

PART 1 - GENERAL

- 1.1 SCOPE
- .1 Furnish and install switched harmonic filter equipment as specified herein and as shown on the contract drawings.
 - .2 This specification contains the minimum requirements for the design, manufacture and testing of switched harmonic filter equipment rated 600 volts and below.
 - .3 Harmonic filter equipment provided under other sections of the specifications as part of other equipment must comply with this section.
- 1.2 REFERENCES
- .1 Design and test the harmonic filter equipment in accordance with the latest standards of NEMA, NEC, IEC, IEEE and ANSI.
 - .2 The complete equipment including all components must be UL listed/recognized and labeled per UL 508A-2013, Industrial Control Panels. Internal capacitor cells must be UL labeled and in compliance with:
 - .1 UL 810-1995, Capacitors.
 - .2 IEEE 18-2012, Standard for Shunt Power Capacitors.
 - .3 CSA C22.2 No. 190-M1985(R2009), Capacitors for Power Factor Correction.
- 1.3 SUBMITTALS
- .1 For review/approval:
 - .1 Submit the following information to the Departmental Representative:
 - .1 Master drawing index.
 - .2 Front view elevation.
 - .3 Floor plan.
 - .4 Top view.
 - .5 Nameplate schedule.
 - .6 Conduit entry/exit locations.
 - .7 Equipment ratings including:
 - .1 Short-circuit rating.
 - .2 Voltage.
 - .3 Continuous current.
 - .8 Major component ratings including:
 - .1 Voltage.
 - .2 Continuous current.
 - .3 Interrupting ratings.
 - .9 Cable terminal sizes.
 - .10 Product data sheets.
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- 1.3 SUBMITTALS .2 For construction:
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- .1 Submit the following information for record purposes:
- .1 Final as-built drawings and information for items listed in Paragraph 1.4.
 - .2 Certified production test reports.
 - .3 Installation information.
- .2 The final (as-built) drawings must include the same drawings as the construction drawings and incorporate all changes made during the manufacturing process.
- 1.4 QUALIFICATIONS .1 For the equipment specified herein, the manufacturer must be ISO 14001 and ISO 9001 or 9002 certified.
- .2 The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Departmental Representative, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- 1.5 REGULATORY REQUIREMENTS .1 The harmonic filter equipment must bear a UL label. Supply certified copies of production test reports demonstrating compliance with these standards when requested by the Departmental Representative.
- 1.6 DELIVERY, STORAGE AND HANDLING .1 Handle and store equipment in accordance with manufacturer's instructions. Include one (1) copy of these instructions with the equipment at time of shipment.
- 1.7 OPERATION AND MAINTENANCE MANUALS .1 Provide equipment operation and maintenance manuals with each assembly shipped and include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.
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PART 2 - PRODUCTS

- 2.1 ACCEPTABLE MANUFACTURERS
- .1 Eaton AutoVar Filter.
 - .2 Schneider Electric Accusine PCS.
 - .3 Siemens.
 - .4 The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Departmental Representative.
- 2.2 RATINGS
- .1 The system operating voltage will be as indicated on the contract drawings.
 - .2 The total capacity of the harmonic filter unit is 300 kvar. The total kvar capacity will be divided into 300 kvar automatically switched in steps of 50 kvar.
 - .3 The harmonic filter unit must be a modular design with provisions for expansion to 600 kvar.
 - .4 The capacitor must be rated for operation at ambient temperatures ranging from -20 degrees C to +46 degrees C and at 6000 ft. (1,800 meters) and below.
 - .5 Total Harmonic Distortion (THD) of 5% of voltage waveforms shall not affect the life of capacitors, contactors or controller.
 - .6 A $\pm 10\%$ variation in line voltage shall not affect the life of the capacitor.
 - .7 Tune the filter to the 4.7th harmonic, tuned option.
 - .8 Harmonically harden the capacitor cells to withstand the dv/dt stresses by harmonic voltage distortions, overrated for higher voltage due to voltage rise by the reactors, continuous overvoltage conditions and system voltage variations.
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2.3 MATERIALS

- .1 Capacitors:
- .1 Individual capacitors must be three-phase self-healing Metallized polypropylene type capacitors with a low loss design.
 - .2 The high grade vapor deposited AlZn (Aluminum-Zinc) metallization will employ edge enhancement, wavy cut and ramp metallization techniques allowing for higher inrush current capability, stable and uniform capacitance and lower losses and operating temperatures.
 - .3 The Metallized elements will be impregnated by an inert gas in vacuum to remove all traces of moisture and contaminants and then hermetically sealed to allow excellent capacitor stability and long useful life. The elements are then encapsulated in an insulating, high viscosity polyurethane resin compound and then sealed in an aluminum can.
 - .4 The polyurethane resin must not be a fire hazard, will have a high flash point of 444 deg F or higher and will provide excellent heat dissipation properties while avoiding any partial discharge/corona effects.
 - .5 Furnish each capacitor cell with a UL recognized pressure sensitive interrupter. The interrupter will disconnect all three phases at the same time to maintain a balanced circuit.
 - .6 Capacitors must be low loss, with maximum dielectric losses of 0.2W/kvar and total value less than 0.45 watts per kvar. The capacitors must have integral finger safe terminals with an insulation voltage rating of 3kV AC or higher.
 - .7 Nominal design life of individual capacitor cells will be 10,000 hours under rated and defined operating conditions.
 - .8 Capacitors must be suitable for a high overcurrent carrying capacity of up to 150% rated current and capable of high inrush current capacity of up to 200 times the nominal current.
 - .9 House the capacitor cells in anti-corrosion enclosures such as an extruded aluminum can and provide an integral grounding stud.
 - .10 Individual capacitor cells must be covered by a five (5)-year warranty.
 - .11 See Section 26 35 33 - Power Factor Correction Equipment for additional requirements.
- .2 Reactors:
- .1 Tune the reactor to the 4.7th harmonic order. Reactor to have copper windings, Class R 220 degrees C insulation system, and be designed with open frame construction.
 - .2 Design the copper winding for maximum temperature rise of 80 deg C. Provide thermal protection by three (3) normally closed auto reset

- 2.3 MATERIALS (Cont'd)
- .2 Reactors:(Cont'd)
 - .2 (Cont'd)

thermal switches designed to operate at 180 degrees C.
 - .3 Size the reactors for at least 140% of the nominal current rating for each stage.
 - .3 Wiring:
 - .1 All power wiring must be 600 volts rated using thermoplastic insulation rated for 105 degrees C temperature rise and sized with ampacity rating at 90 degrees C temperature rise.
 - .2 For floor mounted units, make system wiring connections to copper bus bars braced for 65,000 amperes or greater.
 - .3 Shield bus bars, where provided in a system without the integral door interlocked circuit breaker, from direct access by the operator by a barrier sheet and warning labels.
 - .4 Furnish each assembly with appropriately sized solderless connectors capable of handling conductors in accordance with the NEC. Minimum conductor size must have the capacity 1.35 times rated capacitor current.
 - .5 The complete equipment will come pre-wired and factory assembled. Mechanically secure all wiring connections to the specified torque values before shipment.
 - .4 Contactors: capacitor switching duty contactors, rated for switching of rated capacitance by the contactor manufacturer, employing pre-charge module with pre-insertion resistors for damping of capacitor inrush currents.
 - .5 Discharge resistors: provide capacitors with an easily mounted push-on type premium ceramic discharge resistor module that will reduce residual voltage to less than 50 volts within one minute of de-energization as required by the National Electrical Code Article 460.6. Choose resistors that provide 20-year minimum life.
 - .6 Fuses:
 - .1 In line series fuses on all three (3) phases must be UL listed, labeled and be able to provide major overcurrent fault protection.
 - .2 Line fuses to be current limiting Class T type. Minimum interrupting rating must be 200,000 amperes at 480 volts for fuses rated 30 amperes and above. Design fuses for capacitor application and for a rating of not less than 150% filter current rating.
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2.3 MATERIALS
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- .7 Enclosure:
- .1 Provide the switched harmonic filter equipment with a floor-mounted enclosure. The enclosure must be NEMA 1 gasketed fabricated from 12-gauge steel. Provide an internal grounding lug. Capacitor cells must be accessible for visual inspection and replacement from the front of the cabinet without requiring removal of any other parts or components. The enclosure door must have a three-point latch with key locking handle. Provide removable lifting eyes.
 - .2 Provide the cabinet with unidirectional fans for ventilation and cooling. In case of any fixed stages, the fans must be able to operate continuously without any controller or temperature control.
- .8 Control power and protection:
- .1 The control power will be 120V 60Hz AC derived internally in the PFC cabinet.
 - .2 An On/Off switch with control power to all door mounted controls. The On/Off switch must contain a pilot light to indicate on mode.
 - .3 Mount all controls on enclosure door for easy inspection and service.
 - .4 Provide a door interlock to disconnect control power when enclosure door is open.
 - .5 Provide a ground fault breaker to disconnect control power upon accidental contact with control power and ground.
- .9 Reactive power controller/power factor meter:
- .1 Controller will measure the reactive current on every passage of the voltage through zero.
 - .2 Provide LCD display to indicate the stages that are on.
 - .3 Provide the controller with a programmable target cosine selector in the range of .7 lagging to .4 leading.
 - .5 The time delay between switching of capacitors must be field programmable and have a range of 5 seconds to 20 minutes to reduce hunting and allow voltage decay as required by NEC.
 - .6 All output contacts must be disabled upon main power interruption. The controller shall retain its programming after the restoration of supply voltage. The controller shall bring the capacitor bank back online in a step, phased, normal sequence.
 - .7 Controller must be able to display power factor with indication for an inductive or capacitive power factor.
 - .8 Controller must have the ability to calculate and store in memory the kvar value of each step.
 - .9 Controller must recognize a defective capacitance step and eliminate that step from the circuit.
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- 2.3 MATERIALS .9 (Cont'd)
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- .10 Controller must automatically determine C/K ratio.
 - .11 Controller must indicate insufficient kvar to achieve target power factor.
 - .12 Controller must provide an option for metering and displaying various capacitor parameters such as measuring voltage (V), current of sensed phase (I), Power factor (pf), Reactive power (kvar), Active Power (kW), Apparent power (kVA), frequency (f).
 - .13 Controller must provide an option for supervisory monitoring functions such as undervoltage, overvoltage, harmonics, loss of power and number of operations, RS485 with Modbus RTU protocol.
- .10 Fuse lights:
- .1 Provide cleared fuse indication on the door to facilitate identification of a cleared fuse.
 - .2 On a wall mounted unit, each capacitor fuse will be provided with its own cleared fuse indicating light mounted in close proximity to the fuse for easy indication.
 - .3 For floor mounted units, provide three (3) "Push-to-Test" door mounted cleared fuse pilot lights, one (1) per phase, to indicate a cleared fuse condition in addition to the internal individual blown fuse lights beside the fuses.
- .11 Overcurrent protection:
- .1 Provide overcurrent protection using an integrally mounted UL listed and approved Molded Case Circuit Breaker rated for at least 135% of the total system current. The breaker shall be rated for an interrupting capacity of at least 65,000 symmetrical amperes at 240 or 480 V and 35,000 symmetrical amperes at 600 V. The minimum bus bar dynamic strength bracing rating shall be a minimum of 65,000 amperes calculated per UL 508A.
 - .2 Provide the breaker with a door handle kit that will facilitate door interlock in off position.
- 2.4 NAMEPLATES .1 Each unit will have a 1.0 x 2.5 inch nameplate. The lettering must be black 3/16 inch high, on a grey background.
- 2.5 FINISH .1 Provide harmonic filter equipment enclosures with a baked powdercoat finish. Exterior color to be ANSI 61.
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- 2.6 SYSTEM COMPATIBILITY
- .1 Perform a system compatibility analysis by the automatic capacitor bank manufacturer. Provide the manufacturer, at the time of request for quote, the data listed below.
 - .2 This analysis will be done to identify any potential or existing harmonics current sources. The data will be used to determine if the capacitor bank can be installed without the addition of chokes or filters.
 - .1 Total kvar to be added 300 kvar.
 - .2 kvar currently on the system 225 kvar.
 - .3 Desired power factor 90%.

PART 3 - EXECUTION

- 3.1 FACTORY TESTING
- .1 Test all capacitors in compliance with NEMA, ANSI, UL and CSA requirements for capacitance, dissipation factor, terminal-to-terminal dielectric strength, and terminal-to-case dielectric strength. All capacitor cells must be traceable through construction and testing.
 - .2 Test the automatic power factor capacitor correction unit for proper operation prior to leaving the factory. The following checks, measurements, and operations must be confirmed and recorded for each stage. The certified record of these tests becomes part of the permanent documentation package that travels with the automatic capacitor bank.
 - .1 Wire connections.
 - .2 Torque connections.
 - .3 Phase-to-phase resistance checks.
 - .4 Phase-to-phase capacitance checks.
 - .5 Controller operation, manual operation.
 - .6 Controller operation, automatic operation.
- 3.2 EXAMINATION
- .1 Fully inspect shipments for damage and report damage to manufacturer and file claim upon shipper, if necessary.
 - .2 Verify NEC clearances as dictated on the contract drawings prior to installation. Verify UL labeling of the assembly prior to installation.
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3.3 INSTALLATION .1 Follow the installation instructions supplied by the manufacturer.