GUAM POWER AUTHORITY
P.O. BOX 2977
HAGATNA, GUAM 96932

TRANSMISSION & DISTRIBUTION SPECIFICATION
Specification No. E-052

FOR

34.5 KV PAD MOUNTED STATION SERVICE TRANSFORMER

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1.0 SCOPE

1.1. This specification covers GPA requirements for **34.5 kV single phase or three-phase, dead-front radial feed, 60 Hz, mineral oil filled, 65° C rise pad mounted type station service transformers for use with separable insulated high-voltage connectors.**

1.2. The transformer is intended for use in tropical weather conditions with a corrosive sea air atmosphere, **wind strengths of 175 mph, and subject to moderate and severe earthquakes seismic level Zone-4.**

2.0 APPLICABLE PUBLICATIONS

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

2.1. AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI)

C57	Requirements for Distribution Transformers
C68.1	Techniques for Dielectric Tests
C76	Apparatus Bushings

2.2. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA) STANDARDS

TR 1	Transformers, Regulators and Reactors

2.3. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS

D3487	Mineral Insulating Oil used in Electrical Apparatus
D92	Manual Cleveland Flashpoint Tester
D877	Dielectric Breakdown Voltage of Insulating Liquids

2.4. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

70	National Electrical Code
70B	Electrical Equipment Maintenance

2.5. FEDERAL SPECIFICATIONS

TT-P-636D	Red or Brown Iron-Oxide Primer for Galvanized Metal Surfaces

3.0 DEVIATIONS AND NON-CONFORMANCE REQUIREMENTS

3.1. Deviations from this specification or changes in the material or design after the purchase order has been placed must be approved by the GPA Engineering department and acknowledged by a Purchase Order Amendment issued by GPA.

3.2. Units received with deviations or non-conformances that are not acknowledged per Section 3.1 are subject to rejection. The Supplier of rejected units 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.

3.3. Notification of defective units 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.

3.4. Warranty – the Supplier shall warrant the distribution transformer to be free from defects in material and workmanship under normal use and service conditions. The term of the Warranty shall be the lesser of twelve (12) months from the date of initial installation or eighteen (18) months from date of sale/purchase.

3.5. Statement of Compliance - The Supplier shall provide a signed statement verifying that the products being supplied fully comply with the specifications and drawings. Items not in full compliance with the specification and drawings will be identified with a description of the deficiency and any proposed substitutions. Items not in full compliance with the specifications and drawings must be approved by the GPA Engineering Department, as described in Section 3.1.

4.0 SUBMITTALS

4.1. The bidder shall provide with their bid the following data:

a. Nameplate Data
b. Connection diagrams
c. Guaranteed total loss at 100% voltage and load
d. Guaranteed no-load loss at rated voltage
e. Shop Drawings
f. Low voltage circuit breaker time-current characteristics curve

4.2. Information for shop drawings shall include:

a. Mounting dimensions
b. Location of equipment, devices and terminals
c. Weights
d. Number of gallons of oil
e. Nameplate Data
f. Connection diagrams
g. Guaranteed total loss at 100% voltage and load
h. Guaranteed no-load loss at rated voltage

4.3. After award of contract, shop drawings indicating details of construction and the outline of all connectors shall be submitted to GPA Engineering for review and approval.

4.4. GPA shall be allowed two (2) weeks to review and approve drawings provided in Section 4.2 without affecting the shipping date. Delays in delivery due to drawings that are disapproved during this review period are the responsibility of the Supplier.

4.5. 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.

5.0 CERTIFIED LABORATORY TEST REPORTS

5.1. Certified tests shall be conducted in accordance with ANSI C57 plus a standard production impulse test. Transformers shall have passed all required tests demonstrating compliance with the design requirements and industry standards.

5.2. The Supplier shall also conduct tests to determine transformer load and no-load losses. This test data shall be certified as true and correct by an independent testing firm and submitted to the Authority.

5.3. The Supplier shall furnish two (2) copies of the certified test reports of all tests covered by this specification to the GPA Manager of Engineering prior to shipment.

6.0 LOSS EVALUATION

6.1. Each bidder shall submit with his bid the guaranteed load and no-load losses on each transformer submitted. Guaranteed load losses shall be provided at 85° C and shall be stated at the nominal voltage tap positions.

6.2. 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 **(Provided by Bidder)**

P_{co} = Power Consumption of Cooling Equipment at No Load Operation **(Zero Power Consumption of Cooling Equipment, unless otherwise provided)**

P_k = Load Losses (LL) in kW **(Provided by Bidder)**

P_{cs} = Power Consumption of Cooling Equipment at Rated Power Operation **(Zero Power Consumption of Cooling Equipment, unless otherwise provided)**

IC = Initial Transformer Cost **(Provided by Bidder)**

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

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

$u = k^2$

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 ($) **(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 (%) **(Calculated from the Base Rate Increases from 1998 to 2018)**

k = Is the Average Loading of the Transformer During its Lifetime **(Calculated using data From the GPA Distribution Analysis 2010-2015)**

6.3. A Band of Equivalence method will be used when evaluating the total cost for owning and operating each transformer. Transformers with a TOC that is within 5% of the transformer with the lowest TOC will be considered equivalent. The transformer with the lowest purchase price within this band shall be considered the lowest bid.

6.4. GPA will review actual, certified load and no-load losses for each transformer. In the event the actual losses exceed the guaranteed losses, the Supplier's contract will be reduced. The price reduction shall be the difference between the guaranteed losses and the actual losses at the rates indicated above. Load and no- load loss penalties will be assessed independently. Bonuses will not be awarded for actual losses which are less than guaranteed. Any transformer with no-load losses or total losses greater than the tolerances indicated in ANSI C57 shall be rejected by the Authority.

7.0 RATINGS

Single Phase Pad Mount Transformer

Primary Voltage	34,500 Delta
Secondary Voltage	120/240 Wye
Rating (kVA)	100
Impedance (%)	2.26
Frequency (Hz)	60
Average Winding Rise (C)	65
High Voltage BIL (kV)	150
Secondary Voltage BIL (kV)	30
Feed Configuration	Radial
Fluid	Mineral Oil
Color	Green (Munsell 7GY 3.29/1.5)

Three Phase Pad Mount Transformer

Primary Voltage	34,500 Delta
Secondary Voltage	120/208 Wye
Rating (kVA)	225
Impedance (%)	2.52
Frequency (Hz)	60
Average Winding Rise (C)	65
High Voltage BIL (kV)	150
Secondary Voltage BIL (kV)	30
Feed Configuration	Radial
Fluid	Mineral Oil
Color	Green (Munsell 7GY 3.29/1.5)

8.0 DESIGN

8.1. Taps

a. Unless otherwise specified, taps shall be furnished on the high voltage winding. Tap ratios shall conform to ANSI C57 for 34.5 kV transformers, with two 2½ % taps above and below the rated voltage.

b. Taps shall be full KVA rated and have short circuit capability noted in ANSI C57.

c. The selection of the tap desired shall be obtained through the operation of an externally operated switch.

1. The switch shall be designed for de-energized operation.
2. The switch assembly shall be snap action or the handle designed to permit checking that a switching operation has been completed.
3. The switch assembly shall be designed to prevent accidental operation.
4. Tap positions shall be clearly marked near the switch handle and on the transformer nameplate.
5. A clearly legible yellow sign in accordance with 9.12.c shall be located adjacent to the handle which identifies it as the tap changer handle and includes a warning to not operate energized.

d. The tap changer operating handle shall be located either in the low-voltage compartment, above the low-voltage bushings or hot stick operable at the high voltage compartment without interfering with installed primary cables.

8.2 Protection

a. Transformers shall be supplied with primary bayonet-type, oil-immersed fuses with isolation links.

b. Fuse links shall be replaceable without requiring cutting or grinding of the transformer tank.

c. Bayonet fuses with isolation links shall meet the following requirements:

1. A yellow sign in accordance with 9.12.c reading "CAUTION READ BAYONET OPERATING INSTRUCTION BEFORE RE-FUSING" shall be located adjacent to bayonet fuses.
2. A closed-end trough or catch basin shall be provided to prevent oil dripping on cables and terminations.
3. Free clearance shall be provided for hot stick operation of bayonet fuses.
4. Bayonet fuses with isolation links shall be sized in accordance with Table 3.

TABLE 3
Transformer Fusing
(Bayonet with Isolation Link)

KVA	Rating
100	5
225	6

d. Provide an externally operated load break oil rotary (LBOR) switch for radial feed on the primary side.

e. All transformers covered by this specification shall have an automatic pressure relief valve installed above the hottest temperature oil level in the low voltage compartment, near the right hand most edge to the right of the top bushing to prevent oil dripping on cables and terminations and to prevent spraying.

9.0 CONSTRUCTION

9.1 The transformer shall consist of a welded transformer tank which shall be sealed with a welded cover. The enclosure, tank, doors and base of the transformer (the part that makes contact with the mounting surface) shall be made of Type 304L stainless steel.

9.2 The high and low voltage compartment including doors, door handles, hinges, base and other exterior parts and accessories on the high and low voltage compartment shall be made of Type 304L stainless steel.

9.3 The manufacturer shall identify the type of steel and the thickness of the metal in inches or in gage size, in which case the gage name shall be specified.

9.4 The transformer shall be supplied with a high and low voltage compartment barrier. The compartment barrier shall be removable.

9.5 The compartment with separable insulated high voltage connectors shall be covered by a single door.

9.6 No part of the transformer shall allow deformation or standing water. The top of the transformer shall be convex so water will run off the top.

9.7 The transformer shall have an oil level gauge, fill plug, drain valve, and self-actuating pressure relief device.

9.8 An indication shall be provided for signifying the correct oil level at 25° C if fill plug is not at this level.

9.9 Bushings and Terminals

a. High voltage separable insulated connector bushing.

1. Integral bushings are required. The Supplier shall provide approved load break bushing insert, Elastimold 1601A3R or approved equal.
2. Bushings shall be bonded to tank having a maximum resistance between high voltage bushing shielding and tank of 5000 ohms.
3. Weatherproof protective caps shall be installed to remain in position during shipping and storage and not deteriorate prior to installation of transformer.

b. The low voltage neutral shall be fully insulated and provided with a connected, removable neutral ground strap, which shall be connected so as not to impair the bolted secondary connections.

1. Low voltage terminals shall be six-hole spade for 45 to 225 KVA transformers.
2. Low voltage terminals shall be plated for copper or aluminum cable terminations.

c. The transformer shall have high and low voltage bushings which are externally clamped and replaceable without requiring access to the inside of the tank.

d. Ground nuts for grounding connection shall be provided with ground connector for #4 to 2/0 copper wires.

9.10 Security Requirements

Access to the transformer compartment shall be secured by a minimum of two independent locking arrangements.

a. The transformer locking design shall meet the requirements of the Western Underground Committee Guide 2.13, latest revision, "Security for Pad Mounted Equipment Enclosures." A pentahead bolt design is not required by GPA.

b. The transformer shall be designed to prevent wire entry and pass the following production quality control and receiving inspection test procedure:

1. Any length of #12 AWG medium hard drawn solid bare copper wires shall be inserted into each opening until the wire enters the compartment or reaches an obstacle.
2. If the wire reaches an obstacle, it can be bent and extended a maximum of three times at which time it shall be considered that the wire cannot be inserted into the enclosure.
3. Entry of the wire into a compartment shall constitute a lack of tamper resistance and shall be cause for rejection. It is not necessary for the wire to actually contact energized components since entry into the compartment can establish potential hazardous conditions.

c. The locking design shall be adequately sized for a standard padlock. The padlock shall not

protrude beyond the front of the hood when installed. Hexagonal head bolts shall be Y2 inch and shall be of non-corrosive metal.

9.11 Finish Requirements

a. The tank, compartment and all appurtenances shall be resistant to impact and corrosion under normal operating conditions in Guam's salt air environment.

1. The total external dry-film thickness of the paint shall be 3.5 mils minimum or equivalent protection and 2.0 mils minimum on the interior compartment surfaces.
2. All mating surfaces shall be designed to prevent degradation of corrosion protection e.g. abrasion and impact. Mating surfaces at sill/hood junction shall be designed to prevent standing water corrosion.
3. Surfaces in contact with, and a minimum of two inches above, the mounting surface shall be designed or treated to be resistant to corrosion and abrasion when unit is skidded and slid into place on the mounting pad.

b. The transformer shall withstand the following environmental tests for 2000 hours:

1. ASTM B117, Standard Method of Salt Spray (Fog) Testing.
2. Ultraviolet Test, per ASTM D822, Standard Recommended Practice for Operating Light and Water Exposure Apparatus (Carbon-Arc type) for testing paint, varnish, lacquer and related products (ASTM G23 Type D or better).

9.12 Transformer Identification and Labeling Requirements

a. High voltage and low voltage terminal designations shall be located directly above their respective terminals.

e. Transformer KVA rating, high voltage nameplate designated voltage and low voltage nameplate designated voltage shall be located inside the door and plainly visible with door open.

f. Signs shall be yellow stenciled or approved decals. Decals shall have yellow printing on a black or clear background, or black printing on a yellow background, reverse printed on Scotch Cal material with pressure sensitive adhesive or an equivalent approved by GPA Engineering.

d. Nameplate

1. The nameplate shall be made of corrosion resistant material and shall comply with applicable industry standards for distribution transformers.
2. The nameplate shall be permanent showing all of the required information, including KVA, voltage rating, ratio, BIL, weight, winding material, month and year of manufacture, impedance, high voltage and low voltage

material, etc.

3. The nameplate shall have rounded corners, and shall not be mounted more than W' from the surface so as not to constitute a personnel hazard during bare hand secondary make up.

10.0 QUALITY CONTROL

10.1. The Supplier shall have a quality control program to ensure compliance with the requirements of this specification. The program shall be documented and available for GPA's review if requested.

10.2. Documentation of the quality control program shall indicate where in the production and manufacturing process the quality checks are taken, describe the purpose of the checks, and describe the nature of the check, e.g. if check is visual only or if electrical or mechanical testing is used.

11.0 PACKING AND SHIPPING

11.1. The supplier shall have adequate work and inspection instructions for handling, storage, preservation, packaging and shipping to protect the quality of the transformer and all attachments and to prevent damage, loss and deterioration of the transformer and its appurtenances.

11.2. The transformer shall be placed and crated with suitable material to prevent damage and injury during shipment and handling operations.

11.3. The transformer shall be securely blocked to prevent shifting during transit.

Appendix A

PAD-MOUNTED TRANSFORMER INFORMATION SHEET

NOTE: Please complete the product information and provide the required documents. Incomplete information shall be cause for rejection.

Product Information				
1.	Transformer Phase			
2.	Primary Voltage			
3.	Secondary Voltage			
4.	Transformer kVA Size			
5.	Insulation Class Rating			
6.	Primary Voltage BIL Rating			
7.	Feed Type			Radial
8.	Impedance			
9.	Bay-O-Net	Quantity :	Yes	No
10.	Load Break Oil Rotary Switch (On/Off)		Yes	No
11.	Auto Pressure Relief Valve		Yes	No
12.	Drain Plug/Valve		Yes	No
13.	Fill Plug		Yes	No
14.	Ground Strap		Yes	No
15.	Ground Connector (2 ea.)		Yes	No
16.	Tap Changer		Yes	No
17.	Are all parts of the transformer such as hood, doors, hinges, tank, base and other parts and accessories made of Type 304L Stainless Steel?		Yes	No
18.	Flip Top Hood		Yes	No
19.	Doors		Yes	No
20.	Hinges and Pins		Yes	No
21.	Base and Sill		Yes	No
22.	High/ Low Divider (Removable)		Yes	No
23.	Transformer Base		Yes	No
24.	Is there a Convex Top		Yes	No
25.	Spade Terminal			

Required Documents			
1.	Nameplate Data	Yes	No
2.	Connection Diagrams	Yes	No
3.	Guaranteed total loss at 100% voltage and load	Yes	No
4.	Guaranteed no-load loss at rated voltage	Yes	No
5.	Shop Drawings	Yes	No
6.	Low voltage circuit breaker time-current characteristics curve	Yes	No