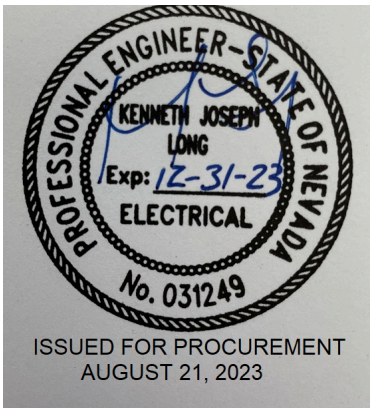
Specification No. 33 73 13.01

Liquid-Filled Main Power Transformer

Southern Nevada Water Authority

69-12.47 kV Monthill Substation
Las Vegas, NV

Exhibit A



Kenneth J Long, PE

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Project No. 3636S (181301299)

Stantec

Revision Chart

Rev.	Reason for Change	Author	Review	Issue Date
A	Released for Client Review	KJL	CAL	01/13/2023
B	Comment Revisions	KJL	MR	05/03/2023
C	SNWA Backcheck Comment Revisions	KJL	LH	08/04/2023
D	Commitment Number Revisions	KJL	LH	08/18/2023
E	Final Backcheck	KJL	MR	08/21/2023

Abbreviations and Acronyms

A	Amperes, measure of electrical current
AC	alternating current
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
BCT	Bushing Current Transformer
°C	Measurement of temperature, degrees Celsius
Contractor	The Construction Contractor responsible for installation
DAP	Delivered-at-Place, Destination
DC	Direct Current
DETC	De-Energized Tap-Changer
DOT	Department of Transportation
DWG	AutoCAD proprietary drawing format
DXF	Data Exchange File
FOB	Free on Board, Destination
HV	High-Voltage (in this text it refers specifically to the high-voltage winding, or series winding)
Hz	Hertz, measure of electrical frequency
IEEE	Institute of Electrical and Electronics Engineers
kV	kilovolts (1000's of Volts)
LV	Low-Voltage (in this text it refers specifically to the low-voltage winding, or common winding)
MCOV	Maximum Continuous Operating Voltage (with reference to a surge arrester's operating voltage)

Abbreviations and Acronyms – continued

MPT	Main Power Transformer (a step-down two-winding transformer serving the Project's distributed electrical load)
MR	Multi-Ratio, refers to CT secondary winding with taps
MSDS	Material Safety Data Sheets
MVA	Megavolt-Amperes, measure of electrical power, one-million volt-amperes
NA	Not Applicable
NEMA	National Electrical Manufacturers Association
NESC	National Electric Safety Code
OLTC	On-Load Tap-Changer
PD	Partial Discharge
PDF	Portable Document Format
pF	Picofarads, measure of electrical capacitance
ppm	parts per million
PSD	Project Specific Data Sheets (Appendix A)
Purchasing Authority	The originator of the purchase order
QA/QC	Quality Assurance/Quality Control
QSR	Quality Surveillance Representative
RFP	Request for proposal
rms	Root mean square, measure of electrical voltage
RV	Regulating Voltage (in this text it refers specifically to the high-voltage regulating winding, or tapped winding)
SR	Single-Ratio, refers to CT secondary winding without taps
SQL	Seismic Qualification Level

Abbreviations and Acronyms – continued

Stantec	Stantec Consulting Services Inc.
V	Volts, measure of electrical voltage or potential
VA	Volt-Amperes, measure of electrical power

Table of Contents

PART 1 - GENERAL

1.1 SUMMARY

A. Southern Nevada Water Authority (“Owner”) is the owner of this project and will be acting as the Purchasing Authority for the project’s substation major material items. Construction responsibilities and additional minor material procurement responsibilities have been contracted to a construction management at-risk (CMAR) Contractor (hereinafter referred to as the “Contractor”).

B. The Owner has contracted preparation of the major material specifications, bid solicitation, and bid evaluation to a consulting services provider, Stantec Consulting Services, hereafter referred to as the “Owner’s Engineer”, *or* simply “OE.” The Owner and OE are identified along with their key personnel identified in table titled “Organization and Management” in Appendix B of this specification.

C. Reference to the Supplier within this specification is intended to mean the equipment manufacturers, their authorized sales representatives, their authorized distributor and/or their subcontractor.

D. This specification is for a 69Δ-12.47Y/7.20 kV, 12/16/20 MVA, three-phase, two-winding transformer. The MPT is being used as single customer distribution substation main power transformer for a water pumping facility. As such, the MPT will function as a step-down transformer. The MPT will be operating under full-load conditions for much of the time, consequently, load losses will be given careful consideration in the evaluation of each Supplier’s proposal. The specific technical parameters for the MPT are provided in the PSD. A separate Supplier’s Data Sheets document will accompany the technical specification, which also serves as the bid form document which the Supplier will fill out and return with their proposal.

E. The MPT will be installed on a 69 kV (nominal) transmission system, to accommodate variations in the system voltage the high-voltage (HV) winding shall be provided with taps to accommodate seasonal fluctuations in the transmission voltage. The HV winding shall be tapped at the following phase-to-phase voltages: -2 x 2-1/2% of the nominal voltage, 69.00 kV (nominal voltage), and +2 x 2-1/2% of the nominal voltage. HV winding taps are to be switched using an in-tank DETC.

F. The OE will provide procurement services, including answers to bidder’s questions during the question period, technical and commercial evaluation of proposals, and a purchase recommendation. The Owner will issue a purchase order to the selected Supplier. The Owner and/or their designated representative will be referred to herein as the “Purchasing Authority.” The Purchasing Authority will designate a Receiving Agent who is authorized to receive the material specified herein at the location identified in table titled “Site Location and Direction” in Appendix B, hereafter referred to as the “Project Site”.

G. The MPT will be designed for the project’s specific power ratings and site conditions as specified in the PSD appendix section of this specification.

H. The proposal will be quoted with Delivered at Place Unloaded (DPU), if shipped from an international supplier. The MPT will be shipped under Free on Board (FOB) Destination freight terms to the Project Site (per INCOTERMS® 2020), if

shipped from a domestic supplier. Autotransformers shall be furnished in the quantity specified and to the Project Site. Delivery will include transference from the transport trailer to the Owner's transformer foundation at the Project Site. Transference by the Supplier shall not occur until after the impact recorder(s) have been reviewed and a determination has been made that the unit was not subjected to excessive forces and accepted by the Receiving Agent and the OE. The preferred transference method is jacking and rolling between transport and foundation. Foundation anchorage is to be performed by the Contractor. An engineered offloading lift plan and drawing is required. However, it need not be sealed with a professional engineer's stamp and signature.

I. The Supplier will separately list in separate line items in the proposal the (i) cost of the goods (ii) cost associated with shipping, transport from factory to the Project Site (iii) assembly, and transference to foundation (including assembly, dressing, oil-filling, and field testing) and (iv) relevant duties and taxes included in the proposal.

J. Unless altered by written directions from the Purchasing Authority, the Supplier will also be responsible for preparing the MPT for initial energization by performing the field assembly, dressing, oil-filling, field testing and commissioning once the transformer has been secured to the Owner's foundation at the Project Site. Oil-filling will not commence until the oil containment system is functional. Installation of the oil containment system is the responsibility of the Contractor. Upon completion of the Supplier's responsibilities to prepare the transformer for initial energization, the Supplier shall provide documentation to the Purchasing Authority that the transformer is ready for initial energization and that the terms of the warranty are in full effect. The Supplier will provide a list of the (i) Factory Acceptance Tests and (ii) Field Tests to be completed at the Project Site as part of their proposal with three weeks advance notice. The Supplier will list the cost associated with field assembly, dressing, oil-filling, field testing and commissioning as described above as a lump sum in their proposal as a separate line item.

1.2 REFERENCES

A. The following publications shall be used in conjunction with this material specification and form a part of this material specification to the extent specified herein. When a referenced publication is superseded by an approved revision, the revision at the time of award applies. Applicable industry documents may include, but shall not necessarily be limited to, those listed below. The Supplier will determine if any local jurisdiction requirements apply based upon the Project location identified in the PSD and notify the OE who will be responsible for their inclusion in the technical specifications.

American Institute of Steel Construction	
AISC Manual - 2017	Manual of Steel Construction (15th Addition)
AISC DG 1 - 2006	Base Plate and Anchor Rod Design (2nd Addition)
Air Movement and Control Association	
AMCA 230 - 2023	Laboratory Methods of Testing Air Circulating Fans for Rating and Certification
American National Standards Institute	
ANSI/AFBMA Std 9	Load Ratings and Fatigue Life for Ball Bearings
ANSI/AFBMA Std 11	Load Ratings and Fatigue Life for Roller Bearings

ANSI C57.19.100	Application of Power Apparatus Bushings
ANSI C57.98	Transformer Impulse Tests
ANSI C57.109	Liquid-Immersed Transformer Through-Fault-Current Duration
ANSI C62.1	Surge Arrestors for AC Power Circuits
ANSI Z55.1	Gray Finishes for Industrial Apparatus
ANSI/ASTM D3487	Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
American Society of Civil Engineers	
ASCE/SEI 7-10 (2010)	Minimum Design Loads for Buildings and Other Structures
American Society for Testing and Materials – International	
ASTM D877/D877M-19 (2019)	Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1816-12 (2019)	Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes
ASTM D3455-11 (2019)	Standard Test Methods for Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin
ASTM D3487-09	Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
ASTM PTC 8.2-1990	Centrifugal Pumps
American Welding Society	
AWS-D1.1/D1.1M 2020 (ANSI)	Structure Welding Code – Steel
Institute of Electrical and Electronic Engineering	
IEEE 21	Test Procedures for Outdoor Apparatus Bushings
IEEE 24	Characteristics & Dimensions for Outdoor Bushings
IEEE 32	Requirements, Terminology, Test Procedure for Neutral Grounding Devices
IEEE 100 - 2000	IEEE Standard Dictionary of Electrical and Electronics Terms
IEEE 242 - 2001	Protection and Coordination of Industrial and Commercial Power Systems
IEEE 262B	Dielectric Test Requirements for Power Transformers
IEEE C2 - 2017	National Electrical Safety Code
IEEE C57.12.00 - 2015	Standard for 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 for Terminal Markings and Connections for Distribution and Power Transformers
IEEE C57.12.90 - 2021	Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
IEEE C57.13 - 2016	Standard Requirements for Instrument Transformers
IEEE C57.19.00 - 2004	Standard General Requirements and Test Procedures for Power Apparatus Bushings
IEEE C57.91 - 2011	Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators
IEEE C57.106 - 2015	Guide for Acceptance and Maintenance of Insulating Oil in Equipment

IEEE C57.116 - 2014	Guide for Transformers Directly connected to Generators
IEEE C57.131 - 2012	Standard Requirements for Tap Changers
IEEE C57.148 - 2020	Standard for Control Cabinets for Power Transformers
IEEE C62.11	Standard for Metal-Oxide Surge Arresters for AC Power Circuit (>1 kV)
Insulated Cable Engineers Association	
ICEA S-73-532 - 2021	Standard for Control, Thermocouple Extension, and Instrumentation Cable (ANSI/NEMA WC 57)
International Electromechanical Commission	
IEC 60214-1: 2014	Tap-changers Part 1: Performance Requirements and Test Methods
IEC 60214-2: 2019	Tap-changers Part 1: Application Guide
National Electrical Manufacturers Association	
NEMA 107	Measurement of Radio Influence Voltage on HV Apparatus
NEMA CC1 - 2018	Electric Power Connections for Substations
NEMA LA1	Surge Arresters
NEMA MG1 - 2021	Motors and Generators
NEMA TR1 – 2013 (R2019)	Transformers Regulators and Reactors
International Electrical Testing Association	
ANSI/NETA ATS - 2021	Standard for Acceptance Testing Specifications
National Fire Protection Agency	
NFPA 70® (2023)	National Electrical Code
NFPA 70E® (2021)	Standard for Electrical Safety in the Workplace
Society of Protective Coatings	
SSPC-SP1	Solvent Cleaning
SSPC-SP2	Hand Tool Cleaning
SSPC-SP3	Power Tool Cleaning
SSPC-SP5	White Metal Blast Cleaning
SSPC-SP6	Commercial Blast Cleaning
SSPC-SP7	Brush-Off Blast Cleaning
SSPC-SP10	Near-White Blast Cleaning
United States Department of Labor - Occupational Safety and Hazard Association	
OSHA 3075 – 2002 (REVISED)	Controlling Electrical Hazards
OSHA 3138-015R (2004)	Permit-Required Confined Spaces
OSHA 3146-05R (2015)	Fall Protection in Construction

1.3 CERTIFICATIONS

A. Materials and equipment shall be suitable for the use intended and labeled and/or listed or certified as acceptable to the approving authority and/or agency having jurisdiction at the Project Site.

1.4 PRACTICES

A. It is the Supplier's responsibility to be knowledgeable and employ designs and manufacturing practices that incorporate the latest revisions of these standards where and when applicable.

B. The Supplier of the assembly shall be the manufacturer of the major components within the finished product. The Supplier shall have manufactured similar electrical equipment within their specified manufacturing facility for a minimum of five (5) years prior to submitting their proposal and shall provide a list of projects and references as an attachment to their proposal.

1.5 COMMUNICATIONS

A. In all cases, communications and correspondence with the Supplier shall be conducted through the Purchasing Authority, with copy to the OE. The Owner, Contractor, and the OE will not accept responsibility for any costs and/or delays resulting from the Supplier's communication through, or correspondence with, persons other than the Purchasing Authority.

B. The Supplier shall provide a single designated representative for all communication and correspondence with the Purchasing Authority.

1.6 MATERIAL SPECIFICATION COMPLIANCE

A. No substitutions for, or deviations from, the specific requirements of this specification will be permitted, without first obtaining written approval from the Purchasing Authority. Statements of clarification, exception, or deviation made by the Supplier within the Supplier's proposal will not be considered binding without confirmation and acceptance by the Purchasing Authority. Any such statements within the Supplier's proposal may result in the proposal being deemed as "Nonresponsive." Nonresponsive proposals may not be given further consideration

1.7 SUBMITTALS – DRAWINGS AND OTHER INFORMATION

A. The Supplier shall furnish the Quality Assurance/Quality Control Procedures requested in Quality Assurance QA/Quality Control Procedures QC Section of this specification

B. The Supplier shall state all the exceptions taken to this specification. If no exceptions are taken, the Supplier shall so state.

C. The Supplier shall provide the following information with the proposal:
   1. A completed Supplier's Data Sheet which was supplied by the Purchasing Authority as part of the request for proposal package.
   2. Pricing of unit and commercial terms. Pricing for shipping and delivery to the site shall be identified as a separate line item.
   3. Delivery time after receipt of order.
   4. Guaranteed load, no-load and auxiliary power losses.
   5. Reference list for equivalently sized BIL and MVA transformer units supplied to the North American utility, industrial, and renewable energy market within the past five (5) years.
   6. Method of shipment, shipment route and transport constraints assessment to confirm ability to deliver to the Project Site.

7. Detailed information on method of core and coil assembly bracing for operation and shipment.
8. Detailed information on vapor phase process for core and coil assembly drying, and the maximum allowable time between vapor phase and filling with oil.
9. Preliminary outline with overall dimensions of the power transformer, including the conservator tank and radiators.
10. Approximate shipping weights of the core and coils, tank and fittings, number of gallons of oil and weight. Weight shall be given in pounds.
11. Supplier shall identify the factory location where transformer(s) is to be assembled and tested.
12. Major components and accessories Bill of Material, including names of sub-suppliers, and material types and models.
13. Provide pricing for the following:
14. Fixed lump sum price for the supervision required to dress-out and field test the transformer once it has been set on the substation foundation.
15. Cost of Field Service Engineer services on a per day basis to help beyond those services included in the dress and test item above.
16. Recommended spare parts and any special tools required for maintenance and operation of the transformer (list to include item, recommended number off, and price per unit).

1.8 MAJOR MATERIAL LIST

A. The Supplier will submit a major material list to the Purchasing Authority for the OE's acceptance within 4-weeks after receipt of order. The list shall include bushings, arresters, tap-changers, cooling fans, and auxiliary protection devices as a minimum.

1.9 APPROVAL DOCUMENTS:

A. PROVIDE a CD and electronic files via online data room or file sharing service containing applicable drawings in both AutoCAD® Data Exchange File (DXF) and Portable Document Format (PDF) soft copy formats. Both soft copy formats of each drawing are to be provided as a set in the approval drawings packet. Soft copies are to be sent electronically via email to expedite the approval process. The Supplier will submit a major material list to the Purchasing Authority for the OE's acceptance within 4-weeks after receipt of order. The list shall include bushings, arresters, tap-changers, cooling fans, and auxiliary protection devices as a minimum.

1.10 FINAL DOCUMENTS:

A. A paper set of final drawings and other information, including installation, operation, and maintenance manuals from this section are to be furnished by the Supplier in a weatherproof envelope and shipped with the equipment. Three (3) additional physical sets of installation, operation, and maintenance manuals shall be sent directly to the Purchasing Authority.

B. All final drawings shall be furnished via online data room or file sharing service and on a CD in both AutoCAD® DXF and PDF softcopy formats. In addition, all instruction manuals and non-drawing documents shall be scanned into a PDF format and supplied in electronic copy per above. Electronic copies of the

submittals and final drawings are also to be sent to the Purchasing Authority and OE via email.

C. Drawings are to be full size (Arch C 18-inches by 24-inches). All quantities and values shown on the drawings, reports, manuals, and bulletins will be shown in both United States customary units and Metric System (SI) units, with the latter being shown in brackets or parenthesis. Drawing content shall be drawn to scale, or preferably 1:1 and displayed in a scaled viewport, with appropriate attention given to layers, particularly segregating text, and dimensions.

1.11 DRAWINGS REQUIRED

A. Provide the following drawings:
1. Assembled transformer outline drawing, including structural details of transformer base, center of gravity, and a detailed list of external components with their corresponding Item Number, sub-supplier, model number, and catalog number as appropriate.
2. Transformer outline drawing of unit as prepared for shipment, including center of gravity, and minimum dimensions and weight of unit prepared for shipment. Identify the location of impact recorders and pressure/vacuum gauge.
3. Nameplate Drawing.
4. Identification of type of winding construction and conductor material used in each winding; this information shall be shown on transformer nameplate drawing, outline drawing, or other documentation. Provide a separate statement regarding the basic design criteria used, including maximum allowable flux density in the core, the maximum turn-to-turn voltages, winding material, and configuration for information only.
5. Bushing outline drawings.
6. Valve schematic diagram, including valve position table for both filling conditions and operating conditions, with BOM item numbers identified on the transformer's outline drawing.
7. Surge arrester outline drawings.
8. Ground bus and grounding connections out line drawings for both the IEEE Segment 1 and Segment 3 tank walls.
9. Schematic and wiring diagrams showing complete terminal box wiring (including customer connection points); number, size, and power requirements of fans and pumps; fan and pump control; alarm and relay connections; and current transformer connections (both used and unused).
10. Current transformer nameplate drawings (or this information may be shown on the main transformer nameplate drawing); CT resistance per winding turn, and resistance of each lead; CT relaying accuracy classes; CT characteristic curves showing ratio correction and secondary excitation for relaying accuracy CT's; and CT factory test results including polarity, ratio, saturation, and insulation resistance.
11. An engineered lift plan for transference of the transformer from the transport vehicle to the jobsite foundation, and if applicable, an intermediate storage site.

1.12 OTHER DOCUMENTS REQUIRED

A. Certified Test Reports.

B. Supplier's Certification: Indicate transformer does not contain PCB's.

C. Supplier's Certification: Certify that Products meet or exceed specified requirements.

D. Supplier's Warranty Compliance Statement (after final field commissioning).

E. Winding Hot-Spot Calibration: Furnish a test circuit diagram for the winding hot-spot temperature equipment (including complete identification of all devices and terminal points), calibration curves, and complete factory test data.

F. Settings and configuration digital file for the Temperature Indicating Relay/Monitor.

G. Operation and Maintenance Data: Provide manufacturer's instructions covering the receiving, handling, installation, oil processing and filling, operation, and maintenance of the transformer and all auxiliary equipment. All operation and maintenance manuals shall be written in English.

H. Safety Data Sheets (SDS) for any chemical compounds that will be delivered in or with the transformer.

1.13 RENEWAL PARTS

A. The Supplier shall furnish a complete list of renewal parts for the transformer and all auxiliary equipment, including identification of each part by name and part number. Parts lists and drawings shall relate specifically to the equipment covered by this specification; typical drawings will not be acceptable.

1.14 CERTIFIED TEST REPORTS

A. Testing Requirements:
   1. The Supplier will perform routine production and design tests for the equipment specified herein in accordance with applicable industry standards, the specific requirements of this specification, and the approved Test Procedure Outline.
   2. The Supplier will provide specific details of the expected results which they deem to be "passing" or "acceptable" as part of the Test Procedure Outline.

B. Pre-Approval:
   1. Submit a copy of the Test Procedure Outline associated with any testing performed under the directions of this specification to the Purchasing Authority for approval and acceptance by the Owner's Engineer prior to the commencement of any testing.

C. Test Equipment Calibration Certificate:
   1. As part of the certified test report, the Supplier shall include a certificate which confirms the model and type of each piece of test equipment, the date the equipment was calibrated, and the date by which recalibration will be required.

1.15 PACKAGING AND SHIPPING

A. Air-filled
   1. The transformer shall be filled with dry breathable air at a pressure of three (3) psig, or with dry nitrogen at a pressure of three (3) psig. A conspicuous tag shall be furnished identifying the gas contents of the transformer

prepared for shipment and specifying the actual gas pressure and the ambient temperature at the time of filling. The transformer shall be equipped with a temporary compound pressure gauge, indicating both positive and negative (vacuum) pressure. The gauge shall have a minimum range of +/- 15 psig. Provide a permanent valve and cap (plug) to replace the gauge once the transformer is oil-filled. The transformer shall be shipped filled with dry breathing air with a dew point of the gas shall be no higher than -50°C. Tag each gasket for field assembly and each spare gasket with the transformer serial number and point of application for shipment.

B. Component Location Marking
   1. Major transformer components that must be shipped detailed for field installation (including, but not limited to, components such as radiators, pumps, conservator supports, and surge arresters supports) shall be marked for installation by means of permanent metal stamping. This metal stamping shall include adjacent marks on the component and the main transformer assembly to show both component location and orientation.

C. Shipping Dimensions and Weight
   1. The supplier shall be responsible for checking the shipping dimensions and weight of the proposed transformer design for suitability for shipment to the specified destination.

D. Notification of Shipment
   1. The Supplier shall notify the Purchasing Authority regarding the projected date of shipment once the production schedule is finalized, and then will notify the Purchasing Authority at least 48-hours prior to delivery of the equipment to make provisions for unloading. Contact information for notification will be provided no later than the time of shipment.

E. Transference and Impact Recorders
   1. Regardless of the transportation method used, the Supplier shall furnish and install at least two (2) separate impact recorders, each with a sealed protective cover. A recorder shall be mounted at each end of the transformer tank wall near the top. The Supplier shall provide a mounting platform for each recorder, which is to be permanently attached to the tank wall. Not less than one hour prior to scheduled departure of the transformer from the factory, the Supplier shall start the recorders and verify that they are operating properly. The impact recorders shall provide a continuous digital record covering the entire shipment period. The recorders shall provide data for impact forces in all three (3) axis as a function of time. At least one of the impact recorders shall be a digital storage device capable of being synchronized to a GPS location tracking module. Data transmission shall be available to the Purchasing Authority on a real-time basis. Digital data logger and tracking module shall be equivalent to SMT and Hybrid, Model MONILOG devices. Impact data recordings shall be presented to the Purchasing Authority's Technical Representative for review and acceptance prior to any transference from one transport to another, including ocean vessel to truck, truck to railcar, railcar to truck and/or truck to foundation.

F. Railroad Rider
1. The Supplier shall contract with a qualified railroad rider to monitor the location of the unit while in the possession of the railroad company. The rider will arrive ahead of the transport car at all railroad yards and/or transference points to arrange for proper handling and transfer. Any deviations or abnormalities reported by the rider will be shared with the Purchasing Authority and the OE.

G. Transference Notification
1. The Supplier shall notify the Purchasing Authority a minimum of three (3) working days prior to the scheduled transference of the transformer(s) from one type of transport to another.

H. Supplier's Representative
1. The Supplier may be asked to furnish a mutually agreed upon representative to be present at the delivery site to verify the transformer condition as received, before unloading from any transport vehicle. This representative shall (1) sign any impact recorder chart(s), (2) witness unintentional-core-ground testing, and (3) verify the internal inspection findings. Impact recorders shall only be removed once the transformer is set upon the substation foundation, and only in the presence of the Purchasing Authority's representative.

I. Transportation without Insulation Fluid
1. Large power transformers are typically shipped without insulating fluid. It is the Suppliers responsibility to deliver the transformer with a positive pressure of inert gas, and to utilize the appropriate means to maintain and monitor this condition. Additionally, the Supplier shall furnish a temporary pressure gauge providing visual indication of positive pressure. The wireless pressure gauge may be equivalent to the CirrusSense™ Model TDWPG, with Bluetooth communication capability.

J. Transformer oil shipment
1. The Supplier shall deliver transformer insulating oil to the Project Site in a bulk tanker truck. The Supplier will coordinate oil delivery with the Purchasing Authority's designated onsite representative to coincide with transformer filling activities (i.e., transformer oil not to be stored on site for extended periods of time). The Supplier shall notify the onsite representative a minimum of three (3) weeks prior to the scheduled date of delivery.

K. Parts removed for shipment
1. All parts removed for shipment shall be suitably crated to prevent damage during shipment and extended storage of three (3) weeks prior to the scheduled date of delivery.

PART 2 - PRODUCTS

2.1 TYPE

A. The MPT shall be a Class II as defined in IEEE C57.12.00, three-phase, two-winding (primary and secondary), outdoor, 60-Hertz, oil-immersed power transformer, with a nameplated 65°C average winding and top oil temperature rise,

and an 80°C winding hottest-spot temperature rise, above a 40°C maximum ambient temperature.

B. To regulate the low-side voltage the low-voltage winding (LV) shall be provided with a regulation winding (RV) having taps at the following phase-to-phase voltages: -16 x 5/8% of the nominal voltage, 12.47 kV (nominal voltage), and +16 x 5/8% of the nominal voltage. The MPT will be capable of continuous operation at each of the tap positions at the low-side voltages specified in the PSD, being regularly switched to maintain low-voltage regulation. LV winding taps are to be switched using an on-tank OLTC.

C. The LV winding set's line and neutral shall have a uniform insulation system insulated to the BIL levels indicated in the PSD. The HV winding set's insulation system shall be uniform between the HV-Bushing line terminal connections to the BIL level indicated in the PSD. The LV winding neutral may be solidly grounded or grounded through an impedance device outside the X0 bushing line terminal. The external impedance device is not included within the scope of this specification and if required will be supplied by others. The tapped portion of the HV winding will have full capacity taps located electrically near the center of each HV winding, providing the voltage ratings specified within the PSD. The winding taps are to be switched with a tap-changer having a BIL rating greater than or equal to the BIL rating of the high-voltage winding's line connection. The use of metal-oxide varistors in parallel with the tapped winding sections to withstand impulse voltages under operation or factory testing is not allowed.

2.2 TRANSFORMER RATINGS

A. The following ambient temperature conditions are defined as "Usual" service conditions for power transformers by IEEE C57.12.00: For air-cooled transformers, the cooling air shall not exceed 40°C, and the average ambient temperature within a 24-hour period shall not exceed plus 30°C. The liquid temperature shall not be lower than minus 20°C. And the altitude shall not exceed 1000 meters(3300 feet) above sea level. Ambient conditions outside of these parameters are not considered as usual service conditions.

B. Site-specific service conditions are listed in the PSD. Site-specific conditions outside of the "Usual" ambient temperature range shall be dealt with as an "Unusual" service condition under the guidelines of IEEE C57.12.00. The Supplier is responsible for identifying steps to be taken to mitigate the effects of unusual conditions, and to implement those steps in their design.

C. Additionally, for every degree Celsius within a 24-hour period above 30°C, the allowable designed top oil temperature rise shall be reduced by the same amount. The Supplier shall either design the allowable top oil rise with a minimum 5% margin to allow for the loss of one (1) fan in each cooling group (ONAF1 and ONAF2) or include an installed spare (stand-by) fan within each cooling group, with a loss of fan detection circuit and automatic cutover scheme to control the spare fans.

D. Ratings:
   1. The transformer's nameplated power (MVA) ratings are to be based on an average winding temperature rise of 65°C, unless specified otherwise in the purchase documentation, or as specified in the PSD appendix.

2. The MVA designed rating that will produce a 65°C rise above an average 30°C ambient temperature shall be calculated using data from the Factory Acceptance Test and reported within the certified factory test report(s).

E. Impedances:
1. The total impedance used for the short-circuit-withstand design calculations shall be the transformer impedances only, without considering any benefit of system impedances. The actual measured (guaranteed) transformer positive sequence percent impedance for the high-voltage (HV) winding to the low-voltage (LV) winding at the specified MVA base rating and referenced to 85°C shall be within a tolerance of +/-7.5% of the impedance specified within the PSD and at the nominal voltage tap.
2. When multiple units of the same design are being manufactured, the actual measured impedance values shall not differ between units by more than +/- 2.5% of the guaranteed percent impedance.
3. Note that these tolerances are more stringent than those allowed by IEEE C57.12.00.
4. In a typical delta-wye-connected two-winding transformer, the zero-sequence impedance from HV delta-connected winding line connection to LV wye-connected winding line connection is expected to be approximately 80 to 90% of the positive sequence impedance. The actual zero sequence impedance shall be determined using measured test data with the HV and LV windings shorted and open circuited as outline in the Factory Acceptance Test Procedure document. The test results are to be included within the Factory Acceptance Test Report document. Calculated values for each are to be included in the Design Review Data document.

F. Angular Displacement:
1. The angular displacement between the high-voltage and the low-voltage phase voltage vectors shall be 30-degrees (Dyn1).

2.3 TRANSFORMER LOADING

A. Normal Loading Guide Application:
1. The complete transformer, including the windings, the cooling system, and all external and internal auxiliary components (such as bushings, current transformers, leads, tap changers, oil expansion, pressure in sealed units, stray flux heating, etc.) shall be as a minimum appropriately rated for operation in accordance with IEEE C57.91. It is the intent of this requirement that when “Unusual” service conditions are noted in the PSD, no transformer auxiliary component or capability shall have or cause greater loss of life or result in more restrictive limitations on transformer loading within the nameplated voltage and current ratings. In particular, the hottest-spot temperature rise of any winding shall not exceed the limitations of the insulation system’s temperature ratings.

B. Overload Loading Guide Application:
1. The transformer shall be designed for an overload rating of 110% of the maximum nameplate MVA rating at a maximum ambient temperature of 40ºC for 4 hours following an 90% pre-load. During the overload period the top-oil temperature shall not exceed 110ºC, the hottest spot temperature shall not exceed 130ºC, no metallic structure shall exceed 120ºC, and insulation system’s calculated loss of life shall not exceed 0.5%. The

Supplier shall provide the method used to calculate the hottest spot temperature and the insulation system's loss of life.

C. Maximum Operating Voltage:

1. The transformer and all components shall be designed to operate continuously at maximum rated MVA for applied voltages up to and including 105% of the voltage rating associated with each tap position without core saturation. Due to assumed network operating configurations, the system voltage applied to the high-voltage bushings may also periodically reach levels as high as the MCOV rating of the high-side metal-oxide varistor arrestors. As such the high-side arresters have been selected to accommodate these possible operating conditions (69,000 x 1.05 [DETC Position 1] x 105% [allowance for periodic system overvoltage] x 1.5 [factor accounting for the delta-connected HV winding served by an effectively grounded transmission system])/1.732 = 65.88 kV.

2.4 TRANSFORMER CONSTRUCTION REQUIREMENTS

A. Core Construction:

1. The transformer design shall employ a core form construction. Cores shall be constructed using grain-oriented, silicon steel laminations. Core joints shall be mitered and utilize multiple step lap construction. The core shall be designed so that the flux density does not exceed 1.7 Tesla at 105% voltage on any tap position. Laminations shall employ a surface insulation and other appropriate design techniques to limit interlaminar power losses. The supplier shall also employ a periodic burr detection and mitigation such that the maximum burr height resulting from slitting and shearing does not exceed 20 microns.
2. The assembled core members (legs, bottom yoke, and top yoke) shall be securely banded, using appropriate material. The use of through-bolts to secure the core members is not allowed. Alignment holes in the laminations to facilitate stacking and assembly may be employed.

B. Winding Design and Conductor Material:

1. The transformer winding sets shall be a circular design. The winding conductor material shall be copper. Winding bracing shall employ an array of radial spacers, equally spaced and aligned from innermost to outermost windings. The use of epoxy bonded continuously transposed conductors (CTC), where applicable, is preferred. Windings shall be designed to withstand short circuit forces based upon a "free" unsupported winding when making inward radical buckling calculations. The containment and withstand of inward radial forces shall not depend upon bracing to the core. Likewise, hoop stresses, tilting stresses, and axial bending stresses shall be contained within each winding assembly. Winding assemblies shall be held in position about the core leg by means of radial spacers, top and bottom end rings, and a clamping system.
2. Winding leads shall be appropriately sized and insulated to carry 115% of the rated continuous current capacity of the winding, without exceeding 10°C average conductor temperature rise above an adjusted top oil temperature rise based upon ambient temperature conditions.

C. Core and Winding Assembly:

1. The core and windings shall be provided with a top and bottom blocked and insulated clamping assembly with either static or dynamic mechanical

clamping (transformer designer's preference) for axial restraint and strength.

2. The Supplier will test the core and winding assembly for grounds before tanking, with records retained for future reference. Provide tank cover mounted bushings that may be accessed at the Project Site to make comparable measurements. All permanent electrical connections shall be made using either compression or crimped type connectors, brazed, or welded joints. Compression or crimped type connector shall employ a 360° radial dye system that must complete a full compression cycle before releasing.
3. The lead-support frame assembly shall be constructed using high-dielectric non-metallic material. Leads are to be secured with clamping blocks. Twine or other non-conductive strapping materials are not an acceptable permanent clamping system. Frame joints shall be secured using polymer-based threaded rod material and nuts made of similar material. Nuts shall be secured with an approved means to prohibit loosening in operation. Frames constructed using cellulose-based laminated pressboard are not acceptable. The lead fixation elements may utilize cellulose-based materials.
4. The core and winding assembly shall be secured to the tank base and cover to prevent damage due to horizontal or vertical forces which may result during shipment, or during a seismic event. The Supplier shall submit design specifics as part of design review package for acceptance by the Owner and OE.
5. Winding and tap leads shall be brought out to the bushings and tap selector switch, being securely held in position by a laminated wood framework. The supporting framework shall be assembled using non-metallic components. Connecting hardware shall be fitted with restraints to avoid loosening over the life of the transformer.
6. The Supplier shall utilize a vapor phase process for drying out the core and coils prior to placement in the tank and vacuum filling. Details of this vapor phase process shall be submitted with the Supplier's proposal. The exposure time between removal from the vapor phase chamber and having the active components under vacuum or an appropriate controlled environment shall not exceed ten (10) hours. Exposure between ten (10) and twenty (20) hours shall require additional vacuum processing of no less than three (3) hours additional vacuum for every hour exceeding ten (10) hours exposure. Exposure beyond twenty (20) hours will require reprocessing in vapor phase. The OE shall be provided with the hourly processing data for water extraction, and the extraction rate is to be confirmed and accepted by the OE prior to removal from vapor phase. The process shall continue until the water content of the cellulosic-based material is less than 0.1% (by weight), and the extraction rated has been nondetectable for at least twelve (12) hours.

D. Voltage Stress Shielding:

1. The Supplier's design shall include adequate shielding for areas particularly vulnerable to partial discharge and other voltage stress related issues. Areas to be address include the high-voltage bushing terminals, high-voltage winding turns impulse control, winding ends, and all bolted hardware bus and lead connections both internal and external to the tank. Areas of the tank exposed to high electric and magnetic fields that could cause excessive heating shall be constructed form non-magnetic material such as stainless steel.

E. Oil Preservation System

1. When applicable, transformers with a top MVA rating above 100 MVA and a primary voltage greater than 115 kV shall be furnished with a conservator system for the transformer's main tank. Transformers with a top MVA rating below 100 MVA and a primary voltage of 115 kV and below may be furnished with either a conservator or inert gas preservation system for the transformer's main tank.

F. Conservator System:

1. The conservator system shall include an expansion tank, and a rubberized nylon fabric air cell (diaphragm) vented to outside air through a dehydrating breather. Only one (1) expansion tank is allowed. The preferred location for the conservator is extended from the main tank cover area associated with IEEE Segment 2 as defined in IEEE C57.12.10, Section 5.
2. The air cell shall be designed for top flange installation (clamps not allowed) and shall prevent contact between oil in the expansion tank and the atmosphere within the air cell. The air cell shall be suspended from the top of the tank by a minimum of two (2) supports (in addition to the top flange. The expansion tank shall be of sufficient volume to operate through an ambient temperature range of minus 40°C to plus 50°C without causing the low-oil-level alarm contacts to close at the lower limit, and without exceeding the recommended full oil level at the upper limit.
3. Suitable valves shall be furnished in the oil line between the expansion tank and the main transformer tank, one valve on each side of the Buchholz-type relay, to facilitate maintenance, calibration, and testing (refer to Additional Auxiliary Protection Device Requirements).
4. The conservator shall be vented to the atmosphere through a dehydrating breather. The breather shall be a Messko Model MTraB 2.5, Type DB200, or an approved equivalent. Piping connections to the breather shall be made using bolted flanges. If necessary, the breather shall also be equipped with a filter heating system. The breather will be supplied with 240 Volts single-phase AC power. The Supplier shall provide device malfunction alarm contacts, with one wired as an input to the Temperature Indicating Relay/Monitor (Device 49T-1) and the other to terminal blocks for the Owner's use. Electrical wiring between the control unit and the breather components and the transformer control compartment shall be routed in appropriate conduit. The dehydrating breather shall be located so it can be safely inspected while the transformer is energized.
5. All circular opening flange-to-flange and manhole cover connections shall have machined mating surfaces and grooves for an O-ring. O-ring gaskets shall be of a Nitrile material having an operating temperature range of -54°C to +104°C. Flat face gasket connections are not acceptable.

G. Inert Gas Preservation System

1. The inert gas equipment shall be fully automatic in operation and shall maintain an adequate supply of dry nitrogen gas under a positive internal pressure by means of a pressure regulator (one [1] for each tank). The pressure regulator shall limit gas pressure to not more than 5 psi for normal operating conditions. Provisions shall be made for automatic pressure relief.
2. A NEMA 4X stainless steel cabinet shall be provided to contain the gas cylinder and regulating equipment and shall be mounted to the side of the transformer tank. The cabinet shall be equipped with a clear viewing window arranged so all gauges are visible without opening the door. One

(1) cylinder of nitrogen gas, size 200 high pressure industrial cylinder meeting DOT specification 3AA2015, shall be furnished with the transformer for use with the regulating equipment and shall remain the property of Owner. Additional cylinders of nitrogen gas necessary for flushing out the transformer during field assembly and for charging it ready for operation shall be furnished by the Supplier. The gas cylinder shall be of U.S. standard design which can be refilled locally.

3. The following inert gas system accessories shall be furnished.
   a. Transformer and OLTC tank gas pressure gauges.
   b. Nitrogen cylinder gas pressure gauge.
   c. Low and high-tank gas pressure alarm relay.
   d. Low-nitrogen cylinder gas-pressure alarm relay.

H. Tank Design/Oil Filling:

1. The tank and any compartment attached thereto that is subjected to operating pressures shall be constructed of steel plate of adequate thickness to withstand the internal top oil pressure in accordance with IEEE C57.12.10 (5 psi minimum). The tank shall also be capable of withstanding full vacuum. The tank shall be of welded steel construction, employing a continuous weld pattern. Mitered or butt weld plate connections at the tank corners are not allowed. Corner joints shall be a “T“ connection with continuous weld seams on both the internal and external fillets. Formed corners are also allowed where the welded seams are a minimum of 4-inches from the tank corner and the plates overlap each other by a minimum of 4-inches. The Supplier shall adhere to the guidelines outlined in AWS-D1.1/D1.1M, Structural Welding Code – Steel, in addition to any other regional or country standards. The Supplier shall submit their welding procedure, and welder certifications, to the OE for review and acceptance prior to commencing fabrication.
2. The transformer tank cover shall be crowned or sloped sufficiently to prevent water from standing on the top, and to accommodate migration of gas to the Buchholz-type relay. The tank cover shall be attached to main tank with a flat gasketed flange having metal gasket stops and secured using a welded construction. The main tank to cover flange shall be constructed such that the cover may be removed and rewelded without damage to the flange gasket and insulated components within the tank.
3. All other flange-to-flange surfaces shall be provided with O-ring recesses (grooves) of an appropriate depth in each flange to develop to correct pressure on the O-ring. All gaskets in contact with oil-bearing surfaces shall be nitrile rubber. Any exceptions where the Supplier feels flange-to-flange connections using a full-face flat gasket would be more appropriate are to be submitted by the Supplier for review and acceptance by the OE.
4. Tank design shall permit energization at oil temperatures of -40 deg. C and above and provide sufficient expansion room to allow top oil temperatures of 110 deg. C when the transformer is properly filled with oil. The tank shall also be designed for oil filling under a full vacuum.
5. The tank shall be furnished with one or more manholes having an opening of not less than 24-inches in diameter. The manholes shall afford access to the lower ends of the bushing terminals and the upper portions of the core and winding assembly.
6. Suitable eyebolts and/or lugs shall be provided for lifting all essential parts. Guides shall be furnished inside the tank to facilitate removal of and replacement of the core and windings.

7. Ground pads shall be welded to the IEEE C57.12.10, Segment 1 and 3 sides of the exterior tank wall, within 24-inches of each corner, and at a height of approximately 18-inches above the bottom of the tank base. Each two-hole pad shall be either copper faced or stainless steel, with 1/2-13 Unified National Coarse (UNC) threaded holes a minimum of ½-inch deep at standard NEMA spacing. Pads shall not protrude beyond the tank wall more than ¾-inch. The Contractor will loop bare grounding conductor between the surge arrester bus bars, the tank ground pads, and the station ground grid on the 1 and 3 sides of the tank.
8. Oil filling connections shall be provided with deflection plates inside the tank to prevent the force of incoming oil from impinging on the core and windings.
9. Provide ample space above the tank bottom for collection of sediment.
10. The tank centers of gravity shall be marked on the IEEE Segment 2 and 3 tank walls for both shipping and installed arrangements. The base shall be designed to accommodate transference by jacking and rolling. The tank shall also be braced and equipped with lifting eyes near the top for crane lifting.
11. The tank shall provide sufficient means to secure the transformer's active components to withstand accelerations during shipment. The transformer shall be designed to withstand a minimum of 3g in the lateral and vertical directions, and a minimum of 5g in the longitudinal direction (direction of travel). The longitudinal direction is intended to be the direction of transport. Refer to Packaging and Shipment Section for more requirements.

I. Dielectric Fluid:
1. The main transformer tank insulating oil (dielectric fluid) shall be a specially refined light mineral oil with oxidation inhibitor for electrical applications. Dielectric fluid shall be resistant to oxidative degradation and have a low viscosity to improve heat transfer in accordance with ASTM Standard D 3487 Type II.
2. The Supplier shall furnish the necessary quantity of dielectric fluid. The Supplier shall provide documentation to the Purchasing Authority prior to fluid delivery at the jobsite which outlines their quality control/quality assurance procedures associated with bulk oil properties and security measures to guard against impurities during transport. The Supplier will provide evidence to the OE verifying that these procedures have been complied with as witnessed by their representative prior to introducing the fluid to the transformer.
3. Fluid shall contain less than 1.0 ppm polychlorinated biphenyl contamination. The Supplier shall indicate the type of fluid and reference applicable industry standard on the transformer nameplate. Prior to introducing dielectric fluid to the transformer, the Supplier shall verify that the source oil has a minimum dielectric strength of 40 kV (ASTM D-877) or 30 kV (ASTM D-1816, with a 1mm gap), and a maximum moisture level of 10 ppm (ASTM D-1533). Affix an EPA "Blue Sticker" indicating the transformer oil is "Non-PCB."

J. Main Tank Base:
1. The main tank base design shall accommodate jacking and rolling in both transverse and lateral directions.
2. The tank base shall be designed with a minimum of four (4) anchorage locations, located in accessible areas. Details of the anchorage plates shall be supplied on the transformer outline drawing. The anchorage plates

(brackets) are to be removable (shipped separate from the main tank) to facilitate anchorage in the field.

3. Once the completed transformer has been dressed and tested, and resting on the Owner furnished foundation, the tank anchorage brackets are to be bolted to the main tank base, and then either welded to embedded anchorage plates (by others) installed flush with the foundation top of concrete or bolted using epoxy set anchor rods (by others) at locations which correspond to the anchorage locations identified in the Supplier's base detail drawing. Affixing the brackets to the foundation (either by welding or anchor bolts) will be performed by the Contractor.

K. Valve Requirements:

1. The Supplier shall provide:
   a. 2-inch ball-type valve(s) appropriately located on the transformer tank wall and/or cover for use with external oil filtration equipment used during installation and/or to perform periodic maintenance.
   b. A 2-inch flanged globe-type combination main tank drain/lower filter valve, with a ⅜-inch sampling device and tethered plug, installed at the bottom of the tank wall. The drain valve shall be located at least 4-inches above the tank base, with an in-tank siphon tube. The Supplier shall furnish a cover over the drain valve to protect it during transit, and from possible damage due to being used as a step. The drain valve shall be United Brass Works, Inc., Model 123TSSB-2", or approved equivalent.
   c. A 3-inch minimum ball-type valve with gasketed bolted-flange connections, located in the tank cover to accommodate vacuum oil filling in the field. Provide a removable blanking cover for each exposed flange connection.
   d. All other valves provided by the Supplier shall be ball-type except for radiator valves, which are to be a 3-inch minimum butterfly-type valve. All valves which are to remain in a fixed position during normal operation shall accommodate a pad-lock in both the "Open" and "Closed" positions.

L. Fall Protection Plate and Fall Arrest Tower:

1. Supplier shall furnish at least one (1) Pelsue Model FB-SW1 weld-on base plate on the top of the transformer tank cover, for use with a Uni-Lite Fall Arrest Tower. The Supplier shall determine if additional plates are required to adequately access the entire tank cover and radiators. Additionally, the Supplier shall furnish a Pelsue Model FT-C70, Uni-Lite Fall Arrest Tower, as part of the accessories package. The plate(s) shall be permanently welded at locations which provide adequate access to the entire tank cover and radiators and shall comply with all requirements for fall protection and confined space rescue as determined by OSHA Section 1910.66 and ANSI Section A10.14.

M. Internal Surge Protection Devices:

1. No internal surge protection devices shall be used.

N. Accessory Location:

1. The location of accessories shall be in accordance with IEEE C57.12.10 wherever applicable, or as convenient for design if not covered by standards. An outline drawing sketch shall be submitted for review with the

Supplier's proposal. The sketch shall indicate approximate overall dimensions in feet and inches.

O. Surge Arrester Ground Connections:
1. The Supplier shall furnish suitable electrical ground connections using ¼-inch by 3-inch copper bus bar between the arrester ground terminals and a 2-hole ground pad at the base of the transformer tank. The ground bus between the surge arresters and the ground pad shall be electrically isolated from the tank with 95 kV BIL (minimum) stand-off insulators. The Supplier shall provide separate ground buses for the high-voltage side and low-voltage side arresters.

P. Neutral Bushing Ground Connections:
1. The Supplier shall provide electrical ground connections, using ¼-inch by 3-inch (8mm by 80 mm) copper bus bar, running from the neutral bushing terminal, and extending down to within 24-inches of the tank base bottom, with a NEMA 4-hole drilling to accept the Owner's ground conductor. If necessary, a braided flexible jumper (no longer than 24-inches) assembly (parallel jumpers to match the continuous current rating of the bushing) may be installed between the bus bar and the bushing terminal. The bus bar running between the neutral bushing and a location near the tank base shall be electrically isolated from the tank with 95 kV BIL (minimum) porcelain stand-off insulators, equivalent to Meister International Part Number 70170. The Supplier shall provide a separate ground bus for the high-voltage (H0) and low-voltage (X0) neutral bushings. The bus bar is not to be terminated at a tank ground connection point (the Contractor will install a separate ground cable between each neutral bus and the station ground grid).

Q. Core and End-Frame Ground Connections:
1. The Supplier shall provide separate core ground and end frame connections external to the tank, using an insulated cable brought up to a suitable bushing on the tank cover or near the top of the tank wall, with a removable copper strap located between the bushing terminal and a 2-hole ground pad welded to the tank. Bushings shall be rated not less than 30 kV BIL and shall be located and labeled to avoid confusion with other bushings. Bushings shall be protected within an enclosure with a removable, weatherproof metal cover. The grounding strap shall be connected to the tank ground pad while the transformer is energized, and only disconnected to perform insulation resistance measurements.

R. External Fasteners and Hardware:
1. All external fasteners and hardware (such as bolts, screws, hinges, and handles) shall be stainless steel.

2.5 BUSHINGS AND SURGE ARRESTERS

A. Bushings:
1. Bushings must meet requirements for physical dimensions and electrical ratings as specified in ANSI/IEEE Standards C57.19.00, C57.19.01, and C57.19.100. Bushings rated 350 kV BIL and above shall be ANSI/IEEE, Hitachi O Plus Dry resin impregnated synthetic (RIS) type bushings with silicone rubber weather sheds or approved equal. Bushings rated 110 kV BIL to above 450 kV BIL shall be ANSI/IEEE, condenser core oil

impregnated paper (OIP) type bushings with porcelain housings and high-creep weather sheds. All porcelain used in bushings shall be wet process, homogenous, nonporous, and free from cavities/flaws. Glazing shall be uniform in color and free from blisters, burns, and other defects. In applications less than 350 kV BIL, the X0, X1, X2, and X3 bushings shall have the same ampere rating and shall be interchangeable. Draw-lead connection is preferred for bushings rated above 550 kV BIL.

2. The bushings minimum requirements for BIL, continuous current, creepage distance, and strike distance shall be as specified in the PSD.
3. The bushings associated with delta-connected windings are to be rated at least one BIL classification greater than the delta-connected winding BIL (550 kV BIL in the case of a delta-connected 69 kV high-voltage winding).
4. The H2 and X2 bushings shall be mounted in line with each other on the centerline of the tank cover. Where applicable, all OIP type bushings shall have an oil level sight glass which can be observed by a person standing at ground level. Bushings shall be standard light gray and rated appropriately to carry, at a minimum, the maximum winding currents + 10% in accordance with the transformer's maximum MVA rating.
5. Bushings rated at 350 kV BIL and greater are to be supplied with high-creep polymer insulator housings with silicone rubber weather sheds. The housings of RIP or RIS bushings are to be silicone composite polymer over the molded bushing core. Weather sheds may be either helical or a conventional straight design. All bushings shall be designed and tested to provide their full BIL rating up to a minimum elevation of 3300 feet above sea level.
6. All bushings shall be removable and replaceable without the need to process the transformer oil. Bushing turrets are to have a bushing mounting height above the conservator's lower isolation valve for draw-lead type bushings. Bushing turrets shall have hand hole access plates which will provide access to the lower terminal of non-draw-lead type bushings after lowering the main tank oil level to an appropriate level. All bushings are to be mounted with the flange oriented horizontally, with a maximum tilt of 10% relative to level.

B. Bushing Terminals:

1. Each bushing shall be furnished with a straight, vertical flat-pad line terminal NEMA CC-1, Annex C, Figures C-3, and C-4, standard hole patterns. The width and thickness of the terminal pad shall be appropriate for the continuous current rating of the bushing. Bushings rated 2,000 Amps through 3,000 Amps continuous current shall have a 4-inch by 4-inch pad width. Bushings rated below 2,000 Amps continuous current shall have a minimum 3-inch by 3-inch pad width. Bushings rated above 3,000 Amps continuous current shall have a minimum 6-inch by 4-inch pad width, with NEMA CC-1, Annex C, Figure C-6, standard hole pattern. Bushing terminals shall be either tin plated bronze, or aluminum; the minimum tin plating thickness shall be 200 micro inches applied through a hot tin dipping process with hot air level control. Bushings with threaded copper studs shall be silver plated and supplied with only bronze stud-to-flat pad terminal connectors that have silver plated thread areas (pads may be tin plated as above).

C. Surge Arresters:

1. The Supplier shall furnish the transformer with station class, metal-oxide, gapless type surge arresters, mounted as close as feasible to the high-

voltage, and low-voltage line bushing connection terminals. Per IEEE C62.11, arresters shall be capable of operating at elevations up to 1000-meters. Polymer housings with silicon-based weather sheds are required. Arrester housings and weather sheds shall have an exterior finish color of light gray.

2. Additionally, the Supplier shall provide surge arrester support brackets which are to be mounted to the transformer tank, and removable for shipping. The high-voltage arrester mounting bracket is to be located on the IEEE Segment 3 tank wall. The low-voltage arrester mounting bracket is to be located on the IEEE Segment 1 tank wall. Arrester locations shall be adjacent to, and in line with, their associated bushing.
3. Arresters with a MCOV rating greater than 76 kV shall be fitted with grading rings at the line terminal end. All arresters will be supplied with four-hole NEMA terminal pads.
4. Energy Discharge (Absorption) Capability – Arresters shall have a minimum Energy Discharge Capability (thermal) of 11.0 kJ/kV of MCOV at 1.0 kA discharge current.
5. Insulating sub-bases are required to isolate the arrester from transformer tank and mounting bracket. The Supplier shall provide electrical ground connections, using 1/4-inch by 3-inch (8mm by 80 mm) copper bus bar, running from the arrester ground terminal, and extending down to within 24-inches of the tank base bottom, with a NEMA 4-hole drilling to accept the Owner's ground conductor. If necessary, a 4/0 AWG copper cable jumper may be looped by the Supplier between the bus bar and the arrester terminals, providing it maintains isolation from the tank. The bus bar running between the arrester area and a location near the tank base shall be electrically isolated from the tank with 95 kV BIL (minimum) porcelain stand-off insulators, equivalent to Meister International Part Number 70170. The bus bar need not be terminated at a tank ground connection point. The Contractor will loop ground conductor between the bus bar, the tank ground pad, and the ground pads imbedded in the foundation. The Supplier shall provide a separate ground bus for the high-voltage and low-voltage surge arresters.
6. The Supplier shall also provide surge arrester support brackets which are to be mounted to the transformer tank, and removable for shipping. Arresters are to be insulated from the support bracket by insulating sub-bases. Sub-bases shall be made from a porcelain body, with a minimum BIL withstand rating of 50 kV.
7. Station class arresters shall be furnished with the duty cycle and maximum continuous operating voltage (MCOV) ratings as specified in the PSD.

D. Arrester Terminals

1. Each surge arrester shall be furnished with a straight, vertical flat-pad line terminal with NEMA CC-1, Annex C, Figure C-4, standard hole pattern. Arrester terminals shall be aluminum or galvanized steel. Arresters shall also be supplied with a clamp-type ground terminal connector to accept 4/0 through 500 kcmil bare copper cables.

E. Bushing Current Transformers

1. The Supplier shall furnish five-tap, multi-ratio Bushing Current Transformers (BCT) for relaying applications as specified in the PSD.
2. Generally, BCTs with a full-tap ratio of 1199:5, or less, shall have a relaying accuracy rating of C800, while those with a full-tap ratio greater than 1199:5 shall have a C800 rating.

3. When specified in the PSD, a single-ratio metering class BCT may be required. Metering class BCT's are to be mounted in the lowest position nearest the winding lead connection end. Metering BCT shall have an accuracy class of 0.15%, unless noted otherwise in the PSD.

2.6 DE-ENERGIZED TAP-CHANGING EQUIPTMENT

A. The Supplier shall provide full capacity taps in the high-voltage winding circuits at the voltages specified in the PSD, which may be switched only when the transformer is de-energized.

B. The DETC shall be furnished in accordance with IEEE/ANSI C57.12.10, IEEE/ANSI C57.131, and as specified. The Supplier shall determine the electrical location of the DETC, considering first cost of the transformer, reducing whole of life maintenance on the DETC, and the system voltage to be accommodated.

C. The DETC operator interface shall be pad-lockable and provide clear indication of the position number or letter corresponding to the designations used on the nameplate. The interface shall be located on an end tank wall (IEEE Segment 2 or IEEE Segment 4), preferably the same wall as the control compartment, no more than 4 ft above the base.

D. The DETC position numbers or letter, with their associated voltages and full-load currents, shall be represented on the transformer's nameplate.

E. The DETC shall be a rotary contact type, MR Type Deetap® DU, or an approved equivalent alternate, having a BIL rating equal to or greater than the winding BIL at the tap winding location on the HV winding.

F. Alternate tap changers models are to be approved by Engineer prior to issuance of a purchase order.

2.7 ON-LOAD TAP-CHANGING EQUIPMENT

A. The Supplier shall provide full capacity taps in the low-voltage winding circuits at the voltages specified in the PSD, which may be switched when the transformer energized.

B. The OLTC shall be furnished in accordance with IEEE/ANSI C57.12.10, IEEE/ANSI C57.131, and as specified. The Supplier shall determine the electrical location of the OLTC, considering first cost of the transformer, reducing whole of life maintenance on the OLTC, and the terminal voltage to be regulated.

C. The OLTC shall be designed for thirty-three (33) 5/8% steps (16 above and 16 below rated voltage). The OLTC shall have sufficient ampacity for 110% of the transformer top ONAF2 rating at 65ºC temperature rise and be rated to withstand the overload identified in Section 3.3.2. The tap changer shall have full rated MVA on all taps above and below normal voltage.

D. The OLTC mechanism shall be vacuum diverter (interrupter) reactive (preventive auto) design utilizing a reversing (change-over) switch and bypass switch. The mechanism shall be designed for a minimum of 500,000 electrical and mechanical operations before contact or vacuum bottle replacement is required. A contact life

curve nominating contact maintenance and replacement intervals for the OLTC being provided shall be supplied with the bid documents.

E. The OLTC shall be a rotary contact type, MR Reinhausen Type RMV-II as appropriate, or approved equal, having a BIL rating equal to or greater than the winding BIL at the tapped winding location within the low-voltage winding. The use of metal-oxide varistors in parallel with the tapped winding sections to withstand impulse voltages under operation or factory testing is not allowed.

F. The Supplier shall furnish a dial-type oil level indicator for the OLTC oil-filled compartment. Indicator design and mounting arrangement shall permit reading from the ground. Each indicator shall be furnished with two contacts. One contact shall be set to close on alarm to activate the Owner's remote I/O device at the minimum safe operating oil level; and the second contact shall be set to close and initiate tripping of the Owner's switching device at a level below the minimum safe operating level but above the level which would result in OLTC damage or failure.

G. The tap changer shall have a direct-driven position indicator, with electrically resettable drag hands. The position indicator and operation counter shall be easily read from the ground without opening any doors. Any control cabinets required for the OLTC shall meet the requirements of Section 3.9 of this specification as applicable.

1. The Supplier shall furnish and install a self-resealing pressure relief device on the OLTC oil-filled compartment, particularly the MR Reinhausen Type MPreC device. Each relief device shall be furnished with an alarm/trip contact and visual indicator. The indicator design and mounting arrangement shall provide visibility of the semaphore from the ground.

H. The Supplier shall furnish and install a dehydrating breather connected to the air space above the oil level within the OLTC.

I. The Supplier shall provide an IEEE C57.12.00 standard thermowell to accept a 1000-ohm platinum RTD to detect top oil temperature in the diverter/interrupter oil-filled compartment. It shall initiate an alarm relay output to indicate an alarm condition. The RTD well probe is to be included as a fourth input to the Temperature Indicating Relay/Monitor (Device 49T-1). The RTD leads shall be routed between the probe and the control compartment in conduit. The probe shall be obtained directly from the 49T-1 supplier, Advanced Power Technologies, Type TTC-PROBE-11, or approved equal.

J. The Supplier shall also provide an auxiliary relay to prevent further automatic OLTC operation in either direction in the event of loss of the control voltage transformer input to the voltage regulating control and to provide automatic return to normal operation upon restoration of the control voltage transformer input.

K. The tap-changer motor drive unit shall be located directly under the tap-changer compartment at a height which is accessible to personnel while standing on the transformer's foundation. The drive motor supply voltage shall be 240 V AC, 60 Hz. It shall not incorporate a centrifugal switch. Mechanically-operated electric limit switches and mechanical stops shall be provided on the drive mechanism to prevent over-travel beyond the maximum raise and lower positions. Provide a means to manually operate the OLTC drive mechanism which is electrically interlocked to prevent operation of the motor while the manual interface is engaged. If the manual interface is detachable, a storage place shall be provided.

The OLTC Motor Drive Unit shall be a MR Reinhausen Type RMV-II or approved equivalent.

L. The Supplier shall provide:
1. A position indicator for the OLTC with maximum and minimum indicating hands and provision for resetting shall be provided. A provision for resetting the indicator while standing at the base of the transformer is required. The position indicator shall be readable while operating the load tap-changer by hand.
2. An operations counter which will register the accumulated number of tap changes performed by the OLTC.
3. Manual and automatic operation capability at the transformer. Control shall be capable of manual and remote operation and all alarm contacts and indicators shall be available from a remote control point.
4. Remote connectivity shall be available via Ethernet.
5. Visibility of the motor drive unit, including tap position, raise/lower command log, etc.
6. A motor drive that is capable of being controlled from the Owner's Supervisory Control System.
7. A controller/monitor device (CTLR) located in the transformer's main control compartment. The CTLR shall be a MR Reinhausen Type TAPCON® 250, with Ethernet communication option, or approved equal.
8. A Beckwith model number M-0329B, or approved equal, and the appropriate adapter panel for use as an OLTC control backup device. Paralleling equipment shall be of the circulating-current type, selectable with a panel-mounted selector switch. Additional control features are to include: a Remote / Local Selector Switch; Auto / Manual Selector Switch; Raise / Off / Lower Momentary Switch; Paralleled / Independent Selector Switch; Voltage Source Internal / External Selector Switch; and voltage test terminals.
9. Provide a separate BCT for the line drop compensator circuitry, which is located on the X1 bushing. Provide auxiliary CT's as necessary.
10. An INCON synchro transmitter model 1292-KS, or equivalent device, to provide the Owner's remote control system with the tap-changer position. A separate contact output shall indicate "on-tap/off-tap" position
11. A motor drive unit which can stall in a non-operating position and be designed to permit full rated operation in the stalled position. For load-tap-changing equipment which cannot stall between operating positions, intermittent duty current-carrying parts may be designed for short time duty.

2.8 COOLING EQUIPMENT

A. Winding Hot-Spot Temperature Control:
1. The Supplier shall provide cooling equipment control from a Temperature Indicating Relay/Monitor (Device 49T-1). This device shall calculate winding temperature using measured current, main tank top-oil temperature measurement, ambient air temperature measurement, and the appropriate transformer parameters obtained from temperature rise testing. The necessary current transformers shall be in addition to the current transformers specified in the Bushing Current Transformer's (BCT) section of this specification. It is the Supplier's responsibility to input the appropriate settings into the 49T-1 and verify its proper functionality.
2. Device 49T-1 will calculate the winding temperature parameters using established IEEE thermal models. The transformer monitor design and

mounting arrangement shall permit reading from the ground. Device 49T-1 shall be capable of being powered by either the 48 Volts DC station battery or 120 Volts AC power sources, with 48 Volts DC being the preferred source. Device 49T-1 shall have a minimum of four (4) direct resistance temperature detector (RTD) inputs. Device 49T-1 shall be an Advanced Power Technologies (APT), Modal Total ECLIPSE, Transformer Monitor, or approved equal. The Supplier shall coordinate with the OE as to the specific features required. The Supplier's proposal shall be based upon using the Total ECLIPSE Part Number 4610D0, which is equipped with the following features:

3. Three (3) RTD probe inputs for: main tank liquid temperature, bottom oil temperature, and ambient temperature
4. One (1) auxiliary CT for hottest-spot temperature indication and anticipatory cooling algorithm based on load and time
5. Twenty-four (24) optically isolated inputs shall be provided for transformer alarms not generated by the monitor
6. Four (4) additional auxiliary CTs shall be provided for auxiliary current monitoring for fan and/or pump motors
7. Four (4) analog input channels capable of accepting 0-10V, 0-1mA, or 4-20mA signals
8. Built-in DNP3 Slave, DNP3 Master, MODBUS RTU or IEC61850 over Ethernet via LC fiber
9. A display with a character height of no less than 19.05 mm (0.75 inches) and which is readable in the daylight with backlight for reading in low light conditions
10. Built-in Web Server which utilizes TLS security
11. A monitor with USB-B Virtual Comm port for use with Advanced Power Technologies' APT Term opens source software
12. Device 49T-1 shall provide calculated winding temperature, using an analog input from RTD inputs from top and bottom oil liquid temperature probes (APT Model TTC-PROBE-12-XXX RTD, where XXX is the probe cable length from 10 to 250 feet, as specified by the Supplier or approved equal), and from independent load BCTs located in the center phase of the high-voltage and low-voltage line connections. Provide an ambient temperature probe, APT Model TTC-PROBE-00-050 or approved equal, with the appropriate length of probe cable. Locate the ambient air probe on the bottom side of the control compartment (without direct contact between the RTD and the compartment surface). Care shall be taken when locating the ambient air temperature prove to avoid the influence of the compartment heater and exposure to direct sunlight. The preferred mounting location for Device 49T-1 will be inside the control compartment (visible through a window) in a panel mounted arrangement.
13. Relay Contacts and Settings: Device 49T-1 shall be furnished with a minimum of the following digital output contacts:
14. Output #1 shall control stage 1 cooling at 60 °C top oil or 75 °C winding or 80% of rated load after 120 seconds
15. Output #2 shall control stage 2 at 65 °C top oil or 80 °C winding or 100% of rated load after 120 seconds
16. Output #3 shall prove a high top oil temperature alarm at 90 °C
17. Output #4 shall provide a high winding temperature alarm at 120°C
18. Both Output #1 and Output #2 shall be programmed for Fail-Safe operation.
19. Device 49T-1 shall also monitor the supply current flowing to each group of cooling fans.

20. Where the radiator top header pipe is located at an elevation higher than the inlet manifold connection, the location of the top oil liquid temperature probe shall be in the header pipe rather than the lower manifold connection to the tank wall.
21. The Supplier shall also provide an oil liquid temperature probe to monitor bottom-oil temperature in the main tank. Mount the probe near the middle radiator inlet manifold connection to the main tank on the low-voltage side (mount on the high-voltage side if radiators are not mounted on the low-voltage side).
22. Device 49T-1 will also function as a remote I/O module for various transformer alarms and relay protection functions. Refer to the Remote I/O Section for addition requirements.
23. RTD capillary leads are to be routed in a combination of flexible and rigid conduit between the probe well connection and the instrument housing.

B. Top Oil Temperature Control:
1. The Supplier shall provide back-up cooling equipment control using an analog top oil temperature gauge (Device 49T-2). The mounting arrangement shall permit reading the gauge by a person standing on ground position. The gauge shall measure top oil temperature using an analog input from separate top oil liquid temperature probe (100-Ohm Platinum RTD, IEEE C57.12.00 Standard Well). Device 49T-2 will provide a minimum of three (3) relay outputs, which are to be incorporated into the cooling equipment control scheme as follows:
2. The first, to start the first stage of force-cooling equipment at ## °C top oil temperature.
3. The second, to start the second stage of forced-cooling equipment at ## deg. C top oil temperature.
4. The third, to activate an alarm at ## °C top oil temperature.
5. The device shall provide remote top oil temperature indication, using a 4 to 20 mA analog output from Device 49T-2, wired as an input to Device 49T-1.
6. Parameters shown as “##” are to be determined by the transformer Supplier and the contact setpoints are to be adjusted in the gauge hand travel prior to shipping and checked by the Supplier during the commissioning process to verify that the setting location has not moved during transit.
7. Device 49T-2 will be a Qualitrol Model 104 SCADA, or an OE approved equivalent. RTD capillary, analog signal, power supply, and relay output circuits will be routed inside conduit as applicable.

C. Radiators:
1. The cooling system shall be either an ONAN/ONAF/ONAF or KNAN/KNAF/KNAF (refer to the PSD) cooling system utilizing two stages of fan-forced circulation as defined in IEEE C57.12.00. The Supplier shall provide removable, interchangeable radiator sections comprised of multiple flat-plate panels connected to header pipes connected to the tank by machined steel gasketed flanges welded to both the radiator section and tank wall.
2. The preferred location for the radiator sections is on the tank wall side associated with IEEE Segment 3 (high-voltage side). If additional locations are required, then the tank wall side associated with IEEE Segment 1 (low-voltage side) may also be used.
3. The following requirements apply to the radiators. The Supplier shall:

4. Provide indicating shut-off butterfly type valves at each radiator section connection, pad-lockable in either OPEN or CLOSED positions, United Brass Works Model 150NOSS, or approved equivalent.
5. Provide a separate oil-tight blank flange for each tank connection for use when the radiator is removed.
6. Provide each radiator section with lifting eyes, oil drain, and vents with threaded plugs.
7. Design radiator sections capable of withstanding, without permanent deformation, the vacuum and pressure conditions specified for the main tank.
8. Ensure that the radiator sections are:
9. Readily accessible for cleaning and completely drainable into the main tank.
10. Designed to prevent accumulation of water on exterior surfaces, and formation of gas pockets while the main tank is being filled with oil.
11. Are hot-dip galvanized. The galvanized finish is to be left in its natural finish.
12. Have a drain valve and threaded venting plug for each radiator section. Drain valve shall be globe type ¾-inch threaded connection to the lower header pipe, United Brass Works Model 125TB, or OE approved equivalent.
13. Have brackets on both sides of each radiator section to facilitate cooling fan mounting. The fans shall be mounted on the side which best suits prevailing wind conditions at the jobsite.

D. Cooling Fans:
1. Cooling fans shall be weatherproof, corrosion resistant, with sealed ball bearings. Fans shall be located on the sides or bottom (not on the top) of the radiators to provide maintenance accessibility with adequate safety clearances from transformer live parts. Fan guards shall be hot-dip galvanized and OSHA approved. Fan blades shall be one-piece cast aluminum, Krenz-Vent Model F26X or F26D, or an approved equivalent. Fan motors are to be rated for operation when connected to a single-phase 240 V AC power source.
2. Provide a mounted stand-by fan in each cooling group, with control functions which activate the stand-by fan upon the loss of a single fan within the group.
3. In addition to a mounted stand-by fan within each radiator bank, the Supplier shall provide one (1) spare fan assembly, including the motor, cord, blades, and guard. The spare fan assembly shall be shipped loose as part of the transformer accessories package.

E. Loss of Cooling Auxiliary Relay
1. Additionally, the Supplier shall provide an alarm indication of loss of AC power to the cooling equipment. These relays shall have a 30-second time delay to avoid an alarm for a momentary power loss. Provide a separate relay for each cooling stage. Additionally, a third relay will monitor the voltage for the fan control circuitry. Each cooling stage shall be protected by a suitable two-pole overcurrent interrupting and isolation device.
2. Wiring for the cooling fans shall be arranged to allow for de-energization of each cooling stage circuit on command from Owner‘s Remote I/O REMOTE ENABLE output contact in the event user’s transformer lockout relay operates. Wiring shall employ Plug/Receptacle connections to facilitate individual fan isolation and/or replacement.

F. Location of Control Devices:
1. Cooling equipment control devices shall be housed in the control compartment. The Temperature Indicating Relay/Monitor (Device 49T-1) described in the Winding Hot-Spot Control Section is to be mounted within the compartment visible through a window. The window material shall be shatter-proof and shall not degrade over time (i.e., shall not craze or become opaque).

G. Control Testing:
1. Leads from the current transformer(s) used for winding temperature calculation shall be wired to suitable shorting-type terminal blocks in the control compartment. This location will permit complete control calibration and testing at ground level without de-energizing the power transformer.

2.9 CONTROL AND RELAY ACCESSORY REQUIREMENTS

A. Auxiliary Equipment Voltages:
1. The transformer shall be equipped for operation with Owner supplied AC and DC power supplies at the nominal voltages specified below, unless written direction otherwise is provided by the Purchasing Authority prior to the design review:
2. The AC power will be single phase, 120V/240 V AC.
3. The DC power will be 48 V DC.

B. Wiring:
1. Auxiliary power and control wiring shall consist of stranded copper wire, 600V class, with insulation (or outer covering over the insulation) that is flame-retardant, heat-resistant, oil-resistant, and moisture-resistant. Both ends of all wires and all terminal block points shall be clearly marked with the designation shown on the supplier's wiring diagrams. Conductor colors and type shall meet the requirements of the National Electrical Code.
2. All interface terminal blocks designated for the Owner's use shall be one-piece molded type, rated 600 Volts, 30 Ampere, equipped with #10-32 washer-head binder screws, and suitable for wire sizes #18 through #10 AWG. All wires shall be terminated using compression-type, non-insulated, ring-tongue terminals. Compression-type wiring terminals shall be made using an aircraft-grade, non-reversible ratcheting tool. Compression tooling will have appropriate certification documentation, which is current and up-to-date. All other interface terminations shall also be made on suitable weatherproof terminal blocks; no wires shall be spliced.
3. All BCT secondary leads shall be wired to short-circuiting type terminal blocks in the control compartment. A separate terminal block shall be furnished for the wiring from each current transformer. Secondary leads and wiring shall be #10 AWG. Leads shall pass through the tank cover or busing turret wall using a bolted, flange-connected, aluminum body, BCT terminal box, with a minimum terminal-to-terminal withstand voltage capability of 2,500 volts at 60 Hertz. Provide a detail of the tank wall BCT lead bushing terminal box as part of the approval drawing package.
4. Wiring runs outside of weatherproof compartment shall be routed within galvanized rigid steel or liquid-tight flexible, ultraviolet-resistant, weatherproof conduit. The use of flexible conduit is to be limited to 24-inch lengths, serving as a transition between supported rigid conduit and an exterior tank wall mounted accessory device or enclosure where necessary.

C. Control Compartment:

1. Per IEEE C57.148, the Supplier shall furnish a NEMA 3S (same as NEMA 3R, except with filter and screen over the vents) control compartment to house cooling equipment control devices and terminal blocks for terminating all auxiliary wiring. The Contractor will bring all external auxiliary power and control wiring in conduit or wireway to the control compartment; the compartment shall be furnished with a removable bottom gland plate for cutting and/or drilling by the Contractor. The compartment doors shall be vertically hinged, removable, each door being operated by a single handle for a three-point latching system and provided with a latch bar for each door to secure the doors in an open position. Plastic Wire Ties may be used inside the control compartment; if used they shall be trimmed using cutting tools designed to tighten and trim wire ties without leaving sharp edges. Plastic wire ties may not be used outside control cabinets where exposed to weather.
2. The controls, terminal blocks, and other devices requiring access for operation and maintenance shall be mounted in the compartment at a height of less than 6-feet above top of concrete (TOC). The bottom of the compartment shall be a minimum of 2-feet above the TOC.
3. All auxiliary device contacts designated for the Owner's use shall be normally open, voltage-free, and ungrounded. Both sides of each contact shall be isolated from all other contacts and independently wired to interface terminal blocks in the control compartment. Form-C contacts shall be brought to the interface terminal blocks via a three-wire circuit.
4. The compartment shall be furnished with two space heaters. Each heater shall be controlled by a separate ON-OFF switch and a separate thermostat. The thermostats shall include clear indication of at least three specific temperatures on the adjustment range. Heater elements shall be rated for 240 V AC, and connected and operated in a derated mode at 120 V AC.
5. The control compartment shall not be located on the same side of the transformer as the conservator tank. The preferred location for the control compartment is on the tank wall associated with IEEE Segment 4.

2.10 ADDITIONAL AUXILIARY PROTECTION DEVICE REQUIREMENTS

A. Auxiliary Device Housings and Enclosures:

1. All auxiliary devices and appurtenances shall be housed or enclosed such that adverse weather conditions and blowing dust will not interfere with their performance.

B. Auxiliary Device Contacts:

1. All auxiliary device contacts shall be normally open, voltage-free, and ungrounded. Both sides of each contact shall be isolated from all other contacts and shall be independently wired to terminal blocks in the control compartment.

C. Conduit and Wireways:

1. Conduit shall be hot-dipped galvanized rigid steel (GRS), compliant with the requirements of National Electric Code Articles 250 and 344, equivalent to those manufactured by Allied Tube and Conduit. Minimum conduit size shall be 1-Inch, or metric equivalent. Conduits may be left in their natural finish.

2. UL Listed flexible liquid-tight steel conduit (FLT), with sunlight resistant gray PVC jacket, T&B Type ATLA, or equivalent, shall be used to transition between rigid conduit and a specific appurtenance where applicable. FLT shall be rated for operation over a temperature range of minus 55 °C to plus 105 °C. FLT lengths are to be limited to 36-Inches maximum. GRS is to be supported at intervals less than 84-Inches. FLT connections shall be made using threaded liquid-tight fittings.
3. Copper-free aluminum conduit bodies (Crouse-Hinds Mark 9 or equivalent) may be used to facilitate wire installation. Covers are to be gasketed and secured with screws. Conduit ports are to be threaded. Care should be taken when locating conduit bodies to provide access for cover removal, while the transformer is in service.
4. Where applicable, wireways are to be NEMA Type 3R feed-through type with a gasketed hinged cover and joined using gasketed flat flanges.

D. Oil Level Indication and Protection:
1. The Supplier shall provide a dial-type oil level indicator (Device 71Q-1). Indicator design and mounting arrangement shall permit reading from the ground. The indicator shall be furnished with two contacts: one contact shall be set to close to activate an Owner's alarm at the minimum safe operating level, and the second contact shall be set to close to initiate tripping of Owner's switching device at a level below the minimum safe operating level but above the level which would result in transformer damage or failure.

E. Rapid-Pressure-Rise Relay:
1. The Supplier shall furnish a flange-connected, under oil type, rapid-pressure-rise relay (Device 63FP) on the main transformer tank wall; the relay shall be Qualitrol Series 900-FLA, with one (1) ANSI Form C relay output contact, IP65 Gore-Tex vent, and with provisions for testing relay operation without removing the relay from the transformer. One associated seal-in relay shall be furnished in the control compartment, Qualitrol Model 909-300-01.
2. The nominal location for the rapid-pressure rise relay is approximately 5-feet above TOC, or as determined optimal by the Supplier. The Supplier shall provide a suitable flange-connected 1-1/2" ø minimum ball valve to permit removing the rapid-pressure-rise relay without draining oil from the transformer tank. The valve shall have provisions for padlocking in both the fully opened and fully closed positions.

F. Pressure Relief Device:
1. The Supplier shall furnish a self-resealing mechanical pressure relief devices (Device 63PR). The pressure relief devise is to be mounted on the main transformer tank cover. The device may be either a Messko Model MPreC, or a Qualitrol Model XPRD.
2. The pressure relief device shall be furnished with an alarm contact and visual semaphore indicator. The indicator design and mounting arrangement shall provide visibility from the ground. The Supplier shall provide a directed oil exhaust system for each pressure relief device, using aluminum piping with a minimum 6-inch-diameter, with a protective screen at the discharge. Discharge shall be no higher than 24-inches above TOC.

G. Buchholz Type Relay:

1. Where applicable, the Supplier shall furnish a Buchholz-type relay (Device 63BH), located between the transformer main tank and the conservator oil preservation system expansion tank. Provide an accumulation system to allow gas that may otherwise be trapped in areas such as bushing turrets to migrate to the Buchholz-type relay shall be provided by the Supplier. The relay shall have provisions for operational testing without removing the relay from the transformer. Each relay shall be equipped with two detecting mechanisms (double float) and a Form-A relay contact associated with each mechanism. One mechanism shall provide detection of gas accumulation, and the other mechanism shall provide detection of rapid liquid flow. The Supplier shall provide the EMB Transformer Protection Relay Type 53 (BS80), with 6-hole flange connections, or an approved equivalent. One seal-in relay shall be furnished in the control compartment, Qualitrol Model 909-300-01, for use with a contact associated with the rapid-liquid-flow mechanism.
2. The Supplier may propose an alternate gas collection configuration using an internal deflection system within each bushing turret. If a deflection system is being proposed, the Supplier shall include a typical detail drawing of their system with their proposal.
3. Ball-type isolation valves shall be provided on both sides of the Buchholz-type relay device. Valves shall be 3-inch minimum, with flanged and O-ring connections.
4. A means of sampling the gas shall be provided, located at a convenient height on the tank wall. The gas sampling device shall be EMB Type ZG1.2, with a lockable enclosure, or an approved equivalent.

H. Fault Gas and Moisture Monitor:

1. The Supplier shall quote as an option the following monitor, and be responsible to:
2. Provide an on-line transformer DGA monitoring system, specifically the GE KELMAN TRANSFIX, or its most current equivalent model.
3. Shall be responsible for mounting the selected monitor on the tank in a non-obstructive location which experiences minimal tank vibration. Vibration snubbing mounts are to be employed as necessary to avoid false alarms/readings due to mechanical vibration.
4. Be responsible for furnishing and installing the stainless-steel tubing supply and return lines, check valve, bleeder port, and appropriate fittings between the monitor and its respective sampling supply and return tank connections.
5. Furnish and install an upper supply port and a lower return port on the transformer’s main tank wall. The minimum port size shall be 1-inch SPS. Install an equally sized stainless steel, double-flanged, ball type valve with O-rings at each port.
6. Commission of the systems at the project site and ensure all parameter values and alarms are readable by the Substation SCADA/Communication System.
7. Coordinate settings with Owner and provide training to Owner’s staff for operation and control. The Systems shall be included in the SCADA System Integrator Check-list and signed-off by Owner’s SCADA and IT Representatives for PI connectivity and operation.
8. Connect the analog outputs as inputs to Device 49T-1. Additionally, connect the Device Failure Form-C alarm relay output to a terminal block in the control compartment for the Owner’s use.

9. If necessary, provide a digital media converter, Dymec 5846HRT-H or an approved equivalent, to convert the monitor's RS-489 serial output to multimode fiber optic media, with ST type connectors. Provide fiber connections between the media converter and the fiber optic cable management system. Connect the power supply inputs to the appropriate DC power source.

I. Remote I/O:

1. The transformer monitor, device 49T-1, will also be used as a Remote I/O device, acting as a peripheral data collection device for the Owner's SCADA system. Refer to the Winding Hot-spot Temperature Control Section for requirements pertaining to device 49T-1.
2. The Supplier shall provide alarm circuit connections to the Remote I/O device from the following alarming devices.

POWER TRANSFORMER REMOTE ALARM MONITORING		
ALARM INPUT (TO APT ECLIPSE)	**ALARM SOURCE (FROM DEVICE)**	**DESCRIPTION**
TB9-IN4 AND 5	27-1, 27-2	LOSS OF FANS - GROUP 1 AND/OR GROUP 2
TB9-IN7 AND 8	63BH, 63FP	GAS ACCUMULATION, RAPID LIQUID FLOW, RAPID PRESSURE RISE
TB9-IN10 AND 11	63H	MAIN TANK - HIGH GAS WARNING, HIGH MOISTURE WARNING
TB10-IN13 AND 14	63H	MAIN TANK - HIGH-HIGH GAS WARNING, HIGH-HIGH MOISTURE WARNING
TB10-IN16 AND 17	49T	MAIN TANK - TOP OIL 65 DEG. C AND AVERAGE WINDING 65 DEG. C RISE
TB10-IN19 AND 20	49T	MAIN TANK - TOP OIL 75 DEG. C AND AVERAGE WINDING 75 DEG. C
TB11-IN22	63PR	MAIN TANK - PRESSURE RELIEF DEVICE (S) OPERATE
TB911IN23	71Q-1	CONSERVATOR TANK - LOW OIL LEVEL

3. The supplier shall provide remote control circuit connections from the Remote I/O device to the appropriate control devices to perform the following functions.

POWER TRANSFORMER REMOTE CONTROL FUNCTIONS	
CONTROL OUTPUT (FROM APT ECLIPSE)	**DESCRIPTION**
TB4-OUT 1	FORCED COOLING STAGE 1 AUTOMATIC START
TB4-OUT 2	FORCED COOLING STAGE 2 AUTOMATIC START
TB4-OUT 3	FORCED COOLING STAGE 1 REMOTE START
TB4-OUT 4	FORCED COOLING STAGE 2 REMOTE START
TB5-OUT 5	REMOTE OLTC RAISE (WHERE APPLICABLE)
TB5-OUT 6	REMOTE OLTC LOWER (WHERE APPLICABLE)
TB5-OUT 7	FORCED COOLING STAGE 1 REMOTE ENABLE (DISABLES LOCAL, AUTOMATIC AND REMOTE FAN OPERATION WHEN NOT ENABLED
TB5-OUT 8	FORCED COOLING STAGE 2 REMOTE ENABLE (DISABLES LOCAL, AUTOMATIC AND REMOTE FAN OPERATION WHEN NOT ENABLED

4. The Form-C output contacts are to be wired to enable remote functions and disable local functions when the relay is picked up.
5. Local/Remote Switch
6. The Supplier shall provide a two-position, manually operated, rotary type control switch (Device 43L/R) in the control compartment for locally enabling and disabling remote output functions of the remote I/O module. In addition to interface wiring associated with the remote output functions, a NO and NC contact associated with the LOCAL switch position shall be wired to terminal blocks for the Owner's use. Additionally, the Supplier shall provide an amber LED indicating light adjacent to the switch handle, which is to be illuminated when Device 43L/R is in the LOCAL switch position.
7. Fiber Optic Cable Management
8. The Supplier shall furnish and install a fiber optic cable management system within the control compartment, including a splice and connector housing, and multimode patch cord between the housing and the Remote I/O Module. The splice and connector housing shall include provisions for up to twelve (12) multimode fiber connections using ST type connectors, and a splice tray for up to twelve (12) splices. The splice and connector housing shall be Corning Number SPH-01P, with connector panel, Number CCH-CP-G5, or an approved equivalent. The patch cord shall have ST type connectors.
9. Auxiliary Device Software
10. A record of the installed software, license data, and support information must be documented and provided to the Owner. The programming of any HMI, logic, control, database settings, etc., must be provided in the Supplier‘s format. Additional licenses must be included to allow the Owner's Engineering team to review the data.

2.11 NAMEPLATE REQUIREMENTS

A. Transformer nameplates and instruction plates shall show all values in both U.S. customary units and Metric System (SI) units, with the latter values shown in brackets or parenthesis. All text shall be in English. Information shown on the main transformer nameplate shall include identification of the conductor material used in each transformer winding; polarity marks for each transformer winding; positive and zero sequence impedance values; and current transformer polarity marks; as well as a listing of the separate volumes and weights of oil in the main transformer tank, the radiators, and the conservator expansion tank.

B. All other items as listed in IEEE C57.12.00 shall be included on a nameplate.

C. The Supplier shall furnish a separate nameplate which provides a listing of all the operational valves and an indication of their position (open or closed) during normal operation. The nameplate shall also include an outline of the transformer, showing the location and type (gate/butterfly/ball) of each valve.

D. Furnish an additional nameplate which provides a diagrammatic location for each current transformer, indicating the ratio and taps for each.

E. A temperature – rating curve shall be shown on either the main nameplate or an auxiliary nameplate.

F. The main nameplate may be mounted either on the exterior of a control compartment door, or on a separate metal plate extended from the tank wall and

located no further than 6-feet from the control compartment. All other nameplates are to be located on the interior of a control compartment door. Nameplates may be made from either stainless steel or marine grade aluminum and affixed using stainless steel hardware.

2.12 PAINT AND FINISH

A. The following referenced surface preparation specifications of the Society of Protective Coatings (SSPC) shall form a part of this specification:
   1. Solvent cleaning (SSPC-SP1): Removal of oil, grease, soil, salts, and other soluble contaminants by cleaning with solvent, vapor, alkali, emulsion, or steam.
   2. Hand tool cleaning (SSPC-SP2): Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, by hand chipping, scraping, sanding, and wire brushing.
   3. Power tool cleaning (SSPC-SP3): Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, by power tool chipping, descaling, sanding, wire brushing, and grinding.
   4. White metal blast cleaning (SSPC-SP5): Removal of all visible rust, oil, grease, soil, dust, mill scale, paint, oxides, corrosion products and foreign matter by blast cleaning.
   5. Commercial blast cleaning (SSPC SP6): Removal of all visible oil, grease, soil, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining shall be limited to no more than 33 percent of each square inch of surface area.
   6. Brush-off blast cleaning (SSPC-SP7): Removal of all visible oil, grease, soil, dust, loose mill scale, loose rust, and loose paint.
   7. Near-white blast cleaning (SSPC-SP10): Removal of all visible oil, grease, soil, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining shall be limited to no more than 5 percent of each square inch of surface area.
   8. Marginally prepared surfaces (maintenance): Remove visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter in accordance with manufacturer's instructions.

B. The control compartment exterior paint finish, and bushing housings shall be Munsell 5.0 BG 7.0/0.4 light gray. Supplier shall furnish one quart of touch-up paint per MVCB. Cast aluminum, aluminum, and stainless steel components shall be left in their natural finish.

C. The control compartment interior shall be painted the Supplier's standard white (preferred) or gray paint finish color.

D. All surfaces of the control compartment, covers, panels, etc., shall be thoroughly cleaned by degreasing and abrasive blasting to remove scale, rust, and corrosion (SSPC-SP2, -SP3, -SP5, -SP6, SP7, and -SP10). Oil and grease shall be removed chemically or with steam, and in accordance with the manufacturer's criteria (SSPC-SP1). Steel surface and fabrication defects shall be corrected. Weld splatter and slag shall be removed. Welded seams, undercuts, recesses, porous surfaces, weld flux, and sharp edges are to be finish to smooth and rounded surfaces. All surfaces shall be dry and then be given at least one primer coat within eight hours to prevent the formation of rust. Vinyl, zinc-pigmented, or chlorinated rubber primers are unacceptable.

E. Prepare steel surfaces in accordance with manufacturer's criteria. Cast aluminum and stainless steel components shall be left in their natural finish.

F. After preparing the primed surfaces, all exterior surfaces shall be given two field coats in accordance with the manufacturer's instructions of an approved finish coating having an acceptable total dry-film finish thickness (DFT). The primer, intermediate, and finish coatings are to be compatible with one another and from the same coatings manufacturer. Electrostatically applied polyurethane powder paint is also acceptable if approved by UL for this application.

G. Mix and thin coatings, including multi-component materials, in accordance with manufacturer's instructions. Keep containers closed when not in use to avoid contamination, and do not use mixed coatings beyond pot life limits. Use application equipment, tools, pressure settings, and techniques in accordance with manufacturer's instructions. Uniformly apply coatings at spreading rate required to achieve specified DFT. Apply coatings to be free of film characteristics or defects that would adversely affect performance or appearance of coating systems. Ensure that edges, corners, crevices, welds, and similar areas receive film thickness equivalent to adjacent areas.

H. Apply coatings in accordance with manufacturer's instructions.

I. The Supplier shall furnish documentation to the OE regarding their standard system, and the OE will review and accept as appropriate. The Supplier will furnish one (1) can of matching paint to accommodate field touch-up. Field coating repairs are to be made in accordance with the manufacturer's instructions.

J. If the equipment's support frame is fabricated using mild steel, then the assembled frame shall be hot-dip galvanized. Support frames fabricated using aluminum or stainless steel may be left in their natural finish. An additional paint finish over the galvanized finish is not required.

2.13 WIND AND SEISMIC WITHSTAND

A. Applicable Documents:
   1. Except as required otherwise in this document, the wind and seismic withstand capability of the equipment shall be in complete accordance with the latest applicable industry codes, and ANSI, ASTM, IEEE, and NEMA standards in effect on the date of invitation to bid. These documents shall include, but shall not necessarily be limited to, the following:
   2. IEEE 693, Recommended Practices for Seismic Design of Substations
   3. AISC, Manual of Steel Construction
   4. ASCE 7-22, Minimum Design Loads and Associated Criteria for Buildings and Other Structures

2.14 TEST REQUIREMENTS, MEASUREMENTS, AND CALCULATIONS

A. Factory tests shall include all tests identified as "Routine" in IEEE C57.12.00, Table 17, and performed in accordance with IEEE C57.12.90. Reports must include evidence of all instrument calibration. Additionally, any special or specific tests identified within this specification shall be performed by the Supplier. The Supplier will submit an Inspection and Test Procedure Outline to the Purchasing Authority for the OE's acceptance at least three weeks prior to the commencement of testing.

B. All test results, measurements, and calculated values shall be recorded on the Supplier's Certified Test Report. All data within the Certified Test Report shall be reviewed and accepted by the OE before the transformer is shipped. All routine and special factory tests may be witnessed by the Purchasing Authority, Owner and/or OE.

C. In addition to these factory tests, the Purchasing Authority may also elect to inspect the core and coil assemblies at one or more production "hold" points prior to final testing. The hold points may include the following:

D. Completed windings prior to initial drying.

E. Core bottom yoke and leg assembly prior to winding nesting.

F. Assembled core (including top yoke) and compressed winding prior to vapor phase drying.

G. Assembled core and coils prior to tanking.

H. The Supplier shall notify the Purchasing Authority at least two weeks prior to each of the scheduled hold point dates.

I. Any test results that are deemed to be "Not Acceptable" or a "Failure" by agreement between the Supplier and the OE require a detailed investigation prior to the performance of any remedial actions and/or retest.

2.15 SPECIFIC TESTING REQUIREMENTS

A. Test Bushings: The high-voltage (H) and low-voltage (X) bushings installed for transformer tests shall be those that will be furnished with the transformer. The use of special test bushings is not allowed without prior acceptance by the Owner's Technical Representative.

B. Dissolved Gas Analysis: The Supplier is responsible for establishing acceptable limits for the incremental increase of the dissolved gases listed below between the initial pretest conditions and subsequent tests. These limits are to be furnished as part of the Approval Documents package and are subject to acceptance by the Owner's Technical Representative.

C. Dissolved Gases to be analyzed:
1. Hydrogen (H2)
2. Carbon Dioxide (CO2)
3. Carbon Monoxide (CO)
4. Oxygen (O2)
5. Nitrogen (N2)
6. Methane (CH4)
7. Ethane (C2H6)
8. Ethylene (C2H4)
9. Acetylene (C2H2)

D. The increase of dissolved gases is defined as the differential between the measured dissolved gases from oil samples taken initially, and immediately after the temperature rise tests are concluded. The initial sample is taken after the assembled unit is dried using a vapor phase process and vacuum filled with oil,

and prior to any electrical tests being performed. The final sample is taken after the average winding temperature rise test is performed at the equivalent top MVA rating of the transformer.

2.16 GENERAL TESTING REQUIREMENTS:

A. The order of tests performed will generally be in accordance with IEEE C57.12.90, and as agreed to in the Inspection and Test Procedure Outline document. The order may be modified as special circumstances present themselves during testing. The tests listed below are not intended to be all inclusive, or in the same order in which they may be performed.

B. Preliminary Tests:
   1. After completion of post-production activities and after the transformer has “soaked” for at least 48 hours, the Supplier shall perform a Sweep Frequency Response Analysis (SFRA) using a Doble M5000 High Sweep Frequency Response Analyzer, or an approved equivalent. The SFRA plot(s) are to be included in the certified test report

C. Construction and Dimensional Checking:
   1. Measurements are to be made by the Supplier’s Quality Control personnel of the construction (paint and weld conditions) and dimensional characteristics of the as-built transformer, noting any significant deviations from the approved outline drawings.

D. Insulation Power Factor:
   1. The Supplier will perform an insulation power factor and capacitance test using the appropriate Doble, or an approved equivalent, instrument with an applied test voltage of 10 kV. The data from this test shall also be used to calculate the equivalent leakage current for the transformer. The calculated leakage current shall be compared to the Applied Potential test current for equivalency. The measured windings-to-ground and windings-to-windings percent power factors, corrected to 20°C, shall each be less than 0.50.

E. Hot-Spot Winding Temperature:
   1. The supplier shall furnish the calculated hot-spot winding temperature rise corresponding to the highest measured value of average winding temperature rise at both the self-cooled rating and maximum forced-air-cooled rating.

F. Switching and Lightning Impulse:
   1. Switching and lightning impulse tests shall be performed on all phase terminals.

G. Short-Circuit Testing:
   1. A specific test may be required if the Supplier has not provided adequate proof that the equivalent design being used has previously been tested and passed per the requirements of IEEE C57.12.90, Section 12. Suppliers are required to present proof of an equivalent design test as part of the bid package. If this proof is not available, the Supplier shall provide a separate line item in their proposal regarding the cost of performing a specific test. The cost of the specific test will become part of the evaluated cost of the transformer.

H. Positive-Sequence Impedance:
   1. H-winding to X-winding positive-sequence impedance shall be measured at the nominal rated voltage and de-energized tap extremes.

I. Zero-Sequence Impedance:
   1. Zero-sequence impedances shall be measured and shall be recorded in an equivalent-T form if applicable (both R and X values).

J. No-Load Loss and Excitation Current:
   1. No-load loss and excitation current shall be measured both at nominal rated voltage and at 110% of nominal rated voltage, both before and after impulse tests.

K. Loss Compliance:
   1. Values of no-load loss and excitation current measured at nominal rated voltage after impulse tests shall be the values used in determining compliance with the supplier's quoted loss and excitation performance. These values shall not exceed the values measured before impulse tests by more than 5.0%.

L. Refer to the Evaluation section of this specification for the allowable tolerances for measured loss values, and their associated penalties. The allowable tolerances for losses identified within this specification may be more stringent than IEEE Standards.

M. The Supplier will not be allowed to ship a transformer that exceeds the quoted guaranteed loss values by more than 10% for No-Load Losses (NL); or by more than 10% for Load Losses (LL); or by more than 6% for total losses (ETC), including auxiliary equipment loads (AL). Mutually agreed upon remedial actions may be taken by the Supplier to make the transformer acceptable for shipment.

N. Insulation Resistance:
   1. Insulation resistance shall be measured at 5.0 kV DC and shall include a 1-minute: 10-minute comparative polarization index. The certified test report shall include actual readings and readings corrected to 20°C. Resistance shall be measured between the windings, and between each winding and ground.

O. DC Winding Resistance:
   1. Measurements on each of the H and X windings including all tap positions shall be made prior to transporting the finished transformer. Comparative measurements will be made by the installation contractor once the unit is placed on the pad.

P. Power-Factor and Excitation-Current Tests:
   1. A power-factor test shall be performed on all windings including all tap positions, surge arresters, and bushings at 10 kV. No winding shall exceed a 0.5% power factor. For each H-terminal, an excitation-current test shall be performed at 10 kV on each de-energized tap. Both the power-factor and the excitation-current tests shall be performed using Doble procedures and format.

Q. Control Wiring: Control wiring and contacts shall be tested with 60-hertz voltage of 1000 Volts applied for 60 seconds. Test jigs may be used to apply the test voltage

to multiple terminals at the same time. “Touch testing” for periods less than 60 seconds will not be acceptable.

R. Unintentional Core Ground:
1. A final test for unintentional core grounds shall be performed after all other tests are complete and as late as practical in the handling sequence prior to shipment.

S. Audible Sound Level:
1. The following sound level tests shall be performed: (1) ANSI average audible sound level tests (a) without forced-cooling equipment in operation and (b) with forced-cooling equipment in operation for each forced-cooled capacity rating, and (2) ANSI one-third octave-band audible sound level test at maximum forced-cooled capacity rating for mid-band frequency of 125 Hz.

T. Leak Test:
1. Leak test the tank by applying a pressure of 8.0 psi for a minimum of 8 hours. If leaks are found, they shall be repaired the test repeated.

U. Dielectric Test Sequence:
1. All units shall undergo the Dielectric Test Sequence outlined in IEEE C57.12.90-2015, Section 10. Refer to the PSD regarding the requirement to perform the Switching Impulse Test.
2. Significant differences between transients recorded by reduced and full test voltage within the Lightning Impulse Test Sequence are not allowed. Negative tolerances are not allowed.
3. The inducted voltage test shall be performed by the Supplier as part of the Dielectric Test Sequence using the procedures outlined in IEEE C57-12-90, Section 10.8. However, the acceptable limits for measured partial discharge are as follows:
4. The increase in the partial discharge levels during the 1-hour period shall not exceed 50 pC.
5. During the last 20-minutes of the one-hour period the discharge rate shall exhibit no sudden sustained increase.
6. Discharge rate within the one-hour period that exceed 300 pC are considered “Non-Passing” and will require further investigation and possible mitigation to be reviewed and accepted by the OE.

V. Average Winding Temperature Rise:
1. The average winding temperature rises for each phase at the maximum forced-cooled rating (ONAF2) shall be separately measured and recorded on the certified test report. If any temperature rise on one phase exceeds the corresponding temperature rise on any other phase by more than 4°C, the OE shall be consulted, and further investigative tests shall be performed, as necessary.
2. The duration of the temperature test at the maximum forced-cooled rating shall be a minimum of eight hours, with the transformer at thermal stability (as determined by IEEE C57.12.90) for the entire eight hours to determine the top-oil and average-oil temperature rises. Following the shutdown for measurements, the test shall be immediately resumed at base rating (ONAN) and continued for one-hour to determine the average-winding temperature rise.

3. During the period of thermal stability just before shutdown at the end of the 16-hour portion of the test, an infrared scan of all four segments of the tank and cover shall be performed. The measured temperatures of the tank and cover shall not exceed 80°C rise above the ambient air temperature.
4. The supplier shall furnish the calculated hot-spot winding temperature rise corresponding to the highest measured value of average winding temperature rise at both the self-cooled rating and the maximum forced-cooled rating.

W. Tests Performed Prior to Shipping:
1. After completion of the before mentioned factory acceptance tests, and prior to removing the insulating fluid in preparation for shipping, the Supplier shall perform a Sweep Frequency Response Analysis (SFRA) using a Doble M5000 High Sweep Frequency Response Analyzer, or an approved equivalent. The SFRA plot(s) are to be included in the certified test report.
2. Dew Point in degrees Fahrenheit of air in the tank.
3. Ambient temperature in degrees Fahrenheit.
4. Pressure of air in the tank.
5. Core Ground Resistance.
6. DC Winding Resistance.
7. After completion of the diagnostic tests and removal of the insulating fluid, and prior to removing the bushings for shipment, the Supplier shall perform a Sweep Frequency Response Analysis (SFRA) using a Doble M5000 High Sweep Frequency Response Analyzer, or an approved equivalent. The SFRA plot(s) are to be included in the certified test report.
8. The inspector's initials and the date shall be recorded. One copy is to be shipped with the transformer and one copy is to be sent directly to the Purchasing Authority at or prior to departure the of equipment from the manufacturing facility.

2.17 PRODUCT EVALUATION

A. The Purchasing Authority's OE will evaluate the Supplier's proposed pricing as part of the bid evaluation process, prior to award of a contract. The bid evaluation process will compare the qualified suppliers' Equivalent Total Cost, lead time, QA / QC procedures, experience in North American equivalent sized transformer market, warranty terms, exceptions and clarification to the specification, engineering, and dress and test cost components.

2.18 LOSS EVALUTION METHOD

A. An Equivalent Total Cost (ETC) will be calculated from the bid price and the present value of Supplier's quoted losses as shown below. The ETC will be used in determining bid awards.

ETC = BID PRICE + (A x NL) + (B x LL) + (C x AP) where:		
ETC	**=**	Equivalent total owning cost in dollars
BID PRICE	**=**	Supplier-quoted bid price in dollars
A	**=**	Loss cost multiplier for no-load losses in dollars per watt
B	**=**	Loss cost multiplier for load losses in dollars per watt
C	**=**	Cost multiplier for auxiliary power in dollars per watt

NL	**=**	No-load losses at 20 deg. C in watts
LL	**=**	Load losses at 85 deg. C in watts (at self-cooled rating, excluding auxiliary power)
AP	**=**	Auxiliary power in watts (with all forced-cooling equipment in service)

2.19 LOSS COST MULTIPLIERS

A. The loss cost multipliers to be used in the loss evaluation method will be as specified below:

No-load loss cost multiplier	(A) =	$8.00 / watt
Load Loss cost multiplier	(B) =	$4.50 / watt
Auxiliary power cost multiplier	(C) =	$4.50 / watt

2.20 LOSS PENALTY

A. If the Supplier's certified factory test reports indicate that either no-load losses are greater than 103% of the guaranteed no-load losses or load losses are greater than 106% of the guaranteed load losses stipulated in the purchase contract, a price reduction will be assessed and deducted from the Purchasing Authority's payment to the Supplier. The amount of price reduction will be equal to the difference of guaranteed losses and actual test report losses which are more than the tolerances stated above times evaluation costs stated in Section 7.3. Price reductions will be computed separately for the no-load losses, load losses, and auxiliary losses with no payment or credit to the Supplier for tested total losses that are less than the guaranteed values in the purchase contract.

PART 3 - EXECUTION

3.1 QUALITY ASSURANCE (QA) / QUALITY CONTROL (QC)

A. Suppliers shall furnish a copy of the appropriate quality assurance/quality control procedures relating to this product and the specific facilities and design services utilized in the manufacturing process to the Purchasing Authority as part of their proposal.

B. Each Supplier shall have a quality assurance program that meets requirements of ISO 9000. Documentation demonstrating that the Supplier has met these requirements shall be part of the bid documents.

C. Compliance and suitability of QA/QC procedures for this product shall be evaluated by means of factory inspection trips, self-evaluations, and other methods as deemed appropriate by the Purchasing Authority.

D. Quality Surveillance:

1. A Quality Surveillance Representative (QSR) may be employed by the Purchasing Authority to be present at the Supplier's facility during the manufacturing and testing of the equipment as specified and to be delivered herein. If a QSR is employed, the QSR will always comply with the Supplier's safety and procedural requirements while in the Supplier's facility and the following additional guidelines shall apply.

E. Cooperation with QSR:
   1. The Supplier shall cooperate with the QSR and arrange a reasonable and mutually agreeable schedule for the required inspections and witnessing of tests on the supplied equipment, consistent with maintaining scheduled progress of the equipment through the Supplier's facility.

F. Authority of QSR
   1. The QSR will have full authority from the Purchasing Authority to make whatever decisions are necessary to ensure that the completed equipment complies with all requirements of the Purchasing Authority's procurement documents, and to ensure that all required inspection and witness activities are carried out.

G. Disagreements
   1. In the event of disagreement between the Supplier and the QSR concerning scheduling of inspection or witness activities or concerning interpretation of the Purchasing Authority's procurement documents, the Supplier and the QSR shall promptly and jointly contact the Purchasing Authority to resolve the matter.

H. Warranty inspection:
   1. The Supplier shall be responsible for replacement or repair should field installation, inspection and/or startup identify warranty or quality related issues. The Supplier shall be responsible for the labor, material, and transportation costs associated with replacement or repair of items covered under warranty.

I. Design review:
   1. The Purchasing Authority reserves the right to have a technical representative visit the Suppliers facilities (or via video conference if required) to conduct a formal design review. The Supplier's design personnel are to present the particulars of the transformer's design to the reviewer for comment and acceptance. The reviewer's acceptance will not relieve the Supplier of their design responsibilities. The design review will be scheduled prior to procuring core and winding materials. The approval drawing package should be issued for at least 2-weeks prior to design review meeting.

3.2 INSTALLATION

A. Prior to the delivery of the equipment to the Project Site, the Supplier shall provide a written procedure for the tasks to be performed during installation to the Purchasing Authority. This procedure will be reviewed with the Purchasing Authority's Owner's Engineer and receive their written acceptance and approval. The Supplier is to ensure that this written procedure is adhered to by themselves and their subcontracted personnel. Failure to follow these procedures may result in the transformer(s) not being accepted by the Purchasing Authority.

B. All dressing and testing, including filling with insulating oil will be supervised by the Supplier.

C. All personnel who are to be admitted to the Project Site will be required to attend a mandatory site orientation and comply with all site safety requirements and

directions of the Contractor for the Project Site. Pre-Job Hazard Assessments are required to be issued to, and approved by, the Contractor prior to conducting work.

D. The Contractor will furnish and install the following items which interface with the assembled transformer(s):
   1. Station service, control, and alarm circuits which are to be terminated at the interface terminal blocks within the control compartment.
   2. Electrical bus connections between the transformer's bushing terminals and the substation switch and bus equipment.
   3. Grounding connections between the substation ground grid and the tank grounding pads, arrester ground bus bars (brought down to less than 3-feet above the base), and neutral bushing ground bus bars (brought down to less than 3-feet above the base).
   4. Weld the transformer base plates to the foundation's embedded steel anchorage plates.

E. Prior to final filling with oil, the following tests will be supervised by the Supplier:
   1. The insulation resistance of the core to ground shall be measured.
   2. The gas pressure shall be checked. If the pressure is near zero or negative, the oxygen content and relative humidity of the gas in the tank shall be measured. If oxygen content is above 1% and relative humidity is above 1%, dry out work may be necessary as directed by the OE.
   3. Insulation resistance shall be measured. If the measured value (temperature corrected) is more than 10% lower than the value prior to shipment, the insulation shall be dried out using a method approved by the OE.
   4. The polarity of each current transformer shall be checked using the inductive kick method.

F. After final filling with oil the following tests will be conducted by the contractor with Supplier support and supervision as part of the commissioning procedure:
   1. Dielectric strength, power factor, interfacial tension, acid number, 2 formaldehyde concentration, oxygen concentration, nitrogen concentration, and carbon dioxide concentration of the oil.
   2. Oxygen content and combustible gas content of inert gas cushion.
   3. Resistance of each winding by means of a Kelvin bridge.
   4. Ratio test with tap changers in each available position.
   5. Sweep Frequency Response Analysis: The analysis shall be performed using a Doble M5000 Series sweep frequency response analyzer, or an approved equivalent. Field test results shall be compared to factory test results and reviewed with the Owner's Technical Representative.
   6. Other tests as specified by the transformer Supplier.

G. The Supplier will submit a written test report documenting results of the field testing to the Purchasing Authority. Final acceptance of equipment will not be made until the OE approves the field tests.

H. Upon receipt of the OE's acceptance of the written test report results from the Purchasing Authority, the Supplier shall then provide a written certificate to the Purchasing Authority indicating that the installation terms of the warranty have been satisfied, and that the warranty is in full effect as of the date of installation completion.

Appendix A. Project Specific Data Sheets

CAPACITY RATINGS

WINDINGS	SELF-COOLED	FIRST STAGE FORCED-COOLED	SECOND STAGE FORCED-COOLED
High-Voltage (HV)	12	16	20
Low-Voltage (LV)	12	16	20
Dielectric Fluid			
Parameter	Options		Specified Cooling Class
Cooling System Fluid	Mineral Oil (ONAN) or Natural Ester (KNAN)		KNAN/KNAF1/KNAF2

VOLTAGE RATINGS

The following voltage and BIL ratings shall be furnished for each winding.

WINDINGS	NOMINAL SYSTEM VOLTAGE	WINDING BIL	Winding Conductor Material
HV (Line Connection)	69 kV	350 kV	Copper
LV (Line Connection)	12.47 kV	110 kV	Copper
LV (Neutral Connection)	12.47 kV	110 kV	Copper

WINDINGS

HIGH-VOLTAGE (HV) WINDINGS		
BASE MVA RATING	12/16/20 at 65 deg. C	
ALTERNATE MVA RATING	N/A	
NOMINAL RATED VOLTAGE	69.0 kV	
CONNECTION	Delta	
SUPPLY WITH AN OLTC IN PLACE OF THE STANDARD DETC? (YES/NO)		No
FULL CAPACITY TAPS AT: 69.0 KV NOMINAL VOLTAGE / PLUS 2 X 2-1/2% STEPS / MINUS 2 X 2-1/2% STEPS		
INSULATION RATINGS		
350 kV	Line-End BIL Rating, Uniform	
Not Required	Switching Impulse Withstand Voltage	
TEST VOLTAGE VALUES		
140 kV	Applied Voltage Test, Shorted Winding-To-Ground	
120 kV	Enhanced Induced Voltage, Phase-To-Ground	
105 kV	1-Hour Induced Voltage, Phase-To-Ground	

LOW-VOLTAGE (LV) WINDINGS	
BASE MVA RATING	12/16/20 at 65 deg. C
ALTERNATE MVA RATING	N/A
NOMINAL RATED VOLTAGE	12.47Y/7.20 kV
CONNECTION	Grounded-Wye through a low impedance to limit ground fault current if necessary (If used, less than 1.1 Ohms)
SUPPLY WITH AN OLTC? (YES/NO)	YES
FULL CAPACITY TAPS AT: 12.47 KV NOMINAL VOLTAGE / PLUS 16 X 5/8% STEPS / MINUS 16 X 5/8% STEPS	
INSULATION RATINGS	
110 kV	Line-End BIL Rating, Uniform
110 kV	Neutral-End BIL Rating
TEST VOLTAGE VALUES	
34 kV	Applied Voltage Test, Shorted Winding-To-Ground

SURGE ARRESTER DUTY CYCLES

TERMINALS	DUTY CYCLE RATING (kV)
H1, H2, H3	90 (70 kV MCOV) *
X1, X2, X3	18 (15.3 kV MCOV) **

* - Surge arrester MCOV rating is based upon installation in a 69 kV high-voltage system served by an effectively grounded sub-transmission system.

** - OE will determine if higher voltage ratings are required should impedance be introduced externally to the neutral circuit.

BUSHING MINIMUM BIL REQUIREMENTS

TERMINALS	BIL (kV CREST)	VOLTAGE CLASS (kV)
H1, H2, H3	550	115
X1, X2, X3	150	25
X0	150	25

BUSHING CONTINUOUS CURRENT RATING REQUIREMENTS

TERMINALS	CONTINUOUS CURRENT RATING	UNDER OIL CONNECTION
H1, H2, H3	800/1200 Amps	Draw Lead
X1, X2, X3	2000 Amps	Bottom
X0	2000 Amps	Bottom

BUSHING CURRENT TRANSFORMERS REQUIREMENTS

BUSHING DESIGNATION	POSITION	QUANTITY PER BUSHING	FULL WINDING AMPERES	ACCURACY/ BURDEN	MIN. THERMAL RATING FACTOR
H1, H2, H3	X	1	600:5 SR	C800	2.0
H1, H2, H3	Y	1***	600:5 SR	C800	2.0
H1, H2, H3	Z	0	NA		
X1, X2, X3	X	1	1200: 5 MR	C800	2.0
X1, X2, X3	Y	1	1200: 5 MR	C800	2.0
X1, X2, X3	Z	1	1000: 5 SR	0.15% @B0.9	2.0
X0	X,	1	1200: 5 MR	C800	2.0
*** - CT is typically used for a high-side bus differential relaying scheme. Mount this bushing nearest the HV Winding lead connection.					

SOUND PRESSURE LEVEL

BASE PRICE: The Average Sound Pressure Level (SPL), measured in dB(A), shall be less than or equal to the values allowed by NEMA TR-1 for an equivalent two-winding transformer.

COOLING CLASS	POWER RATING (MVA)	ALLOWABLE SPL (dB(A))
KNAN	12	70
KNAF1	16	71
KNAF2	20	72

OPTION 1: The Average Sound Pressure Level (SPL), measured in dB(A), shall be a minimum of 6 dB(A) less than the values allowed by NEMA TR-1 for an equivalent two-winding transformer.

COOLING CLASS	POWER RATING (MVA)	ALLOWABLE SPL (dB(A))
KNAN	12	64
KNAF1	16	65
KNAF2	20	66

ON-LOAD TAP-CHANGING EQUIPMENT

The low-voltage windings will be provided with full capacity taps to provide the following voltage connections at the low-voltage bushing connection points.

OLTC POSITION	VOLTAGE (VOLTS)
1	13,716.64
2	13,638.70
3	13,561.16
4	13,483.22
5	13,405.28
6	13,327.34
7	13,249.40
8	13,171.46
9	13,093.52
10	13,015.58
11	12,937.64
12	12,859.70
13	12,781.76
14	12,703.82
15	12,625.88
16	12,547.94
17	12,470.00 (Nominal)
18	12,392.06
19	12,314.12
20	12,236.18
21	12,158.24
22	12,080.30
23	12,002.36
24	11,924.42
25	11,846.48
26	11,768.54
27	11,690.60
28	11,612.66
29	11,534.72
30	11,456.78
31	11,378.84
32	11,300.90
33	11,222.96

Appendix B. SITE SPECIFIC INFORMATION

Completion of “blank areas” in the tables of this Appendix will be supplied once the information is available and/or necessary.

FACILITY SUMMARY

SITE LOCATION AND DIRECTION

Project Name	Stage II Reliability Upgrades Monthill Power Substation	
State	Nevada	
County	Clark	
Nearest City or Town	Las Vegas	
Latitude (approximate substation location)		36°06’42.62” North
Longitude (approximate substation location)		115°04’58.77” West
Driving Directions from Nearest Interstate Highway	Exit 592 off Highway 93	
Project Site Physical Address	Monthill Avenue	
Specific Codes/Publications for Project Locality (if known)		

ENVIRONMENTAL AND LOCAL CONDITIONS

DESCRIPTIONS		DATA	SOURCE
Elevation	1840 FT	Feet above mean sea level	Google Earth Pro
Design – Extreme High Ambient Temperature	47.2	°C	Weatherbase (Las Vegas)
Design – Extreme Low Ambient Temperature	-13.2	°C	Weatherbase (Las Vegas)
Design – Highest Average Ambient Temperature within a 24-hour period	34.6	°C	Weatherbase (Las Vegas)
Average Annual Precipitation	4.2	inches	Weatherbase (Las Vegas)
Ground Acceleration: plus, or minus 0.35g (IEEE 693 Moderate Seismic Performance Level)			

ORGANIZATION AND MANAGEMENT

OWNER PROJECT PERSONNEL

The following staff members have key responsibilities for directing the contracted services for this Project. The project team may include other individuals and support staff as necessary to support the Project.

Owner Name:	Southern Nevada Water Authority
Street Address:	4095 E. Flamingo Rd
Mailing Address (if different)	100 North City Parkway, Suite 700
City State Zip	Las Vegas, NV 89106
COMMERCIAL ISSUES - PURCHASING	Colorado River Commision
Phone	702-856-3611
e-mail	Robert Reese <breese@crc.state.nv.us>
PROJECT MANAGER	Jonathan Tull, PE
Phone	702-691-5228
e-mail	Jonathan Tull <Jonathan.Tull@lvvwd.com>
KEY PROJECT STAFF	
Engineering Manager	Ryan Pearson

TECHNICAL APPLICATION QUESTIONS

Technical questions regarding this material specification or notice of any other technical matters which arise during the proposal process or during equipment design, manufacture, or test, shall be directed to the Owner's Engineer.

Owner's Engineering Firm Name:	Stantec Consulting Services Inc.
Street Address:	601 SW Second Avenue., Suite 1400
Mailing Address (if different):	[same]
City State Zip	Portland, OR 97204-3128
Phone:	503 220-5457
Function/Description	Key Individual/Other Information
KEY PROJECT STAFF	
Transformer Design	Kenneth Long, PE, Principal Engineer
e-mail	Ken.long@stantec.com

END OF SECTION

Stantec

CLIENT: SOUTHERN NEVADA WATER AUTHORITY
PROJECT: 3636S STAGE II RELIABILITY UPGRADES POWER SUBSTATION
TITLE: LIQUID-FILLED MAIN POWER TRANSFORMER

SUPPLIER DATA SHEET
SPECIFICATION NO. 33 73 13.01
EXHIBIT B

ITEM	DESCRIPTION OF SPECIFICATION	UNITS	*RFP* SPECIFIED PARAMETER (SHADED) SUPPLIER'S *PROPOSED* PARAMETER (UN-SHADED)
1.	**PROJECT**		3636S STAGE II RELIABILITY UPGRADES
2.	**LOCATION** (NEAREST TOWN)		MONTHILL AVE, LAS VEGAS, NEVADA 89121
3.	**ALTITUDE** (ELEVATION ABOVE SEA LEVEL)		550 METERS (1800-FEET)
4.	DESIGN AMBIENT TEMPERATURE AT LOCATION		EXTREME HIGH: 47.2°C
			EXTREME LOW: -13.3°C
			HIGHEST AVERAGE WITHIN A 24-HOUR PERIOD: 34.6°C
5.	**CAPACITY/DESIGN**		
	NAMEPLATED CAPACITY AT 65 DEG. C	MVA	12/16/20 KNAN/KNAF1/KNAF2
6.	**RATED NOMINAL VOLTAGE**		
	H-WINDING	kV	69.0
	X-WINDING	kV	12.47Y/7.20
	Y-WINDING	kV	NA
7.	**WINDING CONNECTION**		
	H-WINDING		DELTA
	X-WINDING		GROUNDED WYE THROUGH A NEUTRAL GROUNDING RESISTOR
	Y-WINDING		NA
8.	**WINDING BIL**		
	H-WINDING (UNIFORM)		350
	X-WINDING (UNIFORM)	kV	110
	Y-WINDING	kV	NA
9.	**WINDING MATERIAL**		
	H-WINDING	MATL.	COPPER
	X-WINDING	MATL.	COPPER
	Y-WINDING	MATL.	NA
10.	**PHYSICAL, APPROXIMATE INSTALLED DIMENSIONS**		
	HEIGHT (SHIPPING CONFIGURATION)	**INCHES**	
	HEIGHT (IN SERVICE, HV BUSHING)	**INCHES**	
	WIDTH (IN SERVICE, OUT-TO-OUT OF REDIATORS)	**INCHES**	
	LATTERAL LENGTH (IN SERVICE)	**INCHES**	
	APPROXIMATE WEIGHT (SHIPPING CONFIGURATION)	**LBS.**	
	APPROXIMATE WEIGHT (CORE AND COILS)	**LBS.**	
	APPROXIMATE WEIGHT (IN SERVICE)	**LBS.**	
	INSULATING FLUID VOLUME	**GAL.**	

ITEM	DESCRIPTION OF SPECIFICATION	UNITS	*RFP* SPECIFIED PARAMETER (SHADED) SUPPLIER'S *PROPOSED* PARAMETER (UN-SHADED)
11.	**NO-LOAD LOSSES**		
	GUARANTEED NO-LOAD LOSSES (@ 20 DEG. C) @ 100% NOMINAL VOLTAGE	**kW**	
	NO-LOAD LOSSES (@ 20 DEG. C) @ 105% NOMINAL VOLTAGE	**kW**	
	NO-LOAD LOSSES EVALUATION FACTOR	$/WATT	$8.00
	MAXIMUM ALLOWABLE NO-LOAD LOSSES @ 100% NOMINAL VOLTAGE	WATTS	NOT SPECIFIED
	MAXIMUM ALLOWABLE NO-LOAD LOSSES @ 105% NOMINAL VOLTAGE	WATTS	NOT SPECIFIED
12.	**LOAD LOSSES @ 85 DEG. C, PF=1.0**		
	KNAN RATING (LV + HV – WARRANTED)	**kW**	
	KNAF1 RATING (LV + HV)	**kW**	
	FULL LOAD RATING (LV + HV)	**kW**	
	AUXILIARY LOSSES (COOLING FANS)	**kW**	
	LOAD LOSSES EVALUATION FACTOR	$/WATT	$4.50
	MAXIMUM ALLOWABLE LOAD LOSSES @ONAN	WATTS	NOT SPECIFIED
13.	**EFFICIENCY @PF=1.0; % OF ONAF2 (FULL LOAD) RATING**		
	25%	**%**	
	50%	**%**	
	75%	**%**	
	100%	**%**	
14.	**EXCITING CURRENT**		
	EXCITING CURRENT % OF FULL LOAD CURRENT @ 100% NOMINAL VOLTAGE	**%**	
	EXCITING CURRENT % OF FULL LOAD CURRENT @ 110% NOMINAL VOLTAGE	**%**	
15.	**VOLTAGE REGULATION @ 85 DEG. C**		
	ONAN RATING 1.00 PF	**%**	
	FULL LOAD 0.80 PF	**%**	
16.	**EXCITING CURRENT ON HV WINDING**		
	100% VOLTAGE	**A-RMS**	
	110% VOLTAGE	**A-RMS**	
	115% VOLTAGE	**A-RMS**	

ITEM	DESCRIPTION OF SPECIFICATION	UNITS	*RFP* SPECIFIED PARAMETER (SHADED) SUPPLIER'S *PROPOSED* PARAMETER (UN-SHADED)
17.	**MAXIMUM TIME TRANSFORMER MAY BE OPERATED AT 110% OF RATED POWER WITHOUT EXCEEDING TOP OIL, AVERAGE WINDING, OR HOTTEST SPOT MATERIAL LIMITS**		
	FOLLOWING 4-HOURS FULL LOAD OPERATION @30°C AVERAGE AMBIENT TEMPERATURE	**HOURS**	
	FOLLOWING 4-HOURS DE-ENERGIZATION @30°C AVERAGE AMBIENT TEMPERATURE	**HOURS**	
18.	**% IMPEDANCE**		
	SPECIFIED PERCENT IMPEDANCE VOLTAGE @ 65 DEB. C (NOMINAL VOLTAGE TAP)	%	8.5% @ 85 DEG. C
	SUPPLIER'S GUARANTEED PERCENT IMPEDANCE VOLTAGE	**%**	
	SPECIFIED ACTUAL MEASURED PERCENT IMPEDANCE VOLTAGE TOLERANCE	%	PLUS 7.5% OF GUARANTEED VALUE MINUS 7.5% OF GUARANTEED VALUE
	SUPPLIER'S APPROXIMATE ZERO-SEQUENCE PERCENT IMPEDANCE VOLTAGE	**%**	
	SUPPLIER'S APPROXIMATE X/R	**RATIO**	
19.	**DE-ENERGIZED TAP-CHANGER (DETC)**		
	SUPPLY WITH DETC	YES/NO	YES
	TYPE		ROTARY, DEETAP DU, OR APPROVED EQUIVALENT
	MANUFACTURER		MR REINHAUSEN
	LOW-SIDE OR HIGH-SIDE		HIGH-SIDE
	NUMBER OF DETC TAPPING POSITIONS		5
	TAPPING RANGE AND STEPS	%	MINUS 2X 2-1/2% STEPS/NOMINAL VOLTAGE/PLUS 2 X 2-1/2% STEPS
20.	**ON-LOAD TAP CHANGER (OLTC)**		
	SUPPLY WITH OLTC	YES/NO	YES
	TYPE		ON-TANK, RMV-II OR APPROVED EQUIVALENT
	MANUFACTURER		MR REINHAUSEN
	LOW SIDE OR HIGH SIDE		LOW-SIDE
	NUMBER OF LTC TAPPING POSITIONS		33
	TAPPING RANGE AND STEPS	%	MINUS 16X 5/8% STEPS/NOMINAL VOLTAGE/PLUS 16 X 5/8% STEPS
	MINIMUM LIFETIME OPERATIONS		
21.	**PARALLEL OPERATION**		
	SPECIFICALLY DESIGNED FOR PARALLEL OPERATION	YES/NO	YES
22.	**LINE COMPENSATION**		
	SPECIFICALLY DESIGNED FOR LINE COMPENSATION	YES/NO	YES

ITEM	DESCRIPTION OF SPECIFICATION	UNITS	*RFP* SPECIFIED PARAMETER (SHADED) SUPPLIER'S *PROPOSI* PARAMETER (UN-SHADED)
23.	**NOISE LEVEL**		
	SPECIFIED MAXIMUM NOISE LEVEL	**dB(A)**	BASE PRICE: NEMA STANDARDS FOR AN EQUIVALENT 2-WINDING TRANSFORMER @ SPECIFIED HV WINDING BIL (STANDARD IS 70/71/72) dB(A) @ 350 KV BIL)
	SUPPLIER'S GUARANTEED MAXIMUM NOISE LEVEL @ KNAN RATING	**dB(A)**	
	SUPPLIER'S GUARANTEED MAXIMUM NOISE LEVEL @ KNAF1 RATING	**dB(A)**	
	SUPPLIER'S GUARANTEED MAXIMUM NOISE LEVEL @ KNAF2 RATING	**dB(A)**	
23A.	OPTIONAL SPECIFIED MAXIMUM NOISE LEVEL	**dB(A)**	OPTION 1: BASE PRICE: 6 dB(A) LESS THAN NEMA STANDARDS FOR AN EQUIVALENT 2-WINDING TRANSFORMER @ SPECIFIED HV WINDING BIL
	SUPPLIER'S OPTIONAL GUARANTEED MAXIMUM NOISE LEVEL @ KNAN RATING	**dB(A)**	
	SUPPLIER'S OPTIONAL GUARANTEED MAXIMUM NOISE LEVEL @ KNAF1 RATING	**dB(A)**	
	SUPPLIER'S OPTIONAL GUARANTEED MAXIMUM NOISE LEVEL @ KNAF2 RATING	**dB(A)**	

ITEM	DESCRIPTION OF SPECIFICATION	UNITS	*RFP* SPECIFIED PARAMETER (SHADED) SUPPLIER'S *PROPOSED* PARAMETER (UN-SHADED)
24.	**INDUCED VOLTAGE FACTORY ACCEPTANCE TEST**		
	SPECIFIED 1-HOUR INDUCED VOLTAGE TEST LEVEL MEASURED IN THE HV WINDING	kV rms	105 (PHASE-TO-GROUND)
	SPECIFIED ENHANCED 7200 CYCLES INDUCED VOLTAGE TEST LEVEL MEASURED IN THE HV WINDING	kV rms	120 (PHASE-TO-GROUND)
	MAXIMUM ALLOWABLE MEASURED PARTIAL DISCHARGE ACTIVITY (BEYOND AMBIENT BACKGROUND)	pC	FAILURE DETECTION SHALL BE IN ACCORDANCE WITH IEEE C57.12.90, SECTION 10.8.5
25.	**APPLIED VOLTAGE FACTORY ACCEPTANCE TEST**		
	SPECIFIED APPLIED VOLTAGE TEST LEVEL APPLIED BETWEEN THE SHORTED HV WINDING AND GROUND (NOTE: TEST VOLTAGE IS LIMITED BY THE BIL OF THE WINDING'S NEUTRAL)	kV rms	140 (PHASE-TO-GROUND)
	SPECIFIED APPLIED VOLTAGE TEST LEVEL APPLIED BETWEEN THE SHORTED LV WINDING AND GROUND	kV rms	34 (PHASE-TO-GROUND)
26.	**TOP OIL TEMPERATURE RISE**		
	SUPPLIER'S ESTIMATED TOP OIL TEMPERATURE RISE @ KNAF2 RATING (TAKING INTO ACCOUNT THE 24-HOUR HIGHEST AVERAGE AMBIENT TEMPERATURE SPECIFIED IN ITEM 4 ABOVE)	**DEG. C**	

ITEM	DESCRIPTION OF SPECIFICATION	UNITS	*RFP* SPECIFIED PARAMETER (SHADED) SUPPLIER'S *PROPOSED* PARAMETER (UN-SHADED)
27.	**BUSHING INFORMATION**		

WINDING	CONTINUOUS CURRENT (AMPS)	BIL (kV)	MINIMUM STRIKE (ARCING) DISTANCE-3300 FEET & BELOW (INCHES)	PROPOSED MANUFACTURER	CATALOG NUMBER
H1/H2/H3	800/1200	550	45.0	Hitachi (Alamo, TN)	115N0812BA (Or Approved Equal)
X1/X2/X3	2000	150	11.0		
X0	2000	150	11.0		

IF ALTITUDE CORRECTION FACTORS ARE APPLICABLE DUE TO THE SITE ELEVATION, THEN THE SUPPLIER SHALL PROVIDE BUSHINGS HAVING EITHER A HIGHER BIL RATING, OR A STRIKE DISTANCE WHICH EXCEEDS THE SPECIFIED MINIMUMS BY THE FACTORED AMOUNT.

MINIMUM BUSHING CREEP DISTANCES ARE A FUNCTION OF THE NOMINAL PHASE-TO-GROUND VOLTAGE RATING AND THE LEVEL OF CONTAMINATION AT THE PROJECT'S LOCATION.

SPECIFIED MINIMUM CREEPAGE DISTANCE PER KV (PHASE-TO-PHASE) FOR THIS PROJECT:	INCHES/kV	1.6

ITEM	
28.	**SURGE ARRESTER INFORMATION**

WINDING	MCOV	TYPE (CLASS)	ENERGY CAPABILITY RATING	PROPOSED MANUFACTURER	CATALOG NUMBER
HV	70 kV	STATION CLASS	11.0 kJ/kV MINIMUM		
LV	15.3 kV	STATION CLASS	7.0 kJ/kV MINIMUM		

ITEM	DESCRIPTION OF SPECIFICATION	UNITS	*RFP* SPECIFIED PARAMETER (SHADED) SUPPLIER'S *PROPOSED* PARAMETER (UN-SHADED)
29.	**TRANSFORMER WINDING TYPES**		

WINDING	WINDING TYPE	MAXIMUM SHORT CIRCUIT CAPACITY
HV		
LV		

30. MULTI-RATIO BUSHING CURRENT TRANSFORMER (BCT) INFORMATION

BUSHING	POSITION	FULL RATIO	ACCURACY & BURDEN RATING
H1/H2/H3	X	600:5 MR	C800, TRF = 2.0
	Y	600:5 MR	C800, TRF = 2.0
	Z	NA	
X1/X2/X3	X	1200:5 MR	C800, TRF = 2.0
	Y	1200:5 MR	C800, TRF = 2.0
	Z	1000:5 SR	0.15% @B0.9, TRF = 2.0
X0	X	1200:5 MR	C800, TRF = 2.0

THE “X” POSITION IS IDENTIFIED AS THE POSITION CLOSEST TO THE BUSHING’S LINE TERMINAL. THE SAME BCT CONFIGURATION IS REQUIRED FOR EACH PHASE.

31. APPROVAL DOCUMENTATION SCHEDULE (DURATION AFTER SUPPLIER’S RECEIPT OF PURCHASE ORDER)

MAJOR MATERIAL LIST	WEEKS	
PHYSICAL DRAWINGS	WEEKS	
CONTROL DRAWINGS	WEEKS	
NAMEPLATE	WEEKS	
FACTORY ACCEPTANCE TESTING PLAN AND PROCEDURES	WEEKS	
DESIGN REVIEW	WEEKS	
TYPICAL ALLOWANCE FOR REVIEW AND RETURN	WEEKS	

ITEM	DESCRIPTION OF SPECIFICATION	UNITS	*RFP* SPECIFIED PARAMETER (SHADED) SUPPLIER'S *PROPOSED* PARAMETER (UN-SHADED)
32.	**PRODUCTION SCHEDULE (DURATION AFTER SUPPLIER'S RECEIPT OF ACCEPTED APPROVAL DOCUMENTATION)**		
	CORE AND COIL ASSEMBLY INSPECTION (AFTER VAPOR PHASE AND PRIOR TO TANKING)	WEEKS	
	FACTORY ACCEPTANCE TESTING	WEEKS	
	EX-WORKS	WEEKS	
	NEAREST RAIL SIDING	WEEKS	
	JOBSITE FOUNDATION	WEEKS	
	READY FOR COMMISSIONING AND START-UP	WEEKS	
33.	**WARRANTY PERIOD**		
	SPECIFIED PERIOD (MINIMUM)	MONTHS	60 (AFTER INITIAL ENERGIZATION)
	SUPPLIERS PROPOSED PERIOD	MONTHS	
34.	**IMPACT RECORDERS (SHIPPED WITH EACH UNIT)**		
	TYPE / MAKE / MODEL		
	DIGITAL		
	ANALOG		
COMMERCIAL			
35.	BASE PRICE FOR NEMA STANDARD (INCLUDING ENGINEERING) FOR EACH UNIT	US$	
36.	OPTIONAL PRICE FOR 6 DB(A) DOWN FROM NEMA STANDARD (INCLUDING ENGINEERING) FOR EACH UNIT	US$	
37.	IF APPLICABLE, LETTER OF CREDIT PRICE (PROJECT)	US$	
38.	TOTAL TRANSPORTATION COST ASSOCIATED WITH EACH BASE UNIT FOR DELIVERY TO THE JOBSITE FOUNDATION	US$	
39.	TOTAL TRANSPORTATION COST ASSOCIATED WITH EACH OPTIONAL 6 DB(A) DOWN FROM NEMA STANDARD UNIT FOR DELIVERY TO THE JOBSITE FOUNDATION	US$	
40.	COST ASSOCIATED WITH EACH UNIT FOR THE SUPPLIER TO PROVIDE INSTALLATION (DRESSING AND TESTING) AND FIELD SERVICES PER TECHNICAL SPECIFICATION	US$	
41.	SUPPLIERS PROPOSED PAYMENT TERMS		
42.	NUMBER OF UNITS REQUIRED FOR THIS PROJECT	QTY.	TWO (2)