TRANSMISSION & DISTRIBUTION

SPECIFICATION NO. E-034

For

SUBSTATION POWER TRANSFORMER

OUTDOOR TYPE

34.5 KV/13.8 KV

18/24/30 MVA

34.5 KV/13.8 KV
18/24/30 MVA
POWER TRANSFORMER
OUTDOOR TYPE

Table of Contents

1.0 SCOPE

This specification covers GPA's requirements for three-phase power transformer and accessories.

2.0 SERVICE CONDITIONS AND OPERATION

2.1 The power transformer is intended for use in an average ambient temperature of 32 degrees C with corrosive, salt air environment, sustained wind strengths of 170 MPH, and subject to seismic zone 4 condition.

2.2 Transformer will be used for distribution step-down operation.

3.0 CONFORMANCE TO SPECIFICATION REQUIREMENTS

Transformer shall meet the requirements of the following standards and specifications, including latest revisions with respect to material, design and tests.

3.1 Applicable Standards

AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI)

C57.12.00	General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
C57.12.90	Test Code for Liquid-Immersed Distribution Power and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
C76.1 and C76.2	Requirements for Outdoor Bushing

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

TR 1-80	Transformers, Regulators and Reactors

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D92-78	Flash and Fire Points by Cleveland Open Cup
D877-84	Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrode

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

70	National Electrical Code
70B-83	Electrical Equipment Maintenance

UNDERWRITER'S LABORATORIES, INC. (UL)

467-72	Grounding and Bonding Equipment

3.2 Deviation and Non-Conformance Requirements

3.2.1. Deviations from this specification or changes in materials or design after the Purchase Order has been placed must be approved by the GPA Engineering Department and acknowledged by a Purchase Order Amendment.

3.2.2. Units received with deviations or non-conformance which is not acknowledged as specified in Sub-Paragraph 3.2.1 are subject to rejection. The Supplier is responsible for any corrective action including but not limited to materials, labor, and transportation necessary to dispose of, or make the units conform to the specification.

3.2.3. Notification of defects discovered before or after installation that are believed to be inherent to manufacturing problems or workmanship shall be made and forwarded to the Supplier. The description of the item, documentation of the problem and the described information, disposition and/or follow-up (as appropriate) that GPA expects from the Supplier will be specified. The Supplier's response shall be made within thirty (30) days

unless an extension is acknowledged and approved in writing by the GPA Manager of Engineering.

3.3 Warranty

The Supplier shall warrant for 1-year the satisfactory and successful operation of the apparatus furnished under this specification at the rating, under the conditions, and for the service specified. The Supplier shall further warrant the apparatus against defects of design, material and workmanship.

4.0 DATA TO BE FURNISHED

4.1 The Bidder shall provide with his bid the following data:

1. Transformer
   a. Manufacturer _____
   b. Type, Core _____
   c. Windings, Two-winding _____
   d. Service Area, Outdoor _____
   e. Factory Technician Representative on Site _____
   f. Warranty, 1-Year _____
   g. Quantity _____

2. Delivery Date
   a. 8 months ARO or the earliest date _____

3. Rating
   a. Rated Output Capacity, 18/24/30 MVA _____
   b. Number of Phase, 3 _____
   c. Rated Frequency, 60 Hz _____
   d. HV rating and connections, 34.5 kV/Delta _____
   e. LV rating and connections, 13.8 kV/Grounded Wye _____
   f. Vector Group, Dyn1 _____
   g. HV Tap Steps, 5 _____
      HV Tap Voltage, 34.5 kV +/- 2 x 2.5% _____
   h. LV Tap Steps, 32 _____
      LV Tap Voltage, 13.8 kV +/- 16 x 0.625% _____
   i. Cooling Class _____

4. High Voltage (HV) Bushings

a. Manufacturer/ Country _____
b. Model/ Part No. _____
c. Voltage Class, 35 kV _____
d. Minimum BIL, 200 kV _____
e. Minimum Voltage Creepage, 35 Inches _____

5. Low Voltage (LV) Bushings
   a. Manufacturer/ Country _____
   b. Model/ Part No. _____
   c. Voltage Class, 15 kV _____
   d. Minimum BIL, 110 kV _____
   e. Minimum Voltage Creepage, 15 Inches _____

6. Low Voltage Neutral (LVN) Bushing
   a. Manufacturer/ Country _____
   b. Model/ Part No. _____
   c. Voltage Class, 15 kV _____
   d. Minimum BIL, 110 kV _____
   e. Minimum Voltage Creepage, 15 Inches _____

7. High Voltage (HV) Bushing Current Transformers
   a. Manufacturer/ Country _____
   b. Model/ Part No. _____
   c. MRCT, 1200/5 _____
   d. Class, C800 _____
   e. Burden, 100 VA _____

8. Low Voltage (LV) Bushing Current Transformers
   a. Manufacturer/ Country _____
   b. Model/ Part No. _____
   c. MRCT, 2000/5 _____
   d. Class, C800 _____
   e. Burden, 100 VA _____

9. Low Voltage (LVN) Bushing Current Transformer
   a. Manufacturer/ Country _____
   b. Model/ Part No. _____
   c. MRCT, 600/5 _____
   d. Class, C800 _____
   e. Burden, 100 VA _____

10. Spare Bushings
    a. HV Bushings, 2 each _____
    b. LV Bushings, 2 each _____
    c. LVN Bushing, 1 each _____

11. Guaranteed Efficiency at 100% Power Factor
    a. At 1-1/4 load (125%) _____
    b. At full load (100%) _____
    c. At 3/4 load (75%) _____
    d. At 1 /2 load (50%) _____
    e. At 1/4 load (25%) _____

12. Guaranteed Regulation at 100% Load
    a. At 100% power factor _____
    b. At 80% power factor _____

13. Guaranteed Loss
    a. Total loss at 100% voltage, kW _____
    b. Load loss (P_k) at rated voltage, kW _____
    c. No-load loss (P_o) at rated voltage, kW _____
    d. No-load loss at 110 % voltage, kW _____
    e. Maximum auxiliary power loss, kW _____

14. Guaranteed Exciting Current
    a. At 100% voltage, Amps _____
    b. At 110 % voltage, Amps _____

15. Guaranteed percent impedance, 7.5% _____

16. Calculated zero-sequence percent impedance, % _____

17. Guaranteed maximum average audible sound level for each stage of cooling
    a. Self-Cooled, dB _____
    b. 1st Stage, dB _____
    c. 2nd Stage, dB _____

18. Forced Cooling
    a. Cooling power requirements, kW _____
    b. Auxiliary power, Volts _____

19. Total Auxiliary Load with cooling, LTC, and cabinet space heaters
    a. Power Requirements (P_{co}) at No-Load Operation, kW _____
    b. Power Requirements (P_{cs}) at Rated Power Operation, kW _____
    c. Auxiliary power, volts _____

20. Type of Oil Preservation System _____

21. Method of mounting radiators
    a. Removable or Integral with the tank _____

22. Shipping data
    a. Shipping weight, Lbs. _____
    b. Shipping dimension (LxWxH), Inches _____
    c. Oil or gas filled _____

23. Transformer Overall Dimension (LxWxH), Inches _____

24. Type of transformer winding material used for all windings
    a. HV windings, COPPER _____
    b. LV windings, COPPER _____

25. No Voltage Tap Changer
    a. Manufacturer/ Country _____
    b. Model/ Part No. _____
    c. Current rating, Amps _____

26. Load Tap Changer
    a. Manufacturer/ Country, ABB _____
    b. Model/ Part No. _____
    c. Current rating, Amps _____

27. Automatic Voltage Regulator (AVR)
    a. Manufacturer/ Country, Beckwith Electric/ USA _____
    b. Model/ Part No., M-2001D _____

28. Dissolve Gas Analysis (DGA) or Fault Gas and Moisture Monitor
    a. Manufacturer/ Country, GE USA _____

b. Model/ Part No., Hydran M2 _____

29. Spare Hydran M2 Sensor 0-2000 ppm
    a. Part No.16270, 2 each _____

30. LTC Filtration System
    a. Manufacturer/ Country, Oil Filtration Systems/ USA _____
    b. Model/ Part No., LTCFS-6-S514D/2-120-N4-B _____

31. HV Surge Arresters
    a. Manufacturer/ Country _____
    b. Voltage rating (duty cycle), rms kV _____
    c. Max. continuous operating voltage, rms kV _____
    d. One second TOV capability, rms kV _____
    e. Creepage distance, inches _____
    f. Total weight of each unit, lbs. _____

32. LV Surge Arresters
    a. Manufacturer/ Country _____
    b. Voltage rating (duty cycle), rms kV _____
    c. Max. continuous operating voltage, rms kV _____
    d. One second TOV capability, rms kV _____
    e. Creepage distance, inches _____
    f. Total weight of each unit, lbs. _____

33. Oil
    a. Manufacturer/ Country _____
    b. Product, INHIBITED _____
    c. Type, ASTM D3487 Type II _____
    d. Amount required, Main tank, gals _____
       Conservator tank, gal. _____
    e. Total weight, Main tank, lbs. _____
       Conservator tank, lbs. _____
    f. Method of delivery _____

34. Target Type Fault Indicator
    a. Manufacturer/ Country, Fuji Electric/ Japan _____
    b. Model/Part No., TK Series/ TKL 200-DC12-B _____

35. Anchor Bolts, 1" dia. x 16" L _____

36. Space Heaters at HV and LV Terminal Cabinets _____

37. Attach list of recommended spare parts with quantities.
38. Attach list of special tools.
39. Bidder shall include in his bid the costs for factory witness testing by two (2) GPA representatives.
40. In the event that the factory witness testing is cancelled or does not occur, the bid costs for the testing shall be deducted from the overall cost. The manufacturer shall provide factory test results, videos, and pictures of the testing.

4.2 An outline drawing shall be provided with each bid quotation. This drawing shall include the following information:

a. Projected floor space of the transformer, including radiators and expansion tanks.
b. Height of transformer from floor level to top of high-voltage bushing.
c. Height of transformer from floor level to top of low-voltage bushing.
d. Height of transformer from floor level to top of tank, and to the highest non-removable part.
e. Weight of core and windings.
f. Weight of tank and radiators.
g. Number of gallons of oil and total weight of the oil.
h. Total weight of the assembled transformer including oil.
i. Power requirements for all control and auxiliary equipment.

4.3 Within ten (10) weeks after award of contract, the successful bidder shall provide the following drawings for GPA approval.

4.3.1 Nameplate drawing including all current transformer ratios.

4.3.2 Outline drawing including the following:

a. Accessories and location
b. Weights with and without oil
c. Shipping center of gravity-shown on two views.
d. Installed center of gravity-shown on two views.
e. Anchoring requirements.

4.3.3 Base drawing including anchor bolt locations, completely detailed and dimension from equipment center lines:

a. Bushing outlines including size of stud, thread size and thread length.
b. Surge arrester outlines.
c. Location of radiators.
d. Location of conservator.
e. Control elementary and wiring diagrams.
f. LTC control elementary and wiring diagrams.
g. Current transformer elementary and wiring diagrams.
h. Current transformer ratio correction factor and secondary excitation curves.

The Supplier shall supply three sets of prints of the above requirements. In addition, a list indicating the drawing number and title of each drawing shall be provided.

4.4 Drawings Approval

4.4.1 GPA shall be allowed three (3) weeks to review and approve drawings provided in Section 4.3 without affecting the shipping date.

4.4.2 Drawings returned to the Supplier as approved shall be considered authorization to proceed with the work. The approval of GPA shall in no way abrogate the requirements of this specification.

4.5 Certified Reproducible

4.5.1 At least three (3) weeks prior to shipment of the equipment the Supplier shall furnish GPA an AutoCAD file and a complete set of final certified reproducible vellum for each transformer purchased. Under no circumstances will "Typical Drawings" be accepted. This includes both schematic and wiring diagrams.

4.5.2 Final certified reproducible shall be submitted on full size, right reading, photographic Mylar. The following information shall be shown on each drawing submitted:

a. GPA Purchase Order
b. Supplier's Name
c. Description of Drawing

4.6 Instruction Books

4.6.1 At least three (3) weeks prior to delivery the Supplier shall furnish GPA five sets of complete operating and instruction books for each transformer.

4.6.2 One additional instruction book shall be attached to each transformer.

4.6.3 Each manual or instruction book shall include the following:

a. Both schematic and wiring drawings. No typical drawings are acceptable.

b. List of parts that were shipped loose from the transformer and to be installed in the field.

c. A replacement parts list that includes part number identification.

d. A list of recommended spare parts and complete packing lists of accessory items.

e. Instruction manuals covering step-by-step installation and assembly with illustrative drawings. Each separate part shall be marked with or identification system to aid in erection.

f. Manual recommending proper storage procedures.

g. Operating and "troubleshooting" manual for the transformer.

h. List of all special tools needed for installation and maintenance.

5.0 RATINGS

5.1 Description

Transformer shall be a 3-phase, oil-immersed, outdoor type unit for use on a 60 hertz effectively grounded system. Transformer windings (primary and secondary)

shall be made of COPPER.

5.2 Operations and Environment

The transformer is to be used for step-down operation, in a salt air environment near sea level with ambient temperatures ranging between 75 and 100 degrees F.

5.3 KVA Rating/Temperature Rise

The transformer shall have the following ratings:

Self-Cooled OA	18 MVA
1st stage fans FA	24 MVA
2nd stage fans FA	30 MVA

The average winding temperature use will not exceed 65 degree C (measured by resistance method) when operated at the OA/FA/FA rating.

5.4 Voltage Ratings and Phase Displacement

5.4.1 The primary winding (high voltage) shall be rated 34,500 volts, delta connected.

5.4.2 The secondary winding (low voltage) shall be rated 13,800 Y/ 7970 volts, grounded wye connected.

5.4.3 The phase displacement between the 34,500 volt and the 13,800 volt winding shall be 30 electrical degrees with the low voltage lagging the high voltage in a counter-clockwise phase rotation. The vector group of the transformer shall be Dyn1.

5.5 Basic Insulation Levels (BIL)

The BIL ratings shall be as tabulated:

High Voltage Winding	200 KV
Low Voltage Winding	110 KV
Low Voltage Neutral Winding	110 KV

5.6 Impedance

The percent impedance voltage for the high to low voltage windings (H-X) shall be 7.5 percent on the unit's OA rating; impedance shall have tolerances as specified in ANSI Standard C5.12.00.

5.7 Sound Level

The average sound level of transformer shall be of a standard sound level or reduced sound level. Standard sound levels shall not exceed 70/72/73 db based on the transformer rating in accordance with NEMA TR-1-1971 Standards. Reduced sound level transformers shall be 12dB below the standard and shall not exceed the levels for 58/60/61dB for OA/FA/FA, OA/FA/FOA or OA/FOA/FOA ratings.

The transformer sound level shall be reduced by reducing the flux density of the core.

The Supplier shall state in his quotation the price difference between a standard sound level and a reduced sound level transformer.

5.8 Surge Arresters

Station class metal oxide surge arresters shall be provided.

The Maximum Continuous Operating Voltage rated 27 kV rms shall be 22 kV MCOV for the transformer HV terminals. High voltage arresters shall be cover mounted, ABB type or equal.

The Maximum Continuous Operating Voltage rated 10 kV rms shall be 8.4 kV MCOV for the transformer LV terminals. Low voltage arresters shall be cover mounted, ABB type or equal.

6.0 CONSTRUCTION

6.1 Bushings

6.1.1. High voltage bushings shall be of the paper and oil "capacitor" TYPE, ANSI Standard Inter-changeable, with visible oil level gauge at the top of each bushing. Each bushing shall be provided with a power factor test tap.

Bushing color shall be ANSI 70 light gray. Threaded stud for connection of bushing to cable or straps shall be silver-plated.

6.1.2. Low voltage phase and all neutral bushings shall be of the dry-type, one piece porcelain body, or acceptable condenser type. Threaded stud for connection of bushing to cable or straps shall be silver-plated. The bushing color shall be ANSI 70 light gray.

6.1.3. All bushings minimum creepage distance is 1 inch/ kV. Bushings provided with the transformer shall be in accordance with the following:

BUSHING	VOLTAGE CLASS KV	MINIMUM BIL KV	MINIMUM VOLTAGE CREEPAGE IN	LOCATION
HV Phase	35	200	35	Cover Mtd.
LV Phase	15	110	15	Cover Mtd.
LV Neutral	15	110	15	Cover Mtd.

6.1.4. Two each spare bushing shall be provided for both high and low voltage bushings. And one each spare bushing shall be provided for low voltage neutral bushing.

6.1.5. HV and LV terminal cabinets used for termination of underground power cables to the bushings shall be provided with space heater and cable support. Bushing terminals shall be at least 60-inches from the cable entry at the bottom of the cabinet to avoid stressing the cables when terminated.

6.2 Bushing Current Transformers

6.2.1. Standard multi-ratio current transformers for Authority's use are required as follows:

Each HV Phase Bushing	Two (2) 1200/5 MRCT accuracy C800.
Each LV Phase Bushing	Two (2) 2000/5 MRCT accuracy C800.
LV Neutral Bushing	One (1) 600/5 MRCT accuracy C800.

6.2.2. All secondary tap leads (total of five for each CT) shall be brought out of the top or side wall of the transformer through a gas and oil tight compartment and wired to identified circuit shorting terminal blocks in the transformer control cabinet. All connections between CT's and GPA connection points shall be bolted or crimped. No soldered, split or disconnecting lugs shall be used.

6.2.3. All CT circuits shall be terminated into an eight-pole test switch.

6.2.4. The manufacturer shall provide accuracy curves for the current transformers furnished.

6.2.5. Bushing CT Nameplates shall be provided showing connection and ratio for each tap of each current transformer. These nameplates shall be mechanically fastened and located adjacent to GPA's connection terminals.

6.3 Tap Changers

6.3.1 High Voltage De-energized Manual Taps

Externally operated, full KVA capacity, fixed taps shall be provided to regulate the high voltage + 2 1/2 % and + 5 % from the nominal voltage. The high voltage de-energized tap changer shall be operable by a wheel, crank, or lever accessible by an operator standing at ground level. The operating device shall have provisions for padlocking. Each tap position and associated voltage for that tap shall be clearly identified on a tap position nameplate mounted on the transformer wall directly adjacent to the operating device. The nameplate shall state "For De-energized Operation Only".

6.3.2 Low Voltage Automatic Load Tap Changer

1. Manufacturer: ABB
2. Location: Low voltage winding
3. Regulating Range: 10 percent above to 10 percent below rated voltage in 16 steps of 5/8 percent in each direction.
4. Rating: Delivered full kVA capacity at all LTC positions and at all combinations of LTC positions.
5. Tap Selector Switch and Mechanism:

a. Mount in oil-filled compartment separate from main transformer tank.
b. Maintain physical isolation so it is not necessary to drain oil or break seal of main transformer tank when servicing LTC.
c. Tank Accessories:
    i. Hinged maintenance door with oil-resistant gasket.
    ii. Drain, filter, and separating valves.
    iii. Magnetic level indicator with low level 125 vdc alarm contacts.
    iv. Breather.
    v. Manhole for inspection of contacts without lowering oil level.

6. Controls:
    a. Type: Automatic, solid state.
    b. Features:
        i. Adjustable bandwidth and voltage level.
        ii. High limit/ low limit blocking.
        iii. Line drop compensation.
        iv. Proper operation when operated isolated or in parallel and for real and reactive power flow in both directions through transformer.
        v. Controls for reduction in regulated output voltage of 2-1/2 or 5 percent, either manually at transformer control cabinet or remotely from supervisory control equipment.
        vi. Local and remote LTC control capability.
    c. Equipment:
        i. Current transformer for line drop compensation.
        ii. Position indicator with drag hands to indicate maximum travel.
        iii. Limit switches and stops to prevent travel beyond extreme tap position.
        iv. Crank or hand wheel for manual operation during maintenance.
        v. Positioning devices and off-position contacts.
        vi. Operation counter.
        vii. Potentiometer for remote position indication to Control Room. Provide potentiometer with 1,280 ohms total resistance and 40 ohms resistance with each LTC step.

viii. Form C dry contacts wired to RTU for lower limit, upper limit, and hung-up alarms.
ix. Control circuit protective devices.
x. Control switches for RAISE-LOWER, AUTOMATIC-MANUAL, and LOCAL-REMOTE.
xi. OFF-Position contact wired to indicating light in main cabinet.
xii. Remote control switches for RAISE-LOWER, AUTOMATIC-MANUAL, and a Selsyn type indicator for mounting on the Owner's remote Control Panel.

6.4 Drain, Isolating, Vacuum and Filter Valves

A two inch, globe type, combination drain and lower filter valve shall be provided. This valve shall have a built-in 3/8 inch sampling device. A one inch upper filter valve shall also be provided.

If transformer is designed for vacuum filling, provision shall be made on the top of the tank for a vacuum connection.

Isolating valves and other necessary devices shall be provided to allow ready installation and removal of radiators and drainage of oil from radiators without draining oil from the main tank. Drain, filter, vacuum valves and their hand wheel shall be made of bronze.

6.5 Lifting Facilities

Lifting facilities shall be provided for lifting the cover separately and for lifting the core and coil assembly from the tank using four lifting cables.

Lifting facilities shall also be provided for lifting the complete transformer using four slings. The bearing surface shall be free from sharp edges.

6.6 Jacking Facilities

Jacking facilities shall be located near the extreme ends of the junctions of the transformer segments. Minimum dimensions and clearances for jacking provisions shall be specified on the outline drawing.

6.7 Pulling Facilities

Pulling eyes shall be provided for pulling the transformer along center line.

6.8 Transformer Base

6.8.1 The transformer base shall be designed to permit rolling or skidding of the transformer in any direction. The base shall be designed so that the transformer center of gravity, as normally prepared for shipment, shall not fall outside the base support for a tilt of the base of 15 degrees from the horizontal, with or without oil in the transformer.

6.8.2 The base shall be fabricated with an adequate number of anchor bolt holes designed to put the transformer base in direct contact, shear and tension, with the transformer concrete foundation at all anchor bolt locations.

Anchorage shall be ASTM A-307 anchor bolts 1" dia. x 16" L with heads embedded in concrete with an ultimate compressive strength of 3000 pounds per square inch. Anchor bolts shall be supplied by manufacturer.

6.9 Nameplate

A diagram nameplate shall be furnished and shall be located near eye level above the base of the transformer. The information furnished shall be in accordance with nameplate 1980 American National Standard 057.12.00, Section 5.12. The Supplier shall also stamp on the nameplate the GPA P.O. Number.

6.10 Liquid Thermometer

The transformer shall have top oil gauges with alarm contacts and a 0-1 mA output shall be provided for top oil temperature.

6.11 Liquid Level Indicator

A magnetic liquid level indicator shall indicate level of insulating liquid. Two electrically separate, normally open alarm contacts shall be provided to indicate both high and low liquid levels.

A third contact shall be provided to trip for low liquid level. This contact shall be electrically isolated from the alarm contacts and shall be set so that the trip operation is at a lower liquid level than the low level alarm.

6.12 Hot Spot Thermometer

A three-stage hottest spot winding temperature indicator relay shall be provided in each winding. The second stage contacts shall be wired in parallel to an auxiliary relay to obtain two (2) normally open contacts in addition to fan control contacts. A 0-1 mA output shall be provided for winding temperature.

The loss of cooling and over temperature trip and alarm scheme shall contain the items listed below.

a. Auxiliary contacts from second stage of winding temperature relay.

b. Loss of voltage relay (Device 27-1)

c. Timing relay to allow enough time for a source transfer before operation (Device 95)

d. Timing relay with instant transfer auxiliary switch self-resetting, 6-60 minutes, time delay pickup (Device 2-2). The equipment will be used to give an alarm with loss of voltage and high temperature and de-energize the transformer after a set period of time.

e. Auxiliary time delay relay to give alarm upon loss of voltage to pumps and or fans (Device 27-2).

6.13 Sudden Pressure Relay

A sudden pressure relay shall be provided. This relay shall be factory calibrated for the transformer on which the relay is to be used. The relay shall be provided with two electrically separated contacts for alarm and control. The sudden pressure relay shall be provided with an auxiliary lockout relay with hand reset. The auxiliary relay shall have a normally closed contact from the sudden pressure relay shunting the operating coil of the auxiliary lockout relay. The relay shall be suitable for 125 VDC operations. Relay assembly and location shall allow removal with the transformer energized.

6.14 Mechanical Pressure Relief Device

A self-sealing, mechanical pressure relief device shall be located on the cover.

The relief device shall be furnished with alarm contacts and a visual operation indicator. The indicator shall be resettable with hot-sticks from ground level without the necessity of de-energizing the transformer.

6.15 Automatic Voltage Regulator (AVR)

Digital tap changer device shall be Beckwith Electric's M-2001D or newer version. The device shall be used to control and monitor the transformer LTC.

AVR and associated devices shall be located in a marshalling cabinet inside the control room. If a marshalling cabinet is not required, all AVR and associated devices shall be installed at the transformer cabinet.

The AVR shall have the following features:

a. Line Drop Compensation by R, X, or Z
b. Harmonic Analysis
c. Sequence of Events Recording
d. Source PT Voltage Input
e. Supports DNP 3.0, Modbus, and IEC 61850 Protocols
f. Tap Position Knowledge
g. Beckwith 2025D Tap Position Sensor or newer version compatible with the M-2001D AVR
h. LCD Display
i. Transformer Paralleling
j. RS232 and Ethernet Connections

6.16 Fault Gas and Moisture Monitor

Fault gas and moisture monitor shall be GE Power Systems' HYDRAN M2 or newer version. The dissolved gas monitor (DGA) shall be used for continuous and on-line monitoring of moisture and gas-in-oil for the transformer. The DGA shall have the following features:

a. Monitoring capability for H2, CO, C2H2, C2H4, and H2O.
b. Hourly and daily trend with alarm features
c. History logging of Data and Events
d. Dry Contacts for alarms
e. RS232 and Ethernet Connections
f. DNP 3.0 Protocol
g. NEMA 4X Enclosure
h. Analog and Digital Input/Output Card

Two each Hydran M2 sensor, Part No. 16270, shall be provided as spare.

6.17 LTC Transformer Oil Filtration System

The load tap changer filtration system shall be OIL FILTRATION SYSTEMS' LTCFS-6-S514D/2-120-N4-B or newer version. The LTC filtration system shall be used for continuous online filtration of dielectric oil of a load tap changer transformer featuring:

a. High Efficiency Particulate/ Carbon Removal Filter Element, which can remove particles as small as ½ micron in single pass.
b. Water Removal Element, capable of removing up to 0.25 gals of water.
c. Element Plugged Indication.
d. Variable Operation, system can be run continuously or at 1-4 intervals per day via solid state timer.
e. Automatic Safety Shut-Down and Isolation, if a leak is detected.
f. Cabinet Oil Leak Detection device.
g. Stainless Steel Cabinet.
h. Hour meter.
i. Inlet Make-Oil Adder Valve.
j. Flow Sight.
k. Acid Removal Filter.

6.18 Target Type Fault Indicator

The electromagnetic target type fault indicator shall be TK Series, Fuji Electric Ind. Co. Ltd., TKL 200-DC12-B or approved equal. The fault indicator shall have combinations of contacts that are utilized for output, a plug-in type indicating element with visible indication plate, and manual resetting. The indicators shall be installed inside the transformer control cabinet visible through window glass.

6.19 Core Ground

It is preferred that the core ground connection be above the oil and accessible from a manhole to facilitate testing of the core to tank insulation without lowering the oil. The connector shall be the slotted type with a captive nut connection. The location of core ground should be indicated on the transformer outline drawing.

6.20 Auxiliary Power Source

The auxiliary power will be single-phase 120/240 volt, 60 HZ A/C. The Supplier shall design the transformer cooling system including fans and pumps, LTC motor, controls and accessories to operate on both voltages. The Supplier shall inform GPA of the power requirements needed at the transformer. The terminals provided by the Supplier shall be adequate to receive GPA furnished A/C service conductors.

A 120 VAC, 15 ampere convenience outlet with ground fault protection shall be provided.

Provisions shall be made for an ungrounded 125 VDC incoming supply. All tripping, alarm, and associated devices shall be rated 125 VDC operations.

6.21 Centralized Termination and Control Devices Requirement

All equipment alarms, controls, protection and current transformers shall be brought to individual identified terminals centralized in a weather-proof control cabinet mounted on the equipment tank at a center of cabinet to base height of 5 feet 6 inches. Oil thermometer gauge, high voltage winding temperature gauge, and low voltage winding gauge shall also be located inside the weather proof cabinet. Adequate hinged doors shall be provided with weatherproof latching facilities. The latching assemblies shall be operated by handles that can be reached by an operator standing at ground level. Each handle shall have provisions for padlocking and be acceptable for weather-proofing the doors in the closed position.

All meters and instruments which require resetting shall be mounted less than six (6) feet above the base of the transformer.

Alarm contacts shall be electrically separate, open during normal conditions, self-resetting, suitable for closing 5 amperes, carrying 3 amperes continuously, and opening 3 amperes at 125 volts DC.

Control contacts shall be electrically separate, open during normal conditions, self-resetting, suitable for closing 30 amperes, carrying 10 amperes continuously, and opening 3 amperes at 125 volts DC.

All alarm and control contacts shall be individually wired to the Target Type Fault

Indicators TK Series. Another new set of alarm and control contacts shall be individually wired to the GPA Customer (RTU and Relay Panels).

6.22 Instrument and Control Wiring

6.22.1 THW or THWN wires used by the Supplier shall be of the machine-tool type with 3/64" polyvinyl chloride insulation rated 600 volts, 90 degree C. Other wires with insulation having characteristics which equal or exceed the above requirements for machine-tool type wire are acceptable. Control wire used by the Supplier shall be suitable for wet and dry location, flame retardant, moisture and heat resistant.

6.22.2 All secondary wire, regardless of type, shall be stranded. Wire shall have adequate current-carrying capacity. No. 12 AWG shall be used for control circuits, #10 for CT circuits and #18 for SCADA indication.

6.22.3 Those portions of any secondary wiring in the control box, or those portions of any secondary or control wiring or cable which pass through conduit, shall not be spliced. However, junction boxes with terminal blocks as specified above may be used to extend secondary wiring passing through conduits.

6.22.4 Ring-tongue terminals shall be used for secondary wiring. Spade, slotted spade, flanged spade, and hook terminals are not acceptable. Ring-tongue terminals shall be sufficiently strong to prevent their breakage under conditions of vibration inherent in the equipment in which they are installed.

6.22.5 Terminals shall have insulated ferrules whenever the spacing between the terminals, or their projection above or below the terminal board, or both, is such that they can make contact with one another.

6.22.6 All wires for external connection shall be properly identified and terminated at conveniently located, easily accessible terminal blocks. All terminal blocks furnished by the Supplier shall have No. 10 screws. The screws shall be secured directly into the contact strips and not into nuts embedded in the terminals blocks. The

contact strips shall have sufficient thickness to assure that torque applied to the No. 10 screws to hold the terminal to the contact strips will not damage the threads in the tapped holes. The screws shall be firmly secured to the blocks and shall be separated by insulated barriers. Terminal blocks with clamp type fittings are not acceptable.

6.22.7 Ring-tongue terminals shall be fastened to the contact strips of terminal blocks with machine screws. Barriers shall separate the contact strips.

All circuits shall be protected by molded case circuit breakers. Breakers are to be ambient compensated. The breaker size, supplier's name and catalog number are to be shown on the drawings.

6.22.8 All control, power, alarm, and auxiliary equipment shall be completely wired at the factory.

6.22.9 Hinge wiring and wiring that will be subjected to bending during maintenance or other operations shall be arranged such that the bending or twisting will be around the longitudinal axis of the wire.

6.22.10 Wiring shall not be spliced or tapped. All connections shall be made at the device terminals or on terminal blocks.

6.22.11 All future, spare, and unused contacts and devices shall be wired to terminal blocks.

6.22.12 A minimum of ten percent (10%) spare terminal points shall be provided.

6.22.13 All wirings external to enclosure or cabinet shall be in rigid steel conduits.

6.22.14 All wirings from the transformer components to the cabinets, which may require removal for shipment, shall be installed in place and in such a manner that it is only necessary to connect the wires to the cabinets after they are installed on the transformer.

6.22.15 Wiring Format

a. All terminals shall be numbered, and the numbers shall correspond to the numbers on the wiring diagram.

b. All wires shall be identified at their termination points with the opposite end designation identification by labeled plastic sleeves or equal. Identification shall correspond to the lettered device, numbered terminal format of the wiring diagrams.

6.22.16 **System Phase Rotation**

The system phase rotation for the island-wide system is GPA C-B-A or NEMA 1-2-3 and all equipment purchased under this contract shall be wired and connected NEMA 1-2-3. All phase markings shall be NEMA 1-2-3. Instrument and relay arrangement shall be 1-2-3 left to right with neutral relays underneath phase grouping. GPA will make the external connections of the incoming and outgoing lines such that GPA C-B-A is connected to NEMA 1-2-3. Phase markings C-B-A shall be reserved for GPA's use.

7.0 TANK

7.1 The main transformer tank shall be designed to withstand, without permanent deformation, pressures 25 % greater than the maximum operating pressures resulting from the system of oil preservation used. The maximum operating pressures (positive and negative) which the transformer tank is designed to withstand shall be indicated on the nameplate.

7.2 Vacuum Filling

If tank is designed for vacuum filling (essentially full vacuum) radiators and auxiliary compartments such as expansion tanks, when not designed for full vacuum filling, shall be so designated and isolating valves shall be provided.

7.3 Manholes

Provide one or more circular handholes and at least two circular manholes in the transformer top with neoprene or better gasket material and bolted covers. This

facility must be of sufficient size to allow removal of bushing CTs and allow entrance of a person into the transformer tank (24-inch minimum manhole).

7.4 Ground Pads

In addition to the surge arrester grounds pads, two ground pads, drilled and tapped for NEMA four-hole (1/2 inch bolts on 1-3/4 inch centers) connectors, shall be installed on diagonally opposite corners of the base. If the base is removable, the two pads shall be installed on the transformer tank wall near the base. Ground pads shall be copper-faced steel, stainless steel, or nonferrous pads brazed or welded to the transformer.

8.0 TRANSFORMER OIL

The Supplier shall furnish an adequate quantity of mineral oil for the first fill of each transformer. Mineral oil shall be ASTM D3487 Type II. All furnished oil shall be INHIBITED with DBPC (Ditertiary Butyl Para-Cresol). The oil shall have the following minimum characteristics:

a. Flash Point: Cleveland Open Cup 132 Degrees C.
b. Fire Point: Cleveland Open Cup 145 Degrees C.
c. Specific Gravity at 60 Degree F: 0.865 to 0.910.
d. Viscosity: Saybolt Universal at 100 Degree F - 55 - 63 sec.
e. Acidity: 0.02 Mg KOH/gm 0.1 max.
f. Pour Point: -40 Degree F.
g. Corrosive Sulfur: None
h. Dielectric Strength (ASTM D877): 26 kV Min.
i. Power Factor at 68 Degree F: 0.0% Max.
j. Interfacial Tension: 40 Dynes/CM.
k. Non-PCB (Polychlorinated Biphenyl) Contaminated:
Manufacturer is to mark in a permanent manner that the dielectric fluid is "Non-PCB". Certified test report on residual oil remaining in the transformer after factory testing that indicates that the oil is free of PCB.

9.0 TRANSFORMER COOLING

9.1 Cooling Control

9.1.1 A hot-spot dial type thermometer shall be supplied to indicate the maximum hot-spot temperature of the windings. The instrument shall have adjustable alarm contacts and shall be placed at a

convenient location, easily readable from ground level. The two stages of cooling shall be activated by the contacts on the dial type hot-spot thermometer. The contacts for cooling control within the hot-spot temperature device shall be readily accessible. This can be accomplished by providing all temperature device windings, oil, etc., with split removable bezel rings.

9.1.2 A manual-off-automatic selector switch shall be provided for the control of each stage of cooling equipment. In the "Automatic" position, the cooling equipment shall be activated by the temperature control. In the "manual" position the cooling circuit shall be energized. A contact shall be provided to indicate loss of power to cooling circuits for remote alarm purposes. The contact shall be wired to a terminal strip in the control cabinet for GPA's connection. A selector switch shall be provided to allow either cooling stage to be used as the first or preferred system.

9.1.3 Operation of the cooling system shall not be made by motor starting switches. If a capacitor is needed for starting, then the motor shall be capacitor start and run.

9.2 Heat Exchangers

Heat exchangers must have sufficient capacity to prevent a temperature rise in excess of that specified for each rating of the transformer. Due to severe corrosion problems, GPA prefers heat exchangers made of copper tube and copper fin construction. ALUMINUM heat exchangers are NOT ACCEPTABLE. Heat exchangers shall be removable from the main tank without the need to drain oil from the main tank.

9.3 Radiators

No accessories or pipes shall be installed above the radiators for easy installation and removal during maintenance.

Material of radiator:	Cold rolled Steel, SS41, and 1.0mm thickness	
Internal painting:	Coating with Celerol reaction primer	
Surface preparation:	Grit blasting to Sa 2.5 (SVENSK STANDARD SIS 0559081967) ASTM 2200 D IS 1477 PART 1	
Exterior paint:	Hot-Dip Galvanizing as per ISO-1461	60 Microns
	Epoxy Primer	20 Microns

Epoxy Intermediate Coat	40 Microns
Polyurethane Top Coat	40 Microns
Total Thickness	160 Microns

9.4 Cooling Fans

All cooling fans shall be of the low speed type to reduce wind noise levels. Each fan shall be multi-bladed or multi-lobed with one common hub. Fans with more than one hub are not acceptable. Control of the cooling fans shall contain no motor starting switches and shall be plug-in type with an identified separate conductor case ground. Metal to metal ground for fans is not acceptable.

10.0 TESTS

10.1 The Supplier shall make his plant available to GPA representatives to inspect the transformer during construction, testing and/or packaging for shipment. Bidder shall include in his bid the factory acceptance test costs witness by GPA, which covers airfare, meals, hotel accommodation, and car rental during the entire testing period.

A factory test plan complete with acceptable reading values shall be submitted to GPA for approval. The factory test equipment and test methods used shall conform to the applicable requirements of ANSI, NEMA, ASTM, NFPA, and UL standards. Factory tests will be witnessed by two (2) GPA representatives.

Manufacturer's technical representative shall be on island to verify transformer connections and acceptance tests.

10.2 Five (5) copies of certified test reports shall be supplied for the following tests:

1. Standard Routine Tests shall be performed as listed in the latest revision of ANSI C57.12.00, including Supplement C57.12.00a-1978.
   a. Ratio Tests or TTR on the rated voltage connection and on all tap connections.
   b. Polarity and Phase Relation Tests on the rated voltage connection.
   c. Winding Resistance Measurement shall be performed for each winding.

The resistance shall be measured and recorded with hot and cold windings.

d. Winding Insulation Resistance and Polarization Index (PI) Tests shall be performed for each winding.

e. Core Insulation Resistance Test shall be measured between the core and ground for duration of 1 minute.

f. Insulation Power Factor Tests and Winding Capacitance Test shall be performed in accordance with ANSI/IEEE C57.12.90.

2. Dielectric Tests

a. Lightning Impulse test shall be performed in accordance with ANSI/IEEE C57.12.90. Oscillographic records of the test shall be included in the test reports. The minimum height of each individual tract (at maximum deflection) shall be 30 millimeters. Front of Wave Impulse shall be performed. Test sequence shall consist of reduced full wave, full chopped wave, and full wave.

b. Low Frequency test shall be performed in accordance with ANSI/IEEE C57.12.90. Test shall be performed on auxiliary devices, control, and current transformer circuits.

c. Partial Discharge (Corona) test at full induced-test voltage level. The measurement shall be less than 500pC at one hour voltage level for 60 minutes. Equipment and general method used shall be in accordance with ANSI/IEEE C57.12.14, C57.12.90, and C57.113.

3. Audible Sound Level test in accordance with NEMA TR-I shall be performed for each stage of cooling.

4. Regulation, Efficiency, and Losses. The regulation of each transformer shall be determined for unity (1.0) and eight-tenths (0.8) power factor lagging.

The efficiency and losses of each transformer shall be determined as indicated in the bid data. The guaranteed efficiency and tested total losses shall include losses in all windings.

Measurement of Impedance Voltage, Excitation Current, and Zero-Phase Sequence Impedance shall also be determined.

5. Bushing Tests
   a. Design Tests. Certification that each type, style, and model bushing furnished has passed the test requirements of ANSI C76.1 shall be furnished.

6. Other Tests
   a. Applied Voltage Test shall be performed to confirm insulation status between windings and between windings and earth. Transformer shall withstand specified voltage during 1 minute.

   b. Induced Voltage Test shall be performed to check the insulation status between turns of windings.

   c. Temperature Rise Tests. Temperature tests will be required to check the temperature rise of windings.

   d. Leak Test shall be performed to check leakage or reduction of pressure from welding points. Transformer is filled with oil and applies N2 gas to tank.

   e. Dissolved Gas in Oil Analysis Test shall be performed to check the condition of oil and inside of the transformer using DGA equipment.

   f. Oil Breakdown Voltage Test shall be performed by gathering oil samples from the main tank, main conservator, and OLTC tank.

   g. Dew Point of the air (or gas) in the tank shall be determined just prior to shipment and at the final shipping destination.

10.3 The Supplier shall include the following information in the test report.

   a. Winding hot spot temperature rise in degree C over the average winding temperature rise at the 30 MVA, 65 degree C rating.

   b. Winding Thermal Time Constant.

c. Type of material used in the primary and secondary winding.

11.0 LOSS EVALUATION

11.1 Each bidder shall submit with his bid the guaranteed average load and no-load losses on each transformer submitted on this bid. Guaranteed load losses shall be provided at the transformer's self-cooled (OA) rating and a reference temperature of 85 degree C (65 degree rise + 20 degree C ambient). The requirements and definitions of ANSI Standard C57.12.00, Sections 5.9 and 9.3, shall apply.

11.2 Guaranteed losses will be evaluated by GPA to determine the equivalent cost for owning and operating each transformer. The value of the transformer no-load and load losses will be determined by GPA at the time of purchase to arrive at the projected Total Cost of Ownership (TCO) as follows:

$$TCO = IC + [A \times (P_o + P_{co})] + [B \times (P_k + P_{cs} - P_{co})]$$ Where:

P_o = No Load Losses (NLL) in kW

P_{co} = Power Consumption of Cooling Equipment at No Load Operation

P_k = Load Losses (LL) in kW

P_{cs} = Power Consumption of Cooling Equipment at Rated Power Operation

IC = Initial Transformer Cost

A = $t \times C_{n/2} \times (1 - (1/(1+i))^n) / i$

B = $u \times t \times C_{n/2} \times (1 - (1/(1+i))^n) / i$

u = k^2

t = Operating Hours per Year **(24 Hours/Day X 365 Days/Year = 8760 Hours)**

i = Discount Rate **(5% Used By GPA for Money Certificates Issued)**

n = Expected Lifetime of the Transformer in Years **(GPA Uses 25 Years)**

$C_{n/2}$ = Is the Cost of energy at the Mid-Life of the Transformer

Note: If Annual increase of energy price is assumed to be constant, $c_{n/2}$ can be calculated using C, j & n

$C_{n/2}$ = $(c + (c \times (1+j)^n)) / 2$

c = Is the Initial Cost of Energy ($0.1007) **(Calculated From the weighted average energy rate from the Revenue Report with Fuel-Non Fuel Data Dec 2017)**

j = Is the Annual Increase of Energy Price (1.0985%) **(Calculated from the Base**

Rate Increases from 1998 to 2018)

k = Is the Average Loading of the Transformer During its Lifetime (32%)
(Calculated using data From the GPA Substation Analysis 2018)

Note: Load Losses = Total Losses – No Load Losses

11.3 The Manufacturer shall test each transformer for load and no-load losses. This test data shall be certified as correct and submitted to the Authority prior to or at the time of shipment.

11.4 The Authority will review and consider actual load and no-load losses for each transformer. In the event that the average evaluated losses for like units exceed the average guaranteed losses, the Manufacturer will be penalized at the above rates for the differences. Load and no-load loss penalties will be assessed independently. Bonuses will not be awarded for actual average losses which are less than guaranteed. In addition, any transformer with no-load losses or total losses greater than the tolerances indicated in ANSI Standard C57.12.00 shall be rejected by the Authority.

12.0 OIL PRESERVATION SYSTEM

12.1 The transformer shall have a conservator (expansion tank) type oil preservation system.

12.2 There shall be no contact between oil in the expansion tank and air. This shall be accomplished by use of a nitrile air cell (diaphragm not allowed) vented to the outside air. The expansion tank shall be of sufficient volume to operate through an ambient temperature range of minus 35 degree C to plus 50 degree 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. A shut-off valve, capable of holding the full head of oil in the expansion tank, shall be provided in the oil line between the expansion tank and the main transformer tank.

13.0 FINISH REQUIREMENTS

All metal surfaces shall be thoroughly cleaned of rust, welding scale, and grease, and shall be treated to effect a bond between the metal and paint which will prevent the formation of rust under the paint. A priming coat shall be applied immediately after the bonding treatment. A final finish shall consist of two coats of paint. The exterior final coat shall be ANSI 70 Gray.

14.0 SHIPPING REQUIREMENTS

14.1 Because of severe transportation conditions, the Supplier shall pay particular attention to the proper packaging and bracing of the apparatus to assure its safe arrival. Manufacturer shall install a tilt monitor prior to shipping and results should be within safe recommendations.

14.2 The Supplier shall prepare all materials and equipment for shipment in such a manner as to protect from damage in transit. All small parts and unit components shall be separately boxed or bundled to prevent galling due to rubbing of one part against another. Each item, box or bundle shall be plainly and individually identifiable for content according to item number, GPA P.O. Number, and Supplier's Identifying Number.

14.3 A complete itemized Bill of Lading, which clearly identifies and inventories each assembly, sub-assembly, carton, package, envelope, etc., shall be furnished and enclosed with each item or items at the time of shipment.

14.4 Openings in the transformer tank or radiators resulting from the removal of parts for shipment shall be identified and securely sealed against the entrance of moisture and foreign materials. Covers shall be of sufficient strength to resist puncture.

14.5 Delivery of transformer shall be to actual jobsite as identified by the Manager of Engineering.