) Guide for Transformers Directly Connected to Generators
IEEE C57.149	(2012) Guide for the Application and Interpretation of Frequency Response Analysis for Oil-Immersed Transformers
IEEE C57.152	(2013) Guide for Diagnostic Field Testing of Fluid-Filled Power Transformers, Regulators, and Reactors

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA MW 1000	(2023) Magnet Wire
NEMA SG 4	(2009; R 2013) AC High-Voltage Circuit Breakers

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 1 2024; TIA 24-1) National Electrical Code

UL SOLUTIONS (UL)

UL 248-8	(2011; Reprint Aug 2020) Low-Voltage Fuses - Part 8: Class J Fuses
UL 360	(2013; Reprint Jan 2024) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 489	(2025) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2024) Industrial Control Equipment

UL 508A	(2018; Reprint Jul 2022) UL Standard for Safety Industrial Control Panels
UL 514B	(2012; Reprint Mar 2024) UL Standard for Safety Conduit, Tubing and Cable Fittings
UL 969	(2017; Reprint May 2023) UL Standard for Safety Marking and Labeling Systems
UL 1203	(2023; Reprint May 2024) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 4248-8	(2024) Fuseholders - Part 8: Class J

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with SECTION 01 33 00, "SUBMITTAL PROCEDURES", unless otherwise indicated below:

SD-01 Preconstruction Submittals

Welding Quality Control Plan; G, HDC

Submit for approval the welding quality control plan a minimum of 60 calendar days prior to the start of tank manufacturing. (see paragraph "Welding Quality Control Plan").

SD-02 Shop Drawings

a. Outline and Assembly Drawings; G, HDC

Submit outline and assembly drawings of the transformer for approval no later than 240 calendar days prior to the start of transformer fabrication to demonstrate that the equipment will conform to the requirements and intent of the specifications.

b. Detail Drawings; G, HDC

Submit detail drawings for approval not later than 180 calendar days prior to the start of transformer fabrication to demonstrate that the equipment will conform to the requirements of the specifications.

SD-03 Product Data

Submit for approval the product data no later than 120 calendar days prior to the start of transformer fabrication to demonstrate that the welding materials will conform to the requirements of the specifications.

a. Welding Electrodes and Rods; G, HDC

b. Shielding Gas; G, HDC

SD-05 Design Data

a. Transformer Design Data Review Report; G, HDC

Submit for approval a transformer design data review report within 14 calendar days of the design data review meeting, to demonstrate fully that all parts of the equipment will conform to the requirements and intent of the specifications.

b. Descriptive Data; G, HDC

Submit for approval the descriptive data and catalog data of all accessory devices, ancillary equipment and gaskets to be provided with the transformer not later than 210 calendar days prior to the start of transformer fabrication, to demonstrate fully that all parts of the equipment will conform to the requirements and intent of the specifications. (see paragraph "Descriptive Data")

c. Spare Parts List; G, HDC

Submit for approval a listing of all required spare parts to be provided with the transformer not later than 210 calendar days prior to the start of transformer fabrication (see paragraph "SPARE PARTS").

d. Structural Design Criteria and Seismic Calculations; G, HDC

Submit for approval the structural design criteria and seismic calculations within 45 calendar days after outline and assembly drawing approval. Perform design criteria and calculations utilizing civil or structural engineers who are presently registered professional engineers (PE) in any state or territory of the United States, and provide a cover sheet for the submittal which is stamped or sealed and signed by a PE.

e. Cabinet Heater Sizing Calculations; G, HDC

Submit for approval the calculations not later than 180 calendar days prior to the start of transformer fabrication to verify the ratings of the transformer control and power cabinet heaters, based upon the cabinet sizes, cabinet material, and the regional ambient temperature conditions as shown in Contract Drawing G-005. See paragraph "Lighting, Convenience Receptacle, and Cabinet Heaters" for information.

SD-06 Test Reports

a. Transformer Factory Acceptance Test Report; G, HDC

Submit for approval the transformer factory acceptance test report not later than 14 calendar days following completion of the factory acceptance tests. (see paragraph "Factory Acceptance Test Report").

b. Bushing Design Tests; G, HDC

Submit for approval the transformer bushing design test reports not later than 30 calendar days following completion of the tests

(see paragraph "Bushing Design Tests"). If certified copies of bushing design tests previously conducted within ten (10) years are submitted in-lieu of new test results, submit them when the bushing selection is made, but not later than 60 calendar days prior to the performance of transformer factory acceptance tests.

c. Bushing Routine Tests; G, HDC

Submit for approval the transformer bushing routine test reports not later than 30 calendar days following completion of the tests. (see paragraph "Bushing Routine Tests").

d. Bushing Current Transformer Manufacturer Routine Tests; G, HDC

Submit for approval the transformer bushing current transformer test reports not later than 30 calendar days following completion of the tests. (see paragraph "Bushing Current Transformer Tests").

g. Weld Inspection and Test Report; G, HDC

Submit for approval the weld inspection and test report not later than 14 calendar days following completion of the weld inspections and tests. (see paragraph "Weld Inspections, Tests and Weld Inspector Qualifications").

SD-07 Certificates

a. Transformer Oil Certification; G, HDC

Submit for approval the transformer oil certification documents a minimum of 7 calendar days prior to the delivery of transformer oil to the Little Goose Lock & Dam "Storage Yard". (see paragraph "Quantity and Transformer Oil Certification").

b. Notification of the Date of the Transformer Design Data Review Meeting; G, HDC

For transformer manufacturers located in the United States, notify the COR 30 calendar days in advance of when the transformer manufacturer will be ready for performance of a design data review meeting, to be held at the manufacturer's facility.(see paragraph "TRANSFORMER DESIGN DATA REVIEW MEETING").

For transformer manufacturers located in foreign countries, notify the COR 60 calendar days in advance of when the transformer manufacturer will be ready for performance of a design data review meeting, to be held at the manufacturer's facility.(see paragraph "TRANSFORMER DESIGN DATA REVIEW MEETING").

c. Notification of the Date of Factory Tests; G, HDC

For transformer manufacturers located in the United States, notify the COR 30 calendar days in advance of when the transformer manufacturer will be ready for factory acceptance tests, so that the tests may be witnessed by a Government Representative at the manufacturer's facility.(see paragraph "TRANSFORMER FACTORY ACCEPTANCE TESTS").

For transformer manufacturers located in foreign countries,

notify the COR 60 calendar days in advance of when the transformer manufacturer will be ready for factory acceptance tests, so that the tests may be witnessed by a Government Representative at the manufacturer's facility.(see paragraph "TRANSFORMER FACTORY ACCEPTANCE TESTS").

d. Welder Qualifications; G, HDC

Submit for approval the welding operators and welders qualifications a minimum of 60 calendar days prior to their performance of work. (see paragraph "Welder Qualifications").

e. Weld Inspector Qualifications; G, HDC

Submit for approval the qualifications for the Contractor's Quality Assurance personnel responsible for performing weld inspections a minimum of 60 calendar days prior to the performance of weld inspections. (see paragraph "Inspection and Weld Inspector Qualifications").

SD-08 Manufacturer's Instructions

a. Factory Test Procedures; G, HDC

Submit for approval the transformer factory test procedures a minimum of 60 calendar days prior to the performance of the factory acceptance tests. (see paragraph "TRANSFORMER FACTORY ACCEPTANCE TESTS").

b. Welding Procedures; G, HDC

Submit for approval the welding procedures and specifications, and copies of test reports, a minimum of 60 calendar days prior to the performance of work. (see paragraph "Welding Procedure").

c. Prequalified Weld Procedures; G, HDC

Submit for approval the applicable prequalified weld procedures per the requirements of AWS a minimum of 60 calendar days prior to the performance of work. (see paragraph "Welding Procedure").

1.5 TRANSFORMER WARRANTY REQUIREMENTS

1.5.1 General Warranty Requirements

In addition to the requirements outlined in FAR 52.246-18, provide a manufacturer’s warranty for the power transformers for a period of 5 years from the date of final acceptance of the work. Provide a warranty certificate for each transformer indicating the date of expiry, to be included in the final Operations and Maintenance Instructions. The following transformer issues will also be considered warranty repair items:

a. Transformer gassing quantities or rates exceeding the DGA Status 1 level as defined in Figure 2 Tables 1 through 4 of IEEE C57.104.

b. Transformer oil leaks, at welded joints as well as gasketed connections and valve stem packing.

c. Paint failures resulting in visible loss of adhesion through

bubbling, flaking, peeling, or any visible rust due to paint failure.

d. Transformer bushing dielectric integrity and oil leaks.

e. Transformer control cabinet heater functionality.

1.5.2 Devices Exempt from the Transformer Full Warranty Period

Transformer ancillary devices which are not manufactured by the transformer manufacturer are subject to the device manufacturer's standard warranty period, and are exempt from the 5 year duration of the transformer warranty period. All ancillary devices which as not manufactured by the transformer manufacturer, such as gauges, have a minimum 1-year warranty or the part's manufacturer's guaranteed warranty, whichever is higher of the two

PART 2 PRODUCTS

2.1 TYPE AND RATING

2.1.1 General

Provide single-phase, three-winding, with one high-voltage and dual low-voltage windings, oil-immersed type power transformers suitable for outdoor operation in accordance with this specification. The transformers must be self-cooled/forced air-cooled type, Class ONAN/ONAF, and must be of a design that has an established record of satisfactory operation with the type of oil preservation system specified, and manufactured suitable for shipment by sea transportation, railcar, and trucking by heavy hauler. The power transformers are a step-up transformer to be used in direct connection with electrical power generators and will be subject to backfeed mode as defined in IEEE C57.116.

2.1.2 Transformer Limiting Dimensions and Equipment Arrangement

Provide transformers with the layout, equipment arrangement and dimensional requirements as indicated on contract drawings.

2.1.3 Requirements

Except as otherwise specified herein, the transformers, accessories, and spare parts must conform to the applicable requirements of IEEE C57.12.00, IEEE C57.12.10, IEEE C57.12.70, IEEE C57.12.80 and IEEE C57.12.90, and IEEE C57.116.

2.1.4 Standard Products

Provide material and equipment which are standard products from a manufacturer that is regularly engaged in their production, and are items that have been commercially available for at least 3 years prior to bid opening, unless otherwise specifically approved. Provide all materials that conforms to the requirements of these specifications. Materials must be of industrial quality, free from defects and imperfections, presently being manufactured, and of the classification and grades designated. If the Contractor desires for any reason to deviate from the standards designated in these specifications, submit for approval a statement describing the exact nature of the deviation, including complete specifications for the materials that are being proposed for use.

2.1.5 Descriptive Data

Submit for approval descriptive data for all transformer equipment, which includes catalog and technical data of sufficient detail to verify conformance with the requirements, herein. Highlight or circle the catalog and technical data for the specific device and model, and provide ordering information and cut sheets. The descriptive data is to include the following at a minimum:

1. Electrical core steel, including country of origin
2. Winding conductors, including country of origin
3. Gasket type and material
4. Valves (each type)
5. Oil sampling device
6. Radiators
7. Cooling fans (including wiring connection methods)
8. Nitrogen regulator cabinet
9. Bushings (each type and rating)
10. Core ground bushings
11. Bushing current transformers
12. Bushing current transformer terminal boxes
13. Thermowells
14. Oil level indicator
15. Oil temperature indicator
16. Winding temperature indicator, including associated equipment
17. Pressure relief device, including discharge piping
18. De-energized tap changer, including operating handwheel
19. Rapid Pressure Rise Relay and Seal-in
20. Personal fall arrest system
21. Insulating oil, including vendor and inhibitor
22. Control and power cabinet vibration isolators
23. Fiber-optic probes
24. Fiber-optic tank feed-through plate and connectors
25. Auxiliary power transformer and mounting cabinet
26. Magnetic contactors
27. Molded-case circuit breakers (each type and rating)
28. 480 VAC circuit breaker locking provisions
29. Auxiliary relays
30. Undervoltage relays
31. Control and instrument switches
32. Terminal blocks (each type)
33. Fuses
34. Fuse holders
35. Wire duct
36. Cabinet lighting
37. GFCI receptacle
38. Cabinet heaters
39. Cabinet grounding busbar
40. Cabinet ventilation
41. Thermostat / humidistat
42. Insulated wire and cable (each type) and signal cable
43. Wire labeling method
44. Device nameplate method
45. Conduit and fittings
46. Junction boxes
47. Impact recorders for shipment (analog & digital)

If providing a conservator tank system of oil preservation include descriptive data of the following:

48. Conservator tank bladder
49. Dehydrating breather
50. Buchholz relay

2.1.6 Ratings and Electrical Characteristics

The ratings and electrical characteristics of the transformers are as follows:

a. Continuous rating, at the 65 degrees-C temperature rise, of the high-voltage winding at all taps, kVA:

(1) ONAN Rating: 164,000
(2) ONAF Rating: 218,666

b. Continuous rating, at the 65 degrees-C temperature rise, of each low-voltage winding, kVA:

(1) ONAN Rating: 82,000
(2) ONAF Rating: 109,333

b. Frequency, Hz: 60

c. Number of phases: 1

d. Rated voltage, kV:

(1) High-voltage windings: 500
(2) Low-voltage winding X: 13.2
(3) Low-voltage winding Y: 13.2

e. Winding connections (external to the transformer):

(1) High-voltage windings: Grounded-Wye
(2) Low-voltage windings: Ungrounded Delta

f. Impedance, at ONAN rated current between the high-voltage winding and each low-voltage winding, subject to IEEE tolerances, percent:

(1) 17.7% (H-X)
(2) 17.7% (H-Y)

g. Impedance, at ONAN rated current, between the low-voltage windings (X-Y), as high as feasible for an economic design, but not less than, percent: 40.5%

h. Polarity: Subtractive

i. Basic impulse insulation levels (BIL), kV:

(1) Line ends of the high-voltage windings, not less than: 1425
(2) Neutral ends of the high-voltage windings, not less than: 150
(3) Low-voltage windings, not less than: 110

j. Taps in low voltage windings: None

k. Taps (full capacity) in high voltage winding

(1) Tap 1, percent of high-voltage rating: 107.5
(2) Tap 2, percent of high-voltage rating: 105.0
(3) Tap 3, percent of high-voltage rating: 102.5
(4) Tap 4, percent of high-voltage rating: 100.0
(5) Tap 5, percent of high-voltage rating: 97.5

l. Maximum no-load losses at rated voltage and frequency, kW: 165

m. Maximum load losses at maximum ONAN rated kVA and 1.0 power factor, with each low-voltage winding equally loaded, kW: 314

n. Maximum average sound level at rated voltage and frequency, with all cooling groups in operation, dB: 80

o. ~~Maximum~~Existing Oil Volume, GAL: **15,339**

p. Maximum transformer total weight, completely assembled and oil filled with all accessories installed, pounds: ~~591,500~~596,500

q. The transformers' capacitances must match those of the existing transformers and be designed to be compatible with bank of single-phase shell-type transformers. See the T1 Doble Report attachment at the end of the specifications.

2.1.7 Transformer Type

The existing transformers in T1 Bank are shell-form type transformers. Shell-form or core-form type transformers are acceptable and must meet requirements described in these specifications. The transformers design must fit existing powerhouse connections without modifications to existing equipment and must not exceed the weight specified. The new transformers, including all attached accessories, must meet the limiting dimensions specified in the contract drawings. The transformers must be designed to be compatible for operation with the existing single phase shell-type transformer in T1 Bank. The transformer must be able to be transported from manufacturer location to Little Goose Lock & Dam Storage Yard.

2.1.8 Unusual Service Conditions

2.1.8.1 Magnetic Fields

The transformer will be subject to the following unusual service conditions, as defined by IEEE C57.12.00, paragraph 4.3:

The transformers' high-current low-voltage bushings will be connected to isolated-phase bus ducts and will exhibit strong magnetic fields during operation, which may cause circulating currents in the transformer tank cover and bus duct housings. Corrective measures must be taken during manufacturing to utilize non-magnetic metals in the cover around the bushings and the bushing housing flanges.

2.1.8.2 Backfeed Mode

The transformers must be designed to operate under IEEE C57.116 related service conditions with the transformers being used as a generator step-up transformer and will be subject to periods of backfeed operation.

2.1.9 Impedance Tolerance

The impedance tolerance between the supplied single-phase transformers and the specified impedance must be limited to a maximum of 3 percent, at the ONAN self-cooled rating, to reduce circulating currents when wye-connected and assure proper operation of the transformers differential relaying.

2.2 STRUCTURAL DESIGN CRITERIA AND SEISMIC CALCULATIONS

Provide Structural design criteria and seismic calculations for the transformers, to include the main tank, base, and all major components such as bushings, oil preservation system, cooling equipment and cabinets.

2.2.1 Structural Design Criteria

Structural design criteria must include the following:

a. Indicate the industry design standards (ASCE or IEEE) and allowable stresses or capacities to which steel plate, structural steel shapes, welds, bolts and studs must conform.

b. Indicate the industry standards (ASCE or IEEE) used in developing the seismic forces and analysis techniques used in the design of the transformer and transformer components.

c. Provide the seismic design for equipment restraint in accordance with Chapter 13, "Seismic Design Requirements for Nonstructural Components," of ASCE 7-22 with the seismic design force computed as per Section 13.3 "Seismic Demands on Nonstructural Components". Provide electrical equipment restraint in accordance with the provisions in IEEE 693 Annex D, or Section 13.3 of ASCE 7-22 whichever produces the more adverse seismic effects. For ASCE 7-22, use a spectral acceleration S_{DS} = 0.32, I_P = 1.5 and z=h=1. Use a moderate seismic qualification level For IEEE 693.

d. Provide wind load calculations based upon Exposure Category "D" of ASCE 7-22. Base the effect of wind load forces upon ASCE 7-22, or 40 psf, whichever is greater.

2.2.2 Transformer Mounting

The transformers must be manufactured with structural bases that meets the requirements of paragraph "Transformer Steel Base, and that rests on the existing concrete pedestals with a steel plate cap as shown in supplemental drawings LGP-1-4-2/40 and LGP-1-5-0/21.

2.3 THERMAL DESIGN

The temperature rise above ambient temperature of the transformers or parts thereof, when tested in accordance with its ratings, must not exceed the limits of observable temperature rise for oil immersed apparatus as stated in IEEE C57.12.00 (paragraph 5.11.1). The winding temperature rise by resistance must not exceed 65 degrees-C, and the hottest spot winding temperature rise must not exceed 80 degrees-C on the tap connections that give the highest losses, at all self-cooled and forced-air cooled ratings. The transformers must be designed for satisfactory continuous operation with any combination of simultaneous loads on the low-voltage windings within their ratings, and also for the case where either low-voltage winding carries maximum rated load and the other low-voltage

winding carries no load.

2.4 CORE

The transformers' core steel laminations must be high-quality, non-aging, cold-rolled, grain-oriented steel especially suitable for the purpose, meeting the requirements of ASTM A664 and ASTM A876, and the following:

a. Lamination maximum thickness of 0.270 mm, and the design flux density less than 1.75 Tesla.

b. Electrical core steel core loss, rms exciting power, rms and peak exciting current, and ac permeability design tested in accordance with ASTM A343/A343M, with the design test reports included with the descriptive data.

c. Each roll of sheet steel used must have the surface insulation resistivity tested in accordance with ASTM A717/717M.

d. The core must be assembled with interleaved joints, and rigidly clamped to ensure mechanical strength to support the windings and to prevent shifting of the laminations during shipment, and also to reduce vibration during operation.

2.5 WINDINGS

The single-phase transformers must be manufactured with windings meeting the requirements of paragraph "Ratings and Electrical Characteristics", consisting of one high-voltage winding (H) and two low-voltage windings (X and Y). Consideration must be given to all factors of service, such as high dielectric and mechanical strength of insulation, coil characteristics, and minimum restrictions to free circulation of oil. Coils must be made up, shaped, and braced to provide for expansion, contraction, and shrinkage due to temperature changes and aging in service in order to avoid abrasion of insulation and to provide resistance to movement and distortion caused by abnormal operating conditions. The insulation of the coils must be designed to withstand possible transient voltages that occur when the transformers are operated in backfeed mode and the secondary windings (high-side) are exposed to typical system transients as described in IEEE C57.116, clause 11. Barriers must be provided between windings and core and between high-voltage and low-voltage windings. End coils must have additional protection against normal line disturbances. The windings must meet the following requirements:

a. Winding conductors manufactured from high-conductivity copper magnet wire meeting the applicable requirements of NEMA MW 1000.

b. Winding assembly of a circular coil design if the transformers are a core-form design.

c. Conductor insulation consisting of thermally upgraded Kraft paper.

d. A de-energized tap changer with taps located in the high-voltage windings. The tap changer contacts must be silvered, and capable of withstanding the full short circuit current of the transformers without damage.

e. Basic impulse insulation level (BIL) of the windings as specified in paragraph "Ratings and Electrical Characteristics", and capable of withstanding IEEE Standard dielectric tests, in accordance with paragraph "Power Transformer Tests", corresponding to the specified winding insulation levels.

f. Capable of withstanding without damage the mechanical and thermal stresses caused by short circuits on the external terminals of any winding or windings, with rated voltages maintained across the terminals of all other windings intended for connection to sources of energy, under the conditions listed in IEEE C57.12.00 (paragraph 7.1.1).

g. Fiber-optic probes embedded in the calculated hottest spot for each high and low-voltage winding duct spacers for direct winding temperature measurement, with quantities and distribution as required in paragraph "Transformer Fiber-Optic Winding Temperature Measurement."

2.6 TANK

2.6.1 Fabrication

The transformers must be manufactured with an oil-tight steel tank, with oil-tight covers per the requirements of IEEE C57.12.10 (paragraph 5.8), with the following features:

a. The main transformer tanks and any attached compartment that is subjected to operating pressures designed and manufactured to withstand, without leakage or permanent deformation, an internal maximum operating pressure not less than 10 psi.

b. Manufactured for vacuum filling (essentially full vacuum) in the field, with all valves, fittings and piping affected by vacuum filling rated for such filling.

c. Welded joints between the tank and cover, and between tank sections, designed to prevent weld splatter from entering the inside of the tank during the welding process.

d. Positioning guides inside the tank to assure the core and windings are in the correct position during the assembly process, and provide additional rigidity during transportation.

e. One or more unobstructed manholes in the cover with minimum dimensions of 24 inches by 24 inches, or 24 inches minimum diameter, to afford easy personnel access to the inside of the tank and the upper portions of the core and coils.

f. Handhole access covers in the tank sidewall for access to low-voltage bushing bottom connection, and the de-energized tap changer switch mechanism for future maintenance.

2.6.2 Lifting, Moving and Jacking Facilities

2.6.2.1 Lifting Facilities

Design loads for lifting facilities must have a safety factor of five in accordance with IEEE C57.12.10 (paragraph 5.3.1). Lifting facilities must positively keep the lifting cable in place even when the cable is slack.

Provide transformers with the following lifting facilities:

a. Lifting attachments on the tank covers.

b. Adequate means for lifting the core and coil assembly from the tanks for a core-form design.

c. Lifting facilities and pivot points on the tanks adequate for lifting and pivoting the transformers from the shipping position to the upright position for a shell-form design.

d. Lifting facilities on the tanks adequate for lifting the complete transformer filled with oil. The lifting facilities will also be used for securing of the transformers during shipment.

2.6.2.2 Moving Facilities

Furnish moving facilities in accordance with IEEE C57.12.10 (paragraph 5.3.3).

2.6.2.3 Jacking Facilities

Provide transformers manufactured with jacking facilities to permit jacking the fully assembled transformer filled with oil per the requirements of IEEE C57.12.10 (paragraph 5.3.4). The design loads for jacking facilities must be a minimum of five times the actual loads to allow for possible unequal jacking forces.

2.6.3 Gasketing

2.6.3.1 General

Gaskets between metal surfaces must be set in expansion-limiting grooves so that all contact surfaces are metal-to-metal when tightened. Provide gaskets made of Nitrile NBR (Buna N), with the exception that gaskets for the low-voltage bushings must be fluoroelastomeric rubber, with a Durometer rating between 50 and 70. Circular cross-section gaskets are not acceptable for use in gasket grooves of rectangular cross-section.

2.6.3.1.1 Low-voltage Bushings

Provide low-voltage bushing gaskets that meet the following requirements:

a. Meets the requirements of ASTM D-1418, designation FKM, Type 2.
b. Manufactured with 100% virgin FKM Fluoroelastomer polymer
c. Rated for application in temperature range of -20F to +400F
d. Durometer hardness of 70 (+/- 2)
e. Minimum fluorine content: 66%

2.6.3.2 Sizing

Gasket sizing for rectangular cross-section grooves must be accomplished as follows:

a. Gasket thickness is chosen so that approximately 25-percent of the gasket cross-section protrudes above the depth of the groove, referred to as the 'gasket compression area'.

b. The width of the groove minus the width of the gasket determines

the space available for gasket expansion during compression. The amount of groove space available for gasket expansion during the compression process is referred to as the 'gasket expansion area', which must be greater than the gasket compression area to avoid pinching of the gasket between the metal surfaces when tightened.

c. Proper sizing coordination between the gasket groove and the gasket cross-sections results in 25-percent gasket compression, with a remaining gasket expansion area after tightening of between 5 and 10-percent.

2.6.4 Valves

Provide all valves that conform with IEEE C57.12.10 (paragraph 5.1.8), be of ball-type stainless steel design conforming to MSS SP-72, circular flanged mounting, with reinforced PTFE valve seats, unless otherwise specifically indicated. The valves must be of full-port design, designed for use with insulating oil with a 120 degrees Celsius minimum temperature rating and include hasps for locking the handle. Provide the following valves:

a. Upper filter connection. A 1.5-inch valve with a 1.5-inch female NPT threaded open-end connection and a threaded plug, located on the tank sidewall such that it can be used to fill the transformers with oil while the transformers are under vacuum.

b. Vacuum pump connection. A 3-inch valve with a 3-inch circular-flanged open-end connection, located on the tank cover for use in connecting a vacuum pump during the vacuum filling process. Provide a gasketed blind flange cover with an integral 3-inch NPT female connection and threaded plug for the valve open-end connection.

c. Main drain. A 3-inch valve with a 3-inch circular-flanged open-end connection, located at the extreme bottom of the tank for use in gravity draining of the transformers. Provide a gasketed blind flange cover with an integral 3-inch NPT female connection and threaded plug for the valve open-end connection.

d. Oil sampling valve. A 1-inch valve, with a 1/2-inch NPT threaded open-end connection and a 1/2-inch threaded sampling device, complete with protective cover. This valve may be located at the main drain valve location.

e. Lower filter connection. A 1.5-inch valve with a 1.5-inch female NPT thread open-end connection and a threaded plug, located at the extreme bottom of the tank.

f. Tank air vents. Threaded plugs for venting the radiators. Schrader valves are not acceptable for use as vent valves.

g. Nitrogen gas connection. Two 1/2-inch valves for connection of the nitrogen generator system tubing.

h. Radiator drain. A 1/4-turn valve at the lowest point of each radiator to permit draining, with an NPT threaded open-end connection and threaded plug.

i. Isolation valves.

(1) Radiators. At the inlet and outlet of each radiator to permit removal without draining the oil from the tank. Radiator isolation valves at the transformer tanks may be of a butterfly type.

(2) Rapid pressure rise relay. 1.5-inch isolating valve for the rapid pressure rise relay.

(3) Gas-in-oil monitor interface valve. Two 2-inch valves for future connection to the gas-in-oil monitor

(4) Conservator tank. If providing a conservator tank system, provide a valve isolating the conservator tank from the main transformer tanks, and isolating the Buchholz relay. Isolation valves adjacent to the Buchholz relay may be of a butterfly design.

2.6.5 Connections

2.6.5.1 General

Provide all bolts, studs, machine screws, nuts, and tapped holes designed for customer connection in accordance with ASME B1.1 (inch fasteners). Bolting hardware must be Grade 8 minimum, or equivalent, and all hardware not internal to the tank must be galvanized. Threads for sizes 1/4-inch to 1-inch, inclusive, must be NC or UN series. The sizes and threads of all valves, pipe and fittings, conduit and fittings, tubing and fittings, and connecting equipment, must be in accordance with ASME B1.20.1. Manufacturers' standard threads and design may be used on small items which are integrally replaceable, except that threads for external connections to these items must meet the above requirements.

2.6.5.2 Stainless Steel

Install all stainless steel connecting hardware using an anti-galling compound such as molybdenum disulfide on the threads prior to connection, or the nuts may be of a Nitronic 60 grade stainless steel.

2.6.6 Steel Pipe and Fittings

Provide steel pipe that conform to ASTM A53/A53M, Grade A, Weight Class XS. Dimensions of terminating flanges must conform to ASME B16.1 and ASME B16.24.

2.6.7 Grounding

Provide transformer tanks with four ground pads, with grounding provisions in accordance with IEEE C57.12.10 (paragraph 5.5).

2.6.8 Portable Fall Arrest System

2.6.8.1 Portable Fall Arrest System Anchor Post

Provide one portable fall arrest system anchor post. The anchor post must have the following features:

a. Three-stage, four-position telescoping design of aluminum design.

b. Provision of three independent swivel tie-off points, with horizontal lifeline attachment.

c. Base leveling screws allowing the system to be plumbed to vertical for working stability on inclines up to 15-degrees.

d. Designed for attachment to a uni-anchor mounting plate.

2.6.8.2 Anchor Post Accessories

Provide the following accessories with the portable fall arrest system anchor post:

a. Rescue Davit Arm, with quick mount winch and cable.

b. Carrying bag for the anchor post assembly.

c. Carrying bag for the Davit Arm with mounted winch.

2.6.8.3 Mounting Plates

Provide two portable fall arrest system anchor post mounting plates welded on the transformer covers, located so that the center of each manhole access cover is 36-inches from the mounting plate. The mounting plates must be designed for use with the portable fall arrest system anchor post indicated above.

2.6.9 Transformer Steel Bases

The transformers must be manufactured with an integral structural steel base designed for meeting the following requirements:

a. Suitable for resting on the existing concrete pedestals with steel caps as shown on supplemental drawings LGP-1-4-2/40, LGP-1-5-0/21, and I-003, Volume 1.

b. Capable of supporting the weight of the assembled and oil filled transformers on the existing concrete pedestals with steel caps.

c. Manufactured to be suitable for moving on rollers or skids when the transformers are completely assembled and filled with oil, permitting moving the transformers in a direction parallel to either centerline, with suitable pulling eyes provided.

d. Spare must directly bear on steel bearing plates of the storage structure and the foundation plates in operating locations. Provide at minimum provisions for six (6) 1-inch diameter anchors to be installed in the locations shown in the resource drawings and adequate clearance to install the anchors.

2.7 COOLING EQUIPMENT

2.7.1 Radiators

Provide transformers manufactured with radiators to cool the oil at a 164,000 kVA continuous load, without any cooling groups in operation. The radiators must meet the following requirements:

a. Located on the tanks to ensure uniform circulation of the oil through the windings, with valves installed on each connection to the main tanks so that the radiators may be removed for repairs without

taking the transformers out of service.

b. Fully hot-dip galvanized on the outside and remain unpainted.

c. Designed and manufactured to withstand essentially full vacuum to permit filling of the transformers under vacuum with the radiators in-place and radiator valves open.

d. Provisions for draining and venting each radiator, 1/4-turn ball valve for draining each radiator, and lifting eyes for handling.

e. The welding and fittings must be smooth, both inside and out, so as to present no obstruction to the flow of oil inside, with full penetration welds on the outside of the radiators such that there will be no crevices in which water might collect.

2.7.2 Cooling Fans

Provide Horizontal-draft cooling fans so that the continuous forced-air-cooled capacity of the transformers will be at least 218,666 kVA without exceeding the allowable temperature rise specified in paragraph "Ratings and Electrical Characteristics". Locate the cooling fans to direct the air stream against the radiator and to prevent recirculation of discharged air. Provide cooling fans that meet the following requirements:

a. Balanced cast aluminum fan blades.

b. Hot-dip galvanized steel basket-type fan blade guards.

c. Fan motors to have IP55 enclosure rating.

d. Fan motor housing painted with epoxy primer and aliphatic urethane top-coat.

e. Individual thermal overload protection with automatic-reset.

f. Fan motors with permanently lubricated, double-sealed ball bearings.

g. Fan motors with Class F insulation, Class B temperature rise.

2.7.3 Power Supply Equipment

The power supplies for fan motors will be Government-furnished, 480 V, three-wire, 3 phase, 60 Hz, as indicated on the contract drawings. Provide two 3-pole, 600 V, molded case circuit breaker of proper current rating in the power cabinet for the supply circuit.

2.7.4 Cooling Control Equipment

Furnish and install all necessary protective and control equipment for the fan motors in the control and power cabinets for each transformer (see paragraph "CONTROL AND POWER CABINET EQUIPMENT").

2.8 BUSHINGS

2.8.1 General Bushing Requirements

Provide transformers with one high-voltage, four low-voltage, and one

neutral leads brought out from the tank through bushings as specified below. Bushings of the same voltage and current rating must be interchangeable and as applicable, conform to IEEE C57.19.00 and IEEE C57.19.01. All bushings must meet the following requirements:

a. Of recent manufacture and of a type and style currently being manufactured.

b. Nameplate rated and tested for use at 60 Hz rated frequency.

c. Rated for outdoor service, with UV resistant, porcelain insulating sheds for bushings which will be exposed to direct sunlight.

d. Manufactured so that there will be no stressing of any parts due to temperature changes, and means provided to accommodate conductor expansion.

e. Gastight and oiltight when installed on the transformer tanks.

f. The power factor of each bushing must meet the requirements of IEEE C57.19.01, Table 6, or as otherwise specifically required herein.

2.8.2 High-Voltage and High-Voltage Neutral Bushings

The high-voltage and neutral bushings must be designed to withstand the standard withstand test voltages as indicated in Table 1 of IEEE C57.19.01, and tested in accordance with paragraph "Bushing Tests". Provide Hitachi Type O Plus C bushings that meet the following requirements:

a. Designed for use in an air-to-oil power transformer applications.

b. Manufactured with a normally grounded test tap.

2.8.2.1 High-Voltage Bushing Ratings

a. Insulation class, kV: 500

b. BIL rating, kV: 1,550

c. Minimum current rating, Amperes: 1,600

d. Creepage distance: Light contamination

e. Drawing number: T550W2000VV

2.8.2.2 High-Voltage Neutral Bushing Ratings

a. Insulation class, kV: 25

b. BIL rating, kV: 150

c. Minimum current rating, Amperes: 1,200

d. Creepage distance: Light contamination

e. Drawing number: T025W0412AT

2.8.3 Low-Voltage Bushings

Low-voltage bushings must meet the requirements of IEEE C57.19.01 (1991), and must be tested in accordance with paragraph "Bushing Tests". The bushings must be of solid bulk design of a low-corona design for vertical mounting, and the exterior shell above the mounting flange must be of porcelain design and formed in one piece. Fluoroelastomeric rubber gaskets must be used for the installation of all low-voltage bushings. Provide Hitachi Type RJ Bushing that meet the following requirements:

a. Insulation class, kV: 25

b. BIL rating, kV: 150

c. Minimum current rating, Amperes: 10,000

d. Thermal rating, degrees Celsius temperature rise: 125

e. Drawing number: T025B1000DS

2.8.4 High-Voltage and Neutral Bushing Terminals and Connections

Provide high-voltage and neutral bushings with threaded copper terminal stud with dimensions in compliance with IEEE C57.19.01.

2.8.5 Core Ground Bushings

The transformers must be manufactured with two external bushings for core grounding; one for the main core connection to ground, and one for the core frame connection to ground. The bushings must be mounted adjacent to each other and located on the transformer tank covers, protected with a removable weatherproof metal cover with device nameplates. Provide bushings manufactured with an integral cast copper stud, with an insulating body of either epoxy or solid porcelain, and include a bolted-flange so that they can be removed for maintenance without having to enter the tank. The stud must be silver plated, with tapped holes for connection of removable grounding straps between the bushing bottom terminal and the core and tank wall. The minimum ground wire size from each bushing top terminal to the tank must be #4 AWG equivalent. The core ground bushings must have the following minimum nameplate ratings:

a. Insulation class, kV: 2.5

b. BIL rating, kV: 45

c. Minimum current rating, Amperes: 100

2.8.6 SFRA Test Shipping Bushings

For the purposes of performing SFRA testing with the transformers in the shipping configuration, each shipping cover installed after the bushings have been removed for shipment must include a bushing that is connected to the winding leads, so that the SFRA tests can be performed just prior to each transformer shipment and immediately after each transformer delivery to the Little Goose Lock & Dam "Storage Yard". This assembly permits the SFRA testing on the transformers without having to gain entrance into, or modifying the transformer shipping assembly. The winding leads must be appropriately braced inside the transformer tanks to assure there is no movement during shipment which could damage the bushings, or potentially

alter the SFRA test results. During shipment, the external terminals of these bushings must be grounded to the tank. Testing must be performed per the requirements of paragraph "Sweep Frequency Response Analysis Tests". Each temporary SFRA Test Shipping Bushings must be of the same manufacture and rating as the core ground bushings.

2.8.7 Shipment

For bushings shipped separate from the transformers, each bushing must be crated and packed per the manufacturer's requirements in such a manner to protect the bushing from damage due to moisture, breakage and vibration damage during transit.

2.9 BUSHING-TYPE CURRENT TRANSFORMERS

All bushing-type current transformers must conform to the requirements of IEEE C57.13 and additional requirements in NEMA SG 4, and have revenue metering accuracy classifications as required in Table 6 of IEEE C57.12.10, unless otherwise specifically indicated. The continuous thermal rating factor must be a minimum of 1.33, based upon a 30 degree Celsius average ambient air temperature.

2.9.1 High-Voltage Bushing Current Transformers

Provide two 1200:5, multi-ratio bushing-type current transformers for each transformer high-voltage bushings.

2.9.2 Low-Voltage Bushing Transformers

Provide bushing current transformers on the low-voltage bushings as required for the winding temperature monitoring equipment.

2.10 LOW-VOLTAGE BUSHING HOUSINGS

Provide transformers that are manufactured with four low-voltage bushing housings as indicated on the contract drawings. Provide housings that bolt to the isophase bus housing and to the transformers. The Government will utilize the existing copper conductors to connect the bushing to the isophase bus when the transformers are installed. Provide a weather proof enclosure with an easy to remove cover that allows full access to the bushing and bus bars.

2.11 TRANSFORMER MOUNTED ACCESSORIES

2.11.1 General

Provide rugged outdoor sealed dials, indicators, and gages installed on the transformers with military connectors, tempered glass faces, stainless steel bezel, and stainless steel housings. Provide dials, indicators, and gages with capillary that have stainless steel armor. The dials, indicators, and gages must be mounted at a height of approximately 60 inches above the base of the transformers, unless otherwise indicated, and arranged for convenient reading standing at the level of the base. Provide the following accessory devices that are included in the price for the transformers, and meet the requirements of IEEE C57.12.10 (paragraph 5.1), unless otherwise indicated.

2.11.2 Liquid Level Indicator

Provide one magnetic-type liquid level indicator located on the tank sidewall, equipped with three circuit-closing low-level alarm contacts suitable for use with an ungrounded 125 V DC circuit. The indicator must have a 6-inch dial face with a field-replaceable case, with the dial marked to indicate the 25 degrees Celsius oil level and the maximum and minimum oil levels.

2.11.3 Thermowells

Provide a total of five top oil thermowells and one bottom oil thermowell housed in weatherproof enclosures, with functionality as indicated on Contract drawing E-109 for each transformer. The thermowell locations must be designed such that they are always submerged in the insulating oil during transformer operation. Thermowells must be provided for the following:

a. One thermowell for use with the analog liquid temperature indicator, located on the tank sidewall near the top oil level in the path of the hottest oil.

b. Two thermowells for use with the analog winding temperature indicators, one for each low-voltage winding, located on the tank sidewall near the top oil level in the path of the hottest oil.

c. Three spare thermowells with NPT plugs. One must be for future use with a transformers temperature monitor for top oil temperature, located on the tank sidewall near the top oil level in the path of the hottest oil. One must be for future use with the transformer temperature monitor for bottom oil temperature, located on the tank sidewall.

2.11.4 Analog Temperature Indicating Equipment

The analog indicating equipment must be located on the tank sidewall as shown on the Contract drawings, with functionality as indicated on the control schematics.

2.11.4.1 Liquid Temperature Indicator

Provide one dial-type indicating thermometer for liquid temperature indication with a bourdon-tube sensing element for each transformer. The dial indicator must cover a range of 0 to 120 degrees Celsius and be equipped with two adjustable circuit closing alarm contacts suitable for use with an ungrounded 125 V DC circuit. One switch contact must be used for top oil over-temperature alarm set at 90 degrees Celsius.

2.11.4.2 Winding Temperature Equipment

a. General: Provide Two winding temperature indicators (WTI), with associated equipment, for use in remote indicating of the temperature of each low-voltage winding (X and Y), and for use as an over-temperature trip backup to the future transformer temperature monitor for each transformer. The WTI equipment must be responsive to the current in the phase winding and to the top oil temperature, indicating the approximate hot-spot temperature of the winding, and provided with a means for calibration. Each WTI must include the following:

(1) A bourdon-tube sensing element located in the thermowell for operation of a dial indicator.

(2) A current transformer installed at each low-voltage winding which supplies current to a balancing autotransformer, proportional to the transformer load.

(3) A means for calibration connected each low-voltage winding current transformer and the thermowell heaters.

(4) Thermowell heating elements powered from the current balancing autotransformer, which simulates the winding temperature rise by adding the rise from the heating elements to the top oil temperature.

(5) An ungrounded three-wire 100-ohm platinum resistance temperature detector, which will be used with existing remote temperature recording or logging.

b. Dial Indicator and Switches: The WTI must have four electrically-independent, self-resetting contacts suitable for use on 125 V ungrounded dc circuits. Three switch contacts must be used as follows:

(1) One switch contact for cooling fan control. The setting of this contact is to be determined based on the results of the factory temperature rise tests.

(2) One switch contact for winding over-temperature alarm , set at 110 degrees Celsius.

(3) One switch contact for winding over-temperature trip set 117 degrees Celsius.

c. Leads: The leads from the WTI equipment must be routed through watertight and oiltight conduit fittings, and terminated in the transformer control cabinets. The connecting leads between the RTD elements and control cabinet terminal blocks must be soldered.

2.11.5 Rapid Pressure Rise Relay

Provide a rapid pressure rise relay and all connecting hardware required for each transformer. The rapid pressure rise relay must be designed for operation in oil space and have the following features:

a. Cunstructed with a die cast aluminum housing with ANSI 70 epoxy paint coating and an IP65 rating, designed for horizontal flange mounting.

b. Ambient operating range from -40 degrees Fahrenheit to 180 degrees Fahrenheit.

c. Rated pressure range of -14.7 to 20 pounds per square inch gauge.

d. A snap action, SPDT switch rated for 1/2 amp at 125V DC (resistive).

e. Military connector assembly with cable grip parts provided. Type

SOOW, 16 gauge, 3 conductor cable to be provided and custom fit on-site at an estimated length of 40 feet (to be field verified by contractor).

2.11.6 Rapid Pressure Rise Seal-In Relay

Provide a rapid pressure rise seal-in relay rated for 125V DC operation to latch in the momentary switch actuation from the existing rapid pressure rise relay, to be installed in the transformer control cabinets, with the following features:

a. Designed specifically for use as a seal-in relay for the rapid pressure rise relay

b. LED Status indicating light and an LED Trip indicating light.

b. Two output relays with contacts rated for 8A at 250 Vac.

c. Reset button to unlatch the relays.

d. Redundant make/break circuit requirements that protect against false trips.

e. Surrounding air temperature range of -49 degrees Fahrenheit to 158 degrees Fahrenheit.

2.11.7 Pressure Relief Device

2.11.7.1 General

Provide each transformer tank with a self-resetting, mechanical-type high-flow pressure relief device mounted on the tank cover to automatically relieve internal pressure, and to protect the tank against rupture due to arcing below the surface of the oil. One pressure relief device must be provided for a volume of insulating oil contained within the main tank of less than 10,000 gallons, and two pressure relief devices must be provided for a volume of oil greater than 10,000 gallons. The relief device must be capable of withstanding full vacuum without rupture or loss of accuracy, designed to minimize oil discharge during operation, and to exclude air and water after it opens. It must be equipped with a metal semaphore-type visual indicator and an alarm contact suitable for operation on a 125 V DC ungrounded circuit. The pressure relief device must have an oil-directed cover.

2.11.7.2 Oil Discharge Piping

Provide metal discharge piping for directing the oil discharged from the pressure relief device to the base of each transformer tank that is sized to match the discharge outlet of the pressure relief device. The discharge piping must extend to approximately 24-inches above the base of the transformers, with mounting supports to the transformer tanks not spaced more than 36 inches apart, and the piping outlet provided with a screen with a maximum hole size of 1/8-inch to discourage entry by animals, birds, and insects. The manufacturing details of the oil discharge piping must be included in the manufacturer's shop drawings.

2.11.8 Gas and Oil Actuated Relay (Buchholz)

If providing a conservator tank system of oil preservation, each

transformer must be provided with a gas and oil actuated relay (Buchholz relay) located in the pipe connecting each transformer tank to the constant-pressure, reservoir tank. The relay must conform to the requirements in this paragraph. Pipe-work must be so arranged that all gas arising from the transformers must pass into the relay, and the size and arrangement of pipe-work must conform with the recommendations of the relay manufacturer. A flanged, flexible section of oil pipe must be provided between the Buchholz relay and the transformer tanks. The relay must have the following features:

a. Provide a relay that is manufactured of a corrosion-resistant, oil-tight alloy casting, have flanged housing connections, and must have graduated inspection glass windows that enable the volume of gas and the contact system to be inspected.

b. Two floats (one for gas accumulation and one for low oil level) and one flap with counterbalance weight for the detection of oil speed.

c. A push-button for testing the relay electric circuits.

d. A pneumatic test device.

e. The relay must have independent alarm contacts wired back to the transformer control cabinets that close on collection of gas or at low oil level, and contacts that close following an oil surge. Mercury-based contacts will not be acceptable. The normally-open, electrically separate alarm and tripping contacts must not be exposed to oil, and must have a rated nominal current of 2A a.c./d.c. and a rated nominal voltage of 240V a.c./d.c.

f. Operation of the relay must be immune to seismic disturbances.

2.11.9 De-Energized Tap Changer Control

Provide each transformer with an external, manually operated tap changer for changing connections to the taps in the high-voltage windings when the transformers are de-energized. The tap changer control must have the following features:

a. Include an operating hand wheel, indicating pointer and dial, and means for locking the tap changer in any desired tap position.

b. The operating hand wheel must be mechanically interlocked with the tap mechanism to prevent its removal when the mechanism is not in a completed tap position.

c. Transmission of motion from the operating hand wheel shaft to taps by interaction of rigid members.

d. The tap changing mechanism must render it impossible to leave a winding open or short circuited when the operating wheel is placed in a locked position.

2.11.10 DGA Mounting Brackets

Provide mounting brackets for installation of a future on-line DGA monitor. Mounting brackets should have multiple holes to accommodate positioning of future upper and lower unistrut mounting brackets to accommodate a DGA monitor that the Government will procure in the future.

2.11.11 Contacts and Devices

The contacts of all relays, gages, and thermometers must be insulated from ground and must be of a positive snap-action type. Alarm contacts must be suitable for operation on 125 V DC ungrounded circuits and rated 0.5 amperes (resistive) at 125 V DC.

2.12 INSULATING OIL

2.12.1 Quantity and Transformer Oil Certification

Provide all the oil required to fill the transformers to the proper operating levels at Little Goose as well as the oil required for factory tests. Submit for approval the transformer oil certification documents prior to prior to the factory tests and delivery of the transformer oil to the Little Goose Lock & Dam "Storage Yard", indicating that the oil furnished for placing the transformers in service will meet the requirements specified below.

2.12.2 Type of Oil

The grade of insulating oil furnished must be unused, produced from a naphthenic base crude petroleum specifically prepared and refined for use in electrical equipment as an insulating and cooling medium. Paraffinic and Paraffinic-blends are not acceptable. Except for the oxidation inhibitor, the insulating oil must be free from additives of every kind, either natural or synthetic in any quantity, such as silicone or ester oil contamination from hoses or processing equipment.

2.12.3 Chemical, Physical and Electrical Characteristics

The insulating oil provided must have all tests performed per the requirements of ASTM D3487, Table 1, Type II, with an oxidation inhibitor content of between 0.25 and 0.30 percent by mass, prior to shipment.

2.12.4 Sampling

Samples for testing must be obtained as specified in ASTM D923.

2.12.5 Testing

Chemical, physical, and electrical tests must be conducted by the Contractor in accordance with the test methods listed in ASTM D3487, Table 1. A PDF copy of the test reports must be submitted for approval prior to shipment of the oil.

2.13 OIL PRESERVATION SYSTEM

2.13.1 General

Provide transformers with either an inert-gas pressure system or a constant oil pressure system. Any oil preservation system provided must meeting the dimensional requirements shown in the Contract drawings.

2.13.2 Inert-Gas Pressure System

2.13.2.1 General

An inert-gas pressure system is the preferred oil preservation system. If the transformers are provided with an inert-gas pressure system, the system must conform to all the requirements listed in section "Inert-Gas Pressure System." The system must consist of a nitrogen cylinder regulator enclosure that holds two cylinders, one of which is connected to the single regulator and supplies the blanket space and all associated stainless-steel piping and two 1/2-inch stainless-steel ball valves located at the top of the tank for connection of the nitrogen piping. The nitrogen gas must be supplied from the high-pressure cylinders through a pressure regulator, conforming to the requirements of IEEE C57.12.00 paragraph 6.6.3. Two cylinders of nitrogen gas must be furnished with the transformer for use with the regulating equipment and must remain the property of the Government.

2.13.2.2 Additional Gas Space

Use the vacuum bracing, and, if required, an additional external gas expansion tank to implement the inert-gas pressure system.

2.13.2.3 Pressure Regulating Equipment

The pressure regulator must be of a make and type which has been in successful operation with transformers for a period of not less than five years. All fittings and tubing for nitrogen connections between the pressure regulating equipment and the transformer tanks must be furnished with the transformers, and must be stainless steel flex tubing manufactured at the correct length for the routing and application with integral screw-on fittings, and matching terminations. The tubing must be anchored to the transformer tanks along its length a maximum of every 36-inches. The pressure regulating equipment must maintain the transformers' nitrogen pressure as follows:

a. Low pressure regulator: 0.5 psi

b. High pressure regulator: 5.0 psi

c. Pressure relief valve: 6.5 psi

2.13.2.4 Alarm functions

Alarm contacts suitable for use on a 125 V DC ungrounded circuit, wired back to the control cabinet to indicate the following:

a. Empty cylinder alarm: 200 psi

b. Low pressure alarm: 0.25 psi

c. High pressure alarm: 8.5 psi

2.13.2.5 Enclosure

A NEMA 3R rated steel enclosure mounted as low as possible on the transformer tanks containing the gas cylinders and pressure regulating equipment, meeting the requirements of NEMA 250 with the following features:

a. A gasketed window permitting viewing of the gauges without opening the door.

b. A removable stainless steel floor with a 'lipless' threshold.

c. A means for locking of the door.

d. A door activated light.

e. A thermostatically controlled heater.

f. A GFCI outlet.

g. The enclosure must be grounded to the transformer tanks by means of a bonding jumper.

2.13.2.6 External Gas Expansion Tank

If required to implement the inert-gas oil expansion tank, provide an external gas expansion tank located as indicated on the contract drawings.

2.13.3 Air Cell, Constant-Pressure, Reservoir Tank System

2.13.3.1 General

If the transformers are provided with a constant oil preservation system of oil preservation, the system must conform to all the requirements listed in section "Air Cell, Constant-Pressure, Reservoir Tank System." The system must consist of one oil reservoir mounted on the transformer tanks, with the location and height coordinated with the high-voltage bushing turrets. The dimensions of the transformers must fit within the dimensional requirements shown in the Contract drawings. The tanks must also meet all electrical clearances as required in IEEE 1427 from the high voltage equipment when installed in place. The reservoir tank must be designed for full vacuum during vacuum treatment and oil-filling, with valves provided for equalizing the pressure to the air bladder during these processes. The reservoir must be provided with a sump chamber to collect any impurities, and a minimum of two locations within the tank for suspending the air bladder, other than the flanged air vent connection. The reservoir liquid level indicator must be arranged to close the set of low-level alarm contacts when the oil level becomes too low or the air bladder sinks.

2.13.3.2 Air Bladder

The oil reservoir must contain an air bladder arranged to prevent direct contact between the oil and air. The air bladder material must be nylon-impregnated nitrile rubber designed for long life and for service in contact with hot oil, and must include a minimum of two integral straps used for suspending the air bladder from the inside top of the reservoir tank. The air bladder must be vented through a weather-tight maintenance-free electronic dehydrating breather provided with a suitable desiccant. Dimensions and drawings of the air bladder must be included in the descriptive data.

2.13.3.3 Maintenance-Free Dehydrating Breather

Provide one maintenance-free dehydrating breather designed for a generator

step-up transformer less than or equal to 200MVA for each conservator tank, utilized for removing atmospheric moisture from the air drawn into the reservoir tank air bladder, must be located on the transformer tanks at a height of approximately 48 inches above the base of the transformers. The hygroscopicity must be based upon a silica gel and sensor-controlled heated high-grade steel filter. During normal operation, the silica gel dries the air entering the piping to the reservoir tank. When the relative humidity exceeds a selected value, the self-regulating heating element inside the dehydrating breather is activated, and extracts moisture from the silica gel, which condenses and drips out of the filter system. The vent piping connecting the oil reservoir air bladder to the maintenance free dehydrating breather must be metal, of 1-1/2-inch minimum diameter, and galvanized inside and out to help reduce corrosion. Provide a maintenance free dehydrating breather with the following characteristics:

a. Visual sight inspection glass.

b. Sealed control housing suitable for outdoor operation.

c. Designed for ambient temperature operation between -40 and 80 degrees C.

d. Status indicators for Power On, Heater On, and Device Malfunction, with one normally closed contact for Device Malfunction annunciation.

e. Supply voltage of 120 V AC - 240 V AC, 60 Hz

f. Filter heating system

g. Test button

h. Analog output: 4-20 mA

2.14 TRANSFORMER CONTROL AND POWER CABINETS

2.14.1 General

Provide the transformers with control and power cabinets, mounted on the transformers' Segment 3 tank sidewall, as indicated. The fabrication and assembly of each cabinet must conform to the requirements of UL 508, UL 508A, and NEMA 250. The cabinets must be manufactured such that all 480 V AC wiring and equipment reside only in the power cabinet, and the control cabinet only includes wiring and equipment at maximum operating voltages of 125 V DC or 120 V AC. The cabinets must have the following features:

a. Environmental enclosure rating of NEMA Type 4.

b. Fabricated out of type 304 stainless steel that will remain unpainted on the exterior.

c. No. 12 Manufacturer's Standard Gage minimum thickness.

d. Rainproof enclosure vents of NEMA Type 3R construction, installed on the control cabinet enclosure back panel.

e. Bundled wire runs within the cabinet, routed through low-smoke, halogen-free wiring duct with slotted walls and interior corner guards

to protect the wiring.

f. "Piano-hinges" will not be acceptable for cabinet doors.

g. Cabinet interiors powder-coated white.

h. Solar shielding provided on the top, front and side panels of the enclosures, with cut-outs as required for the enclosure door viewing windows.

i. Door handles provided with provisions for locking, with all doors keyed the same.

j. Ground bonding jumper from each cabinet to the main transformer tanks.

2.14.2 Cabinet Mounting and Conduit Interface Provisions

The control and power cabinets must be configured as indicated on the contract drawings. Provide a structural steel framework for mounting the control and power cabinet assemblies to the transformer tanks' cabinet mounting frame rails, utilizing vibration isolation mounts. The vibration isolation mounts must be natural rubber with integral mounting stud provisions, sized for the maximum anticipated load of the cabinet assembly, and be a standard commercially available product for the purpose. Removable, gasketed plates must be provided in the bottom of the control and power cabinets, to which the external conduit connections to the Project will be installed. All wire and cable entering the control and power cabinets must be through conduit, and all conduit connections to the cabinets made through the base bottom plate of the cabinets.

2.14.3 Control Cabinet Requirements

Provide control cabinets with device layouts must be as indicated on contract drawings, and have the following features:

a. Devices mounted on the back of hinged panel doors that are not visible from the panel door fronts mounted such that device mounting screws do not penetrate the panel doors.

b. Provide windows in the control cabinet doors made of tempered glass, utilizing Claytonrite style rubber seals installed with silicone sealant so as to provide a waterproof installation.

c. Provide a 2-inch diameter wiring access hole between the power and control cabinets near the base of the cabinets, with protective bushings, for the routing of 120 V ac power from the control cabinet to the power cabinet for heaters and lights, and the permissive wiring to fan contactors..

d. Provide terminal blocks and wiring layouts such that all wiring for interconnection to the Project are located in the same vicinity near the base of the cabinet.

e. Provide two internal swing-panels for future installation of the transformers temperature monitor controls and annunciators.

f. Provide a 90-degree hinged, fold-down computer tray on the inside of the control cabinet door, with a means of securing the tray in the

upright position.

2.14.4 Power Cabinet Requirements

Provide all 480 V AC protective and control equipment for the cooling fans, including the molded-case circuit breakers, contactors, and power terminal blocks in each transformer's power cabinets, as indicated, conforming to the applicable requirements of NEMA ICS 2. The 480 V AC Government power supply will route through conduit connected directly from the Project to the base of the power cabinet, as indicated on contract drawings.

2.14.5 Device Nameplates

Provide an engraved nameplate for each item mounted in the transformer control and power cabinets that are comprised of anodized aluminum or stainless steel, engraved and provided with black lettering. Each nameplate must be fastened to the panels in proper locations, with either corrosion-resistant black finished round head screws, or on screw posts with corrosion-resistant black finished nuts. Nameplates must not be fastened to the wire ducts or duct covers. Labeling and marking must meet the requirements of UL 969, paragraph 7.3, "Marking and labeling systems for hazardous locations products".

2.15 CONTROL AND POWER CABINET EQUIPMENT

2.15.1 Cooling Control Equipment

2.15.1.1 General

The control equipment must be fully automatic, and manufactured to start and stop the fan motors as each transformer's winding temperature requires. The controls must de-energize all fans in the event of a transformer shutdown operation, as indicated. Provide additional circuit breakers for branch circuit protection of cooling circuits as required. All cooling control equipment must meet the applicable requirements of the NFPA 70.

2.15.1.2 Stages of Cooling

The cooling control circuits must provide for the following:

a. Provide transformers that are self-cooled through natural convection of the oil with no cooling fans in operation, capable of operation at the 100% base nameplate rating (ONAN) without exceeding the maximum allowable temperature rise.

b. Provide a winding temperature indicator fan contacts to activate the forced-air cooling group when the transformers are operating at a winding temperature corresponding to a load equal to the 100% self-cooled (ONAN) rated condition, as obtained during performance of the factory temperature rise testing.

c. When the maximum safe winding temperature for continuous operation has been reached, the winding temperature indicator alarm contact must provide an alarm for "Winding High Temperature" indication. This winding temperature setting must be at 110 degrees-C.

d. When the maximum allowable winding temperature has been reached,

the analog winding temperature indicator must initiate a transformer shutdown utilizing the lockout relay in the powerhouse and set at a temperature of 117 degrees-C.

2.15.2 Transformer Fiber-Optic Probes and Connectors

Fiber optic probes must be installed in each transformer's windings and terminated at the fiber-optic feed-through plate interface on the tanks for future use with a temperature monitor. The fiber-optic probes must be made of non-conducting materials allowing for them to be immersed in oil and held in close contact to transformer windings for direct accurate measurement of temperature. Provide probes, connectors and their installation that meet the following requirements:

a. Provide probes that function based on the principles of Gallium Arsenide (GaAs), be capable of measuring transformer temperatures from -40 degrees Celsius to 200 degrees Celsius.

b. The fiber-optic jacket must feature a continuous slit to allow for complete oil immersion.

c. Utilize Fiber-optic feed-thru connectors at a tank wall plate, for connection of the internal fiber-optic probes to the fiber-optic extension cabling.

d. Feed-through connectors with internal sealing using glass metal soldering.

e. Stainless steel tank wall plate interface for the feed-thru connectors, including a removable, weatherproof cover.

f. Provide 2-inch conduit from the feed-through wall plate interface down to the control cabinets for routing of fiber-optic extension cables.

g. Provide the necessary extension cables from the wall plate to the control cabinets.

2.15.3 Auxiliary Power Transformer

The auxiliary power transformer must have 480 V AC primary - 120 V AC secondary, single-phase, conforming to the requirements for general purpose transformers in UL 508, and must be mounted on the transformer tanks adjacent to the power cabinet, as indicated. The auxiliary transformer will be used to power all AC circuits rated below 480 VAC as indicated. The Volt-Ampere capacity must be coordinated with the connected control circuits, and indicated on the shop drawings. The auxiliary power transformer must have the following characteristics:

a. Isolating transformer design, with an electrostatic shield

b. Housed in a NEMA Type 3R rated enclosure

c. Manufactured with all copper windings with a 200 degrees-C rated insulation system

d. Finger-safe terminals

2.15.4 Magnetic Contactors

The rating, performance and service characteristics must conform to the requirements of NEMA ICS 2 for contactors with continuous current ratings for the duty indicated. Contactors for motor control must be rated for full-voltage starting (Class A controllers). Provide NEMA Size 2 contactors as a minimum, and must be rated for at least 200,000 complete operations under rated load without more than routine maintenance. The interruption arc and flame must be minimized by suitable arc chutes or other means so that no damage will be done to other portions of the device. The arc chutes, if provided, must be easily removable without removing or dismantling other parts. The contacts must be easily removable. All current-carrying contact surfaces must be silver-surfaced or of other approved material to prevent the formation of high resistance oxides. The contactor must operate without chatter or perceptible hum while energized. Coils must be rated for continuous operation for 120 V ac circuits. Alternating-current contactors must be three-pole, except where otherwise noted, and must be insulated for 600 V ac and of the electrically-operated, magnetically-held type.

2.15.5 Molded-Case Circuit Breakers

2.15.5.1 General

Provide Molded case circuit breakers that are listed to UL 489, and have voltage ratings and interrupting ratings hereinafter stated. They must be the manually-operated, quick-make, quick-break, automatic-trip, bolt-in, heavy-duty, industrial type. All poles of each breaker must be operated simultaneously by means of a common handle, and must be enclosed in a common molded plastic case. Single pole trip units with handle ties are not permitted. The operating handles must clearly indicate whether the breakers are in "On," "Off," or "Tripped" position. Miniature circuit breakers, circuit breakers listed for residential and commercial use, and plug-in type breakers are not acceptable.

2.15.5.2 Trip Units

The circuit breakers must be of the automatic type provided with combination thermal and instantaneous magnetic or solid state trip units, with instantaneous trip units set at approximately 10 times the continuous ratings of the circuit breakers. The Government reserves the right to change the indicated trip ratings, within frame limits, of the trip devices at the time the shop drawings are submitted for approval.

2.15.5.3 480 V AC Circuits

Circuit breakers for 480 V AC circuits must be rated 600 V AC, and have a minimum interrupting capacity of 18,000 Amperes at 480 V AC, and must come equipped with an integrated trip-handle padlocking provision.

2.15.5.4 120 V AC Circuits

Circuit breakers for 120 V AC circuits, must be rated not less than 250 V DC, and either 120/240 or 240 V AC, with a minimum NEMA interrupting capacity of 10,000 Amperes symmetrical.

2.15.5.5 125 V DC Circuits

Circuit breakers for 125 V DC circuits must be of the heavy duty type

conforming to the applicable requirements of UL 489, rated for not less than 125/250 or 250 V DC operation with a minimum NEMA interrupting capacity of 10,000 A dc.

2.15.6 Control and Instrument Switches

Control and instrument switches must be of the rotary switchboard type with handles on the front and the operating mechanisms on the rear of the panels, and have the following features:

a. Suitable for operation on 600 V AC or 250 V DC circuits, capable of satisfactorily withstanding a life test of at least 10,000 operations at rated current, and capable of continuously carrying 20 Amperes without exceeding a temperature rise of more than 30 degrees Celsius above ambient.

b. Provided with ample contact stages to perform the functions of the control system.

c. Self-aligning contacts which operate with a wiping action.

d. A positive means of maintaining high-pressure on closed contacts.

e. Compression springs or pivoted joints must not be depended upon to carry current.

f. The covers or plates on the switches must be readily removable for inspection of contacts.

g. A single-breaking inductive load minimum interrupting rating of 1.5 Amperes for 125 V DC, or 10 Amperes for 120 V AC.

h. An escutcheon clearly marked to show each operating position, with the switch identifications engraved on the escutcheon plate and on a separate nameplate.

2.15.7 Terminal Blocks

Provide terminal blocks for control signal and current transformer secondaries with the following features:

a. Washer-head screw type, designed for connection of two No. 10 AWG conductors to each terminal.

b. Rated, at minimum, for 90 degree C terminations.

c. White or other light colored marking strips for circuit designation, with each connected terminal of each block having the circuit designation or wire number indicated on the marking strip with permanent marking fluid. One reversible or spare marking strip must be furnished with each terminal block.

d. Terminal blocks provided to terminate all external cables, containing at least two spare terminals, or 10 percent of total terminals as spares, whichever is greater, per terminal block.

2.15.7.1 Control Signal Type

Provide terminal blocks for control wiring, with a sliding link disconnect

molded or fabricated type with barriers, rated not less than 600 volts with 30 Ampere capacity.

2.15.7.2 Short-Circuiting Type

Provide dedicated short-circuiting type terminal blocks for each current transformer's secondary leads, which will allow for shorting together the secondary leads of the current transformers without opening any circuit.

2.15.7.3 Power Distribution Blocks

Provide power distribution blocks to be used for branch circuits and feeders 600 volts and less with wire size #12 AWG and larger. Power distribution blocks must have lugs suitable for copper conductors, must be two-pole for single-phase circuits (phase and neutral conductors, or two phase conductors), and three-pole for three-phase circuits (three phase conductors).

2.15.8 Fuses and Fuseholders

Provide Class J fuses meeting the requirements of UL 248-8, rated for 600 V AC operation, and be dual-element with a 10 second time-delay at 500 percent overload. Provide Class J fuseholders, meeting the requirements of UL 4248-8, and be of a finger-safe modular type, consisting of a removable fuse carrier which allows fuse replacement away from the base.

2.15.9 Lighting, Convenience Receptacle, and Cabinet Heaters

Provide cabinet lighting, convenience receptacle and heaters that have the following features:

a. Lighting consisting of 120 V AC Size A19 LED bulbs with a medium E26 base, each with integral heat sink and 800 Lumens minimum output, complete with industrial grade socket with bulb safety cage, wiring, and door-activated switches.

b. Provide a 125 V AC, 3-wire, 20 Ampere, hospital grade GFCI type receptacle for the inside the control cabinet.

c. Provide industrial grade enclosure heaters in each cabinet to prevent condensation when the outside temperature is as low as -25 degrees Celsius, while maintaining a minimum interior cabinet temperature of 10 degrees Celsius. The enclosure heaters must be mounted on the cabinet side panels towards the bottom, and be of a touch-safe, positive temperature coefficient (PTC) resistor type with an integral fan. The heaters must have a rated operating voltage of 120 V AC, and be thermally sized for the cabinet volume in which they are installed. Submit for approval the Cabinet heater sizing calculations, with considerations given to cabinet sizing and material. Provide a separate humidity and temperature control device which controls the cabinet heaters and independently monitors the relative humidity and enclosure temperature, which have the following characteristics:

1) Temperature setting range: 0C - 60C
2) Relative humidity setting range: 50% - 90%
3) Operating voltage: 100 VAC - 240 VAC
4) Switching relay output (minimum): 10A resistive, 1.6A inductive @ 240 VAC

5) Inrush current (minimum): 30A for 10 sec
6) Heaters set at 20 C
7) Humidistat set to 20% relative humidity

2.16 INSULATED WIRE AND CABLE

Provide all insulated wire and cable that conform to the requirements of Section 26 05 19.00 26 INSULATED WIRE AND CABLE.

2.17 CONDUIT SYSTEMS

2.17.1 General

Run all wiring from the transformer devices and accessories listed below in rigid galvanized steel conduit greater than 1-inch in diameter, installed plumb and level, and terminated at devices, connection boxes and at the control cabinet using fittings suitable for wet locations. Conduit runs used on the transformer tanks' cover must be installed so as to help maintain an obstruction-free walking surface. The conduit systems must be electrically continuous and all threaded joints must have the threads coated with an approved high temperature lithium based, anti-galling conductive joint compound, rated for -70 degrees-C 1800 degrees-C, such as Crouse-Hinds Type HTL high temperature thread lubricant. The use of PTFE (polytetrafluoroethylene) tape at conduit threaded joint connections will not be allowed. Conduit threads must be tapered, and no running threads will be allowed. Conduit runs must be deburred and cleaned of shavings and debris prior to the routing of wire and cable.

2.17.2 Corrosion Protection

Provide conduit, conduit fittings, conduit bodies, and conduit outlet boxes made of ferrous metal materials that is hot-dip galvanized in accordance with ASTM A123/A123M and ASTM A153/A153M.

2.17.3 Conduit and Fittings

a. Rigid Metal Conduit. Provide rigid metal conduit that is zinc-coated both inside and outside by the hot-dip galvanizing method, conforming to the requirements of ANSI C80.1.

b. Rigid Metal Conduit Fittings. Provide threaded fittings for rigid conduit that is made of solid zinc or malleable iron conforming to the requirements of UL 514B and/or NEMA FB 1. Malleable iron fittings must be zinc-coated both inside and outside by hot-dip galvanizing method, with hubs having a grounding screw on the locknut.

c. Liquid-Tight Flexible Metal Conduit. Provide liquid-tight flexible metal conduit that is made from steel strip that is zinc-coated by the hot-dip galvanizing method with a water-proof extruded PVC cover conforming to the requirements of UL 360. The liquid-tight flexible metal conduit must have either have an integral bond wire or be an interlocked design with no bonding wire. Lengths of liquid-tight flexible metal conduit connections to equipment must not exceed 36-inches, and must be securely fastened to the transformer tanks.

d. Liquid-Tight Flexible Metal Conduit Fittings. Provide fittings for liquid-tight flexible metal conduit that is made from steel or malleable iron with a zinc coating and positive bonding, conforming to the requirements of UL 514B.

2.17.4 Conduit Bodies

Provide conduit bodies and covers that meet the following requirements:

a. Be made from malleable cast iron, be corrosion resistant and UL listed.

b. For the purposes of mechanical and environmental integrity, all conduit bodies must be raintight and suitable for use in hazardous locations, conforming to UL 1203 installed in outdoor locations subject to adverse environmental conditions.

c. Conduit body covers must attach to the conduit bodies that come with a neoprene gasket, and be attached by screw connections.

d. Provide conduit bodies for use in locations to provide for change in conduit direction, access to conductors, and as pull boxes.

2.17.5 Conduit Outlet Boxes

Provide conduit outlet boxes and covers that meet the following requirements:

a. Be made from malleable cast iron, be corrosion resistant and UL listed.

b. For the purposes of mechanical and environmental integrity, all conduit outlet boxes must be raintight and suitable for use in hazardous locations, conforming to UL 1203 installed in outdoor locations subject to adverse environmental conditions.

c. Provide conduit outlet boxes and covers made from malleable cast iron with externally threaded body and internally threaded cover. All conduit entrances must be bossed, drilled, and tapped with tapered NPT threads. Conduit entrances must be located on the bottom or sides of the box to the greatest extent possible to prevent the ingress of water. If required, outlet and junction boxes must be equipped with external mounting lugs.

2.18 SPARE PARTS

Provide all spare parts that are duplicates of the original parts furnished and interchangeable therewith. Furnish the following spare parts, and submit for approval a spare parts list, indicating the quantity furnished, manufacturer, catalog or model number, and the retail cost of each item in US Dollars.

a. One complete set of all gaskets needed to seal all openings into the transformer tanks at the cover, manholes, handholes, openings for accessory devices, openings for each type bushing, and pipe connections for radiators.

b. One complete set of all gaskets required to replace the shipping gaskets, for use during final assembly of the transformers.

c. One complete relay and contactor of each type and rating

d. One pressure relief device (Qty. 1)

e. One liquid level indicator (Qty. 1)

f. One winding temperature indicator (Qty. 1)

g. One oil temperature indicator (Qty. 1)

h. One bushing current transformer, of each type and rating

i. One rapid pressure rise relay and seal in relay (Qty 1)

j. Two fans, complete with motors, cables and connections (Qty. 2)

k. One crated radiator complete with inlet and outlet isolating valves, vent and drain valves, and blank flanges (Qty. 1)

l. Three fiber-optic extension cables that connect from the feed-through wall plate to the control cabinet (Qty. 3)

m. One fuse of each type and rating

n. One pressure regulator for nitrogen-gas equipment (Qty. 1) (if supplying nitrogen blanket type oil preservation system)

o. One Buchholz Relay (Qty.1) (if supplying a COPS type oil Preservation system)

p. One spare valve of each type and size

2.19 NAMEPLATES

Transformer nameplates must be Type 316 stainless steel, with the information chemically etched then filled with baked enamel paint.

2.19.1 Transformer Nameplate

Each transformer nameplate must conform to the requirements of IEEE C57.12.00, Table 6, and also include the following information:

a. Government contract number

b. Transformer X/R ratio

c. Estimated weight of the insulation system

d. The nameplate or an adjacent nameplate must also include the following information for each current transformer furnished: the accuracy class, the primary and all secondary ampere ratings, the thermal rating, and identification of the terminals to which the current rating applies.

2.19.2 Lifting Nameplate

Provide a lifting diagram nameplate mounted on each transformer, adjacent to the transformer nameplate showing the following:

a. Various sling and lift positions required for proper lifting of the core and coil assembly.

b. Lifting or jacking the completely assembled transformer.

c. The overall height required for untanking.

d. Indication that the transformers can be lifted or jacked when filled with oil.

2.19.3 Device Nameplates

Provide nameplates for the following devices that are mounted on each transformer. The nameplate must be permanently affixed onto a bracket adjacent to the device.

a. High-voltage bushings (H1, H0)

b. Low-voltage bushings (X & Y)

c. Core ground bushings

d. Center of gravity markers

e. Winding temperature indicator

f. Oil temperature indicator

g. Thermowells

h. Valves

2.19.4 Additional Transformer Identification

Provide the following additional transformer identification for each transformer:

a. The transformers serial number welded onto the tank, or on the face of the jacking pad nearest the main drain valve, with letters approximately 1-inch in size.

b. The location of the centers of gravity (c.g.) of the completely assembled transformer filled with oil, and for the shipping configuration without oil, permanently marked with weld-on nameplates or tags on two adjacent sides of the transformer tank and identified "c.g. complete" and "c.g. for shipment".

c. Stamping of the serial number on the core frame structure or into the tank immediately adjacent to the transformer nameplate.

d. The 25 degrees Celsius operational oil level must be indicated on the outside of the tank sidewall by either a raised surface weld bead with contrasting paint color, or with an etched nameplate permanently affixed to the tank wall.

PART 3 EXECUTION

3.1 TRANSFORMER DESIGN DATA REVIEW MEETING

3.1.1 General

Conduct a transformer design data review meeting at the transformer

manufacturing facility, with representatives of the Contractor, transformer manufacturer, and the Government representative in attendance, not later than 120 days after contract award. Provide the notification of the date of the transformer design data review meeting, the location, the duration, and the proposed agenda. Notification must be no less than 30 days in advance for domestic travel in the US and 60 days in advance for travel outside the continental US. The intent of the design data review meeting is to:

a. Meet with the manufacturing personnel and tour the manufacturing facility.

b. Discuss the technical specifications which address transformer manufacturing, testing, and shipment.

c. Perform a design data review with transformer manufacturing engineers and key personnel.

3.1.2 Design Data Review Meeting Requirements

The purpose of the design data review portion of the meeting is to help assure prior to official submittals that the key elements of the transformer specification requirements are being met, and to describe the transformer manufacturing and design data features. In preparation for the design data review meeting, the transformer manufacturer must have submitted a transformer design data review report in PDF format for the transformer design, which includes the following elements as a minimum:

a. Transformer nameplate data and ratings

b. Preliminary transformer layout drawing

c. Winding connection diagram

d. Winding design information, including:

(1) Proposed winding material supplier.
(2) Winding manufacturing details, including the turn design, dimensions and weight.
(3) Block diagram of the winding arrangement.
(4) Conductor type
(5) Insulation type
(6) Tabular listing of the calculated and maximum allowable voltage stresses within the windings for chopped-wave and full-wave conditions, including the factory design factor of safety margins.
(7) Block diagram of the windings indicating the various voltage stresses.
(8) Calculated resistance (@ 85 degrees-C reference)
(9) Drying and clamping methods.
(10) Design features added to assure reliable operation in back feed mode.

e. Thermal calculations and distribution throughout the windings, including proposed locations for the fiber-optic temperature probes.

f. Core design information, including:

(1) Proposed core lamination steel supplier

(2) Core manufacturing details, including the number of limbs, dimensions and weights
(3) Core material type
(4) Joint construction
(5) Banding
(6) Acceptable gap/burrs
(7) Cooling ducts
(8) Rated flux density
(9) Calculated exciting current

g. Calculated short-circuit currents and forces

h. Loss calculations

i. Impedance calculations

j. Accessories, including:

(1) Bushings
(2) Cooling equipment
(3) De-energized tap changer

3.2 TRANSFORMER DRAWINGS

3.2.1 Outline and Assembly Drawings

Submit for approval the transformer outline and assembly drawings to demonstrate that the equipment will conform to the requirements and intent of the specifications, to include the following at a minimum:

a. Transformer nameplate information, for both the main and lifting nameplates as required in paragraph "NAMEPLATES".

b. Outline drawings, indicating the following:

(1) Layout and dimensions of the assembled transformer, including an elevation view for each side of the transformer, a plan view, and details of the tank structural base with the centers of gravity indicated with the transformer empty and filled with oil.

(2) Jacking, lifting and pulling facility locations.

(3) Locations of all ancillary equipment, dimensioned to the transformer centerlines or edges, as appropriate, including bushings, control and power cabinets, valves, gauges, relays, nitrogen regulator cabinet, radiators and fans, and grounding pads.

(4) Drawing legend and transformer weight information.

(5) A transformer elevation view indicating clearances required for untanking or disassembling.

(6) Information for the transformer oil levels, including: the minimum oil level in the tank without exposing the core and coil assembly, and the corresponding volume of oil to remove at 25 degrees Celsius; the maximum oil level in the tank to allow access to any bottom connected bushings utilizing handhole access covers, and the corresponding volume of oil to remove at 25 degrees Celsius.

c. Transformer winding layout and configuration diagram, consisting of a physical representation of the active assembly installed in the transformer tank, including a sectional elevation view of sufficient detail to identify the following basic features of the core/coil fabrication:

(1) Core legs
(2) High-voltage winding
(3) Low-voltage winding
(4) Winding taps
(5) De-energized tap changer and lead support structure
(6) Bushing configuration and connections
(7) Shielding (if present)
(8) Pressboard
(9) Tank wall surface

d. Control and power cabinets layout, including internal device layouts and component lists.

e. Electrical schematic diagrams which reference the associated detailed wiring connection diagrams, including:

(1) Cooling power schematic diagrams
(2) 120 V AC and 125 V DC control schematic diagrams
(3) Annunciation schematic diagrams
(4) Transformer accessories block schematic diagrams

f. General electrical drawings including:

(1) Wiring and ferruling methods
(2) Wire types, sizes and color coding
(3) Graphic symbols
(4) Device nameplates and marking methods

3.2.2 Detail Drawings

Submit for approval the transformer detail drawings, to include the following at a minimum:

a. Further refinement of the outline and assembly drawings, including the routing of conduit, piping, and locations of junction boxes and external devices.

b. Shipping drawing showing the outline of the transformers disassembled as required for shipment, including the following:

(1) Overall shipping dimensions, including indication of centers of gravity for the transformers in the shipping configuration. All devices remaining installed on the transformers during shipment must be indicated.

(2) Lifting details and overall height required for the slings and crane hook, including recommended sling length and ratings.

(3) Location of temporary covers for bushings, valves and control and power cabinets left installed during shipment.

(4) Method and locations for securing the transformers during

shipment.

(5) Details indicating the method of installing the SFRA test shipping bushings, their locations, and a description of the method of bracing the winding leads to these bushings during shipment.

(6) Location of impact recorders, shipping gas pressure gauge and pressure regulator system.

(7) A note indicating the requirement for shrink-wrapping of the transformers for shipment, and the type of material used.

c. Wiring connection diagrams showing terminal block and conductor designations, including detailed control and power cabinet interconnections and device locations, based upon the actual equipment arrangement.

d. A transformer outline drawing indicating the locations of all gaskets on the transformer, a schedule of each gasket type and size cross-referenced to the location on the outline drawing, and a detail for each design of gasket showing the gasket dimensions, groove dimensions and compression requirements.

e. A transformer outline drawing indicating the locations of typical welds, with structural weldment details for each type of weld.

3.3 TRANSFORMER FACTORY ASSEMBLY

3.3.1 General

Each transformer must be completely assembled and adjusted at the factory, and be subjected to the manufacturer's routine shop tests and other tests as specified below. All parts and accessories must be properly match-marked and identified for ease of re-assembly after delivery to Little Goose Lock & Dam "Storage Yard". After the transformer has been completely assembled and oil-filled, the overall weight of the transformers must be measured using a load cell when lifted with a crane or moved with an air pallet, and the measured weight must be included in the factory test reports, the as-built drawings, and on the final nameplate information.

3.3.2 Welding

3.3.2.1 General

Welding will not be accepted if the welding does not conform to the requirements of this specification, unless otherwise approved by the Government. Develop procedures for the welding all metals included in the work. Do not start welding until welding procedures, welders, and welding operators have been qualified and approved. Weld symbols must be in accordance with AWS A2.4. In all instances requiring adherence with AWS specifications, equivalent country of origin standards will also be accepted. If using equivalent country standard, welding submittals must provide table showing equivalency with AWS standards.

3.3.2.2 Welding Quality Control Plan

Before the start of tank manufacturing, submit for approval a welding

quality control plan which describes the methods, equipment, and procedures utilized to ensure quality control including but not limited to material tracking, weld tracking, NDT equipment calibration, non-conformance reports, weld repair, and inspection witness points. Indicate any manufacturer specific requirements used to verify the tanks are oil-tight in addition to those required herein.

3.3.2.3 Welder Qualifications

Welding operators and welders must be qualified and, as necessary, requalified for the particular type of weld to be performed. Qualification must be in accordance with AWS D1.1/D1.1M. The welder record of qualification must be submitted and approved. The Contractor must certify by name, the welders and welding operators so qualified including the date of qualification, code, and procedures under which qualified. Certification and testing of welders and operators must be performed by an independent testing company. Prior qualification may be accepted provided the welder has performed satisfactory work within the preceding three months under the code for which qualified, documentation of continuous welding in process and certification of prior qualification from an independent testing company is furnished. If at any time, the work of an operator appears questionable, such operator will be required to pass additional qualification tests to determine their ability to perform the welding of work on which they are engaged. All such additional qualification tests for welding operators and the physical tests of the welded specimens must be witnessed by the Government, unless waived in writing.

3.3.2.4 Welding Materials

Welding materials must comply with AWS specifications. Welding equipment, electrodes, welding wire, and fluxes must be capable of producing satisfactory welds when used by a qualified welder or welding operator using qualified welding procedures.

3.3.2.5 Welding Procedures

Submit for approval a complete schedule of welding procedures including certified copies of reports of test results, consisting of detailed procedure specifications for each structure to be welded, and tables or diagrams showing the procedure to be used for each required joint. Do not perform welding without an approved procedure. Applicable prequalified weld procedures in AWS D1.1/D1.1M may be submitted for approval. Weld procedures not meeting the requirements of prequalified weld procedures in AWS D1.1/D1.1M may be submitted and qualified through testing under AWS D1.1/D1.1M or ASME BPVC SEC IX. All welds must be made using low-hydrogen welding rods or electrodes/electrode-flux combinations capable of depositing weld metal with a maximum diffusible hydrogen content of 8 mL/100g (H8). If the use of other filler metals is preferred, submit for approval a written justification of why an alternative is preferred and indicate where these welds will be utilized. Perform all welding using the electric-arc method, by a process which will exclude the atmosphere from the molten metal. Submit for approval the product data on welding electrodes and rods and shielding gas. All welded joints must conform to AWS publications, or as otherwise specified or approved, and the qualification plates representing those joints must be tested in accordance with AWS D1.1/D1.1M or AWS D1.6/D1.6M. All oil piping welds must meet the requirements of ASME B31.1.

3.3.2.6 Preheat and Interpass Temperature

Preheating must be performed as required by Section 3 of AWS D1.1/D1.1M, or as otherwise specified except that the temperature of the base metal must be at least 70 degrees Fahrenheit.

3.3.2.7 Weld Inspections, Tests and Weld Inspector Qualifications

a. All welds must be visually inspected to ensure conformance to the requirements of this specification, the appropriate section of AWS D1.1/D1.1M, and the approved welding procedure. Submit for approval the weld inspector qualifications, meeting the requirements of AWS D1.1/D1.1M and ANSI/ASNT CP-189, for the personnel responsible for inspections. Inspections must be performed visually, and during the transformer leak tests per the requirements of paragraph "Pressure Test". If the weldment is determined to be the cause of failure to pass the pressure test, the Government reserves the right to either a Non-Destructive Examination or Destructive Examination of any welds with the cost borne by the Contractor.

b. The following tests must be performed on all welds, and the results included in a Weld Inspection and Test Report:

(1) Dye penetrant test performed on all welds.

(2) Magnetic particle test performed on all lifting lug welds.

(3) Ultrasonic test performed on 25-percent of all full penetration welds.

3.3.3 Manufacturing Inspection by Government Personnel

Manufacturing inspections of each transformer may be performed by a representative of the Contracting Officer, at the option of the Government. These inspections would be performed at, but not necessarily limited to, the following manufacturing hold points:

a. Manufacturing facility inspection during the Design Data Review Meeting.

b. Weld inspection during tank manufacturing, to include dye penetrant, magnetic particle and ultrasonic testing.

c. Inspection of the windings after completed, but prior to being landed on the core. During this inspection, winding and core material bill of material information must be provided, and the materials inspected, for comparison with the manufacturer's design data to assure conformance.

d. Transformer manufacturing: Inspection of the completed core and coil assembly prior to tanking. Winding and core assembly drawings, including the lead support structure, must be made available during performance of these inspections.

e. Completely assembled transformers during performance of the factory acceptance tests.

3.4 FACTORY CLEANING AND PAINTING

3.4.1 General

All interiors and exteriors of the tanks, enclosures, cabinets, and other metal parts which are not galvanized or of corrosion resistant material and are exposed to oil or weather must be thoroughly cleaned and painted. Cleaning must be by degreasing and abrasive blasting or other means to remove all grease, scale, corrosion, and foreign substances. All paint must be lead-free.

3.4.2 Interior Surfaces

All interior surfaces of the main tanks must be given at least one priming coat and one finish coat of oil-resistant paint or enamel. The interior tank color must be white. After painting of the tank interior, the surfaces must be allowed to cure for one week prior to the introduction of insulating oil.

3.4.3 Exterior Surfaces

All exterior surfaces of the transformers, except as otherwise indicated, must be given a primer and two finish coats of paint in the factory. The paint color must be Munsell 5BG 7/0.4 high gloss (ANSI No. 70 gray), per the requirements of ASTM D1535, and must consist of a polyurethane top coat over an epoxy base coat. The dry film thickness of the primer must be a minimum of 1.5 mils, and that of the top and base finish coats a minimum of 3.5 mils. At minimum, supply one gallon of primer and one gallon of the polyurethane paint, from the same batch used on the transformers, for transformer field paint repairs. All SDS information must be provided with the touch-up paint, in the English language, and included in the Operations and Maintenance Manual. With prior approval of the Contracting Officer, other comparable paint types may be used. The cover surface of the transformer tanks must have a non-slip additive added to the paint, so that the color is the same as the tank color.

3.4.4 Machined Surfaces

All machine finished or corrosion-resistant surfaces must remain unpainted, and be thoroughly cleaned, coated with a suitable, easily removed, corrosion resistant compound, and wrapped or otherwise protected from damage in shipment.

3.5 TRANSFORMER FACTORY ACCEPTANCE TESTS

3.5.1 General

Perform all routine power transformer tests as indicated in IEEE C57.12.00, Table 17 on each transformer, fully assembled with all components installed which are being provided for the final assembled transformer. In addition to the required routine tests, the following design tests and specific test requirements must be performed, unless otherwise specifically indicated. Do not perform any power transformer acceptance tests until all submittals required up to the point of factory testing have been reviewed by the Government and given an Action Code 'A' or 'B' approval. The factory acceptance tests, including test equipment, test methods, measurements, and computations, must be in accordance with the applicable requirements of IEEE C57.12.00, IEEE C57.12.80 and IEEE C57.12.90, unless otherwise specified, and submit for approval the

Factory Test Procedures. Except where otherwise specified in the Standards, all measurements and tests involving alternating voltage must be made with 60 Hz sine wave voltage. The cost of performing all tests must be borne by the Contractor and must be included in the unit prices for the items of the Schedule. The Government representative will witness all tests required herein unless waived in writing, and do not ship any transformer, or parts until it has been released for shipment by the COR. Submit the notification of the date of factory tests as follows so that arrangements can be made for the Government representative to be present at the tests:

a. **For transformer manufacturers located in the United States**, notify the COR 30 calendar days in advance of when the transformer manufacturer will be ready for factory acceptance tests, so that the tests may be witnessed by a Government Representative at the manufacturer's facility.

b. **For transformer manufacturers located in foreign countries**, notify the COR 60 calendar days in advance of when the transformer manufacturer will be ready for factory acceptance tests, so that the tests may be witnessed by a Government Representative at the manufacturer's facility.

3.5.2 Factory Acceptance Test Report

Submit for approval an electronic PDF copy of the Transformer Factory Acceptance Test Report for each transformer tested, including digital waveform printouts, data files for the SFRA, insulation power factor, and leakage reactance tests, and complete data on all tests performed. The witnessing representatives of the Contractor and the Government must sign reports of all witnessed tests. The certified test reports must include the information as listed in IEEE C57.12.00, paragraph 8.7, and include all additional required tests results with the corresponding digital waveform and color thermal imaging printouts.

3.5.3 Dissolved Gas-In-Oil Analysis

Samples of the transformer insulating oil must be taken from each transformer, and dissolved gas-in-oil analysis tests performed as indicated, herein. Identity of samples and results of analyses must be included in the certified test reports, and the results of all insulating oil tests made available for inspection by the Government representative during the transformer factory acceptance testing.

a. After oil-filling of each transformer, and prior to the performance of any transformer factory acceptance tests.

b. After performance of dielectric tests.

c. After performance of temperature rise tests at each cooling rating.

d. Eight hours after performance of all transformer factory acceptance tests, to allow any possible generated gases to fully disperse within the oil.

3.5.4 Temperature Rise Test

Perform a temperature rise test on one transformer with measurements made at each cooling rating (ONAN, ONAF). During the temperature rise tests use

temporary fiber leads and temporary multi-channel fiber-optic temperature monitor to monitor and record the temperatures on all of the embedded winding fibers. During the temperature rise tests, obtain thermal images of all parts of the transformer utilizing a color infrared camera, and include the thermal images with corresponding temperatures indicating the ambient and hottest temperatures, including loading conditions, in the transformer's factory acceptance test report. The tank wall hot-spot temperature rise must not exceed 70 degrees-C while operating at 100 percent of its forced-air cooled rating.

3.5.5 Core Insulation Resistance

In the case of a core type transformer, the transformer core insulation resistance test must be performed on each transformer at each core ground bushing, for the main core connection to ground, and the core frame connection to ground.

3.5.6 Impulse Tests

All transformer impulse tests must be completed on a winding connection (bushing) before performing tests on a different winding connection. The impulse tests must be made by direct application without 60-Hz excitation. Computer-based waveform recordings must be taken of surge voltages during all impulse tests and of neutral current during the reduced full-wave and full-wave impulse tests, with the digital waveforms adjusted to give the same deflection on reduced-voltage and full-voltage impulse waves to facilitate comparison. Comparisons must also be made of the consecutive chopped-wave impulse waveforms. Waveform comparisons must be printed, and provided in the certified test report. Any deviation in voltage or neutral current wave shape between reduced-voltage and full-voltage full-wave tests, must be explained to the satisfaction of the COR or it may be considered cause for rejection of the transformer.

3.5.7 Induced Voltage Test With Partial Discharge Measurements

3.5.7.1 General

Partial discharge measurements during the induced voltage test must be per the requirements of IEEE C57.12.90, paragraph 10.8, and IEEE C57.113. It is recognized that sizable partial discharge readings during tests are likely to occur from causes external to the transformer, such as partial discharge in the high-voltage test circuit, noise from shop equipment, other tests being performed, and radiation or induction pickup through air between the measuring circuit and the high-voltage test equipment. All reasonable precautions must be taken to minimize such external interference, and if necessary, the manufacturer must demonstrate that this partial discharge is not internal to the transformer. It is permissible to utilize special bushing corona shields during performance of the tests.

3.5.7.2 7,200 Cycle Enhancement Level

During the 7,200-cycle test, the partial discharge level, excluding background noise, must not exceed 500 pico-coulombs. Any variation in corona intensity before and after application of full 7,200-cycle test voltage must be explained to the satisfaction of the Contracting Officer.

3.5.7.3 One-Hour Level

During the one-hour test, the partial discharge level must not exceed 300 pico-coulombs, and the increase in partial discharge levels must not exceed 100 pico-coulombs.

3.5.7.4 Data Reporting

All records, meter readings, and data taken during the above described tests, together with a diagram of the circuit employed, must be incorporated in the certified test report. The measurement of partial discharge using the apparent charge (pico-coulomb) method must be performed during the induced voltage test, and the measurements included with the test report.

3.5.8 Audible Sound Level Test

Perform an audible sound level test and it must be performed, and must not exceed the manufacturer's guaranteed sound level included in the proposal documents. The sound level tests must be performed at the ONAN rating, and at the ONAF rating with all cooling fans in operation. If the sound level exceeds the manufacturer's guaranteed level, the transformers must be modified as required to reduce the sound level and the test repeated. The abatement technique used to reduce the tested sound level to the guaranteed sound level must be subject to approval of the Contracting Officer. All data records taken during the sound level test, including a diagram of the transformer and how the measurements were taken, must be included in the certified test report. The data reporting format must be similar to that indicated in Figures 30 and 31 of IEEE C57.12.90.

3.5.9 Leak Test

Perform a leak test on each transformer tank and radiators when filled with oil. The test pressure must be a minimum of 4 psi, maintained for a minimum of 24 hours with no loss in gas pressure during the test period. The dial gauge used for this test must have a scale of 0 - 10 psi. During the pressure test, an alcohol-based industrial marking chalk, or another similar method of oil leak detection, must be applied to the tank welded seams and all gasketed connections and monitored for oil leaks. After the leak test is completed, all chalk must be cleaned off each transformer.

3.5.10 Leakage Reactance Measurement Test

Perform a leakage reactance measurement tests per the requirements of IEEE C57.152, paragraph 7.2.12, between the high-voltage winding and the low-voltage winding, for use as baseline data for future testing. Voltage, current, and phase angle measurements must be recorded, and the corresponding impedance calculated. Use standard equipment for performance of the leakage reactance test. The proposed test setup and procedures must be included in the factory test procedures submittal.

3.5.11 Sweep Frequency Response Analysis Tests

3.5.11.1 Required Tests

Two Sweep Frequency Response Analysis (SFRA) tests must be performed at the manufacturing facility, per the requirements of IEEE C57.149, at the following manufacturing stages for use as baseline data for future testing and for shipping purposes for each transformer.

a. After all factory tests have been performed, and while each transformer is still fully assembled and filled with oil.

b. After each transformer has been drained of oil and disassembled for shipment, and in its shipping configuration (see paragraph "SFRA Test Shipping Bushing). The test equipment and connections must be as indicated in paragraph "Test Equipment and Test Parameters", below, with the tests performed at the rated tap position.

3.5.11.2 Test Equipment and Test Parameters

Use a Sweep Frequency Response Analyzer for performance of the SFRA test. The proposed SFRA setup and procedures must be included in the factory test procedures submittal. The excitation source must be capable of providing consistent and controlled peak to peak voltage over the entire frequency range, with the test equipment parameters as follows:

a. A test voltage of 20V peak-to-peak minimum.

b. Testing performed over the 20 Hz to 2 MHz frequency range as a minimum.

c. Frequency response measurements made using a log-based scale for frequency.

d. An interference bandwidth (IBW), or equivalent, of less than 1 Hz at 10Hz used for each measurement frequency.

e. Record the magnitude of the response on a decibel (dB) scale for each measurement point.

f. The dB accuracy within 1 dB at every measurement point, using calibrated equipment.

g. A test set with a dynamic range better than 100 dB.

h. Record the phase, in degrees, for each measurement point, with an accuracy within 1 degree at every measurement point, using calibrated equipment.

i. High frequency coaxial test cables, with a 50 ohm matched impedance.

j. A three lead system, which consists of a signal, a reference and a test measurement lead.

k. All cables of the same length. A consistent ground connection should be available at the bushing end of the leads and be the same length for each cable.

l. The size and type of all temporary grounding leads identified.

3.5.11.3 Test Cable Integrity

Prior to the performance of any SFRA tests, the integrity of the test cables must be tested by a short-circuit test. Each coaxial test cable must be laid together, side-by-side on the floor, with the measurement clips connected together and the ground clips connected together. The

frequency response of the test cables when connected in this fashion should be "flat", with the exception of a gradual "roll-off" above 100 kHz due to pre-fitted cable grounds, and any variation could indicate damage within the coaxial cables. Any anomalies in the cable test results must be brought to the attention of the COR.

3.5.11.4 Test Connections

During performance of the SFRA tests, the test coaxial cables must be directly connected to the transformer bushings. For tall bushings, ground jumpers may be used to facilitate connection of the coaxial cable ground shield to the base of the bushing. All windings must be tested as indicated below, for the 'neutral' (or rated kV) tap position, and for the tap position that includes all of the windings, with each SFRA result identified by the applied and measured terminals. The SFRA tests must be per the requirements of IEEE C57.149, Table 5, Group 2, second column).

3.5.11.5 Data Reporting

Test equipment must be capable of producing a test report file which is in the Extensible Markup Language (XML) format. Test data must be able to be viewed without the editing, reorganizing or reformatting of the data. A simple format of separate measurements being in separate spreadsheet columns is required. The test data must show all waveforms in graphical form with the response in linear scale dB units on the Y-axis and the Frequency in logarithmic scale Hz on the X-axis. The Y-axis must auto-scale and the X-axis must display the range from 20 Hz to 2 MHz, as a minimum. The electronic version of the test report must include the complete data on a CD in the format and organization that will permit the file to be viewed completely using standard spreadsheet software. Data reporting must meet the requirements of IEEE C57.149, paragraph 5.

3.5.11.6 Data Interpretation

SFRA testing produces traces which provides information related to the physical geometry of the test specimen. The factory SFRA tests performed creates baseline data for use in future testing, and helps in recognizing obvious manufacturing defects, such as open circuits, short circuits, and winding deformations.

3.5.12 De-Energized Tap Changer Test

Each transformers' completely assembled de-energized tap changer (DETC) must be subjected to five complete tap changing cycles (end-tap to end-tap) during the process of transformer testing to demonstrate that all linkages, contacts, and indicating mechanisms are properly assembled and aligned and free from excessive slack, deformation, or fragility.

3.5.13 Transformer Turns Ratio Test

For Each transformer perform a transformer turns ratio (TTR) test on each tap in accordance with "Ratio Tests" paragraph of IEEE C57.152 after the completion of the DETC testing.

3.5.14 Insulated Wire and Cable

Perform testing on all insulated wire and cable within each transformer's control and power cabinets, extending to all transformer mounted equipment per the requirements of SECTION 26 05 19.00 26, INSULATED WIRE AND CABLE.

3.6 BUSHING TESTS

3.6.1 General

Bushing tests must be performed in accordance with IEEE C57.19.00 and IEEE C57.19.01. Any bushing that fails to pass all tests to which it is subjected will be rejected. Provide electronic PDF copies of all bushing and bushing current transformer test reports for each transformer.

3.6.2 Bushing Design Tests

Bushing design tests must be performed on one bushing of each type provided in accordance with IEEE C57.19.00, unless these tests have previously been performed on bushings of the same manufacture, design, type, and rating as those being provided within 10 years of the date of this contract, in which case the requirements for repeating these design tests will be waived and certified copies of the test results of satisfactory tests of this kind must be furnished to the Contracting Officer. If any bushing given the impulse tests fails to pass any of the tests, then all bushings of the same type and rating must be subjected to the impulse tests at no additional cost to the Government.

3.6.3 Bushing Withstand Test Voltages

The bushings must be tested per the applicable requirements of IEEE C57.19.01, Table 1.

3.6.4 Bushing Routine Tests

Each new bushing provided must be subjected to routine tests by the bushing manufacturer in accordance with IEEE C57.19.00, Table 3. Power factor tests must be performed on each design bushing per the following requirements:

a. Perform a power factor test at 10 kV for C1. The power factor must not exceed 0.35 percent.

3.6.5 Bushing Current Transformer Manufacturer Routine Tests

Provide electronic PDF copies of all bushing current transformer test data.

3.6.5.1 Routine Tests

Each bushing current transformer is to be given bushing current transformer manufacturer routine tests, including an applied voltage test, in accordance with IEEE C57.13, Annex B.8.

3.6.5.2 Tests Performed After Installation

Each current transformer is to be checked for proper nameplate and polarity markings prior to installation on the transformers, and be given a polarity and ratio check after installation and prior to the performance of the factory acceptance tests to ensure correct installation. The following bushing current transformer tests are to be performed after all other transformer acceptance tests have been completed, and the test results included in the factory acceptance test report:

a. Excitation curves for each turn ratio.

b. Ratio correction factor curves for each turn ratio.

c. The resistance of the secondary winding at 75 degrees Celsius, including the resistance of the secondary leads from the bushing current transformer to the terminal blocks in the control cabinet.

3.7 TRANSFORMER SHIPMENT, HAULING AND SITE ASSEMBLY

Each transformer and it's equipment, accessories, and spare parts must be prepared for shipment f.o.b. Little Goose Lock & Dam, transported, inspected, unloaded, moved into its storage location in the storage yard, re-assembled, oil-filled, and tested per the requirements of SECTION 48 20 00.04 26.

-- End of Section --

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