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**Transformer, three phase, 75 kVA, MIL-SPEC, 450-120V White Paper**

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**Problem:**

MIL-T-15108 Specification exists for a 440V *single phase* transformers of no more than 100 KVA. This specification was last updated in 1975. Ship power systems have increased in power & require *high power 3 phase* to support the variety of complex loads.

Presently, larger transformers are developed according to program specific specifications using inconsistent design standards & test practices from application to application.

**Technical description**

*Transformer, 3 phase, 75 kVA, MIL-SPEC, 450-120 V*

Primary winding

* + 450 V RMS, line-line, 60 Hz, delta connected, power quality IAW MIL-STD-1399
	+ I line=96.22 A RMS at nominal tap & full load at normal rated input voltage.
	+ Taps provided, upon request, on the primary winding, at +2.5% and +5% of nominal voltage.

Secondary winding

* + 120V RMS, line-line, delta connected
	+ I line=360.85 A RMS at nominal primary tap & full load at nominal rated input voltage
	+ Taps will not be provided on the secondary winding

Electrostatic Shield

An electrostatic shield of a high restively material, will be provided between the primary & secondary winding. The shield design will offer a lower eddy loss component compared to the conventional method/design for an electrostatic shield.

Winding material

All windings & bus bars will utilize oxygen free copper magnet wire (or copper foil sheet); alloy 102 type copper will be used. If magnetic wire is utilized, it will have an HML coating/insulation (220 °C).

Insulation for the windings will be DuPont Nomex 410 along with polyester resin, thermal rating of 220 °C. This includes the ground insulation, inter winding, inner winding, between windings, shields & the outer coil wraps.

Brackets/Enclosure

All brackets to clamp & secure the coil/core assembly together to the inside of the enclosure will be designed for the shipboard environment for humidity, salt fog/spray, thermal, shock & vibration has been considered.

Design Principles

General principles will be IAW MIL-T-15108, along with IEEE C57.12.91, with the appropriate changes to generate a 3 phase transformer incorporating the latest features for this application. Finite element analysis (FEA) will be utilized for thermal, electromagnetic and structural.

The transformer will offer a low inrush current, this will ensure that the peak current, during turn on, will be less than 9X the normal rated current.

The transformer losses will be < 2.2% (1650 watts) at full load current, power factor (PF) of 1.0

Thermal Design

Cooling channels made from SG200 (200 °C rated) fiberglass rods will be used to create adequate cooling ducts in the windings.

The transformer will be natural convection cooled (no fans) to allow it to be self-cooled.

The temperature rise, at 50 °C ambient, will be less than 115 °C average. The coil to spot temperature will be 145 degrees C maximum (30 °C above the average temperature rise). These values are based upon an ambient temperature of 50 degrees C. This will leave a design margin, for the thermal rating of the insulation system, of 25 degrees C.

Mechanical Design

Design will incorporate a ventilated, drip proof, natural convection cooled enclosure that will allow for a protective structure that will protect the transformer, offer suitable space for the cable terminations on either end of the enclosure. The enclosure will also protect personal that are in the area as the enclosure will offer ground pads to properly bond the structure to the ships ground. The enclosure will have features to allow lifting with various methods.

Stainless steel nameplates, with diagrammatic schematic will be provided.

Provision will be provide for hard deck mounting.

Structural & airborne noise specifications will be adhered to which allows for a transformer that will be able to be installed in any location on the ship.

Enclosure size is approximately: 32” W x 18” D x 24” H; total volume of the enclosure will be less than 14K cubic inches. The weight is estimated to be 900 pounds max.

Test Plan (FAT IAW the approved ATP)

1. No load losses & current (exciting current)
2. DC winding resistance
3. Turns ratio & polarity (phase relationship)
4. Dielectric strength
5. Impedance & Short circuit losses
6. No load voltage
7. Full load voltage (PF=1)
8. Regulation (calculation from the NLV and FLV recorded during test)

Type testing includes

Temperature rise: Inside the enclosure with load current at full voltage input to the primary winding. Rise by resistance will be calculated & there will be a series of fiber optic thermal probes will be installed around the coil surfaces, core surfaces, inside the enclosure on both the internal & external surfaces which will also measure the coil hot spot.

Short circuit testing: IAW IEEE C57.12.91.

