This section, in conjunction with Section Q500 and the Schedule of Submittals included in Purchaser’s commercial section of this document, stipulates the requirements for Instruction Manuals that Supplier shall submit for design information and review. Document submittal procedures shall be in accordance with the requirements of this Purchase Order, Section Q500, and the following.

**Q501.1 Submittal Requirements**

The following number of copies shall be submitted unless otherwise indicated in the Schedule of Submittals:

<table>
<thead>
<tr>
<th>Submittal Description</th>
<th>Copies Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proof Copies</td>
<td>1 electronic copy</td>
</tr>
<tr>
<td>Final Copies, each transformer</td>
<td>1 electronic copy, 6 hard copies</td>
</tr>
</tbody>
</table>

**Q501.2 Instruction Manuals**

Supplier shall furnish proof and final instruction manuals for the unloading, storage, installation, operation, and maintenance of the equipment. The manuals shall be delivered as specified in the Schedule of Submittals.

Manuals shall include the following information specific to the furnished equipment. The documents or drawings submitted within the Instruction Manual shall be consistent with the documents or drawings previously submitted for Purchaser's review. Documents or drawings which were previously submitted for review and are included within the Instruction Manual shall be identical, with the same revision number. If these documents or drawings were revised due to design revisions subsequent to issuance of the Instruction Manuals, the document or drawing shall be resubmitted in accordance with Article Q500.4.2.7 in Supplemental Q500 so the Purchaser can provide updated drawings to the holders of the Instruction Manuals.

- Table of contents and index tabs. (If multiple volumes are required, a table of contents listing materials included in each volume shall be supplied for each volume.)
- Specifications, test data, and all performance curves specified in the technical specifications.
- Description of the equipment, including illustrations showing elevations, cross section, and all details of the equipment with all parts named, numbered, and identified with Purchaser's tag numbers. When multiple model numbers are shown on the drawings, the equipment supplied for the project shall be clearly identified.
- Complete and detailed operating instructions, including safety precautions, philosophy of operation and, where applicable, process optimization techniques.
- Detailed minor and major maintenance instructions, including description, use of special tools furnished, and preventive maintenance schedule.
- Instructions for receiving, inspection, storage, and handling of equipment prior to installation.
- Installation instructions.
- Inspection procedures.
- Troubleshooting guide.
- All fluid systems schematics and piping diagrams.
01500 - Technical Scope and Performance Requirements

01500.1 Technical Scope of Work
The work under these specifications shall include furnishing the following:

One (1) Combustion Turbine Step-Up Transformer
One (1) Spare Combustion Turbine Step-Up Transformer (Option)
One (1) Steam Turbine Step-Up Transformer
One (1) Spare Steam Turbine Step-Up Transformer (Option)
One (1) Reserve Auxiliary Transformer

In the event of technical conflicts, errors, or discrepancies, the detailed technical specifications, including this Section 01500 and all higher numbered sections, take precedence over Section 01400, Technical Supplemental Specifications.

01500.2 Drawings and Technical Attachments
This article lists the drawings and other technical attachments that have been prepared for the work under these specifications.

01500.2.1 Engineer’s Attachments
The following listed attachments shall be part of the Purchase Order.

<table>
<thead>
<tr>
<th>Drawing No. or Other Designation</th>
<th>Rev. No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>178592-APU-E1001</td>
<td>42</td>
<td>Electrical Overall One-Line Diagram</td>
</tr>
<tr>
<td>178592-SK-E0002</td>
<td>B</td>
<td>Conceptual Relaying Schematic Steam Turbine Generator</td>
</tr>
<tr>
<td>178592-SK-E0003</td>
<td>B</td>
<td>Conceptual Relaying Schematic Combustion Turbine Generator</td>
</tr>
<tr>
<td>178592-SK-E0004</td>
<td>B</td>
<td>Conceptual Relaying Schematic Reserve Auxiliary Transformer</td>
</tr>
</tbody>
</table>
16151 - Power Transformers

16151.1 General

16151.1.1 Scope of Supply
Scope of supply shall include furnishing the power transformers as specified herein and on the Power Transformers 16151 Specification Sheets included at the end of this section, and delivery of the transformers to the Grand River Energy Center Facility located in Chouteau, Oklahoma, supervision of unloading and placement of transformers on foundations, and field installation and commissioning of transformers.

16151.1.2 Items Furnished by Others and Interfaces
Items furnished by others and not in this scope of supply include the following:

- Unloading and placement of transformers on foundations (under supervision of Supplier)
- Connection of transformer tank to plant grounding system
- Unloading of transformers from transport vehicles, at the Site.
- Construction of transformer foundation
- Placement of transformers on the foundation.
- Connection of transformer HV line conductors to bushings
- Field Installation and Commissioning of the transformer.
- Connection of transformer LV bus conductors to bushings.
- Installation of auxiliary power and control cables to transformer junction boxes and control panels.

16151.1.3 Performance and Design Requirements
Performance and design requirements for the power transformers are indicated on the 16151 Specification Sheets included at the end of this section.

16151.1.4 Codes and Standards
Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work except where they conflict with the Purchaser's specifications. In case of conflict, the latter shall govern to the extent of such difference:

<table>
<thead>
<tr>
<th>Work</th>
<th>In Accordance With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer</td>
<td>IEEE C57 Series and all reference documents</td>
</tr>
<tr>
<td></td>
<td>IEEE C57.93, IEEE Guide for Installation of Liquid Immersed Power Transformers</td>
</tr>
</tbody>
</table>

16151.1.5 Materials
The materials supplied shall be in accordance with the referenced codes, industry standards, and the requirements in this specification.

16151.1.6 Approved Manufacturers of Components
For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications. If the Supplier wants to propose a nonlisted
16151.2.6 Core and Coils
Nuts, bolts, and clamps of the core assembly shall be provided with positive locking devices to prevent loosening. For core form transformers, the complete core and coil assembly shall be removable from the tank for repairs.

The core shall be securely grounded to the tank. For core form transformers, the core ground connection shall be detachable and made in an externally located terminal box, accessible without requiring entry into the main tank.

The outermost core steel packets and tie bars/plates (if located internal to the windings) shall be divided as needed so that the maximum operating temperature does not exceed the Supplier's standard practice. In no case shall tie bar sections be wider than 3 inches (75 mm) or core packet sections wider than 4-1/2 inches (115 mm). For units large enough to require slit core packets and/or tie bars/plates as described above, and having tie bars/plates located adjacent to the core packet, insulation material provided between the bars/plates and the core packets shall be a high temperature, non-cellulosic material such as Nomex.

Core form windings shall be circular. When the coils use paper insulation, it shall be thermally upgraded paper insulation. All windings shall be copper. When a continuously transposed conductor is used, it shall be epoxy bonded. All windings shall be self-supporting for inward (buckling) and outward (hoop) forces. Windings shall not rely on the core assembly for support to resist inward radial short-circuit forces. Winding capability to resist inward radial forces shall be based on the ability of the conductor to resist forces in a "free-buckling" mode.

Supplier shall provide names of all proposed sub-suppliers of thermally upgraded paper for use as winding conductor insulation. For each paper sub-supplier identified, a certificate of compliance with IEEE C57.100 "IEEE Standard Test Procedure for Thermal Evaluation of Insulation Systems for Liquid-Immersed Distribution and Power Transformers", and a lab test report from an independent laboratory indicating paper properties and nitrogen content for paper typically produced by that sub-supplier. Supplier shall stipulate that paper used for insulating winding conductor and leads shall be from one of these sub-suppliers, except in the case of crepe paper used in various winding and lead locations for supplemental insulation which shall be thermally upgraded paper manufactured by Dennison or other sub-supplier approved by the GRDA.

16151.2.7 De-Energized Tap Changer (DETC)
The operating handle shall have provisions for padlocking and shall be located no more than 60 inches (1,500 mm) above ground level. The tap position indicator shall be clearly visible from ground level.

16151.2.8 Load Tap Changer (LTC)
When an on load tap changer is specified, it shall be furnished with the arcing contacts housed in separate compartments, designed to prevent any interchange of oil between the compartment and the main tank. Removable bolted covers shall be provided for access to the switch compartment without opening the main tank or lowering the oil in the main tank. A drain valve with sampling device shall be located in the bottom of each oil-filled compartment to provide complete oil drainage. A magnetic liquid level gauge with a vertical face shall be mounted on the side of the oil-filled compartment. A mechanical pressure relief device shall be mounted on the top of the oil-filled compartment. The tap changer shall provide full rated kVA on taps above and below rated voltage. The tap changer shall be designed to provide at least 500000 operations at the maximum nameplate current rating before contact replacement. When a current limiting series transformer is provided, it must have circular windings and meet all the same criteria as the main core and coil. Series transformers and any internal surge suppression devices must be identified in the proposal.

Equipment for the automatic and manual control of the LTC shall be furnished in a weatherproof compartment mounted adjacent to the tap changer compartment. Access and operation at ground level shall be provided. The following equipment shall be furnished, as necessary, to provide the specified LTC controls:
**Manual Control**

Operating mechanism with motor drive.

Weatherproof compartment with convenience outlet, anti-condensation heater, and light with switches.

Mechanically operated limit switches and stops to prevent overtravel of the drive mechanism beyond the maximum raise and lower positions.

Local position indicator.

Operations counter.

RAISE-LOWER selector switch for manual control.

**Automatic Control**

AUTOMATIC-OFF-MANUAL selector switch.

Voltage testing terminals.

Line drop compensator with adjustable resistance and reactive elements.

Current transformers for line drop compensation.

Voltage regulating relay.

Time-delay relays for first step of a tap position change.

A hand crank for manual operation, with electrical interlock to prevent operation of the motor while the hand crank is being used.

**Remote Control**

REMOTE-LOCAL selector switch.

Remote tap position indicator, selsyn type, for mounting on Purchaser's remote control panel.

Any additional equipment needed for remote/local or automatic/manual control.

Controls shall be provided to hold the LTC in step for operation of three single-phase transformers as a 3-phase bank, if applicable. Means shall be provided for the selection of any single-phase unit to operate as the master or control unit, with the remaining two units to operate as followers. LTC operation shall be blocked for failure of one or both follower units to respond to a tap change signal from the master or for any other out-of-step occurrence. A set of dry alarm contacts shall be provided for an out-of-step condition.

**16151.2.9 Insulating Oil**

Insulating oil for complete filling shall be furnished with each transformer. The oil shall not contain any polychlorinated biphenyls (PCBs) and shall be Type II, inhibited with 0.15 percent to 0.30 percent by weight of DBPC (2-6 ditertiary butyl paracresol). The transformer main nameplate shall state that the oil is inhibited and contains no detectable PCBs (<2ppm) at the time of manufacture.
one piece. For "draw lead" type bushings, the transformer outline drawing shall indicate the size, number of strands, and material of the bushing draw lead. Minimum creep distances shall be as specified on the 16151 Specification Sheets using millimeters per rated system voltage, mm/kV<sub>L-L</sub>.

Outline drawings of each bushing shall be included with the transformer approval drawings. Instruction manuals for each style of bushing shall be included with the transformer instruction manuals.

16151.2.11.1 Terminals. Each bushing with a stud type connection shall be furnished with a removable stud-to-pad four hole terminal of sufficient size to continuously carry the maximum current. Aluminum-to-copper bimetallic transition plates shall be furnished. At 230 kV and above, the terminals shall be corona free. System line connections will first connect to the associated surge arrester, if specified.

16151.2.12 Terminations to the Transformer
If a termination compartment is specified, then an air termination compartment should be provided on the tank wall to allow for cable entry from below. Supplier shall coordinate the design of the air terminal enclosure to accommodate the number and sizes of cables and conduits required for the full capacity of the winding. The terminal enclosure shall be suitable for attaching rigid galvanized or aluminum conduits. In addition, Supplier shall provide a ground bus inside the air terminal enclosure that is suitable for bonding the ground conductors and shields of Purchaser’s cables. Terminal enclosures shall be suitable for vertical cable connections, and Supplier shall provide support points for cable tie-off going up the terminal enclosure to the termination point. SellerSupplier shall also orient the termination points to facilitate termination of the cables, without requiring cable bends. Terminal enclosure shall also be provided on the tank wall to allow for cable entry from below.

If a termination flange is specified, then a bolted flange connection to cable, nonsegregated, segregated, or isolated phase bus duct shall be provided as specified. A short flange should be located close to the tank, and a long flange should be located, via a throat, at the end of the bushing top terminal.

Termination flanges shall be installed to within +/- 1/8" (3 mm) tolerance of the location indicated on the transformer outline drawing. Horizontal flange surfaces shall be level to within 1/8" (3 mm) tolerance side-to-side across the face of the flange. Vertical flange surfaces shall be installed "plumb" and oriented perpendicular to the centerline of the mating bus within 1/8" (3 mm) tolerance side-to-side across the face of the flange.

16151.2.13 Surge Arresters
Metal oxide station type surge arresters shall be mounted adjacent to the associated bushing with the same minimum electrical clearances as used for bushings. Each arrester shall have a copper connection to a transformer ground pad. Arresters shall have full-capacity copper connections to associated bushing terminals, with all associated hardware, to allow for transmission line connection to the arresters.

16151.2.14 Neutral Grounding Resistor (NGR)
If specified, an NGR shall be mounted on the transformer and shall be of the heavy-duty, outdoor, stainless steel strip type with aluminum enclosure. The resistor assembly shall rest on cap and pin or post type porcelain insulators. Electrical terminals on the resistor shall be insulated bushings. One resistor terminal shall be connected by copper bar bus to the transformer neutral and the other resistor terminal shall be connected by copper bar bus to the transformer ground pad. The grounding resistor enclosure shall be painted the same color as the transformer tank.

16151.2.15 Current Transformers (CTs)
CTs shall be of the bushing type and shall be mounted internal to the transformer tank. Multi-ratio CTs must have five leads. The continuous current thermal rating factor (TRF) shall be 2.0 minimum. The CT secondary leads shall be fed through the tank to a CT junction block and then brought down to the transformer control cabinet. CT excitation and overcurrent curves shall be submitted for approval.
shall be simultaneously recorded in microvolts and shall not exceed 100 microvolts during the test.

**Applied Voltage Tests.** A short duration (1 minute) power frequency voltage test shall be performed as a routine test on all line and neutral terminals.

**Leak Test.** An oil leak test shall be performed on each completely assembled transformer, using a test pressure that is 25 percent greater than the normal operating pressure. The leak test procedure shall be submitted to the Purchaser for review and approval.

**Sound Test.** The average audible sound level test is required as a design (type) test or if specified on the 16151 Specification Sheets.

**Control Wiring.** All auxiliary equipment, CT circuits, and control wiring must be tested to verify proper connections. CT ratio and polarity must be checked. The insulation of the control circuits must be verified by applying a power frequency test voltage of 1500 volts for 1 minute or 1800 volts for 1 second with all of the circuits tied together.

**Auxiliary Cooling Losses.** Fan and pump auxiliary power requirements shall be measured and recorded.

**Load Current Test for GSU Transformers.** Each GSU transformer specified herein that is not being subjected to a full temperature rise test shall be given a load current test that amounts to a standard temperature rise test only at the top MVA rating (including the special procedures for measuring all main winding resistances and gradients mentioned above under "Temperature Rise Test"). The purpose of this test is to confirm that the copper-to-oil gradients are within expected limits and to confirm that no other hot spots in the windings or other metallic pieces are present under load current conditions. An oil sample shall be taken after this test for dissolved gas analysis.

Infrared thermographic photos shall be taken of the unit from all sides and top during the hottest part of this test to record hot spot temperature data. Color copies of these photos shall be included in the test report.

**Dimensional Check.** A complete dimensional check shall be performed on each transformer specified herein to confirm that the actual dimensions match the dimensions shown on the drawings previously submitted to the Purchaser. The purpose of this check is to confirm that dimensions shown for isophase bus, non-segregated phase bus/cable bus, or other Purchaser’s interfaces shall be identical to the information shown on the Seller-Supplier’s drawings. The bus connection dimensional check shall confirm that all bus connections have been installed in a manner that makes the connections level (or plumb and true to vertical surfaces, as appropriate) when the transformer is level.

**Sweep Frequency Response Analysis (SFRA) Tests.** Each transformer supplied under these specifications shall undergo an SFRA test using a Doble SFRA test set and leads and be performed in accordance with Doble’s instructions and recommendations. A test shall be performed after all electrical tests specified herein are complete, but prior to draining the oil. Also, the Supplier shall furnish a small temporary test bushing mounted in each bushing cover plate to be used for performing an SFRA after the insulating fluid has been drained and the unit prepared for shipping. One dry SFRA test shall be performed at the factory and the Supplier shall make arrangements to perform a dry SFRA test as part of the receipt inspection procedures. Software data from all tests shall be provided to the Purchaser.
16151.2.26 Photographs
Three sets of color photographs of each core and coil assembly shall be furnished with the instruction books. The photographs shall be taken just prior to placing the completed core and coil assembly into the tank. All photographs shall be 8 inch by 10 inch (200 mm by 250 mm) glossy prints labeled with the transformer manufacturer's name and serial number. Five different views shall be provided as follows: top view, front view, left side view, right side view, and rear view.

High resolution digital photographs in JPEG format may be supplied in lieu of glossy prints.

16151.2.27 Loss Evaluation
The guaranteed transformer losses shall be stated on the 16151 Specification Sheets and shall be at the reference temperature of 167° F or 185° F (75° C or 85° C), as specified.

The US$/kW values stated on the 16151 Specification Sheets will be used to evaluate this data. The guaranteed losses multiplied by the appropriate US$/kW values will be added to the quoted price and used in determining the lowest evaluated bid.

When a budgeted kW value is given for total losses on the 16151 Specification Sheets, each transformer should be designed for guaranteed losses at or below this level. Bids will be evaluated so that a penalty will be assessed only if the guaranteed losses (at top MVA) exceed the budgeted losses using the stated US$/kW multiplied by the amount that the budgeted losses are exceeded; no bonus will be given if these values are below the budgeted amount.

In the event any transformer is tested and found to have losses greater than the guaranteed losses, the Supplier shall pay Purchaser Liquidated Damages in an amount equal to the difference between the actual (tested) losses and the guaranteed losses multiplied by the appropriate US$/kW value. Zero tolerance will be used on tested losses for evaluating penalties. No credit will be given to the Supplier if the tested losses are less than the guaranteed values.

16151.2.28 Shipping - Impact Recorders and Dew Point Temperature
The Supplier shall supply and mount impact recorders (in suitable weatherproof enclosures) directly on each transformer prior to shipment. The impact recorder shall provide a permanent record of the magnitude of axial, transverse, and vertical forces to which the transformer is subjected while in transit. For ocean shipment, the impact recorder shall have a time duration long enough for the transformer to reach the installation site.

For units shipped under dry gas, the moisture content of the insulation shall be estimated by the following method immediately prior to shipment. Dry gas shall be installed in the main tank and held at a pressure of 0-5psig (0-0.35 kg/cm²) for at least 18 hours. The dew point temperature and ambient temperature of the gas shall be measured with a suitable device, and the results used in conjunction with the vapor pressure and percent moisture by weight graphs found in IEEE C57.93 or other graphs agreed upon between Supplier and Purchaser. If the percent moisture by weight of the paper exceeds 0.5 percent, the unit shall undergo further processing until this level is achieved. If the pressure in the main tank is between 0-5psig (0-0.35 kg/cm²) at the time the dew point is measured, it is not necessary to make any adjustments to the readings taken from the aforementioned graphs.

16151.2.29 Design Review
The Purchaser reserves the right to perform an independent review of the Supplier's design. The Supplier shall provide, in a timely fashion, any requested data and information necessary for this review to be performed and shall make the design team available for discussion of the results of this review at a time and location selected by the Purchaser.

16151.2.30 Installation Services
Supplier shall include the following hauling, installation/assembly, vacuum filling, and testing services for each transformer supplied herein. The transformers shall be furnished, on their foundations and
completely assembled, vacuum filled with approved mineral oil, tested and commissioned for service. Any technical assistance required from the factory shall also be included.

- Prepare plans for lifting, jacking, rigging, moving, and transporting the new transformer from the point of common carrier delivery to the appropriate foundation identified by the Purchaser. Such plans shall be submitted to the Purchaser for review and approval.
- Establish and maintain for the duration of Supplier’s activities an oil spill prevention and mitigation plan and provide all oil absorbent blankets and materials. In the event of a spill, the Supplier shall notify GRDA’s site supervisor without delay. The Supplier shall bear all costs of clean up and remediation in the event of an transformer oil spill that results from any of the Supplier’s activities whether caused by failure of equipment, piping or hoses, valves or connectors used by the Supplier, any failure of the transformer tank or accessories that are caused by the Supplier, or any other cause related to activities under the control of the Supplier.
- Verify that all pieces and accessories have arrived at site.
- Check for shipping damage. Report all damage to the Purchaser’s site representative.
- Perform internal inspection (continuous purge of unit required) (-500 C/-580 F dew point or lower).
  - Check pressure on units.
  - Check and record dew point upon receipt and before opening the units.
  - Lower unit pressure
  - Check oxygen content (internal).
  - Inspect unit for shipping damage.
  - Check and record core ground resistance.
  - Check and operate no load tap changer.
  - Install, set up, and check load tap changer in accordance with tap changer manufacturer’s installation procedures, including but not limited to: manual operation tests, motorized operation tests, monitoring system tests, control power tests, and operational tripping tests.
  - Perform transformer turns ratio (TTR) tests
  - Doble sweep frequency response analysis (SFRA) tests in air with temporary bushings that will be compared to the factory tests in air to detect any damage that could have occurred in shipment
  - Review test results and any damage with Purchaser’s site representative
- Assemble all parts and accessories that were removed for shipment
  - Purge unit continuously during assembly
  - Inspect and operate all valves
  - Perform current transformer (CT) insulation resistance (Megger) and ratio tests
- After all assembly is complete and the final internal inspection completed, pressurize the transformer tank to 2 PSI and purge the transformer tank twice, waiting fifteen minutes between filling and dropping pressure. After purge, pressurize 5 PSI for 24 hours. Then perform leak test and take dew point reading.
- After an acceptable dew point is achieved, start pulling vacuum. If the dew point is higher than 0.5%, additional vacuum time is required. Initial vacuum level shall be 0.25 Torr or better. During transformer vacuum processing (drying), the LTC (if applicable) should be considered part of the transformer.
- Perform vacuum drop test (leak rate value must be below 10 Torr-gallons per second)
- Confirm proper operation of all transformer auxiliaries including cooling fans and tap changers.
- Contact the transformer manufacturer to arrange for oil delivery by tanker truck.

16151.2.30.1 Oil Filling. A price quote shall be provided for The Supplier shall include in their scope the initial oil filling of the transformers in the field. This includes all required pumps, heaters, degassing equipment, oil testing equipment, tools, materials, and labor for hot oil impregnating, vacuum filling, and testing at the site. Prior to filling, the following tests (with acceptable results) must be performed on the oil in each shipping container:
Dielectric strength

Moisture content

Power factor

Interfacial tension

Neutralization number

The oil and field work shall be included in the price of the transformer, and the field work shall be priced separately. The Supplier shall fill the transformer with oil at a rate not exceeding 30 gallons per minute, while maintaining 1 Torr vacuum or better.

16151.2.30.2 Acceptance Testing
The Supplier shall provide the following on-site acceptance testing and provide the recorded results.

- Perform a Doble insulation power factor test and record the results. The Doble insulation power factor shall be as good, or better, than as shipped from the factory.
- Perform transformer turns ratio test (TTR) on all NLTC and all LTC tap settings and record the results.
- Perform oil quality test and dissolved gas analysis (DGA) and record the results.
- Perform Doble bushing power factor tests C1 & C2 and record the results.
- Perform Doble excitation current test on all NLTC and LTC taps and record the results.
- Perform insulation resistance test (Megger) on the transformer core and record the results.
- Measure and record the resistance of each winding on all NLTC taps. Record the results and compare to the factory test results and resolve any differences.
- Test each current transformer and record the results. Required tests are: Ratio test on every tap, insulation resistance, saturation and polarity tests.
- Doble sweep frequency response analysis (SFRA) tests with oil and with permanent bushings that will be compared to the factory tests to detect any damage that could have occurred during movement onto the foundation.
- Review test results with Purchaser's representative.
- Prepare and deliver to the Purchaser a complete commissioning and test report. The report shall include all test results, and a complete description of any damage found and repaired.
- Assist the Purchaser in testing and commissioning auxiliary power feeders and control, monitoring and protection device outputs to Purchaser's digital control system and protective relay panels.

16151.2.30.2.1 On-Load Tap Changer Testing
All transformers equipped with on-load tap changers shall undergo the following special tests in addition to routine tests specified by IEEE C57.12.90.

- Load loss measurements shall be taken with the OLTC in extreme raise and lower positions and neutral/rated position and with the OLTC in the lowest bridging position (if equipped with preventative/series auto transformer). Losses for the worst case of all tested positions shall be used for the temperature rise test.
- With transformer de-energized, 4 complete cycles of operation.
- With transformer energized at rated voltage and at no load, 1 complete cycle of operation.
- With one winding short circuited and as high as possible rated current flowing in the tapped winding, 4 tap OLTC operations from 2R to 2L or otherwise across the coarse or changeover selector switch operates.
For all of the above tests, there shall be no abnormal deflections of current or abnormal noises coming from the transformer.

16151.2.30.32 Field Advisor Miscellaneous Installation Services

The Supplier shall attend on site construction coordination meetings as required. The Supplier shall provide written progress reports as required. The Supplier shall update schedule to show progress as required.

16151.2.30.4 Field Advisor

A price quote shall be provided to The Supplier shall furnish the services of one or more field service representatives, as recommended by the manufacturer for technical assistance. The service representatives shall be technically competent, factory trained, experienced in the installation and operation of power transformers, and authorized by the Supplier to perform the work stipulated. Duties may include, but not be limited to, the following:

- Providing technical advice to assist the Purchaser in assembling and installing the transformer and all equipment.
- Inspecting and testing the equipment after installation and directing any changes or adjustments required to assure proper operation.
- Supervision of transformer off-loading and placement on foundation.
- Providing services required as a condition of the warranties.
- Instructing the Purchaser's personnel in the operation and maintenance of the transformer and all accessory equipment.
- Providing technical direction during initial energization and operation.
- Directing the correction of any design, or manufacturing, or installation defects.
- Verifying proper assembly and operation for purposes of validating warranty.

16151.3 Execution

Not Applicable.
### Performance and Design Requirements Reserve Auxiliary Transformer

#### Applicable Standards

| ANSI C57 Series and All Reference Documents |

#### Rating

<table>
<thead>
<tr>
<th>Winding</th>
<th>MVA Ratings at 65 C</th>
<th>Nominal System Voltage</th>
<th>Winding Rated Voltage (kV)</th>
<th>Highest Equipment Voltage (kV)</th>
<th>Line BIL (kV)</th>
<th>Neutral BIL (kV)</th>
<th>Connection</th>
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<td>Delta</td>
</tr>
</tbody>
</table>

#### Frequency, Hz

| 60 | Application | Outdoor |

#### Number of Phases

| 3 | Transformer Type | Auxiliary, 3 Windings |

#### Cooling Class

| 60° C |

#### Temperature Rise

| ONAN/ONAF/ONAF |

#### Transformer Type

| Auxiliary, 3 Windings |

#### Winding Material

| 100% Copper |

#### Vector Group

| HV: Y | XV: Y | XV Lags HV 60 ° CCW |

#### Altitude for Design

| Below 3300 ft (1000 m) |

#### IEEE Standard Temperature Rating of Transformer Nameplate

| 30° C Daily Average / 40° C Max. for Any 24 Hour Period |

#### Site Ambient Temperature Conditions

| 30° C Daily Average / 44.4° C Maximum Temperature |

#### Max. Winding Hot Spot Rise

| 80 |

#### Oil Preservation System

| Nitrogen Blanket |

#### Seismic Ground Acceleration Level

| Refer to Supplemental D100 |

#### Audible Sound at Max. MVA (dBA)

| Manufacturer's Standard |

#### Impedances (at rated voltage, 85° C Reference Temperature 21 MVA Base)

<table>
<thead>
<tr>
<th>Windings</th>
<th>Impedance (%)</th>
<th>Tolerance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-XV</td>
<td>10.0</td>
<td>+/- 7.5%</td>
</tr>
</tbody>
</table>

#### Tap Changers

<table>
<thead>
<tr>
<th>Regulated Windings</th>
<th>Type</th>
<th>Tap Changer Control</th>
<th>Number of Steps</th>
<th>Total % Above Rated kV</th>
<th>Total % Below Rated kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Voltage: HV</td>
<td>On-Load Remote/Local</td>
<td>16</td>
<td>16</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
### Bushings

<table>
<thead>
<tr>
<th>BIL (kV)</th>
<th>Mfr Std</th>
<th>Minimum Porcelain Creep</th>
<th>Termination Compartment?</th>
<th>Termination Flange?</th>
<th>Termination Type</th>
<th>Location</th>
<th>Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV 1300</td>
<td>Mfr Std</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Bushing to Arrestor</td>
<td>Cover</td>
<td>3</td>
</tr>
<tr>
<td>XV 95</td>
<td>Mfr Std</td>
<td>Yes</td>
<td>Short</td>
<td>Yes</td>
<td>Bus to Ground Pad</td>
<td>Cover</td>
<td>1</td>
</tr>
<tr>
<td>H0 150</td>
<td>Mfr Std</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Bushing</td>
<td>Cover</td>
<td>3</td>
</tr>
<tr>
<td>X01 95</td>
<td>Mfr Std</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Bushing to NGR</td>
<td>Wall</td>
<td>1</td>
</tr>
</tbody>
</table>

The Physical Arrangement and Terminal Identification Shall Be X1-X2-X3 from Left to Right When Facing XV Side, and H1-H2-H3 from Right to Left When Facing HV Side.

### Surge Arresters (QTY-One per bushing shown below)

<table>
<thead>
<tr>
<th>Location</th>
<th>kV Rating</th>
<th>MCOV Ratings (kV)</th>
<th>Minimum Porcelain Creep</th>
<th>Mounted on Transformer?</th>
<th>Discharge Counters?</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV Terminals</td>
<td>276</td>
<td>220</td>
<td>Mfr Std</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Neutral Grounding Equipment

<table>
<thead>
<tr>
<th>Connection Point</th>
<th>Method</th>
<th>Ohms</th>
<th>Amperes</th>
<th>kV</th>
<th>Time Duration</th>
<th>Mounted on Transformer?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H0</td>
<td>Solid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>X01</td>
<td>Resistance (NGR)</td>
<td>600A</td>
<td></td>
<td>6.97</td>
<td>10 s</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Current Transformers

<table>
<thead>
<tr>
<th>Location Point</th>
<th>Ratio</th>
<th>Accuracy Class</th>
<th>Position on Bushing</th>
<th>Quantity per Bushing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV Bushings</td>
<td>2000:5 MR</td>
<td>C800 - IEEE Relaying</td>
<td>Lower</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>HV Bushings</td>
<td>1200:5 MR</td>
<td>C800 - IEEE Relaying</td>
<td>Upper</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>XV Bushings</td>
<td>4000:5 MR</td>
<td>C800 - IEEE Relaying</td>
<td>Lower</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>H0 Bushing</td>
<td>1200:5 MR</td>
<td>C800 - IEEE Relaying</td>
<td>Lower</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>X01 Bushing</td>
<td>600:5 MR</td>
<td>C800 - IEEE Relaying</td>
<td>Lower</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

### Paint System and Colors

<table>
<thead>
<tr>
<th>Tank and Accessories Color</th>
<th>ANSI Z55.1 no. 70 light gray, Gloss</th>
<th>Power Supplies</th>
<th>Nominal Voltage</th>
<th>No. of Source</th>
</tr>
</thead>
</table>

Source: 16151, 2014, v1.16  
Power Transformers  
Page 78 of 8880
### Painting System
- **Mfr Std**: ANSI Z55.1 no. 70 light gray
- **Auxiliary Power**: 480V Three Phase

### Porcelain Color
- **Control DC**: 125V
- **Control AC**: 120 VAC, from Auxiliary Power Source
- **Convenience Outlet**: Yes

### Loss Evaluation (at rated voltage)

<table>
<thead>
<tr>
<th>Loss Evaluation</th>
<th>US$/kW</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Load Losses (20°C Reference Temperature)</td>
<td>3100</td>
<td></td>
</tr>
<tr>
<td>Load Losses at Maximum MVA Rating (85°C Reference Temp.)</td>
<td>3100</td>
<td></td>
</tr>
<tr>
<td>Auxiliary Cooling Losses at Maximum MVA Rating</td>
<td>3100</td>
<td></td>
</tr>
</tbody>
</table>

***When a budget loss is given, the design should target this value. Using the US$/kW, total losses (at top MVA) will be evaluated above the budgeted amount.***

### Ancillary Equipment Locations

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen System</td>
<td>2 or 4</td>
</tr>
<tr>
<td>Control Cabinet</td>
<td>2 or 4</td>
</tr>
<tr>
<td>Neutral Grounding Resistor</td>
<td>Opposite control cabinet</td>
</tr>
<tr>
<td>Temperature Indicators</td>
<td>Opposite Same as control cabinet</td>
</tr>
<tr>
<td>Oil Level Indicators</td>
<td>Opposite Same as control cabinet</td>
</tr>
<tr>
<td>Ground Pads</td>
<td>1 and 3 (opposite corners)</td>
</tr>
</tbody>
</table>

### Additional Requirements

Note 1: Supplier shall be responsible for sizing transformer tertiary winding.
Attachments

178592-APU-E1001, Rev. 2, Overall One-Line Diagram
178592-SK-E0002, Rev. B, Conceptual Relaying Schematic Steam Turbine Generator
178592-SK-E0003, Rev B, Conceptual Relaying Schematic Combustion Turbine Generator
178592-SK-E0004, Rev B, Conceptual Relaying Schematic Reserve Auxiliary Transformer