

## Submersible-Type, Single-Phase, Natural Ester Fluid, Distribution Transformers



### 1. Scope

This standard details the manufacturer requirements for single-phase submersible transformers from 25 kVA to 167 kVA and certain accessories.

This standard applies to the following Seattle City Light (SCL) 25 564GrdY/14 760 single-phase SY transformer stock numbers:

kVA	120/240	138.5/277	240/480	Parallel-connected "cut straight" secondary 120/240 cut 120
25	362122	362622	362322	362822
50	362132	362632	362332	362832
75	362134	362634	362334	362834
100	362136	362636	—	362836
167	362142	362642	—	362842

See Section 6.15 for replacement leads for 25-75 kVA transformers.

### 2. Application

This class of transformers is typically installed in underground vaults. They are designed to be submerged continuously and are used to serve homes and small businesses. As of this publication, these units are the second most common transformer type installed annually in the SCL distribution system.

### 3. Industry Standards

Transformers shall meet the applicable requirements of the following industry standards:

**Department of Energy 10 CFR Part 431**; "Energy Efficiency Program for Certain Commercial and Industrial Equipment"

**IEEE C57.12.00-2010**; "Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers"

**IEEE C57.12.20-2011**; "Standard for Overhead Distribution Transformers, 500 kVA and Smaller"

**IEEE C57.12.23-2009**; "Standard for Submersible Single-Phase Transformers: 167kVA and Smaller"

**IEEE C57.12.90-2010**; "Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers"

**IEEE C57.147-2008**; "Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers"

**RCW 19.29.010, Rule 5 -2011**; *Revised Code of Washington*, Rules for Test Tag

**NEMA TR 1-1993 (R2000)**; "Transformers, Regulators, and Reactors"

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### 4. Conflict

Where conflict exists, the following order of precedence shall apply:

1. Seattle City Light purchase order (PO)
  2. City of Seattle General Terms and Conditions
  3. This standard
  4. Other industry standards.
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### 5. Ratings

#### 5.1 Kilovolt-Ampere Ratings

Kilovolt-ampere ratings shall comply with the requirements of IEEE C57.12.23, Section 5.2 and be 25, 50, 75, 100, 167 kVA, or as specified on the purchase requisition.

Kilovolt-ampere ratings shall be continuous and based on not exceeding a 55 °C average winding temperature rise.

The transformers shall have a temperature rise insulation system of 65 °C.

#### 5.2 Voltage Ratings

Voltage ratings shall be as follows, or as specified on the purchase requisition:

25 564GrdY/14 760 - 120/240 Volts

25 564GrdY/14 760 - 240/480 Volts

25 564GrdY/14 760 - 133/266 Volts

25 564GrdY/14 760 - 138.5/277 Volts

25 564GrdY/14 760 - 2400 Volts

## 6. Construction

### 6.1 General

Transformers shall be according to the requirements of IEEE C57.12.23 with the following clarifications and Figure 6.1, below:

- The BIL shall be 125kV per IEEE C57.12.23, Section 5.4.
- Polarity shall be subtractive.

**Figure 6.1. Transformer, showing location of the nameplate on the lid, kVA rating and fluid label**



### 6.2 High-Voltage Bushing Well

One of the high-voltage bushing wells listed below and the matching parking stand shall be supplied. Each bushing well shall be supplied with a tight fitting cap fixed in place with wire run between the bail tabs:

- Elastimold K1601PC-T1
- Central Moloney 702233-51.

### 6.3 Low-Voltage Terminals

Terminals shall be constructed per IEEE C57.12.23, Section 7.2.3. All low-voltage terminals shall be threaded stud type to facilitate easier secondary lead or spade replacement. Cables and studs shall meet the minimum size requirements in Section 7.2.3 and shall have a diameter not less than the cable sizes listed in the table. See Figure 6.3.

**Figure 6.3. Threaded low voltage terminal stud**



#### 6.3.1 Low-Voltage Leads for Transformers Rated 75 kVA or Less

Transformers rated 75 kVA or less shall be supplied with 4 low-voltage leads constructed per IEEE C57.12.23, Section 7.2.3.

Low-voltage cable leads shall have a minimum of 14 inches of flexible lead length.

#### 6.3.2 Low-Voltage Spades for Transformers Rated 100 kVA or more

Transformers rated 100 kVA or more shall be supplied with 4 low-voltage spades constructed per IEEE C57.12.23 Figure 2.

Transformers shall be supplied with a jumper connected to the X2 and X3 terminals. See Figure 6.3.2a.

**Figure 6.3.2a. Transformer with jumper connected to X2 and X3 terminals**



Transformers with "cut-straight" parallel-connected secondary terminals shall be supplied with 2 jumpers: one connected to the X1 and X3 terminals and one connected to the X2 and X4 terminals. See Figure 6.3.2b.

**Figure 6.3.2b. Cut straight parallel-connected transformer with jumpers connected to X1 and X3 terminals and X2 and X4 terminals**



### 6.3.3 Transformer Flat-Tinned Copper Braid Jumper

Jumpers can be purchased from Electric Motion Company (part number EMFB800-4-20), or manufactured. See Figure 6.3.3. Jumpers shall be covered with non-conductive hose material. See Figure 6.3.2b.

If manufactured, jumpers shall be constructed with 4 20-in lengths of flat-tinned copper braid (Continental Cordage 278, Stock No. 013491).

Jumpers shall be connected with 1-3/4 in bolts, 2 washers, and a lock washer and nut for each bolt. Hardware shall be silicon bronze.

**Figure 6.3.3. Flat-tinned copper braid jumper**



## 6.4 Accessories

Accessory equipment shall be provided per IEEE C57.12.23, Section 7.3 and located as shown in Figure 1 of that document.

## 6.5 Overcurrent Protection

Overcurrent protection shall be a cover-mounted Bay-O-Net assembly furnished with a dual sensing fuse as listed below. Isolation links shall not be installed because each transformer is protected upstream by a backup current limiting fuse.

### Cover-mounted Bay-O-Net fuse assembly:

Cooper Power Systems part no. 4001177B53MC

### Dual sensing Bay-O-Net fuse:

Transformer (kVA)	Cooper Power Systems Part No.	Amperes	Stock No.
25	4000358C05B	8	685101
50	4000358C08B	15	685102
75	4000358C08B	15	685102
100	4000358C08B	15	685102
167	4000358C10B	25	685103

## 6.6 Liquid Level Marking

Liquid level indication shall be provided per IEEE C57.12.23, Section 7.3.

## 6.7 Lifting Lugs

Lifting lugs shall be provided per IEEE C57.12.23, Section 7.6.

## 6.8 Enclosure Integrity

The completely assembled transformer enclosure shall comply with IEEE C57.12.23, Section 7.5.

## 6.9 Polarity, Terminal Markings, and Angular Displacement

Polarity, terminal markings, and angular displacement shall be according to the requirements of IEEE C57.12.23, Section 7.2.

Primary terminals, secondary terminals, and ground lugs shall be marked on the lid with minimum one-inch tall letters.

## 6.10 Nameplate

Nameplate shall be according to the requirements of IEEE C57.12.23, Section 7.4 with the following clarifications:

- Tested impedance shall appear on the nameplate.
- Class shall be KNAN.
- Total weight in pounds shall be indicated for each individual transformer.
- Volume in gallons and manufacturer of insulating fluid shall be indicated.
- Total weight in pounds of insulating fluid for each transformer shall be indicated.
- Manufacturer name and part number of the bay-o-net fuse assembly shall be indicated.
- Manufacturer name and part number of the dual sensing fuse shall be indicated.
- The statement "CONTAINS LESS THAN 1PPM PCB AT TIME OF MANUFACTURE." shall appear on the nameplate, as shown in Figure 6.10.

**Figure 6.10. Nameplate, PCB statement**

CONTAINS LESS THAN 1PPM PCB  
AT TIME OF MANUFACTURE.



## 6.11 KVA Rating

The kVA rating shall be marked on the tank and comply with IEEE C57.12.20, Section 7.3.5.

## 6.12 Fluid

Natural ester insulating fluid complying with IEEE C57.147 shall be provided in the transformer up to the liquid level marking. Fluid shall be Cargill Envirottemp FR3.

Each transformer shall have an FR3 label. Locate label on the transformer lid between the X3 and X2 bushings. See Figure 6.13.1.

## 6.13 Tank

Tank shall meet all the integrity requirements of IEEE C57.12.23, Section 7.5.

### 6.13.1 Covers

Cover shall comply with IEEE C57.12.23, Section 7.6 and be completely welded, with no handholes.

Any cover penetrations that cannot be welded shall be sealed with a liquid pipe thread compound such as Rectorseal, liquid Teflon, or similar, not Teflon tape.

Provide 7 in by 12 in clear space on the cover for label installation by Seattle City Light. See Figure 6.13.1. Locate the nameplate, FR3 label, and other hardware on the cover to avoid clear space. Locate other labels and warnings on the side of the transformer as necessary.

**Figure 6.13.1. Tank Cover with Clear Space, FR3 Label, and Nameplate**



### 6.13.2 Tank Material and Finish

Tank material and finish shall comply with IEEE C57.12.23, Sections 7.1 and 7.6 and per Table 6.13.2.

**Table 6.13.2. Tank Material and Finish**

	Tank Material	
	Stabilized Ferritic 409 Stainless Steel	Austenitic 304L Stainless Steel
Paint		
Coating with Light Gray Number 70 Munsell Notation 5BG 7.0/0.4	Required	Optional
Thickness	3 mil	1 coat

### 6.13.3 Tank Grounding

Tank grounding provision shall comply with IEEE C57.12.23, Section 7.6.

### 6.14 Dimensions

Each unit including all accessories shall not exceed a maximum height of 58 in.

Each unit including all accessories shall meet the diameter requirements defined in IEEE C57.12.23, Section 7.1 and be capable of being lowered into a 29 in x 29 in square hatch.

### 6.15 Accessories

#### Replacement Secondary Leads for 25 kVA—75 kVA Transformers

**Description:** Used when transformers are returned from the field in working order but are in need of secondary leads to replace damaged ones.

**Manufacturer:** Carte

Stock No.	Transformer (kVA)	Cable Size	Catalog No.
014258	25	2/0	2652533A09
014259	50	4/0	2652533A10
014260	75	500 kcmil	2652533A01

## 7. Tests

### 7.1 General

All applicable tests shall be performed as specified in IEEE C57.12.00 and in IEEE C57.12.90.

### 7.2 Dielectric Tests

Dielectric tests shall be performed as specified in IEEE C57.12.23, Section 6.2 and IEEE C57.12.90, Section 10. Dielectric test levels shall be in accordance with the levels specified in IEEE C57.12.00, Section 5.10.

### 7.3 Tank Design Tests

Tests shall be performed as specified in IEEE C57.12.23 Section 6.5.

### 7.4 Short Circuit Tests

Short circuit tests shall be performed as specified in IEEE C57.12.90, Section 12.

### 7.5 Audible Sound Levels

Audible sound levels for each unit shall be according to the requirements of NEMA TR-1, Section 0.05. Tests shall be performed per IEEE C57.12.90, Section 13.

### 7.6 Radio Influence Voltage Test

Radio influence voltage shall be according to the requirements of NEMA TR-1, Section 0.03.

### 7.7 Load and No-Load Tests

Load and no-load loss measurements shall be performed and corrected to 85°C and 20°C, respectively, according to the requirements of IEEE C57.12.00, Section 5.9 and shall comply with IEEE C57.12.90.

### 7.8 Documentation

Tests reports demonstrating conformance to all tests completed shall be submitted in a single electronic document.

All documentation shall be in English and use customary inch-pound units.



## 7.9 Test Tag

A weatherproof test tag conforming to the requirements of the Revised Code of Washington RCW 19.29.010, Rule 5 shall be firmly attached to each unit.

Tag shall read "THIS TRANSFORMER HAS BEEN SUBJECTED TO AN INSULATION TEST IN ACCORDANCE WITH THE STANDARDIZED RULES OF IEEE/ANSI. THIS TRANSFORMER HAS BEEN TESTED AT RATED LINE VOLTAGE."

Tag shall indicate:

- Transformer serial number
- Date on which the test was performed
- Name of the person who performed the test.

**Figure 7.9. Test tag**



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## 8. Shipping and Handling

Each transformer shall be supplied on its own pallet.

### 8.1 Pallet Material

Pallet and all pallet accessories shall be constructed of unpainted wood and suitable for yard storage through all weather conditions.

### 8.2 Support

Pallet supplied shall accommodate lifting by both forklifts and pallet jacks:

- Pallet shall be a minimum of 4 inches tall
- The most central pallet stringer shall be centered and a maximum of 7 inches wide.

The bottom of each pallet shall be open or have 8-in openings. See Figure 8.2.

**Figure 8.2. Pallets**



### 8.3 Orientation

Transformer shall be centered on pallet and banded to pallet via its lifting lugs. Transformer shall be oriented on the pallet with secondary terminals perpendicular to the forklift entrance to prevent accessories (secondary terminals, support lugs, etc.) from coming into contact with pallet moving equipment. See Figure 8.3. If accessories are near edge of pallet, enclose them with protective devices to prevent damage.

**Figure 8.3. Orientation**



### 8.4 Arrival Condition

Transformers shall be delivered on enclosed trucks.

Transformers shall be received by Seattle City Light in clean condition.

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## 9. Seattle City Light Processes

### 9.1 Bid Process

Bid process details are available at [www.seattle.gov](http://www.seattle.gov).

Bid documentation shall be submitted with details demonstrating conformance to this standard. Submittal details shall be listed to correspond with this standard's section formatting.

Any exceptions taken to the standard shall be summarized in an attached letter, complete with section numbering relating to this standard. Requests for approved equal components must be submitted with first bid documents; all subsequent requests will be rejected.

### 9.2 Loss Factors

Load and no-load loss measurements shall be performed per Section 7.7.

#### 9.2.1 Load Loss

Load losses shall be assessed at \$2.60 per watt.

#### 9.2.2 No-load Loss

No-load "core" losses shall be assessed at \$5.90 per watt.

### 9.2.3 Loss Assessment

Total Price (\$) = Bid Price + Loss Total

Loss Total = Load Loss + No-load Loss

Load Loss = Losses (Watts) x \$2.60

No-load Loss = Losses (Watts) x \$5.90

The manufacturer will be assessed a penalty for transformers delivered that exceed the total loss value stated and calculated on the bid proposal. The penalty shall be the difference between the total loss values delivered less the total loss value in the bid proposal.

Loss penalties will be calculated on the basis of the average tested losses of all transformers of a given SCL stock code built to a given SCL purchase order.

Tolerances will be allowed in accordance with IEEE C57.12.00, Section 9.3, except, tolerances shall apply to transformers of a given size and voltage; i.e., one line item. Individual transformers that exceed these tolerances may be rejected and returned to the manufacturer.

### 9.3 Bid Completion

Upon completion of the bidding process, the successful bidder shall submit in a single electronic file the following:

- Transformer dimensions
- Nameplate
- Loss data
- Instructional materials demonstrating the proper installation, operation, and maintenance of the equipment
- Certified test data for each transformer type bid and for every category listed in IEEE C57.12.00, Section 8.7. Format test data using numbering system shown in IEEE C57.12.00, Section 8.7.

### 9.4 Inspection and Electrical Testing

Upon delivery, the transformers will be inspected for physical defects and conformance to this standard.

The transformers will be tested electrically for radio influence voltage (per NEMA TR-1, Section 7 at 1MHz and 17.4kV, RIV not to exceed 100 microVolts), losses and a small battery of other tests.

If any transformers fail, the manufacturer will be contacted and given the option to return the lot or return the lot except the units that passed during initial testing.

### 9.5 Guarantee

Any transformer failing due to defective design, material, and/or workmanship within 12 months after being energized or 18 months after delivery, shall be repaired or replaced without cost to the City of Seattle. Any defect discovered within this period shall be corrected on all transformers furnished on the order at the manufacturer's expense, either by repair or replacement.

## 10. Approved Manufacturers and Factories

Manufacturer	Factory
Power Partners	Athens, Georgia, USA
Carte International	Winnipeg, Manitoba, Canada
Central Moloney	Pine Bluff, Arkansas, USA
Howard Industries	Laurel, Mississippi, USA

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## 10. Sources

**Hanson, Brett**; SCL Standards Engineer; subject matter expert and originator of 4320.00  
(brett.hanson@seattle.gov)

**SCL Material Standard 0026.1** (canceled); "Distribution Transformer, Single-Phase,  
Subsurface-Type, Natural Ester Fluid"