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SECTION 26 22 13 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
   * + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
      1. SUMMARY

The transformers in this specification are high performance transformers whose efficiency and other characteristics substantially exceed the minimum requirements of DOE 2016.

* + - * 1. Section includes ultra low-loss, k-rated, distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

Optimized for the application load: Substantially exceed the efficiency requirements of DOE 2016 by optimizing different load profiles to provide energy savings, contribute to LEED optimization credits, and qualify for utility incentives.

K-Rating: In order to be UL-Listed to feed electronic equipment (nonlinear loads), transformers shall be k-rated as specified for each model.

* + - 1. ACTION SUBMITTALS

Products will only be considered for approval if the request is accompanied with the Attachment 1 – Low Voltage Transformer Performance Compliance Form filled out, in its entirety and signed by a company representative, authorized to certify the compliance information included. For the approval request to be considered complete, the required supporting documentation shall be provided.

* + - * 1. Products Data: Include completed "Attachment 1: Low Voltage Transformer Specified Performance Compliance Form" for each transformer type and size to be provided on this project, signed by representative authorized to enjoin the manufacturer.
        2. For each type of product.

Include construction details, material descriptions, enclosure dimensions, dimensions of individual components and profiles, unit weight, and finishes for each type and size of transformer.

Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

Include documentation that transformers comply with specification performance requirements.

Include documentation for selected integrated transformer options.

Include documentation for meter, and current transformer with model numbers, serial numbers, accuracy and calibration information.

Include insulation system data sheets as published by supplier.

Include documentation for performance characteristics, insulation class, temperature rise, core materials, coil materials, impedances, and audible noise level.

Include documentation that primary protection sizing at 125-percent of nominal full load amps will not result in nuisance tripping due to transformer inrush.

Include documentation for transformer power and capacity ratings, primary voltage, secondary voltage, voltage taps, and basic insulation level (BIL). Include the following documentation:

Inrush current (three cycle recovery).

Short circuit current data for primary and secondary.

Efficiency, losses, and heat output.

No load and full load losses according to NEMA ST 20.

Linear load data at 1/6, 1/4, 1/2, 3/4 and full load.

Linear load efficiency at 35-percent loading when tested according to DOE 10 CFR Part 431, Subpart K.

Efficiency under a K-7 load profile at 16.7-, 25-, 50-, 75-, and 100-percent of nameplate rating.

Include documentation that the transformers comply with UL listing for 2-inch clearance from ventilated surfaces.

Include documentation describing nonlinear load test program for factory ISO 9001 procedure.

Include documentation that transformers comply with Special Warranty Paragraph below.

Include ISO 14001:2004 Certificate for manufacturer.

Include ISO 9001:2008 Certificate for manufacturer.

Include ISO 17025 Certificate - Efficiency Test Lab for facility where transformers are tested.

Include documentation that materials used for shipment packaging comply with environmental requirements.

For LEED projects and the contribution to optimize energy performance credit(s), include documentation of calculated energy savings compared to the DOE 2016 baseline reference.

* + - * 1. Shop Drawings:

Provide Vibration Isolation Base Details identifying anchorages and attachments to structure and to supported equipment.

Include diagrams for power, signal, and control wiring.

* + - 1. INFORMATIONAL SUBMITTALS

Coordinate "Qualification Data" Paragraph below with qualification requirements in Section 014000 "Quality Requirements" and as may be supplemented in "Quality Assurance" Article.

* + - * 1. Qualification Data: For testing agency.

Retain "Seismic Qualification Data" Paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 260548.16 "Seismic Controls for Electrical Systems." See ASCE/SEI 7 for certification requirements for equipment and components.

* + - * 1. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.

Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

Certification: Indicate that equipment meets seismic requirements.

* + - * 1. Source quality-control reports.

Retain "Field quality-control reports" Paragraph below if Contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
      1. CLOSEOUT SUBMITTALS
         1. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.
         2. Applicable wiring diagrams, including any modifications.
         3. Performance Validation Report and other completed factory and site testing reports.
      2. QUALITY AND ENVIRONMENTAL ASSURANCE

Retain "Testing Agency Qualifications" Paragraph below if Contractor or manufacturer selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article. Qualification requirements are in addition to those specified in Section 014000 "Quality Requirements." Retain ISO certifications for manufacturer's processes and facilities.

* + - * 1. On-Site Testing Agency Qualifications: Accredited by NETA.

Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

* + - * 1. Certified ISO 9001 Quality Management System.
        2. Certified ISO 14001 Environmental System.
      1. DELIVERY, STORAGE, AND HANDLING
         1. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

* + - * 1. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.
        2. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.
        3. Handling: Follow manufacturer's instructions for lifting and transporting transformers.
      1. WARRANTY

When warranties are required, verify with Owner's counsel that warranties stated in this article are not less than remedies available to Owner under prevailing local laws. Obtain copies of warranty and guarantee language from the manufacturer.

Powersmiths warrant aligns with DOE for the expected transformer lifecycle.

* + - * 1. Standard Warranty Period: Thirty-two (32) years, pro-rated from date of shipment.

The transformer remains functional through a rated seismic event.

* + - * 1. Performance Guarantee: Manufacturer warrants that transformers will meet published performance data for the warranty period.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and Masterworks Paragraph Builder are neither recommended nor endorsed by the AIA or ARCOM. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications. For definitions of terms and requirements for Contractor's product selection, see Section 016000 "Product Requirements."

* + - 1. MANUFACTURERS
         1. Basis-of-Design Product: Powersmiths International Corp.; E-Saver Opal Series: E-SAVER-33L, E-SAVER-25H, T1000-30H.
         2. Acceptable Manufacturers. Subject to having provided the engineer of record submittal documents as listed previously, documenting compliance with this specification, and having received approval 10 days prior to bid closing:

Powersmiths International Corp.

Controlled Power.

Eaton.

General Electric.

Siemens.

Square D; by Schneider Electric.

* + - * 1. Source Limitations: Obtain each transformer type from single source from single manufacturer.
      1. PERFORMANCE REQUIREMENTS
         1. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to International Building Code - 2006/2009 Edition, California Building Code - 2007/2010 Edition, ASCE Standard 7 - 2005, OSHPD with OSHPD CAN 2-1708A.5 (Revised), and ICC-ES AC 156, Effective 01/01/2007.

The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."

* + - 1. GENERAL TRANSFORMER REQUIREMENTS
         1. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

Three-phase, common core, ventilated, dry-type, isolation transformer, with terminals and changing taps accessible by removing front cover plate, 10-kV BIL.

* + - * 1. Comply with NFPA 70.

Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

* + - * 1. Comply with NEMA ST 20- 2014 "Dry Type Transformers for General Applications", and the standards referenced in this publication.
        2. Labeling for intended use by UL, ULc, CSA, or an NRTL acceptable to authorities having jurisdiction.

Retain "Transformers Rated 15 kVA and Larger" Paragraph below for all single-phase transformers 15 to 333 kVA and three-phase transformers 15 to 1000 kVA in size, except for autotransformers, drive, grounding, machine-tool (control), nonventilated, rectifier, regulating, sealed, special-impedance (other than impedances of transformers complying with the DOE 2016 rule), transformers with a tap of 20 percent or more, UPS, and welding transformers that are exempt from the DOE 2016 rule.

Indicate transformer model on the Drawings with each transformer model number designation indicated on the electrical one-line diagram.

* + - * 1. Transformers Rated 15 kVA and Larger:

Exceed efficiency levels established in U.S. Department of Energy, 10 CFR Part 431, April 18, 2013. Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule (DOE 2016).

Nameplate marked with efficiency levels and marked as exceeding DOE 2016 efficiency levels established in DOE 2016.

Requirement in "Shipping Restraints" Paragraph below may not be available from all manufacturers. Verify with manufacturer.

Retain first paragraph below if seismic bracing is required. Coordinate with Parts 1 and 3.

* + - * 1. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems" and comply with Paragraph 2.2, A, "Seismic Performance."
        2. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

One leg per phase.

Optional feature in first subparagraph below may not be available from all manufacturers.

Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.

Grounded to enclosure.

Retaining " without splices" option below is good engineering practice; however, it may not be verifiable after the transformer is delivered, may result in increased cost, and may be contested by manufacturers interested in reducing manufacturing cost and maximizing raw materials usage.

* + - * 1. Coils: Continuous windings except for taps.

Internal Coil Connections: Brazed or pressure type.

Terminal Connections: Welded or bolted.

* + - * 1. Enclosure: Ventilated with lockable hinged door.

NEMA 250, Type 2.

Lockable hinged doors to facilitate front access. Comply NFPA 70E/CSA-Z462 to minimize arc flash risk when opening the enclosure of live equipment.

The standard wall clearance for other manufacturers is 6-inches (152-mm). Powersmiths transformers are UL Listed for a 2-inch (51-mm) clearance.

Rear Clearance: UL Listed for 2-inch (51-mm) clearance from wall, with clearance indicated on nameplate.

KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

Retain "Finish" Subparagraph below for custom finish.

Finish: Comply with NEMA 250.

Finish Color: Manufacturer's standard color.

* + - * 1. Taps for Transformers 15 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

See "Insulation Ratings" Article in the Evaluations for discussion of insulation classes. See "Energy Considerations" Article in the Evaluations for discussion of relative efficiencies. Temperature rise of 115 or 80 deg C only applies to transformers 15 kVA and larger.

* + - * 1. Insulation System Class: 220 deg C, UL-component-recognized insulation system. See individual model description for associated operating temperature rise.
        2. Impedance: 3.8% or greater, to manage downstream fault, arc flash levels and downstream component fault interrupting (kAIC) ratings.
        3. Inrush Currents: Suitable for a 125-percent-rated primary overcurrent protective device, documented by manufacturer.
        4. Grounding: Provided by the installing contractor to suit the installation.

"K-Factor Rating" Paragraph below is required since transformer will supply significant nonsinusoidal load current.

* + - * 1. K-Factor Rating: Transformers are to be K-factor rated in compliance with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

The required K-Factor is defined within the specification section for each model.

Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.

Indicate value of K-factor on transformer nameplate.

Neutral: Rated 200 percent of full load current.

Listed and label as complying with UL 1561.

See individual models for associated K-factor rating.

K-rating for the individual models to follow IEEE C57.110 "IEEE Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents."

Indicate wall-mounted transformers on Drawings. Generally, factory-made wall-mounted brackets are available for transformers up to 75 kVA. High-efficiency, shielding, and K-factor construction increase transformer weight. Verify that wall brackets are available from specified manufacturers for specified sizes. Verify compliance with seismic requirements.

* + - * 1. Wall Brackets: At locations indicated on Drawings for transformers up to 75 kVA.
        2. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to NEMA ST 20-2014, applied to all transformers, including those with K-factor ratings up to 20, as follows:

9 kVA and Less: 40 dBA.

9 to 30 kVA: 42 dBA.

30 to 50 kVA: 42 dBA.

50 to 150 kVA: 47 dBA.

150 to 300 kVA: 52 dBA

300 to 500 kVA: 57 dBA.

500 to 700: 59 dBA.

700 to 1000: 61 dBA.

1000 to 1500 kVA: 64 dBA.

* + - * 1. Factory Sound-Level Tests for all transformers on this project.

Test each transformer for required noise limit. Type testing is not acceptable.

Record sound level tests and provide results for each serial number supplied.

Any non-compliant transformers shipped will be replaced at no cost to the owner.

* + - 1. DISTRIBUTION TRANSFORMERS – LOW LOAD OPTIMIZED

Application Note: This is the appropriate specification for the vast majority of installations. Typical low voltage dry-type transformers are not heavily loaded but they do feed mostly electronic equipment that predominate most work environments, and this is a non-linear load profile for which UL requires the transformer to carry a suitable K-Rating in order for the listing to be valid for the application. A K-7 rating has been found to be appropriate for this application. The transformer design needs to also minimize the operating losses in this application, which combines harmonics and light loading. Achieving very low losses under these conditions embeds significant energy savings compared to a typical DOE 2016 transformer.

A wide range of kVA ratings enables rightsizing to the electrical system, reducing capital cost, operating cost, and reduced cost of the surrounding electrical infrastructure including breakers, panels, conduits and conductors. Overall electrical physical footprint and carbon footprint are reduced.

* + - * 1. Basis-of-Design: E-SAVER-33L.
        2. Winding Material: Copper.
        3. K-Factor Rating: K-7.
        4. Operating Temperature Rise: 130 deg C in 40 deg C maximum ambient conditions.
        5. Continuous Duty Overload Capacity: 105-percent of nominal kVA rating.
        6. Efficiency: Exceed minimum efficiency requirements of U.S. Department of Energy, 10 CFR Part 431 (DOE 2016), by complying with the "Table of Maximum No-Load Losses Efficiency Requirements" at 1/6 load, efficiency at 35-percent load, and efficiency at 25-percent load under a K-7 load profile, when tested in an ISO 17025 certified efficiency test lab.
        7. Table of Maximum No-Load Losses and Efficiency Requirements:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **kVA** | **Max. No load losses (Watts)** | **Efficiency @ 1/6 load under linear profile (%)** | **Efficiency @ 35% load under linear profile (%)** | **Efficiency at 25% load under K7 nonlinear profile**  **(%)** |
| **15** | 34 | 98.17 | 98.24 | 98.18 |
| **20** | 42 | 98.27 | 98.34 | 98.28 |
| **25** | 50 | 98.37 | 98.44 | 98.38 |
| **30** | 57 | 98.47 | 98.54 | 98.48 |
| **45** | 80 | 98.61 | 98.71 | 98.62 |
| **50** | 86 | 98.64 | 98.73 | 98.65 |
| **63** | 101 | 98.71 | 98.79 | 98.72 |
| **75** | 114 | 98.78 | 98.84 | 98.78 |
| **100** | 145 | 98.85 | 98.93 | 98.85 |
| **112.5** | 160 | 98.88 | 98.97 | 98.88 |
| **125** | 175 | 98.90 | 98.99 | 98.88 |
| **150** | 204 | 98.93 | 99.03 | 98.88 |
| **175** | 229 | 98.96 | 99.06 | 98.95 |
| **200** | 255 | 99.00 | 99.10 | 99.01 |
| **225** | 281 | 99.03 | 99.13 | 99.08 |
| **250** | 304 | 99.05 | 99.15 | 99.08 |
| **300** | 352 | 99.09 | 99.20 | 99.08 |
| **400** | 431 | 99.15 | 99.24 | 99.13 |
| **450** | 471 | 99.17 | 99.26 | 99.16 |
| **500** | 511 | 99.20 | 99.28 | 99.18 |
| **600** | 597 | 99.22 | 99.30 | 99.22 |
| **750** | 726 | 99.24 | 99.33 | 99.28 |

* + - 1. DISTRIBUTION TRANSFORMERS – HEAVY LOAD OPTIMIZED

Application Note: This is the appropriate specification for transformers feeding dedicated equipment where the transformer is rightsized for the application and therefore the transformer will have a heavier loading duty cycle. Examples of such loads are lab and other process equipment like elevators and HVAC. These loads are typically driven by electronics and therefore have a non-linear load profile for which UL requires the transformer to carry a suitable K-Rating in order for the listing to be valid for the application. A K-13 rating has been found to be appropriate for this application. The transformer design needs to also minimize the operating losses in this application, which combines a degree of harmonic content and heavy loading. Achieving very low losses under these conditions embeds significant energy savings compared to a typical DOE 2016 transformer.

A wide range of kVA ratings enables rightsizing to the electrical system, reducing capital cost, operating cost, and reduced cost of the surrounding electrical infrastructure including breakers, panels, conduits and conductors. Overall electrical physical footprint and carbon footprint are reduced.

* + - * 1. Basis-of-Design: E-SAVER-25H.
        2. Winding Material: Copper primary, aluminum secondary.
        3. K-Factor Rating: K-13.
        4. Operating Temperature Rise: 105 deg C in 40 deg C maximum ambient conditions.
        5. Continuous Duty Overload Capacity: 120-percent of nominal kVA Rating.
        6. Efficiency: Exceed minimum efficiency requirements of U.S. Department of Energy, 10 CFR Part 431 (DOE 2016), by complying with the "Table of Maximum No-Load Losses and Efficiency Requirements" at 1/6 load, efficiency at 35-percent load, and efficiency at 25-percent load under a K-7 load profile, when tested in an ISO 17025 certified efficiency test lab.
        7. Table of Maximum No-Load Losses and Efficiency Requirements:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **kVA** | **No load losses (Watts)** | **Efficiency @ 35% load under linear profile (%)** | **Efficiency at 50% load under linear profile (%)** | **Efficiency at 50% load under K7 nonlinear profile (%)** |
| **15** | 41 | 98.37 | 98.19 | 97.9 |
| **20** | 53 | 98.44 | 98.28 | 98.0 |
| **25** | 64 | 98.51 | 98.37 | 98.1 |
| **30** | 75 | 98.58 | 98.46 | 98.2 |
| **45** | 110 | 98.66 | 98.57 | 98.3 |
| **50** | 119 | 98.69 | 98.60 | 98.3 |
| **63** | 141 | 98.76 | 98.68 | 98.4 |
| **75** | 162 | 98.83 | 98.75 | 98.5 |
| **100** | 184 | 98.90 | 98.82 | 98.6 |
| **112.5** | 195 | 98.93 | 98.85 | 98.6 |
| **125** | 221 | 98.95 | 98.88 | 98.6 |
| **150** | 274 | 99.00 | 98.94 | 98.7 |
| **175** | 306 | 99.04 | 98.98 | 98.7 |
| **200** | 337 | 99.07 | 99.01 | 98.8 |
| **225** | 369 | 99.11 | 99.05 | 98.8 |
| **250** | 399 | 99.13 | 99.08 | 98.8 |
| **300** | 458 | 99.18 | 99.13 | 98.9 |
| **400** | 567 | 99.22 | 99.15 | 99.0 |
| **450** | 621 | 99.24 | 99.20 | 99.0 |
| **500** | 675 | 99.26 | 99.22 | 99.0 |
| **600** | 781 | 99.29 | 99.25 | 99.0 |
| **750** | 941 | 99.33 | 99.29 | 99.1 |

* + - 1. DISTRIBUTION TRANSFORMERS – OPTIMIZED TO REDUCE HARMONIC IMPACT UNDER HEAVY LOAD

Application Note: This is the appropriate specification for transformers feeding a combination of heavy loading with a harmonic-rich profile. Under these conditions, harmonic currents are at levels that compromise the system power quality including distortion of the voltage waveform. This configuration is less common given the predominance of light loading (see preceding Article "Distribution Transformers – Low Load Optimized" for light load optimization). Given the heavy load level and harmonic-rich non-linear load profile, UL requires the transformer to carry a suitable K-Rating in order for the listing to be valid for the application. A K-20 rating has been found to be appropriate for this application. The transformer design needs to also minimize the operating losses in this application, which combines harmonics and heavy loading. Achieving very low losses under these conditions embeds significant energy savings compared to a typical DOE 2016 transformer.

A wide range of kVA ratings enables rightsizing to the electrical system, reducing capital cost, operating cost, and reduced cost of the surrounding electrical infrastructure including breakers, panels, conduits and conductors. Overall electrical physical footprint and carbon footprint are reduced.

* + - * 1. Basis-of-Design: T1000-30H.
        2. Winding Material: Copper.
        3. Primary Winding: 3-wire delta or wye, to provide the required zero- or 30-degree phase shift as indicated on Drawings.
        4. Secondary Winding: Zig-zag.
        5. K-Factor Rating: K-20.
        6. Operating Temperature Rise: 105 deg C in 40 deg C maximum ambient conditions.
        7. Continuous Duty Overload Capacity: 120-percent of nominal kVA Rating.
        8. Electrostatic Shield: Each winding is independently single shielded with a full-width copper electrostatic shield.
        9. Efficiency: Exceed minimum efficiency requirements of U.S. Department of Energy, 10 CFR Part 431 (DOE 2016), by complying with the "Table of Maximum No-Load Losses and Efficiency Requirements" at 1/6 load, efficiency at 35- and 50-percent load, and efficiency at 50-percent load under a K-13 load profile, when tested in an ISO 17025 certified efficiency test lab.
        10. Table of Maximum No-Load Losses and Efficiency Requirements:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **kVA** | **No load losses (Watts)** | **Efficiency at 35% load under linear profile (%)** | **Efficiency at 50% load under linear profile (%)** | **Efficiency at 50% load under K13 nonlinear profile (%)** |
| **15** | 51 | 98.17 | 98.03 | 97.6 |
| **20** | 61 | 98.29 | 98.15 | 97.7 |
| **25** | 70 | 98.40 | 98.26 | 97.9 |
| **30** | 80 | 98.52 | 98.38 | 98.0 |
| **45** | 111 | 98.64 | 98.52 | 98.2 |
| **50** | 120 | 98.67 | 98.55 | 98.2 |
| **63** | 141 | 98.73 | 98.61 | 98.3 |
| **75** | 161 | 98.79 | 98.67 | 98.3 |
| **100** | 206 | 98.87 | 98.77 | 98.4 |
| **112.5** | 229 | 98.91 | 98.82 | 98.5 |
| **125** | 243 | 98.94 | 98.85 | 98.5 |
| **150** | 270 | 99.00 | 98.91 | 98.6 |
| **175** | 307 | 99.03 | 98.94 | 98.6 |
| **200** | 345 | 99.05 | 98.97 | 98.7 |
| **225** | 382 | 99.08 | 99.00 | 98.7 |
| **250** | 410 | 99.10 | 99.02 | 98.7 |
| **300** | 466 | 99.15 | 99.07 | 98.8 |
| **400** | 547 | 99.20 | 99.12 | 98.8 |
| **450** | 587 | 99.23 | 99.15 | 98.8 |
| **500** | 628 | 99.25 | 99.17 | 98.8 |
| **600** | 738 | 99.28 | 99.21 | 98.9 |
| **750** | 903 | 99.32 | 99.27 | 99.0 |

* + - 1. TRANSFORMER OPTIONS

Select options below to be included. Delete all options NOT included.

* + - * 1. Integrated Load Power and Energy Logger

Factory-installed meter inside the transformer, connected to the transformer secondary, with fused voltage connections. Revenue class current transformer, 0.5 or better.

Access via USB port on front of transformer for meter setup, real time data viewing, event log, and downloading of logged data through an integrated USB access port on the enclosure of the transformer.

Measured parameters: V, I, PF, Hz, kW, kVA, kVAR, kWh, Ad, KWd, kVAd, kVARd, temperature. Real-time data at user selected intervals is logged by meter. Event log for user defined thresholds when measured values are exceeded.

Log any two selected data points for continuous rolling window 10 years. Log additional data points for proportionally shorter periods.

* + - 1. IDENTIFICATION

Retain one of two "Nameplate" paragraphs in this article to specify transformer identification. Coordinate names of transformers with Drawings and schedules.

* + - * 1. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."
      1. SOURCE QUALITY CONTROL
         1. Follow standard industry practice to test and inspect transformers according to NEMA ST20-2014, IEEE C57.12.01, IEEE C57.12.91, UL 1561, and DOE Test Method for Measuring the Energy Consumption of Distribution Transformers under Appendix A to Subpart K of 10 CFR Part 431.
         2. Follow Nonlinear Load Test Program for representative transformers as defined in this specification.

Request at time of order list of units to be tested on this project as defined by project engineer.

* + - * 1. Factory Sound-Level Tests: Conduct sound-level tests as specified.

Request a report from the manufacturer at time of order, that noise compliance test results will be required on this project as defined by project engineer.

* + - 1. FACTORY WITNESS TESTING

At time of order, the customer may request that the Owner's representative witness the performance testing of one or more of the transformers on the project at the manufacturer’s facility, along with a demonstration of integrated metering option, if specified. Retain this Article if factory tests will be witnessed by Owner's representative.

* + - * 1. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
      1. NON-LINEAR LOAD TEST PROGRAM
         1. Determine efficiency by actual measurement using a non-linear load bank. Calculations based on software modeling are not acceptable.
         2. Perform non-linear load testing in ISO 17025 Certified Efficiency Test Lab following a defined protocol, independently audited within the manufacturer’s certified ISO system.
         3. Determine efficiency in accordance with IEEE C57.12.91-1995, Standard Test Code for Dry-Type Transformers. Proprietary or non-standard methodology is not acceptable.
         4. Use a non-linear load bank consisting of phase-neutral loads, and a representative of a mix of electronic equipment.
         5. Use revenue class meters and current transformers with up-to-date calibration certificates. Operate current transformers within approved accuracy loading range. Obtain simultaneous primary and secondary energy and harmonic data with dual meters. Provide meter and current transformer model, accuracy, serial number, and calibration information.
         6. Efficiency: Take measurements at multiple load levels. Plot to show compliance with specification and correlation to the designed efficiency curve.
         7. Include harmonic data, current, and voltage total harmonic distortion (THD) at different load levels.

1. EXECUTION
   * + 1. RESPONSIBILITY
          1. Install transformers, factory-supplied materials, accessories, and options, furnished by the transformer manufacturer.
       2. EXAMINATION
          1. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
          2. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
          3. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

Revise 5-ohm value in first paragraph below to suit Project.

* + - * 1. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
        2. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.
        3. Proceed with installation only after unsatisfactory conditions have been corrected.
      1. PRE-INSTALLATION PERFORMANCE VALIDATION
         1. Performance Validation Reports: For each transformer supplied, identified by serial number.

Include documentation, signed and sealed by manufacturer's professional engineer (PE), identifying each product supplied on project by model and serial number.

Include documentation confirming the transformers are tested in an ISO 17025 certified test lab.

Include documentation that test report complies with DOE Test Method for Measuring the Energy Consumption of Distribution Transformers under Appendix A of DOE 10 CFR Part 431, Subpart K, identifying no-load losses, and efficiency at 35-percent loading.

Include documentation for audible noise complying with NEMA ST 20 Routine Test Report.

* + - * 1. Submit the report(s) to the project consulting electrical engineer to confirm compliance with project requirements.
      1. INSTALLATION

Verify seismic-bracing requirements with authorities having jurisdiction. Wall-mounted transformers may be inappropriate in areas of seismic activity.

* + - * 1. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

Retain subparagraph below for projects in areas of seismic activity.

Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."

If appropriate, retain first paragraph below for projects in areas of seismic activity.

* + - * 1. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.
        2. Construct concrete bases and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

* + - * 1. Secure transformer to concrete base according to manufacturer's written instructions.
        2. Remove shipping bolts, blocking, and wedges.
        3. Install transformer nameplates with specific transformer data. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."
      1. CONNECTIONS
         1. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
         2. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
         3. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
         4. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.
      2. FIELD QUALITY CONTROL

Retain one of first four paragraphs below. Retain first "Testing Agency" Paragraph below if Owner will hire an independent testing agency.

* + - * 1. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

Retain "Testing Agency" Paragraph below to require Contractor to hire an independent testing agency.

Retain "Manufacturer's Field Service" Paragraph below to require a factory-authorized service representative to perform tests and inspections.

* + - * 1. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

Retain "Perform tests and inspections" Paragraph below to require Contractor to perform tests and inspections and retain option to require Contractor to arrange for the assistance of a factory-authorized service agent.

* + - * 1. Perform tests and inspections.

Tests referenced in first two paragraphs below are from NETA ATS and include inspection procedures to verify proper installation. They also include tests and measurements of insulation resistance and turns ratios. Cost of extensive testing may not be warranted for some projects. Revise paragraphs to suit Project.

Retain "Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests" or "Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests" Paragraph below, or both, to specify transformer testing.

* + - * 1. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:

Visual and Mechanical Inspection.

Inspect physical and mechanical condition.

Inspect anchorage, alignment, and grounding.

Verify that resilient mounts are free and that any shipping brackets have been removed.

Verify the unit is clean and free from foreign materials.

Perform specific inspections and mechanical tests recommended by manufacturer including ensuring all bolted connections are torqued to manufacturer's specifications.

Verify that as-left tap connections are as specified.

Verify the presence of surge arresters where specified and that their ratings are as specified.

Electrical Tests:

Measure resistance at each winding, tap, and bolted connection.

Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.

Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.

Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

Retain "Large (Larger Than 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests" Paragraph below for low-voltage transformers larger than 167-kVA single phase or 500-kVA three phase.

* + - * 1. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:

Visual and Mechanical Inspection:

Inspect physical and mechanical condition.

Inspect anchorage, alignment, and grounding.

Verify that resilient mounts are free and that any shipping brackets have been removed.

Verify the unit is clean and free from foreign materials.

Perform specific inspections and mechanical tests recommended by manufacturer including ensuring all bolted connections are torqued to manufacturer's specifications.

Verify that as-left tap connections are as specified.

Verify the presence of surge arresters and that their ratings are as specified.

Electrical Tests:

Measure resistance at each winding, tap, and bolted connection.

Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.

Perform power-factor or dissipation-factor tests on all windings.

Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.

Perform an excitation-current test on each phase.

Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.

Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

* + - * 1. Where integrated metering has been specified to be connected to an external network, provide the required connection and commissioning to Owner’s system.
        2. Remove and replace units that do not pass tests or inspections and retest as specified above.
        3. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.

Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

* + - * 1. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.
      1. ADJUSTING
         1. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
         2. Output Settings Report: Prepare a written report recording output voltages and tap settings.
      2. CLEANING
         1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.
      3. ATTACHMENT 1–LOW VOLTAGE TRANSFORMER SPECIFICATION PERFORMANCE COMPLIANCE FORM
         1. Attachment 1 is required for all requests for approval.

ATTACHMENT 1: Low Voltage Transformer Performance Compliance Form

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **General Requirements for All Transformers** | | | | | | | | | | |
| **PERFORMANCE SPECIFICATION** | **SPECIFICATION SECTION REFERENCE** | **SPECIFICATION REQUIREMENT** | | | | **PROPOSED** | **COMPLY?**  **YES / NO** | | **CONFIRMING DOCUMENTATION REQUIRED** | |
| ISO Registrations | 1.3 B. 14.  1.3 B. 13.  1.3 B. 15. | ISO 9001  ISO 14001  ISO 17025 | | | |  |  | | Copies of Respective Current Registrations in the Name of the Manufacturer | |
| Warranty | 1.8 A. | 32 Years | | | |  |  | | Published Warranty  Certificate | |
| Audible Noise | 2.3 Q. | At Least 3 dB Less than NEMA ST-20 Requirements | | | |  |  | | Test Documentation | |
| Enclosure | 2.3 I. 1. a. | Lockable Hinged Doors | | | |  |  | | Data Sheet | |
| Rear-Wall Clearance | 2.3 I. 1. b. | To Within 2” of Rear Wall | | | |  |  | | Confirmation from UL File | |
| Impedance | 2.3 L. | 4% or Greater | | | |  |  | | Test Documentation | |
| Inrush | 2.3 M. | Suitable for 125% Rated Input Breaker(s) | | | |  |  | | Signature of Factory PE  (see below) | |
| Transformer Taps | 2.3 J. | Two 2.5% Taps Above  Four 2.5% Taps Below | | | |  |  | | Data Sheet | |
| No Load Losses &  Efficiency Performance | 2.4 G.  2.5 G.  2.6 J. | As Per Chart(s) in  Specification | | | |  |  | | Appendix A of DOE 10 CFR Part 431, Subpart K  (Testing in ISO 17025 Certified Efficiency Test Lab) | |
| Guaranteed to Meet Specified Performance | 1.8 B. | As Per Specification | | | |  |  | | Published Warranty  Certificate | |
| **Requirements for Transformers Designed for Low Load Application(s)** | | | | | | | | | | |
| K-7 Rating | 2.4 C. | K-7 Rating | | | |  |  | | Data Sheet | |
| Windings | 2.4 B. | Copper | | | |  |  | | Data Sheet | |
| Temperature Rise | 2.4 D. | 130 Degrees C | | | |  |  | | Data Sheet | |
| Continuous Overload Capacity | 2.4 E. | 105% | | | |  |  | | Data Sheet | |
| **Requirements for Transformers Designed for High Load Application(s)** | | | | | | | | | | |
| K-13 Rating | 2.5 C. | K-13 Rating | | | |  |  | | Data Sheet | |
| Windings | 2.5 B. | Copper Pri./Aluminum. Sec. | | | |  |  | | Data Sheet | |
| Temperature Rise | 2.5 D. | 105 Degrees C | | | |  |  | | Data Sheet | |
| Continuous Overload Capacity | 2.5 E. | 120% | | | |  |  | | Data Sheet | |
| **Requirements for Harmonic Mitigating Transformers** | | | | | | | | | | |
| K-20 Rating | 2.6 E. | K-20 Rating | | | |  |  | | Data Sheet | |
| Windings | 2.6 B. | Copper | | | |  |  | | Data Sheet | |
| Temperature Rise | 2.6 F. | 105 Degrees C | | | |  |  | | Data Sheet | |
| Continuous Overload Capacity | 2.6 G. | 120% | | | |  |  | | Data Sheet | |
| Harmonic Treatment | 2.6 C. & 2.6 D. | As per Specification | | | |  |  | | Data Sheet | |
| Electrostatic Shield | 2.6 H. | Included in Transformer | | | |  |  | | Data Sheet | |
| **Performance testing/report is required for all transformers (Identified by Serial Number), shipped to the project site is to include the following.**  **(Factory test report will be sent to the engineer at the time of shipment. Failure to provide the factory testing documentation as committed will necessitate testing to be performed on the job site and will be scheduled with the engineer and the owner, at no cost to the owner.)** | | | | | | | | | | |
| No Load Losses | 3.3 | | As Per Specification  Requirements | | Testing to be:  (Circle One)  At Factory / On Site | |  | Test  Documentation | | |
| Nonlinear Efficiency Test |
| Audible Noise Test |
| **Signature Attesting Validity of Information Provided** | **Printed Name** | | | **Organization** | | | **Signature** | | | **Date** |
|  | | |  | | |  | | |  |

END OF SECTION 262213