

Specification Number: 26 12 00.20

Product Name: SUBSTATION TRANSFORMERS

SECTION 26 12 00.20 SUBSTATION TRANSFORMERS

Liquid-filled - three-phase, substation type transformers are used in a wide variety of commercial and industrial applications. All units are manufactured in accordance with applicable ANSI/IEEE C57 standards. The fluid filled transformers are offered with one of three different fluids:

Mineral oil – Type 2 biodegradable oil for outdoors

561_silicone fluid (dimethyl polysiloxane) by Dow Corning

Less flammable seed-oil based fluid

Power-Dry II (VPI) dry-type transformers - Vacuum-pressure impregnated (VPI) transformers are particularly suited for a wide range of commercial applications. Vacuum pressure impregnation of the windings includes a preheat, dry vacuum cycle; vacuum immersion; vacuum hold cycle; pressure cycle; and curing. This VPI process saturates the dielectric material, which contributes to its long life and durability. The secondary windings are constructed with sheet or wire conductors and Nomex insulation. The primary windings are wound over the secondary winding in either barrel or disc construction. These processes makes the Power-Dry transformer ideal for office buildings, hotels, and shopping malls.

Uni-Cast II - transformers are an ideal choice for industries such as pharmaceuticals, food and beverage, and medical, as well as other industrial and commercial installations. The primary windings are completely impregnated with epoxy resin, which forms the solid dielectric system. The secondary windings are wrapped in epoxy-impregnated Nomex® and baked to bond the conductor and Nomex, and the end cavities are sealed with air-dried epoxy. This combination provides not only high reliability, but also an economical solution for many applications.

The Power-Cast II - three-phase, cast-epoxy unit substation-type transformers are particularly suited for applications requiring a dry-type transformer with superior performance characteristics. All windings are completely impregnated with epoxy resin, which form the solid dielectric system. This system protects the windings from moisture and environmental airborne contaminants and provides exceptional strength to withstand extreme thermal shock and the mechanical forces of short circuit. These transformers meet the more stringent IEEE standards for liquid-filled transformers, but have the added advantages of a dry-type, making Power-Cast transformers an ideal replacement for the PCB-filled or PCB-contaminated units. Power-Cast units are available in either indoor or outdoor enclosures. If required, special enclosures can be designed to rotate the unit 90° to better fit in space previously occupied by a PCB-filled unit. Combustion byproducts of Power-Cast transformers have been tested and documented to be environmentally safe and nonflammable. All windings are partial-discharge tested to provide a reliable dielectric system. All units manufactured receive the standard production test as prescribed by IEEE C57.12.91 .

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Liquid-filled substation transformers.
- B. Power-Dry II (VPI) substation transformers.
- C. Uni-Cast II substation transformers.
- D. Power-Cast II substation transformers.

1.02 REFERENCES

- A. IEEE C57.12.00 - Standard General Requirements For Liquid-Immersed Distribution, Power, And Regulating Transformers.
- B. IEEE C57.12.01 - Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin-Encapsulated Windings.
- C. ANSI C57.12.10, Safety Requirements 230 kV and Below 833/958 Through 8333/10 417 kVA, Single-Phase, and 750/862 Through 60 000/80 000/100 000 kVA, Three-Phase Without Load Tap Changing; and 3750/4687 Through 60 000/80 000/100 000 kVA with Load Tap Changing.
- D. ANSI C57.12.28 - Switchgear and Transformers, Pad-Mounted Equipment - Enclosure Integrity.
- E. ANSI C57.12.50 - Requirements for Ventilated Dry-Type Distribution Transformers, 1-500 kVA Single-Phase and 15-500 kVA Three-Phase, with High Voltage 601-34,500 Volts, Low Voltage 120-600 Volts.

- F. ANSI C57.12.51 - Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger Three-Phase, with High Voltage 601-34,500 Volts, Low Voltage 208Y/120-4160 Volts.
- G. ANSI C57.12.55, Conformance Standard for Transformers - Dry-Type Transformers Used in Unit Installations, Including Unit Substations.
- H. IEEE C57.12.56 , Standard Test Procedure for Thermal Evaluation of Insulation Systems for Ventilated Dry-Type Power and Distribution Transformers.
- I. IEEE C57.12.58 , Guide for Conducting a Transient Voltage Analysis of a Dry-Type Transformer Coil.
- J. IEEE C57.12.59 , Guide for Dry-Type Transformer Through-Fault Current Duration.
- K. IEEE C57.12.70 , Terminal Markings and Connections for Distribution and Power Transformers.
- L. IEEE C57.12.80 , Standard Terminology for Power and Distribution Transformers.
- M. IEEE C57.12.90 - Test Code for Liquid-Immersed Distribution Power, and Regulating Transformers.
- N. IEEE C57.12.91 , Test Code for Dry-Type Distribution and Power Transformers.
- O. IEEE C57.94 , Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.
- P. IEEE C57.96 , Guide for Loading Dry-Type Distribution and Power Transformers.
- Q. IEEE C57.105 , Guide for Application of Transformer Connections in Three-Phase Distribution Systems.
- R. IEEE C57.109 , Guide for Liquid-Immersed Transformer Through-Fault-Current Duration.
- S. IEEE C57.111 , Guide for Acceptance of Silicone Insulating Fluid and Its Maintenance in Transformers.
- T. IEEE C57.121 Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluid in Transformers.
- U. IEEE C57.124 , Recommended Practice for the Detection of Partial Discharges and the Measurement of Apparent Charge in Dry-Type Transformers.
- V. CSA-C88 - Power Transformers and Reactors.

1.03 SUBMITTALS

- A. Submit shop drawings indicating outline dimensions, connection and support points, weight, specified ratings and materials.
- B. Submit product data indicating standard model design tests and options.
- C. Submit manufacturer's installation instructions.

1.04 OPERATION AND MAINTENANCE DATA

- A. Include procedures for [sampling and maintaining fluid,] cleaning and maintaining unit, and replacing components.

1.05 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in distribution transformers with [three] [] years [documented] experience.

PART 2 PRODUCT

2.01 MANUFACTURERS

- A. Square D Company [no equal] [or approved equal]

2.02 LIQUID-FILLED UNIT SUBSTATION TRANSFORMERS

- A. The transformer(s) shall be the substation type with [side-wall mounted primary and secondary terminations] [cover mounted primary and secondary terminations].
- B. The average temperature rise of the windings, measured by the resistance method, shall be [55°] [65°] [55/65] C when the transformer is operated at rated kVA output in a 40° C ambient. The transformer(s) shall be capable of being operated at rated load in a 30° C average, 40° C maximum ambient, as defined by IEEE C57.12.00 , without loss of service life expectancy.
- C. Coolant and insulating fluid shall be [inhibited mineral oil] [dimethyl polysiloxane 561-silicone transformer fluid by Dow Corning] [less flammable seed-oil based fluid].
- D. Side-wall mounted terminations shall be for: [close-coupling to high and low voltage switchgear sections] [close-coupling to high voltage switchgear on the primary side and terminating in an air-filled terminal chamber for cable connections to the low voltage side] [close-coupling to low voltage switchgear on the secondary side and termination in an air-filled terminal compartment on the primary side for cable entrance] [terminations within air-filled terminal chambers on both high voltage and low voltage side for cable entrance and exit].

- E. Primary and secondary locations shall be as follows: [primary: ANSI Segment 2, i.e. to observer's left when facing the transformer front; secondary: ANSI Segment 4, i.e. to observer's right when facing the transformer front] [primary: ANSI Segment 4, i.e. to observer's right when facing the transformer front; secondary: ANSI Segment 2, i.e. to observer's left when facing the transformer front] [primary: ANSI Segment 3, secondary: ANSI Segment 1].
- F. Bushing location and phase rotation shall be coordinated with primary and secondary switchgear to provide correct alignment when switchgear and transformer are connected in the field.
- G. The transformer(s) shall be rated [kVA ONAN] [/ kVA ONAN/FONFA] [/ kVA ONAN/ONFA]. Primary voltage [delta] [wye], secondary voltage [delta] [wye], [3- wire] [4-wire], 60 Hz with two 2-1/2% full capacity above normal and two 2-1/2% full capacity below normal taps. Impedance shall be [%] Manufacturer's standard impedance], $\pm 7\text{-}1/2\%$. Basic impulse level of the primary winding shall be [kV]. As specified in IEEE C57.12.00 for comparable kV class.
- H. Sound level, as measured by the NEMA audible sound-level test procedure, shall be less than the values specified in NEMA TR-1 when the transformer(s) (is) (are) operated at normal voltage and frequency and no load.
- I. The transformers shall be of sealed-tank construction of sufficient strength to withstand a pressure of 7 psi without permanent distortion. The cover shall be welded. The transformer shall remain effectively sealed for a top oil temperature range of -5°C to 105°C . When required, cooling panels will be provided on the back and front of the tank. Lifting eyes and jacking pads will be provided.
- J. Coils shall be wound with [copper] [aluminum] conductors.
- K. Cores shall be fabricated of high grade, grain-oriented, silicon steel laminations, carefully annealed after fabrication to restore high magnetic permeability. Magnetic flux is to be kept well below the saturation point.
- L. Tank, radiators, and terminal chambers, if provided, shall be treated to remove oil and scale by either shotblast or phosphatizing treatment to provide proper paint adhesion. All exterior surfaces shall be primed, using a high quality solid two-paint catalyzed epoxy. Minimum dry film thickness shall be 2 mils. A durable, hard polyurethane top coat with a minimum dry film thickness of 1 mil shall be applied to all primed surfaces. The color of the finish coat shall be [ANSI 49] [ANSI 61] [ANSI 70] [ANSI 24] and shall be coordinated with the switchgear manufacturer in order to match the color of the switchgear.
- M. Accessories - The following accessories shall be included on all substation transformers:
 1. Padlockable tap changer for de-energized operation
 2. Upper filling plug and filter press connection
 3. Drain valve with a 3/8-inch sampler
 4. Dial type thermometer
 5. Pressure/vacuum gauge [with] [without] bleeder connection
 6. Magnetic liquid level gauge
- N. Pressure relief valve, with manual bleeder and automatic resealing, set to operate at 10 psi with a flow rate of [35 scfm] [50 scfm]:
 1. Alarm contacts on [all gauges] [dial thermometer] [liquid level gauge] [pressure vacuum gauge]
 2. Pressure relief diaphragm to operate at 10 psi and relieve 10,000 scfm at 15 psi
 3. Sudden pressure relay permitting remote alarm or trip due to a predetermined rate of pressure rise [with] [without] seal-in delay
- O. The transformer(s) shall be designed for use with fans to increase the current carrying capability in accordance with the ratings of Article 2.02 paragraph G preceding. The transformer shall be equipped with forced air cooling or be designed for the future addition of forced air cooling. The fan control equipment will be actuated by contacts that sense [the temperature of the top oil] [the average winding temperature] of the transformer. Temperature sensors, motor starter for fan motors, test modes of operation, as well as fans and fan motors, will be provided on units designated ONAN/ONFA. Temperature sensors and details for future mounting of fans and controls will be provided on units designated ONAN/FONFA. Fan motors will operate from a 240 V, single-phase, 60 Hz source of power provided by the user.
- P. Testing - Tests shall be conducted in accordance with the provisions of IEEE C57.12.90 and shall include, as a minimum, the following tests:
 1. Ratio
 2. Polarity
 3. Phase Rotation
 4. No-Load Loss
 5. Excitation Current

6. Impedance Voltage
7. Load Loss
8. Applied Potential
9. Induced Potential
10. Impulse Test
11. Temperature Test (typical data from previous unit is acceptable)
12. Sound Test (typical data from previous unit is acceptable)

2.03 POWER-DRY (VPI) SUBSTATION TRANSFORMERS

- A. The transformer(s) shall be the unit substation type with side-mounted primary and secondary terminations.
- B. Primary terminations shall be designed for close coupling to [a metal enclosed air load break switch section] [a switchgear section] [an air terminal chamber to be provided with the transformer]. Secondary terminations shall be designed for close coupling to [a switchgear section] [a switchboard section] [an air terminal chamber to be provided with the transformers].
- C. Orientation shall be primary on the [left] [right] when facing the transformer front.
- D. The transformer(s) shall be rated [kVA AA] [/ kVA AA/FFA] [/ kVA AA/FA]. Primary voltage volts [delta]. Secondary voltage []volts [wye] [delta], [3-wire] [4-wire], 60 Hz with two 2-1/2% full capacity above normal and two 2-1/2% full capacity below normal primary taps. Impedance shall be [%] [manufacturer's standard impedance], $\pm 7-1/2\%$. All transformers shall have an average temperature rise of [150° C] [115° C] [80° C] above a 40° C maximum, 30° C average ambient.
- E. The basic impulse levels (BIL) shall be a minimum of [60 kV for the 15 kV class] [optional 95 kV BIL available] [10 kV for the 1.2 kV class].
- F. The coils shall be wound with [aluminum] [copper] conductors.
- G. All insulating materials are to be in accordance with IEEE Standard C57.12.01 for 220° C UL insulation system.
- H. The coils and all clamping structure and buswork shall be assembled on the core, and then dried at atmospheric pressure in an oven through which hot air is continuously circulated. The totally assembled core and coil assembly shall be vacuum pressure impregnated in polyester varnish. The total VPI process shall apply a one (1) cycle polyester protective shield of varnish the coils and a protective shield to the bus, core and support structure. The varnish shall be cured on the core and coil assembly following an established temperature vs. time baking cycle in a hot air circulating oven. The VPI process shall effectively impregnate the entire core and coil assembly, which results in a unit, which is virtually impermeable to moisture, dust, salt air and other industrial contaminants.
- I. All cores to be constructed of high grade, grain-oriented, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. Core laminations shall be miter cut at the core corners to reduce hot spots, core loss, excitation current, and sound level.
- J. The transformer enclosures shall be ventilated [indoor] [outdoor] and fabricated of heavy gauge, sheet steel construction. Enclosures are to be provided with lifting devices bolted or welded to the base structure and shall have jacking pads designed to be flush with the enclosure. The base is to be constructed of structural steel members to permit skidding or rolling in any direction. Rubber vibration isolation pads shall be installed by the manufacturer between the core and coil and the enclosure. The core shall be visibly grounded to the ground bus or ground pad by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.
- K. The paint color shall be [ANSI 49] [ANSI 61].
- L. Transformer sound levels shall be warranted by the manufacturer not to exceed the values specified in IEEE Standard C57.12.01 .
- M. Metal-oxide, gapless-type distribution class lightning arresters shall be installed by the manufacturer on the high voltage side of the transformer to provide additional protection against high voltage lightning or switching surges.
- N. Fan cooling equipment shall include 3-phase electronic winding temperature monitor controlled automatically by a Type K thermocouples placed in the low voltage air duct. The temperature monitor must contain yellow and red indicating lights. The yellow lamp indicates fan power, while the red lamp signal that alarm and trip contacts have been activated. A 0-1 milliampere output is required for remote indication. Alarm contacts shall be provided for fans, alarm, and trip function. An audible alarm must sound when the highest phase temperature exceeds a preset point. The fans must be able to operate in

either manual or automatic mode. Minimum six fans shall be provided. Fan controller must be POWERLOGIC ® system compatible. Forced air cooling system shall include: fans, control wiring, controller with test switch, current limiting fused in the power supply to the controller, indications lights, alarm silencing relay, auto/manual switch, and necessary accessories to properly control the system.

- O. The transformer shall be pre-wired for TRANSPARENT READY web enabled communication [non-TRANSPARENT READY].
- P. Testing - Tests shall be conducted in accordance with the provisions of IEEE C57.12.91 and shall include, as a minimum, the following tests:
 - 1. Ratio
 - 2. Polarity
 - 3. Phase Rotation
 - 4. No-Load Loss
 - 5. Excitation Current
 - 6. Impedance Voltage
 - 7. Load Loss
 - 8. Applied Potential
 - 9. Induced Potential
 - 10. Impulse Test (typical data from previous unit is acceptable)
 - 11. Temperature Test (typical data from previous unit is acceptable)
 - 12. Sound Test (typical data from previous unit is acceptable)

2.04 UNI-CAST II SUBSTATION TRANSFORMER

- A. The transformer(s) shall be the substation type with side-wall mounted primary and secondary terminations.
- B. Transformer(s) shall be Uni-Cast II, dry-type construction, mounted in a suitable, ventilated [indoor] [outdoor] enclosure.
- C. The average temperature rise of the transformer windings shall not exceed 100° C when the transformer is operated at full nameplate AA and FA rating. The transformer(s) shall be capable of carrying 100% of nameplate kVA rating in a 40° C maximum, 30° C average ambient as defined by IEEE C57.12.01 .
- D. Terminations shall be side-wall mounted for: [close-coupling to high and low voltage switchgear sections] [close-coupling to high voltage switchgear on the primary side and terminating in an air-filled terminal chamber for cable connections to the low voltage side] [close-coupling to low voltage switchgear on the secondary side and termination in an air-filled terminal compartment on the primary side for cable entrance] [terminations within air-filled terminal chambers on both high voltage and low voltage side for cable entrance and exit].
- E. Primary and secondary locations shall be as follows: [primary: ANSI Segment 2, i.e. to observer's left when facing the transformer front; secondary: ANSI Segment 4, i.e. to observer's right when facing the transformer front.] [primary: ANSI Segment 4, i.e. to observer's right when facing the transformer front; secondary: ANSI Segment 2, i.e. to observer's left when facing the transformer front].
- F. The transformer(s) shall be rated [kVA AA] [/ kVA AA/FFA]; [/ kVA AA/FA]. Primary voltage volts [delta]. Secondary voltage []volts [wye] [delta], [3-wire] [4-wire], 60 Hz with two 2-1/2% full-capacity above normal and two 2-1/2% full-capacity below normal primary taps. Impedance shall be [%] [manufacturer's standard impedance] ±7-1/2%. Sound level shall not exceed [the maximum specified in IEEE Standard C57.12.01 for the applicable kVA size of dry-type transformer] [dB].
- G. Forced air cooling shall increase the allowable full-load kVA by 33-1/3%.
- H. Both high voltage and low voltage windings shall be of [aluminum] [copper] conductors. High voltage windings shall each be separately cast as one rigid tubular coil. Each primary coil shall be reinforced with fiberglass mat. The casting process shall provide complete, void-free resin impregnation throughout the entire insulation system. The coil supports shall maintain constant pressure during thermal expansion and contraction of the coils. There shall be no rigid mechanical connection between high voltage and low voltage coils. The secondary windings shall be completely wrapped in epoxy-impregnated Nomex and then oven baked. To seal the end cavities, the coil ends shall be potted with an air-dried epoxy
- I. The impulse rating of the high voltage windings must be at least equal to the basic impulse level specified by IEEE C57.12.91 for oil-filled transformers of the same voltage class, without the use of supplemental surge arresters.
- J. The impulse rating of the low voltage winding must be at least 10 kV for low voltage windings rated 1.2 kV and below.

- K. The transformer core shall be constructed of high grade, grain-oriented silicone steel laminations, with high magnetic permeability. Magnetic flux density is to be kept well below the saturation point. The core shall be cruciform in shape, with mitered joints to keep core losses, excitation current, and noise level at a minimum. The outside surfaces of the core shall be protected against corrosion by painting with a suitable coating after assembly. Core dipping is not acceptable.
- L. The enclosure(s) shall be constructed of heavy-gauge sheet steel. All ventilating openings shall be in accordance with NEMA and NEC standards for ventilated enclosures. The cabinet shall have a minimum of four [hinged doors] [removable panels with lifting handles].
- M. The base(s) shall be constructed to permit rolling or skidding in any direction, and shall be equipped with jacking pads designed to be flush with the transformer enclosure.
- N. Fan cooling equipment shall include 3-phase electronic winding temperature monitor controlled automatically by a Type K thermocouple placed in the low voltage air duct. The temperature monitor must contain yellow and red indicating lights. The yellow lamp indicates fan power, while the red lamp signal that alarm and trip contacts have been activated. A 0-1 milliampere output is required for remote indication. Alarm contacts shall be provided for fans, alarm, and trip function. An audible alarm must sound when the highest phase temperature exceeds a preset point. The fans must be able to operate in either manual or automatic mode. Minimum six fans shall be provided. Fan controller must be POWERLOGIC ® system compatible. Forced air cooling system shall include: fans, control wiring, controller with test switch, current limiting fused in the power supply to the controller, indications lights, alarm silencing relay, auto/manual switch, and necessary accessories to properly control the system.
- O. The transformer shall be pre-wired for TRANSPARENT READY web enabled communication [non-TRANSPARENT READY]
- P. Provision for future forced air cooling equipment shall include mounting provision for fans, bussing sized to the fan-cooled rating, and provisions for mounting the fan control system.
- Q. The transformer shall comply with all applicable portions of NEMA TR-1 and IEEE C57.12.01 .
- R. Testing shall be done in accordance with IEEE C57.12.91 and shall include, as the minimum, the following tests:
 - 1. Ratio
 - 2. Polarity
 - 3. Phase Rotation
 - 4. No-Load Loss
 - 5. Excitation Current
 - 6. Impedance Voltage
 - 7. Load Loss
 - 8. Applied Potential
 - 9. Induced Potential
 - 10. The transformer primary windings must be free of partial discharge up to at least 1.2 times the rated line-to-ground voltage. Each high voltage coil shall be subjected to a partial discharge test to verify its partial discharge.
 - 11. Impulse Test
 - 12. Temperature Test (typical data from previous unit is acceptable)
 - 13. Sound Test (typical data from previous unit is acceptable)

2.05 POWER-CAST II SUBSTATION TRANSFORMER

- A. The transformer(s) shall be the substation type with side-wall mounted primary and secondary terminations.
- B. Transformer(s) shall be of solid-cast, dry-type construction, mounted in a suitable, ventilated [indoor] [outdoor] enclosure.
- C. The average temperature rise of the transformer windings shall not exceed 80° C when the transformer is operated at full nameplate AA and FA rating. The transformer(s) shall be capable of carrying 100% of nameplate kVA rating in a 40° C maximum, 30° C average ambient as defined by IEEE C57.12.01 .
- D. Terminations shall be side-wall mounted for: [close-coupling to high and low voltage switchgear sections] [close-coupling to high voltage switchgear on the primary side and terminating in an air-filled terminal chamber for cable connections to the low voltage side] [close-coupling to low voltage switchgear on the secondary side and termination in an air-filled terminal compartment on the primary side for cable entrance] [terminations within air-filled terminal chambers on both high voltage and low voltage side for cable entrance and exit].

- E. Primary and secondary locations shall be as follows: [primary: ANSI Segment 2, i.e. to observer's left when facing the transformer front; secondary: ANSI Segment 4, i.e. to observer's right when facing the transformer front] [primary: ANSI Segment 4, i.e. to observer's right when facing the transformer front; secondary: ANSI Segment 2, i.e. to observer's left when facing the transformer front].
- F. The transformer(s) shall be rated [kVA AA] [/ kVA AA/FFA] [/ kVA AA/FA]. Primary voltage []volts delta. Secondary voltage [] volts [wye] [delta], [3-wire] [4-wire], 60 Hz with two 2-1/2% full-capacity above normal and two 2-1/2% full-capacity below normal primary taps. Impedance shall be [%] [manufacturer's standard impedance], $\pm 7\text{-}1/2\%$. Sound level shall not exceed [the maximum specified in IEEE Standard C57.12.01 for the applicable kVA size of dry-type transformer] [dB].
- G. Forced air cooling shall increase the allowable full-load kVA by [33-1/3%] [50%]. NOTE: 50% increase is not available for transformers rated 500 kVA and 750 kVA or above 5000 kVA while also maintaining an 80° C rise.
- H. The impulse rating of the high voltage windings must be at least equal to the basic impulse level specified by IEEE C57.12.90 for oil-filled transformers of the same voltage class, without the use of supplemental surge arresters.
- I. The impulse rating of the low voltage winding must be at least [30 kV for low voltage windings rated 1.2 kV and below] [45 kV for low voltage windings rated 2.5 kV and below] [60 kV for low voltage windings rated 5 kV and below].
- J. The transformer core shall be constructed of high grade, grain-oriented silicone steel laminations, with high magnetic permeability. Magnetic flux density is to be kept well below the saturation point. The core shall be cruciform in shape, with mitered joints to keep core losses, excitation current and noise level at a minimum. The outside surfaces of the core shall be protected against corrosion by painting with a suitable coating after assembly. Core dipping is not acceptable.
- K. The enclosure(s) shall be constructed of heavy-gauge sheet steel. All ventilating openings shall be in accordance with NEMA and NEC standards for ventilated enclosures. The cabinet shall have a minimum of four [hinged doors] [removable panels; removable panels with lifting handles].
- L. The base(s) shall be constructed to permit rolling or skidding in any direction, and shall be equipped with jacking pads designed to be flush with the transformer enclosure.
- M. Fan cooling equipment shall include multi-phase electronic temperature monitor controlled automatically by sensors placed in the LV air ducts. The temperature monitor must contain yellow and red indicating lights. The yellow lamp indicates fan power, while the red lamps signal that alarm and trip contacts have been activated. A 0-1 milliamper output is required for remote indication. Alarm contacts shall be provided for fans, alarm, and trip function. An audible alarm must sound when the highest phase temperature exceeds a preset point. The fans must be able to operate in either manual or automatic mode. A fan exerciser circuit must operate the cooling fans for approximately one minute every six days [Minimum six fans shall be provided; each fan must have a 6-inch diameter blade and develop a minimum 350 CFM at 1500 RPM] [Minimum six "squirrel cage" centrifugal blowers shall be required; each blower must develop a minimum 800 CFM at 1500 RPM] and shall be controlled automatically by sensors placed in the LV air ducts. Forced air cooling system shall include: fans, control wiring, controller with test switch, current limiting fuses in the power supply to the controller, indication lights, alarm silencing relay, and necessary push buttons to properly control the system. Fan controller must be POWERLOGIC ® system compatible.
- N. The transformer shall be pre-wired for TRANSPARENT READY web enabled communication [non-TRANSPARENT READY]
- O. Provision for future forced air cooling equipment shall include mounting provision for fans, bussing sized to the fan-cooled rating and provisions for mounting the fan control system.
- P. Low voltage bus shall be silver flash plated copper throughout.
- Q. The transformer shall comply with all applicable portions of NEMA TR-1, and IEEE C57.12.01 .
- R. Testing - Testing shall be done in accordance with IEEE C57.12.91 and shall include, as the minimum, the following tests:
 - 1. Ratio
 - 2. Polarity
 - 3. Phase Rotation
 - 4. No-Load Loss
 - 5. Excitation Current
 - 6. Impedance Voltage
 - 7. Load Loss

8. Applied Potential
9. Induced Potential
10. The transformer windings must be free of partial discharge up to at least 1.2 times the rated line-to-ground voltage. Each winding shall be subjected to a partial discharge test to verify its partial discharge.
11. Impulse Test
12. Temperature Test (typical data from previous unit is acceptable)
13. Sound Test (typical data from previous unit is acceptable)

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that pads are ready to receive work.
- B. Verify field measurements are as [shown on drawings.] [instructed by manufacturer.]
- C. Verify that required utilities are available, in proper location and ready for use.
- D. Beginning of installation means installer accepts conditions.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install safety labels to NEMA 260.

3.03 FIELD QUALITY CONTROL

- A. Test dielectric liquid to ASTM D877, using 25,000 volts minimum breakdown voltage, after installation and before energization from system.
- B. Test transformer to IEEE C57.12.90 .
- C. Test transformer to IEEE C57.12.91 .

3.04 ADJUSTING

- A. Adjust primary taps so that secondary voltage is within [2] [] % of rated voltage.