

## **SECTION 26 22 00**

### **LOW VOLTAGE TRANSFORMERS**

#### **PART 1 - GENERAL**

##### 1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Divisions 0 and 1 and Section 26 00 01, "Electrical General Provisions", govern this Section.

##### 1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide low voltage transformer work as shown, scheduled, indicated and as specified.
- B. Types: The types of low voltage transformers required for the project include, but are not limited to,
  1. Dry- Type General Purpose Transformers.
  2. K-Factor Rated Dry-Type Transformers.
  3. Dry-Type Harmonic Mitigating Transformers.

##### 1.3 STANDARDS:

- A. Products shall be designed, manufactured, tested and installed in compliance with the following standards:
  1. NEMA ST 1 - Specialty Transformers.
  2. ANSI/NEMA ST 20 - Dry Type Transformers for General Applications.
  3. ANSI C33.4.
  4. ANSI C89.2.
  5. ANSI/UL 506 - Specialty Transformers.
  6. UL 1551
  7. NEMA TP-1 and EPA Energy Star compliant.
- B. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- C. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- D. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:

##### 1.4 QUALITY ASSURANCE:

- A. Listing and Labeling: Provide transformers specified in this Section that are listed by Underwriters Laboratories (UL), certified by CSA, bear the EPA ENERGY STAR logo. Transformers shall meet relevant NEMA, UL, CSA, NFPA, EPA Energy Star Program.

- B. Characteristics: Transformer, with characteristics and options specified, must deliver the energy savings required under the EPA ENERGY STAR program and bear the EPA ENERGY STAR logo.
- C. Minimum Linear Load Efficiency: NEMA TP-1 and EPA ENERGY STAR compliant; 97.5 percent for 30 kVA, 97.7 percent for 45kVA, 98.0 percent for 75 kVA, 98.2 percent for 112.5kVA, 98.3 percent for 150 kVA, 98.5 percent for 225 kVA, 98.6 percent for 300 kVA, 98.7 percent for 500 kVA.
- D. Non-linear Load Efficiency: Greater than 98 percent for all transformers 45kVA and above, greater than 97 percent for transformers 30kVA and smaller. Load per section "Factory Test Reports" above.
- E. Manufacturers: Provide products complying with these specifications and produced by one of the following:
  - 1. Dry- Type General Purpose and K-Factor Rated Dry-Type Transformers.
    - a. General Electric Company.
    - b. Hevi-Duty Electric Corporation.
    - c. Square D Company.
    - d. Cuttler Hammer.
    - e. Siemens.
    - f. Power Smith.
  - 2. Harmonic Mitigating Transformers:
    - a. Powersmiths International Corp.
    - b. Power Quality International, Inc.
- F. Energy Star: Manufacturer must be a US Environmental Protection Agency (EPA) ENERGY STAR Partner.
- G. UL Label: All transformers shall be UL-labeled.

#### 1.5 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
  - 1. Include data on features, components, ratings and performance for each type of transformer specified. Include dimensioned plans, sections, and elevation views. Show minimum clearances and installed devices and features.
    - a. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics.
    - b. No load core loss, full load winding conductor loss, full load losses, efficiency at 25 percent, 50 percent, 75 percent and 100 percent rated loads, percent regulation with 80 percent and 100 percent power factor loads, sound level, tap configurations, insulation system type and rated temperature rise.
  - 2. Cut sheets of the transformers with load ratings, sound ratings, and all associated accessories clearly indicated.
  - 3. Include outline and support point dimensions of enclosures and accessories; unit weight; voltage; kVA; impedance ratings and characteristics; loss data; efficiency at 25, 50, 75

and 100% rated load; sound level; tap configurations; insulation system type, and rated temperature rise.

4. Additional information as required in Section 26 00 01, "Electrical General Provisions".
5. Wiring Diagrams: Detail wiring and identify terminals for tap changing and connecting field-installed wiring.
6. Product Certificates: Signed by manufacturer of transformers certifying that the products furnished comply with requirements, including harmonic performance guarantee.
7. Factory Test Reports: Base data for electrical characteristics on actual laboratory tests of typical transformers for harmonic performance and energy efficiency. Testing to be conducted using three (3) single-phase 120V nonlinear load banks with personal computer harmonic profile (100 percent current THD) at 35 percent or more of transformer nameplate load level. Test results to be submitted at time of quotation to include transformer efficiency, change in voltage THD between transformer primary and secondary terminals, ratio of 3rd harmonic current in primary delta current profile compared to that in secondary phase current.
8. Copies of manufacturer's design and routine factory tests required by referenced standards, including results of zero sequence impedance and reactance tests.

#### 1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING:

- A. Transport, handle, store and protect products.
- B. Deliver transformers individually wrapped for protection and mounted on shipping skids.
- C. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.
- D. Handle transformers carefully to avoid damage to material components, enclosure and finish. Use only lifting eyes and brackets provided for that purpose. Damaged transformers shall be rejected and not be installed on project.
- E. Store transformers in a clean and dry space and protect from weather. Do not stack transformers.
- F. 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 is not in a space that is continuously under normal control of temperature and humidity.
- G. Transformers shall not be used as work tables, scaffolds or ladders.

### **PART 2 - PRODUCTS**

#### 2.1 MATERIALS AND COMPONENTS:

- A. General: Except as otherwise indicated, provide transformer manufacturer's standard materials and components as indicated by his published product information, designed and constructed as recommended by the manufacturer, and as required for a complete installation.

#### 2.2 DRY TYPE GENERAL PURPOSE, K-RATED AND ISOLATION TRANSFORMERS:

- A. General:

1. Indoor transformers shall be dry type, 2-winding transformers, voltage, phase and kVA rated as shown, noted or scheduled. Transformers shall be designed for 60-hertz operation, self-cooled per NEMA Class AA and shall have manufacturer's standard impedance.
2. Primary winding of 3-phase standard transformers shall be delta-connected. Secondary windings of 3-phase transformers shall be wye or as required to cancel zero sequence current flux for phase cancellation type, with the common neutral brought out. Transformer primary and secondary voltages shall be as shown on the Drawings.
3. Suppression transformers shall have the primary and secondary coils physically separated.

**B. Construction:**

1. Transformer core shall be of a common core construction using cold rolled, oriented, high permeability silicon steel, formed as a coil. Windings shall be **[copper or electrical grade aluminum]** individual windings terminated with **[tin-plated aluminum bars] [or] [tin-plated or silver-plated copper bars]** or wire electrically welded to the ends of the windings. Foil windings shall not be acceptable.
2. Transformer coils shall be vacuum pressure impregnated (VPI) **[or dipped]** with non-hydroscopic, thermosetting varnish and shall have a final wrap of electrical insulating material designed to prevent injury to the magnet wire. Transformers having coils with magnet wire visible will not be acceptable. The core and coil shall be completely isolated from the enclosure by means of vibration absorbing mounts.
3. All ventilating openings shall be of the baffled type. Ventilated dry-type transformers installed in sprinklered space shall have rain shields on all openings.
4. The base of the transformer shall be constructed of heavy gauge steel. The transformer enclosure shall be degreased, cleaned, phosphatized, primed, and finished with baked enamel.

**C. Taps:** Transformers shall have taps as follows:

KVA Rating	Taps
0.25 to 2 kVA, single phase	No taps
3-15 kVA, single phase	Two 2.5% taps below normal voltage
25-100 kVA, single phase	Six 2-1/2% taps, two above and four below normal voltage
167-250kVA, single phase	Four 2-1/2% taps, two above and two below normal voltage
9-15 kVA, three phase	Two 2.5% taps below normal
30-300 kVA, three phase	Six 2-1/2% taps, two above and four below normal voltage
500 kVA, three phase	Four 2-1/2% taps, two above and two below normal voltage

- D. Temperature Rating:** Transformers shall utilize an insulation system that has been properly temperature classified and approved by UL and shall have temperature ratings as follows. **[Energy saving temperature rise, where specified, shall be obtained by increasing the**

**transformer conductor size and shall not employ larger air ducts or cooling aids to lower the resistance temperature rise.]** The maximum top of case temperature shall not exceed **[35°F (energy saving design)] [50°F (standard and K Factor rated designs)]** rise above ambient.

KVA Rating	Temperature Rating
0.25 to 2 kVA	Maximum winding temperature rise of 80°C with an insulation system temperature classification of 155°C
3-9 kVA	Maximum winding temperature rise of 115°C with an insulation system temperature classification of 185°C
15 kVA and above	Maximum winding temperature rise of <b>[80°C (energy saving design)] [115°C (energy saving and K Factor rated design)] [150°C]</b> with an insulation system temperature classification of 220°C.

- E. K-Factor Non-Linear Load Ratings: Transformers, where shown on the drawings, shall be K Factor rated to serve non-linear loads. Transformer primary and secondary temperature shall not exceed 220°C at any point in the coils while carrying the transformer full rated capacity of non-linear loads at the load K Factor shown on the drawings.
- F. K-Factor Rated Transformer Neutrals: Neutral terminals for phase cancellation K Factor rated transformers shall be designed for 200 percent of the secondary phase conductor ampacity
- G. Load Rating:
  1. Transformers shall be capable of operating at 100% of nameplate rating continuously while in an ambient temperature not exceeding 40°C.
  2. Transformers 5 kVA and larger shall be capable of meeting the daily overload requirements of ANSI Standard C57.12.
- H. Vibration Isolation: Each transformer core and coil shall be mounted in the transformer enclosure on rubber vibration isolators. Vibration isolators shall limit the transmission of sound from the 120 Hz harmonic to 10% of its unisolated level, and shall certified as such on the Shop Drawings.
- I. Grounding: The core and coils shall be visibly grounded to the frame of the transformer cubicle by means of a flexible grounding strap of adequate size.
- J. Sound Rating: The transformer shall have sound levels equal to or lower than those ratings established in the latest revision of NEMA ST-20 and as shown in the following table. Sound ratings shall be measured per ANSI C89.91.

KVA (600 Volt Class)	Transformer Rating Maximum Sound Level Decibels Per NEMA ST-20

0-09	40
10-50	45
51-150	50
151-300	55
301-500	60

K. Testing:

1. The manufacturer shall have thoroughly tested each transformer for proper operation before shipment.
2. The manufacturer shall have performed the following additional tests on units identical to the design type being supplied. Furnish proof-of-performance of these tests in the form of test data sheets upon request.
  - a. Sound levels.
  - b. Temperature rise tests.
  - c. Full-load core and winding losses.
  - d. Percent regulation with 80 and 100% power factor load.
  - e. Percent impedance.
  - f. Exciting current.
  - g. Insulation resistance.
  - h. Efficiency at 1/4, 1/2, 3/4, and full load.
  - i. Noise attenuation on suppression transformers.

- L. Shield: Provide an electrostatic shield between the transformer primary and secondary to attenuate source side line interference for transformers indicated to be shielded and for all transformers with a K-factor rating greater than 1.0.

2.3 DRY TYPE HARMONIC MITIGATING TRANSFORMERS:

- A. General: Transformers shall be dry type, 2-winding transformers, rated as shown, shall have manufacturer's standard impedance and shall include windings to treat third harmonics in secondary windings. Transformers shall be Powersmiths International Corp. **[K-Star-D] [N-1000D]** series or an approved equal.
1. Primary winding of 3-phase transformers shall be delta-connected. Secondary windings of 3-phase transformers shall be wye connected, with the common neutral brought out. Transformer primary and secondary voltages shall be as shown on the Drawings.
  2. Transformers shall be designed to treat **[3<sup>rd</sup>] [all major harmonics produced by phase-neutral, phase-phase, and 3-phase six-pulse electronic equipment: 3rd, 5th, 7th, and 9th in addition to other zero sequence currents].**
  3. 3rd harmonic and other zero sequence currents shall be treated in the secondary windings the transformer through flux cancellation, and shall not be coupled into the primary winding. Trapping these currents in the primary delta winding, as is the case for the delta-wye transformer configuration, is not acceptable.

4. [5th and 7th harmonics for single output transformers are treated by introducing the appropriate primary-to-secondary phase-shift in the transformer such that these currents subtract at the common bus with 5th and 7th harmonic currents produced by other similar harmonic current sources fed from the same bus. See Drawings for phase shift of each transformer. Fundamental current imbalance shall be reduced on the primary side of the transformer compared to the secondary side.]
  5. Transformer efficiency shall comply with EPA ENERGY STAR Energy Savings Program.
  6. Harmonic cancellation performance guarantee shall be provided by the manufacturer.
- B. Harmonic Cancellation: Transformer secondary windings shall be wound to cancel zero-sequence current flux to cancel 3<sup>rd</sup> harmonic current. Zero sequence impedance/reactance shall be less than 0.95%/0.3%. Transformer secondary shall be connected to cancel zero sequence current flux (3<sup>rd</sup>, 9<sup>th</sup>, 15<sup>th</sup> etc). These currents shall not be coupled into the primary windings of the transformer. **[Provide windings with 0 or 30 degrees phase shift with winding arrangements as required to cancel zero sequence current flux (3<sup>rd</sup>, 5<sup>th</sup>, 7<sup>th</sup>, 9<sup>th</sup>, 15<sup>th</sup> etc) as scheduled on the drawings.]**
- C. Construction:
1. Transformer core shall be a common core construction using cold rolled, grain oriented, high permeability silicon steel, formed as a coil. Windings shall be copper individual windings terminated with tin-plated or silver-plated copper bars or wire electrically welded to the ends of the windings, Neutral terminals shall be designed for 200 percent of the secondary phase conductor ampacity. Foil windings shall not be acceptable.
  2. Transformer coils shall be vacuum pressure impregnated (VPI) with non-hydroscopic, thermosetting varnish and shall have a final wrap of electrical insulating material designed to prevent injury to the magnet wire. Transformers having coils with magnet wire visible will not be acceptable. The core and coil shall be completely isolated from the enclosure by means of vibration absorbing mounts.
  3. All ventilating openings shall be of the baffled type. Ventilated dry-type transformers installed in sprinklered space shall have rain shields on all openings.
  4. The base of the transformer shall be constructed of heavy gauge steel. The transformer enclosure shall be degreased, cleaned, phosphatized, primed, and finished with baked enamel.
- D. Taps: Three phase transformers shall have a minimum of four 2-1/2% taps, two above and two below normal.
- E. Temperature Rating: Transformers shall utilize an insulation system that has been properly temperature classified and approved by UL. Transformers shall have a maximum winding temperature rise of 115°C (energy saving design) with an insulation system temperature classification of 220°C. Energy saving temperature rise, where specified, shall be obtained by increasing the transformer conductor size and shall not employ larger air ducts or cooling aids to lower the resistance temperature rise. The maximum top of case temperature shall not exceed 35°F (energy saving design) and 50°F (K Factor rated designs) rise above ambient.
- F. Non-Linear Load Ratings: Transformers, where shown on the drawings, shall be K-20 rated to serve non-linear loads. Transformer primary and secondary temperature shall not exceed 220°C at any point in the coils while carrying the transformer full rated capacity of non-linear loads at the load K Factor shown on the drawings.

G. Load Rating:

1. Transformers shall be capable of operating at 100% of nameplate rating continuously while in an ambient temperature not exceeding 40°C.
2. Transformers shall be capable of meeting the daily overload requirements of ANSI Standard C57.12.

H. Energy Efficiency Ratings: Transformers shall be 98% efficient and shall bear the EPA ENERGY STAR logo and shall be NEMA TP1 compliant.

I. Lugs: Transformers shall be provided with lugs suitable for use with the cable size and material installed. Fasteners used to attach lugs to terminals and buses shall be carbon steel Grade 5 hex head cap screws and nuts with carbon steel flat washers and lock washers. Transformer wiring compartments shall provide adequate space for wiring to all lugs.

J. Vibration Isolation: Each transformer core and coil shall be mounted in the transformer enclosure on rubber vibration isolators. Vibration isolators shall limit the transmission of sound from the 120 Hz harmonic to 10% of its unisolated level, and shall certified as such on the Shop Drawings.

K. Grounding: The core and coils shall be visibly grounded to the frame of the transformer cubicle by means of a flexible grounding strap of adequate size.

L. Sound Rating: The transformer shall have sound levels equal to or lower than those ratings established in the latest revision of NEMA ST-20 and as shown in the following table. Sound ratings shall be measured per ANSI C89.91.

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M. Testing:

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2. The manufacturer shall have performed the following additional tests on units identical to the design type being supplied. Furnish proof-of-performance of these tests in the form of test data sheets upon request.
  - a. Sound levels.
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  - c. Full-load core and winding losses.
  - d. Percent regulation with 80 and 100% power factor load.
  - e. Percent impedance.
  - f. Exciting current.

- g. Insulation resistance.
  - h. Efficiency at 1/4, 1/2, 3/4, and full load.
  - i. Noise attenuation on suppression transformers.
- N. Shield: Provide a full width copper electrostatic shield between the transformer primary and secondary to attenuate source side line interference.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION OF TRANSFORMERS:**

- A. General: Install transformers as indicated in accordance with the applicable requirements of the NEC and the National Electrical Contractor's Association "Standard of Installation". Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. Manufacturer's Recommendations: All installation shall be in accordance with manufacturer's published recommendations.
- C. Conduit Connections: All conduit directly connected to transformer enclosures shall be flexible steel conduit extending for a minimum of **[24] [48]** inches from transformer enclosure as measured along the conduit center line. Run a bonding jumper, sized per NEC Table 250-95, on outside of flexible conduit.
- D. Cable Connections: Make transformer cable connections with compression-type lugs suitable for termination of 75 degrees C rated conductors. Position lugs so that field connections and wiring will not be exposed to temperature above 75 degrees C.
- E. Housekeeping Pads: All floor standing transformers shall be provided with a nominal reinforced concrete housekeeping pad. Refer to Section 26 05 01, "Electrical Basic Materials and Methods", for additional requirements.
- F. Transformer Isolation: Install floor-mounted transformers on concrete housekeeping pads with vibration isolating pads suitable for isolating the transformer noise from the building structure in accordance with Section 26 05 01, "Electrical Basic Materials and Methods". Maintain a minimum of six (6) inches free air space between enclosure and walls.
  - 1. Install transformer plumb and level.
  - 2. For floor and trapeze transformer installations, use one pad type Korfund Elasto-Grip, waffle at each corner of the transformer, sized for load of 50 pounds per square inch.
  - 3. For wall hung transformer installations (15kVA and less), use spring type Korfund Series P. Provide sound pads at each corner of the transformer sized for ½ inch deflection. Securely anchor wall-mounting brackets to wall to provide adequate support.
- G. Suspended Transformers: Suspend transformers (45kVA and less) from structure by means of trapeze hangers constructed of ½ inch galvanized all-thread rods and metal framing channels. Make double-nut connections between rods and channels. Locate transformers to provide adequate ventilation and accessibility.
- H. Identification: Refer to Section 26 02 53, "Identifications for Electrical Systems", for transformer identification.

#### **3.2 TESTING:**

- A. Pre-Energization Check: Check for damage and tighten connections prior to energizing transformer. Verify removal of coil shipping anchor bolts before transformer is energized.
- B. Insulation Tests: Prior to energization, check transformer windings for continuity. Test the insulation resistance from primary phase winding to winding, primary winding to secondary winding, secondary phase winding to winding, and from each winding to ground. Tests shall be made with a Biddle Megger or equivalent test instrument at a voltage of not less than 1000 volts dc with readings taken after 30 and 60 seconds of operation at Megger slip speed. Transformers which do not meet or exceed manufacturers winding insulation resistance specifications shall be replaced and the new transformer shall be tested, until an acceptable resistance is obtained.
- C. Winding Current: During initial no-load energization, check current in each primary winding.
- D. Tap Settings: Measure and record load current and voltage of transformers while loaded to verify proper transformer tap setting. Select the appropriate tap setting on transformer so that the actual secondary voltage is + 1/2 of a tap span at full load.
- E. Test Submittals: Contractor shall furnish all instruments and personnel required for tests. Submit four copies of certified test results to Architect for review. Reports shall include transformer tested, date and time of tests, serial number, tap setting, input and output voltages, primary and secondary winding currents, insulation test results, manufacturers winding insulation resistance specifications, relative humidity, temperature, and weather conditions.
- F. Notification: Notify Architect in writing of any deviation from manufacturer's pre-shipment test data.

**END OF SECTION 26 22 00**