Functional specification for Triplex Indoor Power Centers (IPC) 750–2500 kVA

1.0 Scope

1.1. This specification covers the electrical and mechanical characteristics of Eaton's Cooper Power series 750 – 2500 kVA Triplex Indoor Power Centers (IPC). These triplex designs shall be a three-phase transformer assembly consisting of three single-phase transformers connected into one complete assembly. Product is per catalog data CA202001EN.

1.2. The Triplex IPC shall be a three-phase assembly engineered to be constructed and interconnected in the field.

2.0 Applicable Standards

2.1. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following IEEE®, Department of Energy, and NEMA® standards.

IEEE Std C57.12.00™-2010 – IEEE Standard for Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE Std C57.12.28™-2014 – Sections 5.3, 5.4, 5.5 – Coating System Requirements

IEEE Std C57.12.36™- 2007 – IEEE Standard Requirements for Liquid-Immersed Distribution Substation Transformers

IEEE Std C57.12.70™-2011 – IEEE Standard for Terminal Markings and Connections for Distribution and Power Transformers

IEEE Std C57.12.90™-2010 – IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and IEEE Guide for Short-Circuit Testing of Distribution and Power Transformers

NEMA® TR 1-1993 (R2000) – Transformers, Regulators and Reactors, Table 0-2 Audible Sound Levels

10 CFR Part 431 – Department of Energy–Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule

3.0 **Ratings**

3.1. The three-phase Triplex IPC assembly shall be designed in accordance with this specification and the base kVA rating shall be one of the following:

750, 1000, 1500, 2000 or 2500

3.2. The high voltage and the basic lightning impulse insulation level (BIL) shall be selected from Table 1.

OR

The transformer shall have a dual high voltage to be reconnected with an externally operable, de-energized switch. The voltages provided and the basic lightning impulse insulation level (BIL) shall be chosen from Table 1 and shall not exceed a 3:1 ratio.

OR

The high voltage and the basic lightning impulse insulation level (BIL) shall be specified on the data sheet. The high voltage shall not exceed 15 kV.

Table 1 – High voltage ratings and BIL

High voltage ratings (volts)	Basic impulse insulation level – BIL (kV)
2400 Delta	45
4160 Delta	60
4800 Delta	60
7200 Delta	75
12000 Delta	95
12470 Delta	95
13200 Delta	95
13800 Delta	95
14400 Delta	95
4160GrdY/2400	60
8320GrdY/4800	75
12470GrdY/7200	95
13200GrdY/7620	95
13800GrdY/7970	95

* Note to specifier – The above table is not intended to list every voltage available.

3.3. The low voltage and the basic lightning impulse insulation level (BIL) shall be chosen from Table 2.

Table 2 – Low voltage ratings and BIL

Low voltage ratings (volts)	Basic impulse insulation level – BIL (kV)
208Y/120	30
480Y/277	30
575Y/332	30
600Y/347	30
690Y/398	30
240 Delta	30
480 Delta	30
240 Delta with 120 Mid-Tap	30
480 Delta with 240 Mid-Tap	30

* Note to specifier – The above table is not intended to list every voltage available.

3.4. One of the following shall indicate the high voltage and low voltage connections of the transformer. If a special connection is required it shall be requested on the inquiry.

[ ] Delta - Wye
For Delta - Wye configurations the low voltage neutral shall be a fully insulated X_o bushing. The low voltage shall lag the high voltage by 30°.

[ ] Delta - Grounded Wye
For Delta - Grounded Wye configurations the low voltage neutral shall be a fully insulated X_o bushing with ground strap. The low voltage shall lag the high voltage by 30°.

[ ] Delta - Delta
For Delta - Delta configurations the transformer shall be provided without a neutral bushing. There shall be no phase shift between the high voltage and low voltage.

[ ] Grounded Wye - Wye
For Grounded Wye - Wye configurations the high voltage neutral shall be internally tied to the low voltage neutral and brought out as the H_oX_o bushing. There shall be no phase shift between the high voltage and low voltage.

[ ] Wye - Grounded Wye
For Wye - Grounded Wye configurations the high voltage neutral shall be brought out as the H_o bushing on the high voltage side and the low voltage neutral shall be brought out as the X_o bushing with ground strap on the low voltage side. There shall be no phase shift between the high voltage and low voltage.

[ ] Wye - Delta
For Wye - Delta configurations the high voltage neutral shall be brought out as the H_o bushing on the high voltage side. The low voltage shall lag the high voltage by 30°.

3.5. Each single-phase transformer shall be furnished with full capacity high-voltage taps. The tap-changer shall be clearly labeled to reflect that the transformer must be de-energized before operating the tap-changer as required in Section 4.3 of IEEE Std C57.12.34™-2009 standard. The tap-changer shall be operable on the higher voltage only for transformers with dual high voltages. The unit shall have one of the following tap configurations:

[ ] Two – 2 ½% taps above and below rated voltage (split taps)
[ ] No Taps
[ ] Four – 2 ½% taps below rated voltage (four below)
[ ] NEMA® taps (14400, 13800, 13200, 12870, 12540)
[ ] Non-standard tap configuration: _____

3.6. The dielectric coolant shall be listed less-flammable fluid meeting the requirements of National Electrical Code® Section 450-23 and the requirements of the National Electrical Safety Code® (IEEE Std C2™-2002 standard), Section 15. The dielectric coolant shall be non-toxic*, non-bioaccumulating and be readily and completely biodegradable per EPA OPPTS 835.3100. The base fluid shall be 100% derived from edible seed oils and food grade performance enhancing additives. The fluid shall not require genetically altered seeds for its base oil. The fluid shall result in zero mortality when tested on trout fry *. The fluid shall be certified to comply with the US EPA Environmental Technology Verification (ETV) requirements, and tested for compatibility with transformer components. The fluid shall be Factory Mutual Approved®, UL® Classified Dielectric Medium (UL-EOUV) and UL® Classified Transformer Fluid (UL-EOVK), Envirotemp™ FR3™ fluid.
*(Per OECD G.L. 203)

3.6.1. The transformer, filled with Envirotemp™ FR3™ fluid, shall have a 65°C average winding temperature rise rating. The above winding temperature rise shall not exceed 65°C when loaded at base kVA rating.

OR

The transformer, filled with Envirotemp™ FR3™ fluid, shall have a 55/65°C average winding temperature rise rating. The above winding temperature rise shall not exceed 55°C when loaded at base kVA rating. The transformer shall provide an additional 12% continuous operating capacity at the 65°C rating.

(**Note:** For additional PEAK (75°C) ratings please refer to PS202010EN)

3.7. The percent impedance voltage, as measured on the rated voltage connection, shall be per Table 5 of IEEE Std C57.12.36™-2007 standard.

3.8. The transformer shall be cooled by the natural circulation of air over the tank surface and any corrugate or radiators if required, allowing only the base kVA rating shall be provided with Class KNAN.

3.9. UL® Listing/Classification and FM® Approval

3.9.1. Each single-phase transformer shall be UL® Listed (certifying compliance with IEEE® standards only) per UL® XPLH.

3.9.2. Each single-phase transformer shall be combination UL® Listed & Classified to comply with NEC® 450-23 listing restrictions for installations on, near, or inside of buildings per UL® XPLH.

OR

Each single-phase transformer shall be FM® Global (FM) Approved to comply with NEC® 450-23 listing restrictions for installations on, near, or inside of buildings.

4.0 **Construction**

4.1. The core and coil shall be vacuum processed to ensure maximum penetration of insulating fluid into the coil insulation system. While under vacuum, the windings will be energized to heat the coils and drive out moisture, and 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 corner 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.

4.2. Each single-phase transformer shall be provided with a containment pan designed to contain 100% of the fluid within that transformer.

4.3. Panel type, removable radiators, complete with flanged shut off valves on the tank side shall be provided. Welded radiators are not acceptable.

4.4. Each tank must be welded using precision cut, cold-rolled steel plate and equipped with extra-heavy duty, welded-in-place lifting lugs and jacking provisions. The tank base must be designed to allow skidding or rolling in any direction.

4.5. The transformers shall be of sealed tank construction of sufficient strength to withstand a pressure of 7 psig without permanent distortion, and 15 psig without rupturing.

4.6. Each tank shall include a pressure relief device as a means to relieve pressure in excess of pressure resulting from normal operation. The venting and sealing characteristics shall be as follows:

Cracking Pressure: 10 psig +/-2 psig
Resealing Pressure: 6-psig minimum
Zero leakage from reseal pressure to -8 psig
Flow at 15 psig: 500 SCFM minimum

4.7. Each tank shall be cleaned with an alkaline cleaning agent to remove grease and oil. An iron phosphate coating shall then be chemically bonded to the metal to assure coating adhesion and retard corrosion. The tank shall be primed with an electrodeposited powder epoxy to provide a barrier against moisture, salt, and corrosives. The top-coat shall be a liquid polyurethane coating to seal and add ultraviolet protection. The tank coating shall meet all requirements in IEEE Std C57.12.28™-2014 standard. The exterior of the unit shall be painted ANSI® 61 or ANSI® 70 gray. If a special paint color is required, a federal spec number or paint chip must be provided at the time of order.

4.8. Flexible conduit runs for all control wiring shall be limited to a maximum of 60 inches. All conduit runs exceeding 60 inches shall be enclosed in metal raceway or rigid conduit.

4.9. The primary and secondary connections between each single-phase transformer incorporated into the Triplex assembly shall be externally re-connectable in the field

4.9.1. The high voltage and low voltage interconnections within the Triplex assembly shall be electrically isolated from each other.

4.10. At the specifier's option the high voltage and low voltage terminations shall each be enclosed in full or partial height air terminal chambers configured for:

[ ] Side entry – For direct connection to metal clad switchgear, metal enclosed switchgear, or other adjacent equipment (required with the primary air disconnect switch option).

[ ] Top entry – For accommodating cable glands, conduit hubs, or bus duct which may be adapted to match the top of the chimney for bus termination. A lift-off front panel is included.

[ ] Bottom entry – For underground feeds and to accommodate arresters. A lift-off panel is included.

4.11. Each tank shall be complete with an anodized aluminum laser engraved nameplate. This nameplate shall meet IEEE Std C57.12.00™-2010 standard for Nameplate B. An additional nameplate shall be supplied for the entire three-phase assembly rating.

4.12. High voltage bushings and terminals

4.12.1. Each single-phase transformer shall be provided with cover-mounted, electrical grade high-voltage bushings rated for full three-phase duty.

4.13. Low voltage bushings and terminals

4.13.1. The low-voltage line and neutral bushings shall be cover-mounted, molded epoxy bushings with NEMA® spades.

4.14. Overcurrent protection and switching

4.14.1. The optional overcurrent protection scheme provided with the transformer shall consist of one of following attributes. If for any reason a special protection scheme is required it shall be clearly stated on the inquiry.

[ ] Primary Air Load-break Switch ((5, 15, 25, & 35 kV) 600 A) shall be provided that is in accordance with IEEE Std C37.20.3™-2013 standard and NEMA® SG-5. The switch shall include an EPR-insulated copper cable transition and provisions for mounting surge arresters. The switch shall be a three-pole, two-position gang operated air interrupter to include a manual stored energy mechanism for ease of operation. The switch shall be enclosed in modular self-supporting, bolted design including an electrostatically applied paint finish exceeding IEEE Std C37.20.3™-2013 standard. A 500 W cabinet heater shall be provided. A 1200 A Primary Air Load-break Switch is available as an option. **Note:** The transformer must be specified as Side Entry in order to provide the primary load-break switch.

[ ] The transformer primary switch shall be non-fused. It shall include a copper bus transition to the transformer. **Note:** Copper bus transition required when full load current exceeds 600 A.

[ ] The transformer primary switch shall include non-disconnect power fuses.

[ ] The transformer primary switch shall include disconnect power fuses.

[ ] The transformer primary switch shall include current-limiting non-expulsion power fuses.

4.15. Overvoltage Protection

4.15.1. The overvoltage protection scheme provided with the transformer shall consist of one of the following attributes. If for any reason a special protection scheme is required it shall be clearly stated on the inquiry. **Note:** Arresters are mounted inside a primary air load-break switch. A full height air terminal chamber must be selected if a primary air load-break switch is not.

[ ] Primary overvoltage protection shall be provided by externally mounted, UltraSIL polymer-housed Evolution Distribution Class MOV arresters.

[ ] Primary overvoltage protection shall be provided by externally mounted, UltraSIL polymer-housed VariSTAR Intermediate Class MOV arresters.

[ ] Primary overvoltage protection shall be provided by externally mounted, UltraSIL Polymer-Housed VariSTAR Station Class MOV surge arresters.

[ ] Primary overvoltage protection shall be provided by VariSTAR [light-duty] [heavy-duty] under-oil MOV Distribution Class arresters.

[ ] Provisions for arresters

5.0 Finish Performance Requirements

5.1. The tank coating shall meet all requirements in IEEE Std C57.12.28™-2014 standard including:

- Salt Spray
- Crosshatch adhesion
- Humidity
- Impact
- Oil resistance
- Ultraviolet accelerated weathering
- Abrasion resistance–taber abraser

6.0 Production Testing

6.1. All units shall be tested for the following:

- Ratio, polarity and phase relation tests using all tap settings
- Winding resistance measurement tests
- Insulation power factor
- Full wave and reduced wave impulse test
- Applied and Induced potential tests
- No-Load losses at rated current
- Total losses at rated current
- Percent impedance at rated current
- Excitation current (100% voltage) test
- Leak test

6.2. Transformers shall conform to efficiency levels for liquid immersed distribution transformers, as specified in the Department of Energy ruling “10 CFR Part 431 Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule; April 18, 2013.” Manufacturer shall comply with the intent of all regulations set forth in noted ruling (commonly referred to as DOE 2016).

6.3. In addition, the manufacturer shall provide certification upon request for all design and other tests listed in IEEE Std C57.12.00™-2010 standard, including verification that the design has passed short circuit criteria per IEEE Std C57.12.00™-2010 and IEEE Std C57.12.90™-2010 standards.

6.4. In the event of proposal bid evaluated with guaranteed losses due to a loss evaluation (see section 11.0), manufacturer shall conform to guaranteed average losses as specified in IEEE Std C57.12.00™-2010 standard. The no-load losses of a transformer shall not exceed the specified no-load losses by more than 10%, and the total losses of a transformer shall not exceed the specified total losses by more than 6%.

7.0 Approved Manufacturers

7.1. Eaton's Cooper Power Systems Division

8.0 **Accessories**

8.1. The following standard accessories shall be provided:

- De-energized tap-changer
- 1.0" upper fill plug with filter press connection
- 1.0" drain valve with sampling device
- Automatic pressure relief device
- Welded cover with bolted manhole
- Lifting lugs (4)
- Liquid level gauge
- Dial type thermometer
- Pressure/vacuum gauge
- SS ground pads (4)
- Nitrogen blanket with purge valve
- Touch-up paint (2 aerosol cans)

8.2. The following optional accessories shall be provided if specified:

[ ] Copper low voltage bushings (standard with all-copper windings)
[ ] Bleeder valve
[ ] NEMA® 4 control box (standard with fan package)
[ ] NEMA® 4X control box (stainless steel)
[ ] Rapid pressure rise relay
[ ] Seal-in panel for rapid pressure rise relay
[ ] Winding temperature indicator
[ ] Auxiliary contacts for liquid level gauge
[ ] Auxiliary contacts for dial type thermometer
[ ] Auxiliary contacts for pressure/vacuum gauge
[ ] Auxiliary contacts for pressure relief device
[ ] 1.0" globe-type upper fill valve
[ ] Infrared (IR) viewing windows (specify quantity and location)
[ ] Castors for each single-phase transformer

9.0 **Special Features**

9.1. The following special features may be provided if specified:

[ ] All copper windings
[ ] Primary air disconnect switch
  [ ] 1200 A loadbreak rating (requires 1200 A copper bus bar)
  [ ] Outer front door (covers viewing area and switch)
  [ ] Key interlocks for interlocking switch with secondary
  [ ] Copper bus transition to transformer (required for 600 A and greater)
  [ ] Auxiliary switch (remote indication of primary switch position)

[ ] Line-side bus (bottom entry only)
[ ] Thermostat for space heater

[ ] 304L stainless steel construction
[ ] Tank base
[ ] Primary enclosure
[ ] Secondary enclosure

[ ] K-factor transformer
[ ] Current transformers for relaying/metering
[ ] Step-up operation

10.0 **Optional transformer evaluation**

[ ] No unit evaluation, but include quote losses as reference only on bid.
[ ] Unit loss evaluation, guaranteed average losses. Criteria to properly evaluate quoted losses:

- Core loss evaluation (A-factor) ____ $/watt
- Winding loss evaluation (B-factor) ____ $/watt

(Eaton may be contacted for sample loss evaluation method)

11.0 **Shipping**

11.1. All components shall be palletized.

11.2. Separately packaged pallets will be shipped with each Indoor Triplex Unit assembly containing all of the components. Each pallet shall be moveable via standard hydraulic hand trucks.

11.3. The control cabinet shall be removed from all control wiring for shipment purposes. All control wiring shall also be removable from the transformer.

11.4. If single phase transformers are to be shipped drained of fluid due to weight limitations, the manufacturer shall not be responsible for field filling.

11.5. Radiators will be shipped detached.

11.6. Physical constraints for the largest component:

11.6.1. Length _____
11.6.2. Width _____
11.6.3. Height _____
11.6.4. Weight _____

11.7. Physical constraints for the site:

11.7.1. Loading dock height _____
11.7.2. Maximum truck length _____

12.0 **Data with proposal**

12.1. The following data shall be submitted with the proposal:

- Core losses (when requested per Sections 6.4 and 10.0).
- Winding losses (when requested per Sections 6.4 and 10.0).
- Percent impedance
- Estimated drawings or typical drawings

12.2. The following checked data shall be submitted with the proposal for the single phase transformers:

[ ] Exciting Current @ 100% and 110% rated Voltage.
[ ] Efficiencies must be provided at loading levels of 100%, 75%, 50%, and 25%.
[ ] Percent regulation must be provided at 0.8 PF and 1.0 PF.

13.0 **Drawings**

13.1. The following will be provided by request after receipt of order:

[ ] Construction drawings
[ ] Record drawings
[ ] Approval drawings
[ ] CAD drawings

14.0 **Service**

14.1. The manufacturer of the transformer shall have regional service centers located within 2 hours flight time of all contiguous 48 states. Service personnel shall be factory trained in commissioning and routine service of quoted transformers.