PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. The requirements of the General Conditions, Supplementary Conditions and the following specification sections apply to all Work herein:
   1. Section 26 00 10 - General Requirements
   2. Section 26 00 20 - Scope of Work
   3. Section 26 05 19 - Electrical Conductors - 600 Volts
   4. Section 26 05 26 - Grounding and Bonding
   5. Section 26 05 48 - Vibration and Seismic Controls
   6. Section 26 08 13 - Testing

1.2 SUMMARY

A. Furnish and install Harmonic Mitigating Transformers (HMT) as specified herein and as required for proper transformation of power throughout the Project as indicated on the Drawings.

1.3 REFERENCE STANDARDS

A. Each transformer shall be designed, manufactured, tested and installed in accordance with the latest applicable industry standards including the following:
   1. ANSI/NEMA ST-20 - Dry Type Transformers for General Applications.
   2. ANSI/NEMA TP-1 - Guide For Determining Energy Efficiency for Distribution Transformers.
   3. IEEE-519 - Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.
   4. IEEE-1100 - Recommended Practice for Powering and Grounding Sensitive Electronic Equipment.
   5. Underwriter's Laboratories

B. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed, in accordance with the requirements of the authorities having jurisdiction, and suitable for its intended use on this Project.

1.4 SUBMITTALS

A. The following submittal data shall be furnished according to the General Conditions and Section 26 00 10 and shall include, but not be limited to:
   1. Harmonic Mitigating Transformers* complete with:
      a. Capacity data, bus data, construction details, electrical characteristics, and physical dimensions.
      b. Technical data per NEMA ST20 for each distinct configuration on the Project.
      c. Linear and nonlinear load efficiency at 25%, 50%, 75%, and 100% of nameplate rating.
      d. Manufacturer's Nonlinear Load Test Program detailed description. This shall include as a minimum, metering system details, load waveform, and harmonic spectrum. The testing procedure must be approved by the Engineer.
      e. Copy of factory test of a representative transformer of each applied rating.
      f. Independent Performance Validation under single-phase nonlinear load by an independent test lab, as a minimum including 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.
      g. Detail of the vibration isolation being utilized.

B. All items or equipment listed above with asterisks (*) shall be certified by the manufacturer using Manufacturer Certification "MCA" as set forth in Section 26 00 10. See Section 26 00 10 for certification requirements.

1.5 WARRANTY

A. Comply with the requirements of the General Conditions and Section 26 00 10.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. If it complies with these Specifications, Harmonic Mitigating Transformers manufactured by one of the following manufacturers will be acceptable:
1. General Electric Type MH Harmonic Mitigating Transformers
2. Hammond.
3. Mirrus.
4. Power Quality International.
5. Powersmiths International Corporation.
6. Siemens.
7. Eaton.
8. Square D.

2.2 RATINGS

A. Harmonic Mitigating Transformers shall be located as shown on the Drawings and shall have capacities, current characteristics, and ratings indicated.

2.3 WINDING CONFIGURATION

A. Primary: 480 Volt, 3-phase, 3-wire, delta.

B. Secondary: 208Y/120Volt, 3-phase, 4-wire output.

C. Harmonic cancellation 3rd, 9th, and other zero sequence harmonics shall be treated in secondary windings through flux cancellation. Fifth (5th) and 7th, harmonics shall be treated on the common primary bus by a phase shift between paired transformers.

2.4 HARMONIC PERFORMANCE

A. Transformers shall be designed to treat all major harmonics produced by phase-neutral, phase-phase, and 3-phase six pulse electronic equipment: 3rd, 5th, 7th, and 9th.

B. Performance Validation: Provide documentation to validate testing of transformer harmonic performance and energy efficiency. Testing to be conducted using three single phase 120V nonlinear load banks with personal computer harmonic profile (100% current total harmonic distortion) at 25% or more of transformer nameplate load level. Test results to be submitted at time of quotation to include transformer efficiency, change in voltage total harmonic distortion between transformer primary and secondary terminals, ratio of 3rd harmonic current in primary delta current profile compared to secondary phase current.

C. Linear Load Efficiency: Transformers shall be NEMA TP-1 and EPA Energy Star compliant. Performance shall meet or exceed the following: 97.5% for 30 kVA, 97.7% for 45 kVA, 98.0% for 75 kVA, 98.2% for 112.5 kVA, 98.3% for 150 kVA, 98.5% for 225 kVA, 98.6% for 300 kVA, 98.7% for 500 kVA.

D. Nonlinear Load Efficiency: Transformer nonlinear load efficiency shall meet or exceed 97% for all transformers while serving nonlinear loads as described in the Performance Validation Test above totaling between 40% and 60% of the nameplate rating of the transformer.

E. Third (3rd) Harmonic Treatment: 3rd, 9th, and other zero sequence currents shall not be coupled into the transformer primary winding to the extent of delivering a minimum 50 times reduction of 3rd harmonic in the primary delta current profile compared to that in transformer secondary phase current.

F. Fifth (5th) and 7th Harmonic Treatment: 5th, 7th, 17th, 19th harmonics shall be treated through the primary-to-secondary phase-shift in each transformer as indicated in the Drawings such that these currents subtract at the common bus with those produced by other similar sources.

G. Voltage Distortion: Change in voltage total harmonic distortion between transformer primary and secondary terminals shall be no more than 0.75% per Performance Validation Test.

2.5 GENERAL

Harmonic Mitigating Transformers shall be two winding type and be constructed and tested in accordance with ANSI and NEMA standards listed hereinbefore. They shall be designed to withstand for two cycles the maximum fault current which would occur with a bolted fault at the secondary terminals with an infinite bus on the primary side. Each transformer shall comply with the following:

A. Factory assembled and tested, convection air-cooled units of types and ratings specified.

B. Frequency: 60 Hertz

C. Core: Grain-oriented, non-aging silicon steel, 3-leg, common core.

D. Coils: Continuous copper windings without splices, except for taps.

E. Internal Coil Connections: Brazed or pressure type.

F. Primary Winding: One coil per phase and per core leg; 3-phase, 3-wire input.

G. Secondary Winding: Multiple coils per phase and per leg; single 3-phase, 4-wire output.

H. Phase Shift: Primary to secondary to treat targeted harmonics. Zero or 30 degree shift as indicated on the Drawings.

I. Insulation Class: Class 'R'.

J. Rated Operating Temperature Rise: 130°C above 40°C ambient.

K. Varnishing: The manufacturing process shall incorporate vacuum pressure impregnation using polyester resin for both primary and secondary windings.

L. Taps: Full capacity taps in primary side windings are as follows:
1. Three (3) through 30 kVA: Two (2) 5% taps; one above and one below rated voltage.
2. Forty-five (45) kVA and Above: Four (4) 2.5% taps, 2 above and 2 below rated voltage.

M. Impedance: Positive and negative sequence: 3.0 – 4.0% (up to 75 kVA), 3.0-4.8% (112.5-300 kVA). Zero sequence impedance and reactance: 0.95% and 0.3% respectively.

N. Enclosure Type: Indoor, ventilated, drip-proof, NEMA-1 or outdoor, ventilated, rain-proof, NEMA-3R as indicated on the Drawings.

O. Finish: Epoxy powder coating. Enclosure color shall be manufacturer's standard ANSI 61 gray or black.

P. Sound Levels: Pursuant to NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91:
1. 10 – 50 kVA: 45 dB.
2. 51 – 150 kVA: 50 dB.
3. 151 – 300 kVA: 55 dB.
4. 301 – 500 kVA: 60 dB.

Q. Electrostatic Shielding: Each winding shall be independently single shielded with a full-width copper electrostatic shield.

R. Neutral conductor rating shall be 200 percent of phase rating.

S. Transformer primary, secondary, and neutral bus pads shall be suitable to accept compression connectors without field modification of lug pads. Provide compression lugs in conductor sizes and quantities as indicated. Refer to Section 26 05 19 for termination requirements for all conductors.

T. Provide a copper ground bar for equipment grounding conductor terminations within the transformer enclosure. The ground bar shall be bonded to the transformer enclosure. The ground bar shall accommodate the quantity and size of equipment grounding conductors indicated on the Drawings, the bonding jumper from the transformer "XO", and the grounding electrode conductor without field modification. Provide compression connectors for all field terminated ground conductors as required by Section 26 05 19 titled "Electrical Conductors-600 Volt".

U. Provide a copper ground bar for equipment grounding conductor terminations within the transformer enclosure. The ground bar shall be grounded to the transformer enclosure with a bonding jumper. The ground bar shall accommodate the quantity and size of equipment grounding conductors terminated within the transformer as well as the transformer "XO" to enclosure bond without field modification. Space shall be adequate for compression connectors as required by Section 26 05 13 titled "Electrical Conductors-600 Volt".

V. Each floor mounted dry type transformer less than 150KVA shall be mounted on Type ND neoprene vibration isolators manufactured by Mason Industries or an Engineer approved equal, to limit transmission of one hundred and twenty (120) cycles per second to ten percent (10%). Vibration isolators shall incorporate bolt holes for bolting to equipment bases, bottom steel plates for bolting to equipment pads, and shall be sized for 3/8" minimum static deflection. External isolators may be omitted on dry type transformers with internal vibration isolation mounts that comply with the vibration transmission limit. Refer to specification section 26 05 48 "Vibration and Seismic Controls" for requirements for vibration isolation transformers 150KVA and larger.

W. Each suspended dry type transformer shall be suspended with Type HD double deflection neoprene vibration isolation hangers manufactured by Mason Industries or an Engineer approved equal, to limit transmission of one hundred and twenty (120) cycles per second to ten percent (10%). Vibration isolators shall incorporate bolt holes for bolting upper and lower hanger rods, and shall be sized for a maximum of 0.4" maximum static deflection. The quantity and rated capacity range of vibration isolators shall be selected based on the transformer and mounting hardware weight.

PART 3 EXECUTION

3.1 INSTALLATION

A. The Electrical Subcontractor shall install all dry type transformers pursuant to the manufacturer's recommendations and as indicated on the Drawings.

B. Set transformers on vibration isolation mounts. Refer to Section 26 05 48, titled "Vibration and Seismic Controls". Bolt neoprene mounts to floor when transformers are floor mounted and bolt transformer skids to mounts.

C. Loosen and/or remove shipping bolts in accordance with manufacturer's instructions where internal vibration isolations mounts are used.

D. Where primary feeders come from the floor below, they shall terminate at the end of transformer enclosure with a metal grounding bushing with neoprene throat insert. Ground the busing to the transformer enclosure.

E. Conduits shall enter the side of the transformer enclosure. The conduits within 36 inches of the enclosure shall be flexible steel.

3.2 FACTORY TESTING

A. Testing Under Nonlinear Electronic Equipment Load of a representative transformer of each applied rating:
   1. Manufacturer must have a nonlinear Load Test Program operating in the product environment and documented per quality Standard ISO9001.
      a. As a minimum, the nonlinear load bank shall consist of three phases of 12V switch-mode power supplies typical of commercially supplied models capable of producing current total harmonic distortion up to at least 100% current THD, with the capability of blending in other load profiles such as 3-phase rectifiers and resistive load.
      b. Acceptable Alternate Nonlinear Load Bank Configurations:
         1) Crest factor 3 load used in the UPS industry.
   2. Factory test results shall be submitted at time of product submittals.
   3. Efficiency: Measurements shall be taken at multiple load levels and plotted to show compliance with specifications and correlation to the designed efficiency curve.
   4. Harmonic data including current and voltage total harmonic distortion at different load levels shall be included with the test report.

3.3 FIELD TESTING

A. Refer to Section 26 08 13 for additional testing requirements for Harmonic Mitigating Transformers.

END OF SECTION