GUAM POWER AUTHORITY
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TRANSMISSION & DISTRIBUTION SPECIFICATION
Specification No. E-012

FOR

SINGLE-PHASE POLE-MOUNTED DISTRIBUTION TRANSFORMER

SINGLE PHASE POLE MOUNTED DISTRIBUTION TRANSFORMER

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1.0 SCOPE

1.1. This specification covers GPA requirements for single-phase, 60 Hz, mineral oil filled, self-cooled, self-protected, 65 degree C rise pole mounted type distribution transformers.

1.2. The transformer is intended for use in tropical weather conditions with a corrosive sea air atmosphere, sustained wind strengths of 155 MPH with 3 second gusts to 170 MPH and International Building Code 2009 Zone 4 seismic requirements shall apply.

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	IEEE Standard for Overhead-Type Distribution Transformers 500 kVA and Smaller
C68.1	Techniques for Dielectric Tests
C76	Apparatus Bushings
255.1	Gray Finishes for Industrial Apparatus and Equipment

2.2. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA) STANDARDS:

TR 1	Transformers, Regulators and Reactors

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

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. US DEPARTMENT OF ENERGY (DOE)

10 CFR Part 431 Subpart K - Distribution Transformers

2.6. National Electric Safety Code (NESC) Part 2: Safety Rules for Overhead Lines

Section 250 General Loading Requirements

2.7. International Building Code 2009

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 receipt.

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 the following data with their bid submittal:

a. Nameplate Data
b. Connection diagrams
c. Guaranteed total loss at 100% voltage and load
d. Guaranteed no-load loss at rated voltage
e. Physical dimension drawings
f. Low voltage circuit breaker time-current characteristics curve
g. Completed GPA Product Information Sheet

4.2. 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.

4.3. Information 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

4.4. 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)($0.1007)**

j = Is the Annual Increase of Energy Price (%) **(Calculated from the Base Rate Increases from 1998 to 2018)(1.0935%)**

k = Is the Average Loading of the Transformer During its Lifetime **(Calculated using data From the GPA Distribution Analysis 2010-2015)(20.05%)**

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

7.1. The primary voltage rating is 13,800 V.

7.2. Secondary Voltage ratings shall be either 120/240, 277, 240/480 volts as required.

7.3. The insulation class is 15 kV and the primary-voltage BIL is 95 kV. The secondary voltage BIL shall be 30 kV.

7.4. The required transformer kVA ratings will be indicated on the purchase order. The following kVA ratings are standard for GPA pole mounted transformers.

5, 10, 15, 25, 37.5, 50, 75, 100 and 167

7.5. The transformer impedance shall be as indicated in Table 1. ANSI tolerances may be applied to these values. The impedance value shall be provided on the nameplate.

TABLE 1
Transformer Impedance

Size (kVA)	Minimum Impedance (%)	Maximum Impedance (%)
5 - 37.5	1.0	4.5
50 - 167	1.5	4.5

7.6. The transformer shall meet the latest energy efficiency standards for liquid immersed distribution pole mounted transformers required by the United States Department of Energy.

7.7. The Average Winding Rise shall be 65°C.

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 13.8 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 9.9c shall be located adjacent to the handle which identifies it as the tap changer handle and includes a warning to not operate energized.

6. The operating handle for the tap switch shall be located on the tank wall as shown in Figure 1.

8.2 Protection

a. All transformers require and shall be furnished with the following:

1. A single two-pole or two single-pole low voltage circuit breaker(s) with an overload setting. Circuit breaker calibration shall be verified after installation in the units. The breaker is internally mounted in oil with the operating handle externally operated. The switch position shall be clearly marked on the transformer.

2. An overload signal light.

3. An automatic pressure relief valve.

b. Unless otherwise specified, transformers shall be provided with externally-mounted surge arresters.

1. The arresters shall be rated 12 kV (MCOV 10.2 kV rms).

2. Two arresters shall be required to be mounted on the mounting pads as shown on Figures 1 and 2.

3. Arresters shall be provided with connectors for #4 to #2 aluminum or copper conductors.

4. Arresters shall be normal duty constructed within polymer housing.

c. All transformers shall be supplied with arrester mounting pads equipped with stainless steel 1-1/4" x 1/2" bolts and washers for mounting surge arresters.

d. All transformers shall be supplied with a tank ground pad equipped with a ground nut with grounding connector for #4 to #2 copper wires.

9.0 CONSTRUCTION

9.1. The transformer tank, cover, cover band, and associated hardware shall be made of stainless steel.

a. The manufacturer shall identify the type of steel, and the thickness of the metal in inches or in gage size, in which case he shall specify the gage name.

b. Stainless steel shall be type 304L stainless steel and shall be identified by the addition of the words "stainless steel" to the nameplate and the stenciled letters "SS" 3 inches high (minimum) on the tank front below the KVA rating.

c. The transformer cover shall have an insulating type coating having a minimum dielectric strength of 15 kV, 60 second withstand.

d. The tank shall have a recessed tank bottom which offers protection when sliding over rough surfaces.

e. The tank shall have an internal mark which indicates the proper oil level at 25°C per ANSI C57.

f. The cover shall be electrically bonded externally to the tank.

g. Lifting lugs conforming to ANSI C57 shall be integrally welded to the tank and finish coated with the tank assembly. Lifting provisions shall be arranged in such a manner that a lifting sling will not be in conflict with other transformer parts or accessories and shall permit reasonably balanced lift during handling and installation of the complete unit.

9.2. The transformer tank shall be constructed in such a manner as to remain leak proof throughout the life of the transformer.

9.3. Transformer covers shall be tightly gasketed and securely clamped to prevent entrance of moisture.

9.4. Single-position upper and lower support lugs for direct-pole mounting shall conform to IEEE Standard C57.12.20, except as otherwise specified below and to the requirements stated in Section 1.2, certified to withstand extreme wind loading for sustained wind speeds of 155 MPH and 3 second gusts of 170 mph.

a. Type B support lugs as defined in IEEE C57.12.20 shall be installed on all transformers regardless of the kVA rating. Support lugs shall be angular and not rectangular. When viewed from the top of the transformer, the edges of the members of the support lug at the point of attachment at the transformer tank to the concavity shall form a 65° angle+/- 10° when measured at the concavity; edges that are parallel from the point of attachment at the transformer tank to the concavity are not acceptable.

b. Hanger brackets for all size transformers shall have a concavity at the contact area with the pole such that it conforms to the surface of a concrete pole as shown in Figure 1; the concavity shall comply with IEEE C57.12.20 for Type B support lugs.

9.5. Approximate transformer weight and dimensions are provided in Table 3.

9.6. The transformer tank shall withstand a static pressure of 50 psig while remaining intact.

a. A pressure relief cover design is acceptable relieved at a minimum of 8 psig if designed to reseal.

b. The tank may vent at the cover gasket at 15 psig or higher without resealing.

9.7. The transformer shall be provided without radiators or cooling fins.

9.8. Bushings and Terminals

a. High voltage bushings shall have a minimum creepage distance of 17 inches.

b. Transformer high-voltage and low-voltage bushings shall be glazed wet process porcelain. The color shall be ANSI Z55.1 No. 70 gray.

c. Terminals on the high voltage bushings shall conform to ANSI C57. Terminals shall accommodate wire sizes from #4 to #2 copper or aluminum.

d. Transformers shall have a minimum clearance of 6 inches from the pole face to any energized part.

e. Low voltage terminals shall conform to ANSI C57 and shall be suitable for use with both copper and aluminum conductor sizes from #4 AWG to 250 kcmil. All 167 kVA transformers shall be equipped with 4-bolt NEMA spade terminals.

f. The transformer shall consist of three low voltage terminals and shall be suitable for series, three-wire, and parallel operation. The internal leads shall be long enough to easily allow the change of connections for the desired type of operation. The internal secondary leads shall be permanently embossed with the letters A, B, C, and D per ANSI C57. The polarity of the transformer shall be subtractive.

9.9. 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 color shall be ANSI Z55.1 No. 70 gray

2. The total external dry-film thickness of the paint shall be 3.5 mils minimum or equivalent protection as approved by GPA Engineering.

3. Pressure relief valves may be painted to conform to ANSI Z55.1 No. 70 gray provided painting does not alter the operating characteristics.

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

1. ASTM 8117, Standard Method of Salt Spray (Fog) Testing.

2. ASTM D822, Standard Recommended Practice for Operating Light and Water Exposure Apparatus (Carbon-Arc type) for Testing Paint, Varnish, Lacquer and Related Products (ultraviolet test).

3. ASTM D529, the Accelerated Test of Bituminous Materials.

c. Signs for bushing identification and tap positions shall be yellow stenciled or

approved decals. Decals shall be reflective with black lettering on an amber background, reverse printed on Scotch Cal material with double activated adhesive or an equivalent approved by GPA Engineering.

d. The transformer kVA rating shall be permanently displayed on the side near the low voltage bushing and on the bottom of the transformer tank with 3 inch high numbers using either paint or labels. Painted numbers shall be black; labels shall be reflective with black lettering on an amber background, reverse printed on Scotch Cal material with double activated adhesive or an equivalent approved by GPA Engineering.

e. 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, etc.

3. The nameplate shall not extend beyond the mounting bracket.

9.10. The Supplier shall have information regarding the manufacturing process including general fabrication, assembly, operation and finish available to GPA upon request.

9.11. The core and coil shall be vacuum processed to ensure maximum penetration of insulating fluid into the coil insulation system. While under vacuum, the transformer will be filled with preheated filtered degassed insulating fluid. The core shall be manufactured from burr-free, grain-oriented silicon steel and shall be precisely stacked to eliminate gaps in the comer joints. The coil shall be insulated with B-stage, epoxy coated, diamond pattern insulating paper, which shall be thermally cured under pressure to ensure proper bonding of conductor and paper.

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.

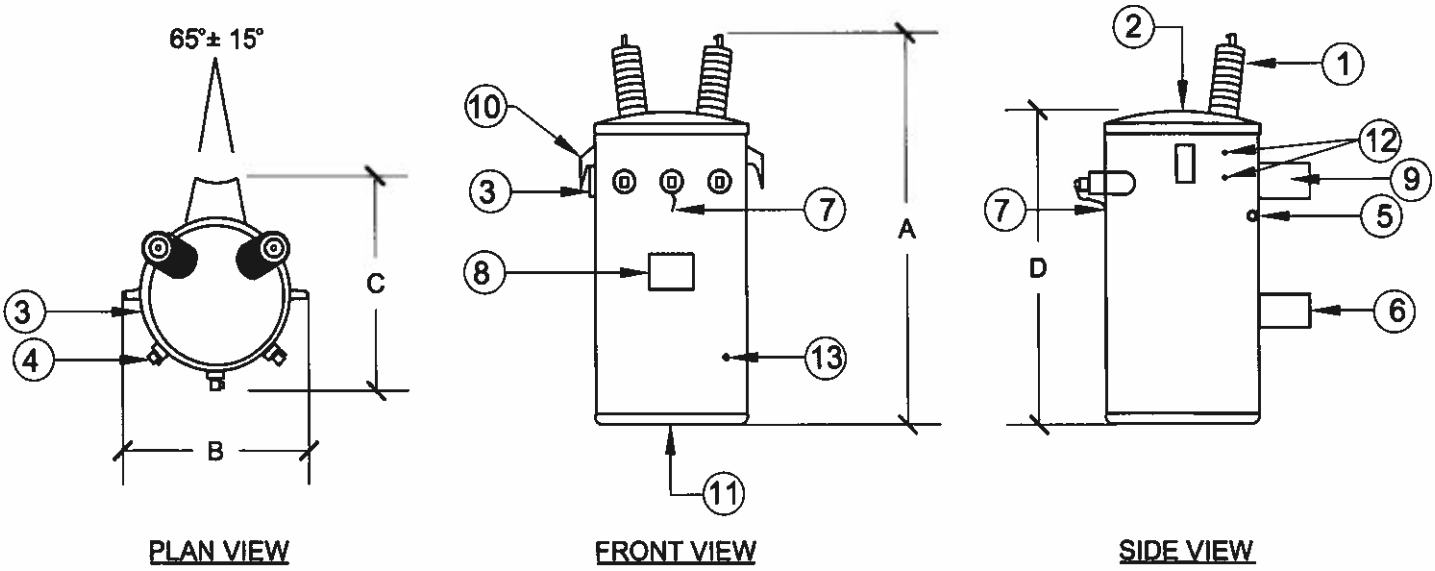
11.2. The transformer shall be placed and crated with suitable material to prevent damage and injury during shipment and handling operations.

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

TABLE3
Approximate Transformer Sizes
(See Figure 1 for Dimensions)

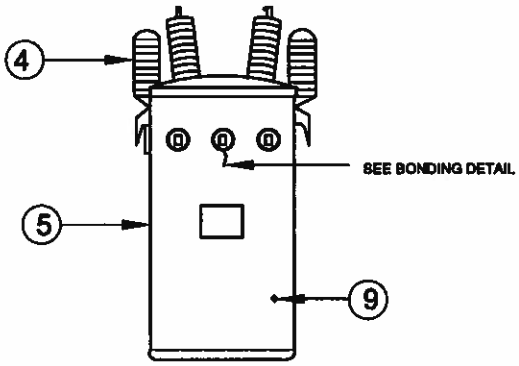
Size kVA	Dimensions (inches)				Weight (lbs.)	Gallons of Oil
	A	B	C	D		
5	34	16	19	22	220	6
10	37	16	19	26	233	9
15	39	18	20	23	317	11.5
25	43	20	24	32	410	14
37.5	48	20	24	37	539	16.5
50	49	23	37	33	650	23
75	55	23	28	44	881	34.5
100	55	28.5	31.5	35	1030	42
167	55	28.5	35	43	1340	46

FIGURE 1

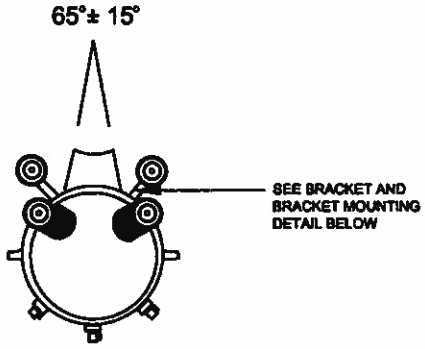


1. High Voltage Bushing
2. Cover
3. Secondary circuit breaker handle and light location
4. Low voltage eyebolt terminals
5. Tap Changer
6. Nameplate (attached to hanger bracket)
7. Secondary neutral bushing bonding to tank
8. Transformer size decal
9. Hanger bracket
10. Lifting lugs
11. Recessed bottom
12. Arrester mounting pads on both sides
13. Tank ground pad with grounding connector for #4 to #2 copper wire

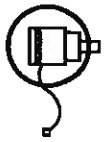
FIGURE 2



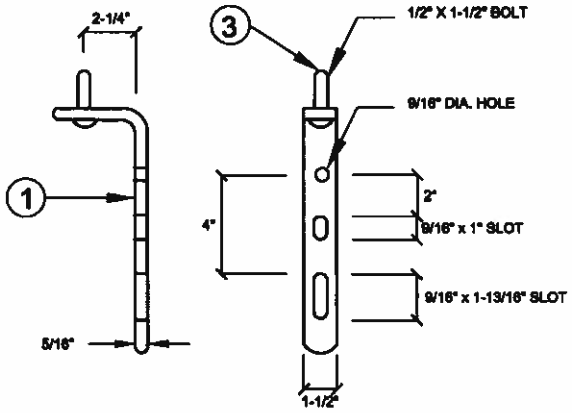
FRONT VIEW



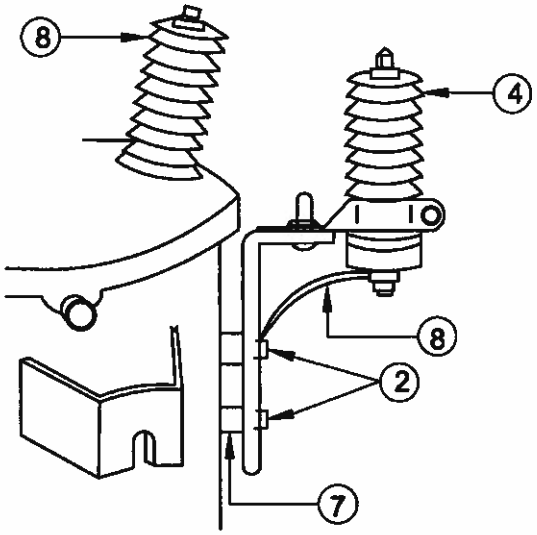
PLAN VIEW



BONDING DETAIL



BRACKET DETAIL



BRACKET MOUNTING DETAIL

1. Arrester Mounting Bracket
2. Bolt
3. Carriage Bolt
4. Surge Arrester
5. Transformer
6. High Voltage Bushing
7. Arrester Mounting Pads
8. Grounding Strap
9. Tank ground pad with grounding connector for #4 to #2 copper wire