

**Submersible-Type, Single-Phase and Three-Phase,  
 Natural Ester Fluid, Specialty Transformers**



**1. Scope**

This standard provides the manufacturer requirements for underground, single-phase specialty transformers and three-phase auto-transformers from 25 kVA to 225 kVA. Seattle City Light (SCL) stock numbers are as listed in Tables 1.1 and 1.2.

**Table 1.1. Single-Phase Specialty Transformers**

kVA	High Voltage		Low Voltage	Taps
	125/216Y	277/480Y		
25	390001	390048	125/250	5
50	390002	390049	125/250	5
75		390050	125/250	5
100	390004	390051	125/250	3
167	390005	390055	125/250	0

**Table 1.2. Three-Phase Auto-Transformers**

kVA	High Voltage		Low Voltage	Taps
	480Y/277	216Y/125		
30	391124	216Y/125	216Y/125	5
45	391130	216Y/125	216Y/125	5
75	391134	216Y/125	216Y/125	5
112.5	391138	216Y/125	216Y/125	5
150	391140	216Y/125	216Y/125	5
225	391146	216Y/125	216Y/125	5

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## 2. Application

This class of transformers is used in network areas and installed in underground vaults. They are designed to be submerged under water continuously and are used to serve existing homes and small businesses whose services still connect at 125/250 V. It is no longer a standard practice to provide 125/250 V service for new buildings. As of this publication, these units represent a small percentage of the transformers installed annually in the SCL distribution system.

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## 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: 167 kVA and Smaller”

**IEEE C57.12.24-2009**; “Standard for Submersible Three-Phase Transformers, 3750 kVA and Smaller”

**IEEE C57.12.28-2005**; “Standard for Pad-Mounted Equipment – Enclosure Integrity”

**IEEE C57.12.40-2011**; “IEEE Standard for Secondary Network Transformers, Subway and Vault Types (Liquid Immersed)”

**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”

There is currently no single industry standard for single-phase isolating transformers and three-phase auto transformers connected to a network.

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## 4. Guidance in Case of Conflict

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

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

## 5. Ratings

### 5.1 Kilovolt-Ampere Ratings

Kilovolt-ampere ratings shall comply with the requirements of IEEE C57.12.23, Section 5.2. They shall be 25, 30, 45, 50, 75, 100, 112.5, 150, 167, or 225 kVA, or as specified on the purchase requisition.

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

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.

- 125/216Y - 125/250 Volts
- 277/480Y - 125/250 Volts
- 480Y/277 - 216Y/125 Volts.

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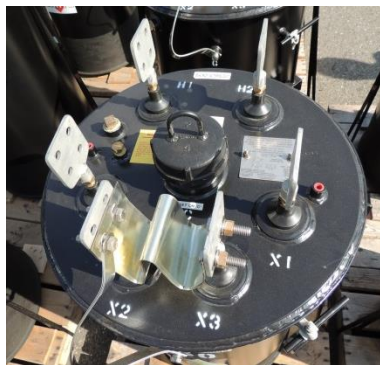
## 6. Construction

### 6.1 General

Transformers shall be constructed according to the requirements of IEEE C57.12.23 and IEEE C57.12.24 with the clarifications below and in Figures 6.1a and 6.1b.

- The BIL shall be 30 kV per IEEE C57.12.00, Table 4.
- Polarity shall be additive.
- Transformers shall be suitable for continuous submerged operation per IEEE C57.12.24 Section 4.2.
- Terminals and accessories shall be located as shown in Figures 6.1a and 6.1b.

**Figure 6.1a. Single-Phase Specialty Transformer Showing Location of the Terminals and Accessories**



**Figure 6.1b. Three-Phase Transformer Showing Location of the Terminals and Accessories**



## 6.2 High-Voltage Terminals

Terminals shall be constructed according to the requirements of IEEE C57.12.23, Section 7.2.3. All terminals shall be threaded stud type to facilitate spade replacement. See Figure 6.2.

**Figure 6.2. Threaded Terminal Stud**



## 6.3 Low-Voltage Terminals

Terminals shall be constructed according to the requirements of IEEE C57.12.23, Section 7.2.3 with the clarifications listed below:

- All terminals shall be threaded stud type to facilitate secondary lead or spade replacement. See Figure 6.2.
- Transformers shall be supplied with four low-voltage spades constructed according to the requirements of IEEE C57.12.23 Figure 2.

## 6.4 Taps

A full-capacity de-energized tap changer shall be supplied and located as shown in Figures 6.1a and 6.1b. Units shall be shipped with the tap changer set to the nominal (center) tap.

Taps shall comply with the specific tap voltages listed in Tables 6.4a, 6.4b, and 6.4c. Ideally, these transformers would have five taps in 2.5-percent increments with the center position at 480/277V, but because this cannot be consistently achieved in units of this design, the following criteria shall be followed.

1. Set the center tap close to 277.0V. The acceptable range is 276.8 – 280.0.
2. Keep tap offsets close to 2.5% and 5% above the center tap voltage. If the windings don't allow for these offsets, focus attention on the taps above 277V and try to approach +2.5% and +5% taps.

**Table 6.4a. Taps for Single-Phase 125/216Y Transformers**

Stock No.	kVA	Taps				
		A	B	C	D	E
TBD						

**Table 6.4b. Taps for Single-Phase 277/480Y Transformers**

Stock No.	kVA	Taps				
		A	B	C	D	E
TBD						

**Table 6.4c. Taps for Three-Phase 480Y/277 Transformers**

Stock No.	kVA	Taps				
		A	B	C	D	E
391124	30	505Y/291.7	493Y/284.7	481Y/277.8	469Y/270.8	457Y/263.9
391130	45	503Y/290.5	492Y/283.8	480Y/277	468Y/270.3	456Y/263.5
391134	75	503Y/290.3	496Y/286.3	482Y/278.2	468Y/270.2	461Y/266.1
391138	112.5	503Y/290.2	487Y/281.3	479Y/276.8	472Y/272.3	456Y/263.4
391140	150	502Y/289.8	492Y/284.1	482Y/278.4	472Y/272.7	462Y/267
391146	225	505Y/291.7	493Y/284.7	481Y/277.8	469Y/270.8	457Y/263.9

The tap changer shall be accessible through a pipe nipple welded to the cover and enclosed by a pipe cap. A tap position indicating plate shall be provided. A stainless-steel tap changer wrench shall be provided in a holder mounted near the tap changer.

**Figure 6.4. Tap Changer Access and Wrench**



### 6.5 Liquid-Level Marking

Liquid-level indication shall be provided according to the requirements of IEEE C57.12.23, Section 7.3.

### 6.6 Lifting Lugs

Lifting lugs shall be provided according to the requirements of IEEE C57.12.23, Section 7.6.

### 6.7 Enclosure Integrity

The tank shall meet the integrity requirements of IEEE C57.12.40, Section 5.3 and IEEE C57.12.32.

### 6.8 Polarity, Terminal Markings, and Angular Displacement

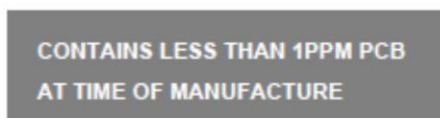
Polarity, terminal markings, and angular displacement shall be according to the requirements of IEEE C57.12.23, Section 7.2. Primary terminals, secondary terminals, and ground lugs shall be marked on the lid with letters at least one inch tall.

### 6.9 Nameplate

A nameplate shall be provided that meets the requirements of IEEE C57.12.40, Section 9 and IEEE C57.12.00, Section 5.12 (Nameplate C for all kVA ratings) with the following clarifications:

- Nameplate shall be 300-series stainless steel and affixed to the transformer with stainless steel or silicon bronze fasteners.
- Class shall be KNAN.
- BIL shall be listed.
- Impedance shall be listed.
- Tested X/R ratio shall be listed.
- Total weight in pounds shall be indicated for each transformer.
- Volume of insulating fluid shall be indicated in US gallons.
- Vector diagram for three-phase transformers shall be included.
- Tap voltages shall be listed.
- Tank design pressures shall be listed to comply with Section 6.12 of this document.
- The statement "CONTAINS LESS THAN 1PPM PCB AT TIME OF MANUFACTURE." shall appear on the nameplate.

**Figure 6.9. Nameplate, PCB Statement**



## 6.10 KVA Rating

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

## 6.11 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 Cooper Envirotemp FR3. Each transformer shall have a minimum five-inch-diameter label indicating the fluid brand.

## 6.12 Tank

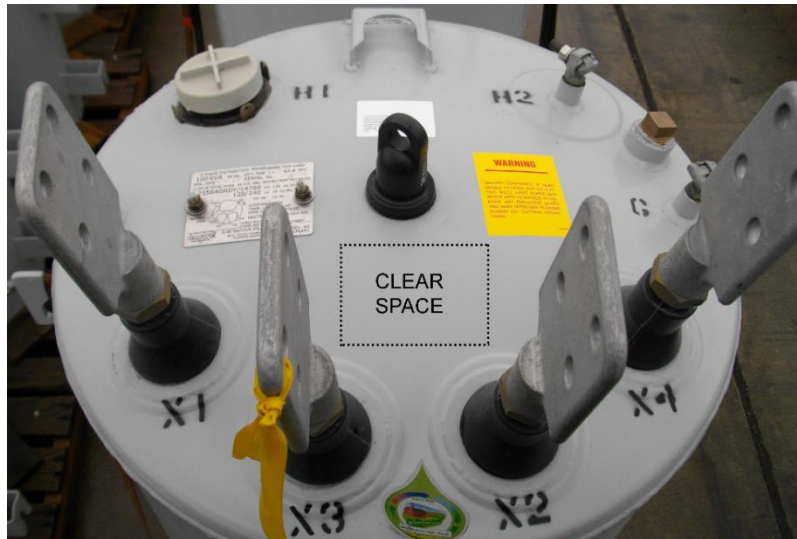
The tank shall meet the requirements of IEEE C57.12.40, Section 5.2 and IEEE C57.12.28.

### 6.12.1 Covers

Provide 7 in by 12 in clear space on the cover for label installation by Seattle City Light. See Figure 6.12.1. 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.

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.

**Figure 6.12.1. Tank Cover with Clear Space, FR3 Label, and Nameplate**



### 6.12.2 Tank Material and Finish

The tank shall be constructed of 304L stainless steel and comply with the requirements of IEEE C57.12.40 Section 5.2.1 Subway Type.

The tank finish shall comply with IEEE C57.12.28 and be black if paint is used.

### 6.12.3 Grounding

Single-phase transformer tank grounding shall comply with C57.12.23, Section 7.6, except a total of three ground bosses and connectors shall be provided: two on the tank wall near the primary terminals and one on the tank wall near the secondary terminals. A removable ground strap, sized for the short-circuit rating of the transformer, shall be provided and connected between the neutral terminals and the secondary ground pad. See Figure 6.12.3a.

**Figure 6.12.3a. Single-Phase Ground Lug**



The three-phase transformer tank grounding provision shall comply with IEEE C57.12.24, Section 7.5.9 (b) with a two-hole pad near the low-voltage terminals. A removable ground strap, sized for the short-circuit rating of the transformer, shall be provided and connected between the neutral terminals and the secondary ground pad. See Figure 6.12.3b. Two additional ground bosses and connectors that comply with C57.12.23, Section 7.6, shall be provided: one on the tank wall near the primary terminals and one on the tank wall near the secondary terminals. Unused tapped holes shall be coated with oxide-inhibiting compound and plugged.

**Figure 6.12.3b. Three-Phase Ground Terminal**



### 6.12.4 Strength

The tank shall be designed to withstand negative and positive 7 psig as specified in IEEE C57.12.24 Section 7.5.2. Each transformer shall be leak tested per IEEE C57.12.24 Section 7.5.2.

### 6.13 Dimensions

Each unit including all accessories shall not exceed a maximum height of 60 inches.

Each unit including all accessories shall be capable of being lowered into both a 28- by 40-inch rectangular hatch and 40-inch-diameter round opening.



## 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. Units shall be tested on a design basis with 7 psig negative for 30 seconds. Units shall be tested on a routine basis with 7 psig positive for 6 hours. Any permanent deformation is a failure and will be rejected.

### 7.4 Short-Circuit Tests

Short-circuit tests shall be performed as specified in IEEE C57.12.90, Section 12 on a design basis.

### 7.5 Audible Sound Levels

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

### 7.6 Radio Influence Voltage Test

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

### 7.7 Load and No-Load Loss Tests

Load and no-load loss measurements shall be corrected to 85 degree C and 20 degree 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.

The 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."

The 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 example



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## 8. Design Changes

The manufacturer shall inform Seattle City Light in writing of all design changes that could affect the transformer's understood or published capabilities.

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## 9. Shipping and Handling

Each transformer shall be supplied on its own pallet.

### 9.1 Pallet Material

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

### 9.2 Support

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

- Pallet shall be minimum 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-inch openings. See Figure 9.2.

**Figure 9.2.** Pallet



### 9.3 Orientation

The transformer shall be centered on the pallet and banded to the pallet through its lifting lugs. The transformer shall be oriented on the pallet to prevent transformer accessories (secondary terminals, support lugs, etc.) from coming into contact with pallet moving equipment, or the accessories shall be enclosed by protective devices to prevent damage.

#### 9.4 Shipping and Arrival Condition

Transformers may be delivered on enclosed or covered flatbed trucks. If transformers are delivered on flatbed trucks, they shall be side-loaded. Because Washington State law requires a 10-inch minimum side board when driving a forklift or pallet jack onto the bed of a truck or trailer, most flatbed trucks or trailers must be side-loaded to facilitate offloading.

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

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### 10. Seattle City Light Processes

#### 10.1 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. Bids shall be organized to correspond with the sections of this standard.

Any exceptions taken to the standard shall be summarized in an attached letter with references to the numbers of affected sections in this standard. Requests for approved equal components must be submitted with first bid documents; all subsequent requests will be rejected.

#### 10.2 Loss Factors

Load and no-load loss measurements shall be performed according to the requirements of Section 7.7.

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

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

**Loss Assessment:**

$$\text{Total Price (\$)} = \text{Bid Price} + \text{Loss Total}$$

$$\text{Loss Total} = \text{Load Loss} + \text{No-load Loss}$$

$$\text{Load Loss} = \text{Losses (Watts)} \times \$2.60$$

$$\text{No-load Loss} = \text{Losses (Watts)} \times \$5.90$$

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.

#### 10.3 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.

#### 10.4 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.

#### 10.5 Guarantee

Any transformer failing due to defective design, material, and/or workmanship within 12 months after being energized or 18 months after delivery, whichever period is shorter, 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.

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#### 11. Issuance

Stock Unit: EA

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#### 12. Approved Manufacturers and Factories

<b>Manufacturer</b>	<b>Factory</b>
Carte International	Winnipeg, Manitoba, Canada

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#### 13. References

**Hanson, Brett**; SCL Standards Engineer; subject matter expert and originator of 4410.00 (brett.hanson@seattle.gov)

**SCL Material Standard 0039.0 (canceled)**; "Specialty Transformer, Liquid-Immersed, Submersible One-Phase and Three-Phase, 25 Through 225 kVA"