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| | | REV. 10 | DATE: 11/28/06 |

**Subject:**

# PADMOUNT TRANSFORMERS THREE-PHASE

## RECORD OF REVISION

7 Revised nameplate designation "CONTAINS NO PCB AT TIME OF MANUFACTURE." Editing and re-grouping of subsections throughout document. Deleted inappropriate reference to ANSI C57.12..20. Added finish color specification Munsell Green No. 7GY 3.29/1.5. 6/21/99.

Editing for clarification. Add References. Remove allowance of insulating barriers to meet termination cabinet BIL requirements in 5.2.5. Specify Z-bar style setscrew secondary connectors for certain transformers in 5.3.3. Allow direct connect primary bushing wells without clamps in 5.4.1 and 5.4.2. Update bushing insert/flange catalog numbers per 5.4.6. Specify drain wire requirements in 5.4.7. Modify bushing stand arrangement. Specify high current bayonet fuse assy. & fuse holder in 5.5.1 and5.5.3. Identify flapper valve on bayonet assembly in 5.5.2. Add ester based biodegradable oils, minimum characteristics, conditions of supply and assessment of benefits, 5.7.4 – 5.7.6. Change tank grounding and add ground bus requirement in 5.8. Change value of losses and loss penalties to reflect most recent marginal cost information, Section 8. 12/2002.

8 06/27/06 Revised 5.1.5. Deleted the words, "However, the maximum tap position for 4x12 kV transformers may be 12,480 volts."
Revised 5.4.4. Changed the phrase, "For transformers rated 500 KVA and less," to "For transformers that call for setscrew connectors per section 5.3.7." to clarify the discrepancy between 5.3.3 and 5.3.7.
Revised 5.4.4 Added the phrase "The threaded stud on the secondary neutral bushing shall be the required length to accommodate the setscrew connector and the grounding strap.
Revised 5.7.2 added the phrase, "excluding parking spans."
Revised 5.8.6. added the phrase, "Where a bolted cover is provided, a hand hole suitable for CL fuse replacement is not required."
Revised 5.6.1, Added the phrase, "There shall not be any residue of the natural ester-based dielectric fluid on the transformer other than in the tank itself upon delivery. This includes but not limited to residue from the filling process or from the pressure release valve during transportation." SMUD has experienced problems with receiving pole bolt transformers with ester-based dielectric fluid on the bushings. The fluid polymerizes during transportation and becomes sticky thus collecting dirt. The polymerized fluid is difficult to remove.
Removed Reference to ANSI C57.12.26 and added reference to C57.12.34. Added reference ASTM D1535, and ASTM D6871. Eliminated reference to integrated circular flange on pentahead bolts. Added drawing UVD 2.2A to the reference list and pad design for proper cabinet sizing. Added requirements to provide touch-up paint instructions and material.
Added recommendations for touch-up painting requirements. Added shipping and packing section. Revised fuse table to match new standard UZE 1.1, dated January 2006. Revised testing requirement to include design tests, and all applicable routine factory tests. Included testing of large transformers for oil dielectric strength. Added new standard drawing, UVD2.3A. Revised all engineering references to SMUD Standards Engineer.

9 Revised the load loss costs per the latest energy cost data. Revised format to agree with K014. 9/15/06.

10 Revised cost of losses data per 11/06 energy price forecasts. Incorporated 20,800V delta rated transformers w/ 125kV BIL and specified standard fusing. Revised tap changer to specify "de-energized operation," not "No-Load" tap changer. Eliminated mandatory oil dielectric test before shipment, but specified testing at discretion of Stds Engineer at cost of Manufacturer.

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| Mike Rudek 11/28/06 | |
| AUTHOR DATE | |
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| PRINCIPAL DESIGN ENGINEER – STANDARDS DATE | |
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| RESOURCE SUPERVISOR – DESIGN & STANDARDS DATE | |

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**Subject:**

# PADMOUNT TRANSFORMERS THREE-PHASE

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| Mike Rudek | 11/28/06 | |
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| RESOURCE SUPERVISOR – DESIGN & STANDARDS | DATE | |

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**Subject:**

**PADMOUNT TRANSFORMERS THREE-PHASE**

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# 1 PURPOSE

This specification provides the requirements for the design, manufacturing, and testing of three-phase, 60 Hertz, liquid-filled, self-cooled, 45kVA – 2500kVA, padmount type distribution transformers for use on the Sacramento Municipal Utility District's (SMUD) distribution system. This specification covers the electrical and mechanical features for 12kV, 4kVx12kV, and 21 kV primary distribution transformers with a 480/277V, or 208/120V connected secondary winding.

# 2 SCOPE

This specification applies to all the electrical and mechanical features of three phase 12,000 volt, combination 12kV or 4160V, and/or 20,800 volt primary, 60 Hz, liquid-filled, self-cooled, padmount type transformers (units). The successful bidder shall provide all work and material to design, fabricate, test, and deliver the specified equipment along with any drawings, manuals or other documents required.

Except as specified, work and material required for the installation of the transformer will be provided by SMUD.

# 3 REFERENCES

3.1 IEEE C57.12.34, IEEE Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled Three-Phase Distribution Transformers (2500 kVA and Smaller) -
High-Voltage: 34500 GrdY/19920 Volts and Below;
Low Voltage: 480 Volts and Below

3.2 ASTM D3487, Standard Specification For Mineral Insulating Oil

3.3 ASTM D6871, Standard Specification for Natural (Vegetable Oil) Ester Fluids Used in Electrical Apparatus

3.4 ANSI/NEMA C57.12.28 Pad-mounted Equipment - Enclosure Integrity

3.5 IEEE 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V

3.6 IEEE C57.12.00, General Requirements for Liquid-Immersed, Distribution, Power, and Regulating Transformers

3.7 IEEE C57.12.90, PART 1: Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers

3.8 ASTM D1535, Standard Practice for Specifying Color by the Munsell System

3.9 ANSI/IEEE C57.12.70 Terminal Markings and Connections for Distribution and Power Transformers.

3.10 IEEE C57.12.80, Standard Terminology for Power and Distribution Transformers.

3.11 IEEE 100, The Authoritative Dictionary of IEEE Standards Terms

# 4 DEFINITIONS

Refer to IEEE C57.12.80, Standard Terminology for Power and Distribution Transformers, and IEEE Standard 100 – The Authoritative Dictionary of IEEE Standards Terms

# 5 SPECIFICATION

## 5.1 GENERAL

5.1.1 The transformer shall be built, tested, and delivered in accordance with the applicable industry standards as defined in Section 3, unless specifically addressed otherwise in this specification or in writing by the SMUD Standards Engineer.

5.1.2 The transformer shall be a liquid filled, natural convection flow design.

5.1.3 The primary voltage rating, kVA and other aspects will be specified in the bid document. The low voltage winding will be specified in the bid document as either 480Y/277 volts, or 208Y/120 volts.

5.1.4 Units with primary windings rated 20,800 and 20,800 GrdY/12,000 volts shall have an insulation class of 125 kV BIL. All other units shall have a 95 kV BIL insulation class. Dual rated units shall meet the minimum BIL requirements of the highest voltage rating, as outlined above.

5.1.5 The transformer shall have an externally operable manual tap changer, for de-energized operation, providing full capacity taps. Two 2-1/2% taps above and two 2-1/2% taps below rated voltage are required on the high voltage windings.

5.1.6 On units with primary windings specified as 4160 x 12,000 volts, the voltage selection shall be made by an externally operable dual voltage switch, and the transformer primary winding shall be connected delta at either voltage. When the dual voltage switch is in the 4 kV position, the tap changer shall be automatically switched out of the circuit.

5.1.7 Transformer impedances shall not be less than the following:

| | |
|---|---|
| 150 kVA and below | 2.0% |
| 300 kVA | 3.5% |
| 500 kVA | 4.0% |
| 750 kVA and above | 5.3% |

Units with impedance values less than the listed values may be rejected by SMUD. All other impedance requirements, per IEEE C57.12.34 and IEEE C5712.00, shall be met. Identically rated transformers shall be suitable for parallel operation and shall be built to industry tolerance for impedance of ±7.5% per IEEE C57.12.00.

5.1.8 When a transformer's impedance is specified in the bid document, it shall be designed to be used in a parallel application, at rated voltage, with a transformer of the same impedance. The industry tolerance for impedance of ± 7.5% of the stated value, per

IEEE C57.12.00, shall apply. Transformers not meeting this impedance tolerance, when specified, shall be rejected.

5.1.9 Exceptions to the requirements of this specification shall only be allowed upon written approval by the SMUD Standards Engineer.

## 5.2 ENCLOSURE CONSTRUCTION

5.2.1 The enclosure shall be a secured compartmental design with separate primary termination compartment and secondary termination compartment in accordance with IEEE C57.12.34 and ANSI C57.12.28.

5.2.2 The manufacturer shall have an established welding certification and quality assurance program in place for all performed welding in the manufacturing of the transformer.

5.2.3 There shall be separate doors covering the primary and secondary compartments. Door handles of cast material shall not be permitted. A tamper-resistant design is required, and shall be in accordance with ANSI C57.12.28. Security of the cabinet shall include the use of pentahead bolts and padlocks.

5.2.4 Doors shall include latches or bars, which secure the doors in the open position.

5.2.5 A partition shall be provided between the primary high voltage compartment and the secondary compartment. The compartments shall be clearly identified.

5.2.6 In order to eliminate gaps between the transformer base and District pad openings, the transformer cabinet and tank shall be dimensionally sized to overlap the pad opening as indicated on attached District Construction Standards:

Attachment 11.1: UVD2.2 for transformers below 2000kVA, or
Attachment 11.2: UVD2.3A for transformers 2000kVA and above.

Radiators may overhang the pad dimensions, and shall be clearly shown in the final drawings.

5.2.7 The coating system shall be in accordance with ANSI C57.12.28, latest revision. The finish color shall be Munsell Green No. 7GY 3.29/1.5 (reference ASTM D1535) or District approved alternative.

5.2.8 The manufacturer shall provide recommended procedures for touch-up of the painted surfaces and shall include the paint product and coating catalog description necessary for procurement of the material.

5.2.9 An automatic pressure relief device shall be provided that will operate to relieve tank pressure at approximately 10 +/-2 PSIG and reseal at 6 PSIG minimum, in accordance with IEEE C57.12.34.

## 5.3 TANK GROUNDING

5.3.1 Tank grounding provisions shall be in accordance with ANSI Standard C57.12.34. As

an alternative, both ground pads may be located in the high voltage compartment of the termination cabinet. These additional requirements shall apply:

a) Ground connectors shall be installed in each ground pad. Connectors shall be Penn Union LSN-050N, or District approved equal. The location of the connectors shall allow the installation of a 1/0 AWG stranded copper ground bus. The connectors shall be installed to support the bus at a distance of three inches from the face of the transformer. The 1/0 AWG wire ground bus will be provided and installed by the District.

b) Both ground pads shall be at the same height on the transformer tank and they shall have a minimum horizontal separation of 30 inches.

5.3.2 The ground pads shall be at sufficient height so that operating personnel may attach personal ground clamps to the bus, using an eight-foot hot stick held at waste level, without interference from the transformer sill or other accessories. The grounding pads shall be no closer than four inches from the tank sidewalls or any compartment barriers.

## 5.4 SECONDARY TERMINALS

5.4.1 The low voltage bushing arrangement and clearances shall be in accordance with Figure 12, of IEEE C57.12.34.

5.4.2 The low voltage neutral terminal shall be a fully insulated bushing. A ground strap shall be provided rated for the short-circuit rating of the transformer as defined in IEEE C57.12.00. A grounding pad shall be provided near the low voltage neutral terminal for accommodating the required ground strap.

5.4.3 Transformers shall be provided with secondary connectors as described in the table below:

| KVA Rating | Low Voltage | Connector Type |
|---|---|---|
| < 150 kVA | All | 6-position setscrew |
| 150 kVA – 300 kVA | All | 8-position setscrew |
| 500 kVA | 480Y/277 V | 8-position setscrew |
| 500 kVA | 208Y/120 | 10-hole NEMA spade |
| > 500 kVA | All | 10-hole NEMA spade |

5.4.4 For transformers that call for setscrew connectors per section 5.4.3:

a) The low voltage line and neutral bushings shall incorporate external threaded studs in accordance with IEEE C57.12.34, figure 13(b). The threaded stud on the secondary neutral bushing shall be the required length to accommodate the setscrew connector and the grounding strap.

b) The low voltage line and neutral bushings shall be supplied with Z-Bar type “slip-fit” setscrew connectors. Connectors shall accommodate aluminum or copper conductors. Six position connectors shall accommodate 6 AWG through 500 kcmil

conductors. Eight position connectors shall accommodate 1/0 AWG through 750 kcmil conductors and shall be installed with bushing braces. Each connector shall have one additional landing position to accommodate a street light circuit. The connectors shall be similar to HOMAC catalog number Z3035-USLSW or Z4047-USLSW for 5/8 or 1" bushing studs, or District approved equals. Setscrews shall be secured with a non-adhesive means, such as shrink-wrap, to prevent loss during transport.

c) Setscrew connectors shall be installed such that six or eight secondary cables will terminate from the bottom

d) Braced low voltage connectors shall be provided on all units rated 150 kVA and above (8-position connectors).

5.4.5 For transformers that call for 10-hole NEMA spade connectors as specified in paragraph 5.4.3:

a) The spade connector shall be in accordance with IEEE C57.12.34, figure 13(a).

b) Bushing braces shall be installed.

5.4.6 When bracing is required, detailed drawings of the spade and setscrew connector bracing designs must be submitted for District approval.

## 5.5 PRIMARY VOLTAGE TERMINALS

5.5.1 Each transformer shall be supplied with six (6) bushing wells for use on a loop-feed system.

5.5.2 Each **bushing well** shall be rated 15.2/26.3 kV, 200 ampere continuous. They shall comply with all applicable requirements and Figure 3 of IEEE 386, latest revision. The bushing wells shall be fixed stud type Cooper/RTE No. BW150F, ABB Catalog No. 609C030G03 or District approved equal. As an alternate the transformer may be supplied with "direct attachment" type bushing wells such as the Central Moloney Tuf Well II Catalog No.701918-52, Cooper/RTE No. 0239731B01 or District approved equal, with a leakage wire supplied to attach to a bushing insert grounding tab.

5.5.3 Primary bushing wells that utilize a clamp for attachment shall be installed with three-stud type external clamps that shall be Cooper/RTE No. 2038214C51, ABB No. 9820A33H01, Kuhlman No. 4210212-006 or District approved equal.

5.5.4 The arrangement of parking stands and high voltage bushing wells shall be provided in accordance with figure 5(a) of IEEE C57.12.34. Dimension K shall be 6.5 inches and shall be within the allowable tolerance.

5.5.5 The transformer primary bushing wells shall be completely protected from paint over-spray and other contamination that may occur during manufacture.

5.5.6 The transformer shall be supplied with installed 200A load break bushing inserts in accordance with ANSI/IEEE 386 latest revision. The inserts shall have all-copper current paths and shall be manufactured using a peroxide curing process.

a) Transformers rated 20,800 volts and 20,800 Grd.Y/12,000 volts shall be supplied with bushing inserts rated 15.2/26.3kV. Acceptable inserts shall be Elastimold 2701A4, RTE/Cooper LBI225, or Hubbell 9U02BAB001 only.

b) Bushing inserts for all other transformers shall be rated 8.3/14.4kV and shall be Elastimold 1601A4, RTE/Cooper LBI215, or Hubbell 9U02AAB001 only.

5.5.7 For each bushing, a leakage current wire shall be connected between the insert grounding tab and the bushing well clamp or a bushing well tank stud. In all cases the wire shall be connected as per manufacturer's recommendations so as to provide a low resistance current path to the transformer tank. Exposed wire ends shall be bent towards the tank, clipped and twisted so as to minimize any stick or scratch hazard to personnel.

5.5.8 Bushing inserts shall be supplied with a cover as protection from dust, paint over-spray and/or other possible contamination or abrasion that may occur during manufacture, shipping or storage.

5.5.9 Details of parking stand dimensions shall be in accordance with Cable Accessory Parking Stand details shown in Figure 5(a) of IEEE C57.12.34.

5.5.10 Detailed drawings of the bushing arrangement and the support design shall be submitted to the SMUD Standards Engineer for approval prior to manufacture of the transformer(s). Any other bushing arrangement must be approved in writing by the District Standards Engineer.

## 5.6 DIELECTRIC FLUID

5.6.1 The transformer shall be shipped completely filled with a dielectric (insulating) fluid that has received approval by the District. The Bidder shall specify the brand and name of fluid that will be supplied.

5.6.2 Upon delivery, there shall be no residue of the dielectric fluid on the transformer, other than within the tank itself. This includes but not limited to residue resulting from the filling process, fluid that might be released from the pressure release devices during transportation, or fluid that might drip from wetted seals or gaskets.

5.6.3 The insulating fluid to be supplied shall be identified in the bid document as either:

a) Mineral Oil: Type II, anti-oxidant, inhibited mineral oil dielectric fluid, in compliance with the latest revision of ASTM D3487, or

b) Natural Ester Fluid: Natural ester fluid (vegetable based) in compliance with the latest revision of ASTM D6871. The ester fluid shall be Cooper Envirotemp® FR3™ fluid or approved equivalent. Approval of ester-based fluids shall be obtained in writing from the SMUD Standards Engineer.

Alternative ester-based fluids must be fully miscible and compatible with Cooper Envirotemp® FR3™ fluid and mineral oil dielectric per section 5.6.3 a), and shall

meet the following minimum requirements:

| | |
|---|---|
| Dielectric Constant, ASTM D924 @25 C | >3 |
| Dielectric Breakdown, ASTM 1816 (0.04" gap, after filling) | >25kV |
| Flash and Fire Point: | >300 C |
| Viscosity, ASTM D445 @40 C | <=45cSt |

In addition, the natural ester fluid shall be shown to retain greater than 90% of it's dielectric strength and fire point when contaminated with mineral oil fluid in percentages less than 7.5% by weight. The fluid shall retain electrical, chemical and physical characteristics with water content up to 400mg/kg so as to perform acceptably in service as a transformer dielectric. The fluid shall be certified to be biodegradable, non-toxic, non-carcinogenic, and non-bioaccumulating. Accelerated aging tests shall demonstrate that the fluid will extend the life of the transformer paper insulation by more than two times as compared to mineral oil dielectric. Certified test results, and/or EPA reports, shall be submitted to the District as verification of fluid characteristics and performance. A Material Safety Data Sheet for the alternate natural ester fluid shall be submitted to the District. (Contact the SMUD Standards Engineer for further requirements for approval of an alternative natural ester-based fluid.)

5.6.4 Transformers supplied with natural ester dielectric fluid shall be designed to meet all other requirements of this specification when filled with either the natural ester or mineral oil dielectric fluid, so long as the physical, electrical, and chemical properties of the fluid are within the requirements of the appropriate ASTM standard.

5.6.5 The insulating fluid shall be refined, prepared and inhibited such that it is compatible with existing acid refined oils and with other natural ester oils that have been approved for use in transformers by the District.

5.6.6 The properties and characteristics of the natural ester dielectric shall be such that equipment used for handling of mineral oil dielectric fluid, can be used to transfer, filter, and dry the fluid, although processing time might be extended.

5.6.7 The dielectric fluid shall be certified to be free of polychlorinated biphenyls, i.e., non-PCB.

5.6.8 The nameplate of the transformer shall specify that the insulating fluid is free of PCBs. The designation on the nameplate shall read "CONTAINS NO PCB AT TIME OF MANUFACTURE" or similar District approved wording. Proposed similar wording shall be submitted to the SMUD Standards Engineer for approval.

5.6.9 Dielectric fluids shall be properly prepared, dried and filtered before adding to clean dry transformers. When natural ester dielectric is supplied, the fluid shall not be

contaminated with mineral oil dielectric residue, such a may remain in transfer piping, or filter equipment if improperly purged. (Separate oil handling facilities and processes are recommended, to prevent cross contamination of natural ester and mineral oil dielectric fluids.) After filling, transformer shall be sealed and may be topped with a nitrogen blanket as recommended by the manufacturer.

5.6.10 The District may test the insulating fluid by taking samples from the bottom of the transformer tanks, 48 hours or more after delivery of the units. These test results will be used to confirm compliance with these fluid requirements, and to determine that the internal cleanliness of the transformer is acceptable. If fluid samples that do not meet the appropriate ASTM D3487 or ASTM D6871 requirements, or meet a minimum dielectric strength of 25kV when tested per ASTM D1816 (0.04 inch gap), the delivered transformer shall be rejected. The supplier will be responsible for all corrective actions, and any associated costs, to repair or replace the rejected transformer.

5.6.11 The SMUD Standards Engineer can require the manufacturer to perform similar bottom sample dielectric tests after assembly is complete and prior to shipment of each transformer. Such tests shall be required until rescinded in writing by the SMUD Standards Engineer. The cost of performing such tests shall be the responsibility of the supplier. Units that do not pass such tests shall not be shipped to the District.

5.6.12 Insulating fluids that do not meet these requirements may be furnished only upon written approval of the District's Standard Engineer.

## 5.7 PRIMARY PROTECTIVE EQUIPMENT

5.7.1 Each transformer shall be supplied with one oil-immersed partial range current limiting fuse(s) per phase. The current limiting fuse manufacturer and catalog information shall be identified on the transformer nameplate.

5.7.2 Each primary phase (three total) shall be protected with a Cooper Flapper Valve type bayonet fuse assemblies, part number 4000361C99FV, or No. 4000361C89FV for high current applications (or SMUD approved equivalent). These bayonet fuses shall be installed in series with the current limiting fuses, inserted between the transformer winding and the high voltage bushing.

There shall be a minimum of 4 inches between a fuse holder and the nearest barrier, device, or obstruction excluding parking stands. The bayonet fuse shall be easily removable with a hot stick from the ground position without interference with the cabinet in any manner.

5.7.3 On units rated 4,160 x 12,000 volts:

a) A dual voltage switch shall place the isolation link between the bayonet fuse and the primary winding when the dual voltage switch is in the 4,160 volt switch position. The dual voltage switch shall place the partial range current limiting fuse

between the bayonet fuse and the primary winding when the dual voltage switch is in the 12,000 volt position. The isolation link manufacturer and catalog information shall be identified on the transformer nameplate.

b) The load-sensing fuses provided in each bayonet fuse holder shall be sized and rated for use of the transformer at the 4,160 volt rating.

5.7.4 Stencils on the tank wall shall be provided to identify the phases of each fuse, such as Fl, F2 and F3.

5.7.5 Fuses and isolations links shall be installed per the following Fusing Schedules:

**Notes:**

1) SMUD System Planning shall review application of transformers to ensure acceptable coordination of protection on 21kV system.
2) These fuses are parallel operating fuses.
3) These recommended Bayonet fuses for 21kv applications are limited to grdY/grdY transformers with less than 50% delta loading. SMUD System Planning will approve these fuses before use.
4) Any fuses substituted shall have equivalent Time/Current Curves and minimum interrupting capabilities as those specified above and must be approved by SMUD System Planning and the SMUD Standards Engineer.

**Notes:**

5) Backup fuses and Isolation links are not field-replaceable.

6) Dual rated, 4 x 12 kV, transformers shall be fused at the manufacturing facility in accordance with section 5.7.3. Suppliers shall supply the 4 x 12 kV transformers with the listed Bayonet fuse sizes for 4.16kV operation requirements along with the associated Isolation links. Suppliers shall also supply the 4 x 12 kV volt transformers with current limiting fuses as listing in the 12kV section of this table, for use when the transformers are operated in 12kV mode. The isolation links are switched into service when the transformers are operated at 4160v. The current limiting fuses are switched into service when the transformers are operated at 12 kV. Current limiting fuses shall have the same rating as for 12 kV transformers. SMUD personnel shall replace the BON fuses with the appropriate 12kV fuse cartridges when operating the 4 x 12 kV transformers in the 12kV mode.

## 5.8 ACCESSORIES AND MISCELLANEOUS

5.8.1 Insulated drip shields shall be supplied and installed on bayonet fuse assemblies to prevent oil damage to bushings. The drip shields shall be Cooper No. 4004352BO2 or SMUD approved equal.

5.8.2 Units rated 500 kVA and below shall be supplied with the following accessories:

- Upper filling plug and filter press connection.
- Combination drain, lower filter valve, and sampling device

5.8.3 Units rated 750 kVA and above shall be supplied with the following accessories:

- Liquid level gauge
- Pressure-vacuum gauge
- Upper filling plug and filter press connection
- Combination drain, lower filter valve, and sampling device
- Top oil thermometer

5.8.4 A suitable marking inside the tank shall indicate the correct oil level at 25$^{o}$C on all units.

5.8.5 An automatic/manual pressure relief device shall be provided that will operate to relieve tank pressure at approximately 10 +/-2 PSIG and reseal at 6 PSIG minimum on all units.

5.8.6 A hand hole suitable for current limiting fuse replacement shall be provided. Where a bolted cover is provided, a hand hole suitable for current limiting fuse replacement is not required.

## 5.9 TRANSFORMER LABELING

5.9.1 Bushing and fuse designations shall be marked by stenciled lettering on the tank. Decals will not be allowed.

5.9.2 An instruction nameplate of corrosion-resistant material shall be located in the low voltage compartment.

5.9.3 Nameplate information shall be consistent with ANSI IEEE C57.12.00.

5.9.4 Where natural ester-based dielectric oil is supplied, the transformer will be marked with a permanent decal designating the brand name of the fluid, and stipulating that the fluid is biodegradable.

5.9.5 The switch position on a 4 x 12 kV unit shall be marked with a stencil or by permanent decal.

# 6 TECHNICAL DOCUMENTATION TO BE SUBMITTED WITH BID

**6.1** Each bidder shall submit with their bid the following technical information on each rating of transformer:

a) A dimensioned outline drawing showing maximum overall dimensions, estimate base mounting dimensions, dimensions of compartments, and arrangement and estimated location of mounted devices, such as bushings, parking stands, relief valve, etc.

b) Transformer net weights (approximate)

c) The following performance data:
- Rating
- Temperature rise at rated load
- Guaranteed No-load and Guaranteed total losses
- Percent regulation at rated load - 100% power factor
- Percent regulation at rated load - 80% power factor
- Percent impedance

d) A statement certifying the transformer shall perform in accordance with the rating when using either mineral oil per section 5.6.3 a), or ester-based fluids per section 5.6.3 b) when shipped with ester-based insulating fluid.

e) A copy of the MSDS for the transformer insulating fluid.

f) Information of the fuses being supplied with the transformer including manufacturer, type, catalog number, and rating. In addition if the fuses submitted are different manufacturers than those specified in section 5.7.5 and time current curves for the load sensing and current limiting fuses shall be provided.

**6.2** When ester-based insulating fluids are required, the bidder shall submit with their bid the complete electrical, chemical, and physical characteristics of the supplied natural ester-based dielectric fluid proposed for use in the transformers, consistent with the requirements of section 5.6 of this specification. The bidder shall submit a current MSDS for the fluid to be supplied. If the fluid is other than Cooper Enviortemp® FR3™, the

bidder shall also provide:

a) certified test results and/or EPA reporting showing that the fluid is biodegradable, non-toxic, non-carcinogenic, and non-bioaccumulating, and

b) accelerated aging test results showing that the fluid will extend the life of transformer paper insulation.

The District will consider approval of the proposed fluid before bid award.

**6.3** The bidder shall be sufficiently experienced in the manufacture, delivery, and support for the equipment described in this specification. The bidder shall provide a list of customers, including an individual's name and contact information that have received similar equipment from the bidder.

**6.4** The manufacturer shall submit a copy of their quality assurance manual used in the manufacture of the equipment being supplied. The quality assurance information should include the certification process for welding performed by shop personnel.

**6.5** It shall be expressly understood that the technical information, as furnished by the successful bidder, shall constitute guarantees, with variance there from only insofar as allowable by applicable NEMA, IEEE, ASTM and ANSI Standard tolerances.

## 7 TESTING AND INSPECTION

**7.1** The applicable Design Tests in accordance with IEEE C57.12.00, C57.12.90 and C57.12.34 shall be successfully performed for all designs prior to shipment. The reports substantiating that the Design tests were successfully performed must be kept on file at the production facility for at least three years after delivery and be made available to SMUD upon request.

**7.2** Each transformer shall have passed the following routine tests in accordance with IEEE C57.12.34, C57.12.00, and C57.12.90 and ASTM requirements:

a) Resistance Measurements (for transformers 1000 kVA and above)

b) Ratio tests

c) Polarity and phase relation tests

d) No-load losses and excitation current tests

e) Load losses and impedance voltage

f) Low frequency dielectric test

g) In addition, on units larger than 500kVA, a routine impulse test shall be run in accordance with IEEE C57.12.90 section 10.4.

**7.3** A test report in electronic format (reference section 9.2 for approved formats) for all routine tests performed shall be supplied to the SMUD Standards Engineer for each unit to

be provided under this specification. Test reports should be delivered before the tested units are shipped, as this will be a basis for acceptance of the shipment. Test reports must be delivered to the SMUD Standards Engineer, identified in writing or in the bid document, via email.

**7.4** When ester based fluids are used other than Cooper Envirotemp® FR3™, the Bidder shall provide test results from the fluid manufacturer, as proof that the fluid meets the full requirements of Section 5.6 of this specification.

**7.5** The District, or its representative may at any time perform audits, inspections, or observe the supplier's operations. The supplier shall cooperate and provide access to documentation, manufacturing, or testing. The District's inspector shall be provided with full access to the facilities used for manufacturing.

a) These inspections do not relieve the Supplier of their responsibilities for full compliance with all the requirements of these specifications.

b) The District will notify the Supplier of any situation where the work is not in accordance with the requirements of these specifications.

**7.6** All costs incurred by the Supplier as a result of rejection of material shall be considered incidental to the work. No separate payment will be made.

## 8 SHIPPING AND PACKAGING

**8.1** All units to be shipped in open rack type flatbed trailers. Closed van type trailers are unacceptable and will be rejected. Stacking of object(s) on top of each enclosure is not permitted, unless previously approved in writing by the SMUD Standards Engineer.

**8.2** Units shall be mounted on a solid top wooden pallet, or other approved pallet, for ease of removal with a forklift truck from the side of the trailer. Pallets shall be of adequate size and construction to reduce risk of damage to transformers during loading, transport and unloading. Pallets shall not be modified during shipment.

**8.3** Units shall be protected during shipment so as to prevent damage to all exterior surfaces. All corners should be protected with a reinforced edging material to prevent chafing. Units showing damage to the paint finish are subject to rejection by SMUD and corrective action by the manufacturer.

## 9 DRAWINGS AND MANUALS

**9.1** Final Drawings and Manuals for each piece of equipment supplied shall be submitted to

the SMUD Standards Engineer for review and approval prior to the manufacturing or shipment. These shall include:

a) Detailed drawing of the unit showing final overall dimensions including radiators, foot print dimensions, clearance requirements, weight,

b) Exterior mounted devices including bushing and parking stand locations, fuses, relief valves, drain valves, and secondary terminations and supports (as applicable), etc.

c) Parts list including catalog numbers

d) Nameplate

e) Installation, Maintenance, and Operation Instructions

f) Recommended Spare Parts List

**9.2** An electronic version of the final documents shall be provided in Acrobat (*.pdf), Microsoft Word (*.doc), and/or AutoCAD (*.dwg) format to the SMUD Standards Engineer.

**9.3** All required submittals must be complete, of good quality, and approved by the SMUD Standards Engineer prior to the equipment manufacturing, shipment, acceptance, and payment.

## 10 MATERIAL AND DESIGN CHANGES

Following approval by the District of the specific design(s) and materials submitted to the District by the supplier, the supplier shall not make changes in such design(s) or materials without notification to the District approval by the SMUD Standards Engineer. Any necessary clarifications to this specification shall be made in writing from the SMUD Standards Engineer.

## 11 ATTACHMENTS

**11.1** Construction Standard UVD2.2, THREE PHASE TRANSFORMER PAD PRECAST,

**11.2** Construction Standard UVD2.3A, THREE PHASE TRANSFORMER PAD PRECAST FOR 2000 KVA OR LARGER

## 12 LOSS EVALUATION

**12.1** Each manufacturer shall submit with their bid the guaranteed no-load losses, and the guaranteed load losses (or guaranteed total losses) at rated kVA for each bid item submitted.

**12.2** Guaranteed losses will be evaluated by SMUD at the following rates to determine the

equivalent first cost for owning and operating each bid item:

| | |
|---|---|
| No-load losses | $ 5.90/W |
| Load losses (total losses minus no-load losses) | $ 1.06/W |

The equivalent first cost (sum of the price, California state sales tax, cost of no-load losses, and the cost of load losses) will be a criteria used to determine the lowest responsive bidder.

**12.3** The manufacturer shall test each transformer to determine no-load, load and total losses, in accordance with the requirements of ANSI C57.12.00 and C57.12.90. Test data shall be certified as correct and submitted to SMUD prior to or at the time of shipment. Test data should be submitted by e-mail to the SMUD Standards Engineer (or designee), and to the SMUD Material Coordinator. Data should be submitted in Excel spreadsheet (.xls) or comma delimited (.csv) format or other approved format.

In addition, certified test reports shall be sent under a separate cover to:

Sacramento Municipal Utility District
Supply Chain Services
ATTN: Procurement Professional, MS B203
P.O. Box 15830
Sacramento, CA 95852-1830

This address may be defined differently with notification from SMUD to the supplier.

**12.4** For long-term contracts the District will review tested transformer losses at the end of each calendar quarter. Otherwise, the District will review losses at the time of each order shipment. The District will compare the average of the certified test losses for each bid item, against the guaranteed average losses quoted in the bid.

Where the average of the tested no-load losses or load losses for a bid item exceeds the quoted bid item commitment, the Contractor will pay the evaluated total difference to the District. The costs of losses used for evaluating the total difference shall be in accordance with paragraph 12.2 of this specification.

**12.5** Bonuses will not be awarded for shipment of units with losses less than the guaranteed losses. Losses, and associated equivalent first costs, will not be balanced between shipments or calendar quarters, or between transformers with different ratings.

**12.6** Any transformer with no-load losses or total losses that exceed the guaranteed losses by more than the tolerances listed below may be rejected by SMUD:

| | |
|---|---|
| No-load losses | 10% |

Total losses at rated kVA 6%

The supplier must contact the SMUD Standards Engineer for approval prior to shipping any unit with tested losses that exceed the tolerances stated.

**12.7** The supplier shall contact the SMUD Procurement Specialist assigned to the contract before shipping any unit with tested losses that exceed the above tolerances. The District may reject such units. If SMUD accepts delivery of such units, the Contractor will be penalized at the following rates for all excess losses (tested losses minus guaranteed losses) for each unit accepted.

| | |
|---|---|
| No-load losses | $ 11.80/W |
| Load losses at rated kVA | $ 2.12/W |

ATTACHMENT 11.1

ATTACHMENT 11.2