**section 16280**

**MEDIUM voltage (2.4kV to 14.4kV) METAL ENCLOSED POWER FACTOR correction CAPACITOR BANK specifications**

1. **General**
   1. Scope
      1. The contractor shall furnish and install metal enclosed capacitor 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 metal enclosed capacitor bank rated [2.4KV] [3.3KV] [4.16KV] [4.8KV] [6.6KV] [6.9KV] [7.2KV] [11.4KV] [12.47KV] [13.2KV] [13.8KV] OR [14.4KV].
      3. This specification covers the electrical characteristics and mechanical features of a three phase, 50 or 60 hertz, self-contained, free standing, metal enclosed capacitor bank. The application of these units is for power factor correction.
   2. standards
      1. The metal enclosed capacitor equipment shall be designed, manufactured and tested in accordance with the latest standards of NEMA, NFPA 70, IEEE and ANSI.
      2. 600V control wires, 600V control devices and 600V terminal blocks shall be UL labeled/listed/recognized.
   3. Submittals

The following information shall be submitted for the project:

* + - 1. Front view elevation
      2. Floor plan and/or top view with conduit entry locations
      3. Shipping Drawing with dimensions and weight
      4. Nameplate Drawing
      5. Three-line power diagram
      6. Control Schematics
      7. Wiring Diagrams
      8. Control panel front view layout
      9. Installation & Handling Instructions
      10. Equipment ratings: Short-circuit rating, Voltage, Continuous current, BIL, Frequency, Full Load Amps, Capacitor bank feeder sizing amps
      11. Product data sheets
      12. O & M Manual
      13. Material Safety Data Sheet for liquids
      14. Inspection/Maintenance schedule & checklist
      15. Test Reports
      16. Quality Checklist
      17. Spare Parts List
  1. Qualifications
     1. The manufacturer of the assembly shall be the manufacturer of the enclosure and capacitors. All assembly shall be performed at a manufacturing facility in the USA.
     2. The facility where the equipment is assembled shall be ISO 9001 certified. Supplier to provide ISO 9001 certificate for the facility where the capacitor bank will be manufactured.
     3. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of ten (10) years. The manufacturer shall have a minimum of 25 years of electrical equipment manufacturing presence in USA.  The manufacturer shall have at least 400 similar units in operation. An acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
     4. The manufacturer shall provide calibration report of every piece of test equipment and torque wrench used during the manufacturing process.
     5. The manufacturer shall have work instructions for all manufacturing processes.
     6. Capacitor bank assembly shall be engineered, manufactured and tested under the direct supervision of a registered professional electrical engineer.

1. **EQUIPMENT**
   1. ratings
      1. The system operating nominal voltage and frequency shall be \_\_\_\_\_kV \_\_\_\_Hz.
      2. the capacitor bank shall be (select one): \_\_\_\_ Non-filtered with air core inrush reactor or \_\_\_\_ Filtered \_\_4.2nd/\_\_4.4th/\_\_4.6th/\_\_4.7th tuned with iron core reactor
      3. the total capacity of the metal enclosed capacitor unit shall be \_\_\_\_\_\_\_\_ KVAR. The total KVAR capacity shall be divided into \_\_\_\_\_\_\_\_ KVAR non-switched (fixed) and \_\_\_\_\_\_\_ KVAR automatically switched in steps of \_\_\_\_\_\_\_ KVAR.
      4. The metal enclosed capacitor bank unit shall a modular design with provisions for expansion to \_\_\_\_\_\_\_KVAR.
      5. The capacitor bank shall have the following automatic stages :

STAGE 1 \_\_\_\_KVAR, STAGE 2 \_\_\_\_KVAR, STAGE 3 \_\_\_\_KVAR, STAGE 4 \_\_\_\_KVAR, STAGE 5 \_\_\_\_KVAR, STAGE 6 \_\_\_\_KVAR. The capacitor bank shall have a fixed stage \_\_\_\_\_KVAR (specify if required).

* + 1. The capacitor bank shall be rated for continuous duty at 40°C ambient at 3,300 ft. (1,000 meters) and below. [Option: For high altitude and higher ambient temperatures specify altitude and temperature for de-rating].
    2. Total harmonic distortion (THD) of up to 5% of voltage waveforms shall not affect the life of capacitors.
    3. A +/- 10% variation in line voltage shall not affect the life of the capacitor. [Option: for anti-resonant and harmonic filter applications the capacitor ratings shall be as required per design calculations].
  1. Enclosure
     1. Enclosure shall be NEMA 3R outdoor enclosure with gaskets and air filters.
     2. The structure shall be front accessible, free standing with necessary provisions for ventilation and handling. There shall be no side access or operating handles mounted on the side of the enclosure. (For harmonic filter applications: Provide rear doors for access to the iron core reactors for easy access to reactors).
     3. The steel thickness of enclosures shall be 11 gauge or equivalent.
     4. The capacitor bank line-up shall not have any side access panels. The capacitor bank main and ground switch operators shall be mounted on front so that there is no side access required and side operator clearances are not required.
     5. There shall be thermostatically controlled heaters for condensation control. Each section shall have a space heater and thermostat.
     6. Disposable air filters and stainless steel screens shall be provided to prevent dust and insect entry. Filters shall be removable for replacement or cleaning purposes from outside without opening enclosure door. Air filters shall be industrial grade and meet UL Standard 900 and CAN-4-S111. Air filters shall be constructed with heavy duty, premium grade fiberglass media. Air filters shall have double-sided expanded metal retainers, on both the air-entering and air-leaving sides, for maximum rigidity and durability. Air filters dimensions shall be 14” x 24” x 1”. [Option: Washable aluminum air filters when specified].
     7. Structures shall be bolted steel frame, formed steel doors and side sheets, flat and sloped to rear steel top and rear covers. All enclosure outside sheets shall be internally bolted such that no bolts or hardware is exposed to outside.
     8. Thermostatically controlled forced air ventilation shall be provided in all compartments. Each section with capacitor and reactor shall have minimum two cooling fans controlled by a dedicated thermostat. Reactor sections shall have redundant cooling fans and redundant power circuit (If specified or required due to high ambient temperatures and/or high altitude locations). All louvered openings for air flow shall have stainless steel insect screens.
     9. The capacitor bank shall be modular design for ease of future expansion. If future expansion is required then the last section shall have a bus cut-out opening with weather proof bolted gland plate.
     10. Capacitor bank shall have a 4” base channel. The bottom sides shall have skirt plates so that there is no access to animals under the capacitor bank. The bottom plates of the capacitor bank enclosure shall be 4” above the ground.
     11. Each section door shall have a viewing window. Viewing window glass shall be double pane with ASTM rating. Viewing window shall be 10.5” X 7.0”. Viewing window shall be reinforced with brackets on the rear side of the door.
     12. Each stage of the capacitor bank shall be installed in an individual compartment isolated by steel sheets from other stages.
     13. The equipment shall be modular design with maximum 90”wide x 49”deep sections. Each shipping section shall weigh less than 6000LBS for ease of handling and installation on site. The equipment shall be designed and shipped in sections such that no large lifting cranes are required on site. The shipping sections shall be designed such that they can be moved on pallets using regular fork lift truck.
     14. Each modular 45” wide section shall have dedicated thermostats, space heaters, and cooling fans.
     15. The equipment shall be shipped on wood pallets for ease of handling and installation. Each shipping section shall have removable lifting eyes on each corner.
     16. Each section door shall have warning labels, danger high voltage, section #, and caution labels.
     17. The enclosure steel shall be fabricated at the same facility where the capacitor bank is assembled.
     18. The doors shall have gaskets, heavy-duty non-corrosive hinges, pad lockable and keyed heavy-duty non-corrosive handles. The doors shall be latched at three points. Doors shall have welded grounding studs and shall be bonded to the equipment ground bus.
     19. The door hinge pins shall be stainless steel. There shall be six heavy duty hinges for each door. The doors shall have door stops. The door latching mechanism shall have heavy duty rollers on all three latching points.
     20. The roof shall be sloped to the rear. There shall be a drip shield provided over each door. The drip shield shall be welded to the top of the frame. The drip shield shall extend 3” from the door front surface. The top roof sheet shall have welded braces for rigidity and weight support.
     21. Each unit shall have a rating nameplate. The lettering shall be black 3/16-inch high, on a silver background.
     22. The main incoming section shall have a rating nameplate located on the inside door in addition to the external nameplate.
     23. Metal enclosed capacitor equipment enclosures shall be provided with a powder coat paint finish. Exterior color shall be ANSI 61 light gray.
     24. Automated and continuously monitored electrostatic powder coat line operation shall be used. Each steel piece shall be pretreated, coated, and cured. The overall paint type and process shall meet UL1332 standard for organic coating of steel enclosures for outdoor electrical equipment use.
     25. Powder paint properties shall be as follows:
         1. Color: Medium Gay – ANSI 61 (Munsell 8.3G/6.10/0.54)
         2. Paint Process Electrostatic Application of Powder Paint
         3. Specific gravity: 1.5 to 1.75
         4. Application Voltage: 50 to 100 kilovolts
         5. Film thickness: 1.5 – 2.5 mils
         6. Cure schedule: 30 minutes at 380°F
         7. Salt spray: The enamel film should be exposed in a salt spray cabinet conforming to ASTM B 117. Using a razor blade, scribe a single vertical line per ASTM D 1654 through the enamel to bare metal. The panels shall be supported at 15 degree angle from the vertical and shall be exposed for 600 hours to a 5 percent salt fog maintained at a temperature of 35°C (95°F). Panels shall show no breakdown further than 1/8 inch from the scribe. Minimum rating of "5" per ASTM D 1654, Procedure A, Method 2.
         8. Painting process shall be as follows:
            1. Spray de-grease and clean
            2. Alkaline wash
            3. Iron phosphate spray coating
            4. Spray rinse
            5. Oven dry 300°F
            6. Electrostatic powder spray paint coating
            7. Oven cure 300°F to 400°F
     26. Each shipping section shall have temporary labels identifying the shipping section number. All shipping split hardware shall be included with the equipment.
  2. Incoming Section
     1. Unit shall have an integrally mounted, assembled isolation disconnect (if specified) with current limiting fuses (if specified), and grounding switch (if specified) OR Incoming section shall have NEMA termination pads with main fuses (or without main fuses).
     2. \_\_\_\_Distribution class or \_\_\_Intermediate class polymer arresters shall be provided for lightning protection. Arrester MCOV Rating shall be \_\_\_\_\_. All arrester shall be tested for 100% partial discharge inception voltage and 100% 60Hz sparkover level. Arresters shall be constructed of metal oxide varistors in series with insulating ceramic ring assembly. The components of the arrester shall be encapsulated. The arrester terminal & cap shall be stainless steel.
     3. Current limiting line fuses shall be provided for equipment short circuit protection sized a minimum of 135% of required amperage.
     4. Main switch and ground switch shall have externally operable handles with padlocking provisions.
     5. Control power transformer shall be provided in each incoming section. The primary of the CPT shall be fused. {Specify: Provide two CPTs for all three phase voltage sensing}.
     6. Incoming section shall be designed for top, bottom and rear side customer power cable entry. For bottom entry a removable bolted cover plate shall be provided.
     7. The incoming section shall have adequate power cable bending radius space for customer’s cables.
     8. The incoming section shall have cable supports for customer’s power cables. Customer’s power cable terminations shall be NEMA 2-hole or NEMA 4-hole depending upon the maximum current of the capacitor bank.
     9. Insulated barriers shall be provided between main fuses.
  3. switch
     1. Main switch
        1. The main switch shall be 3-pole, load break with puffer type arc extinguishing system. The switch mechanism shall be single spring action which opens or closes by charging the spring past dead center. The switch shall use chain drive handle. Main switch shall have externally operable handles with padlocking and kirk key interlocking provisions.
        2. 5kV Class Capacitor Bank Main Switch Ratings:
           1. Maximum rated voltage 8.3KV.
           2. 600A Continuous Current [200A and 1200A rated switches available when specified or required by design].
           3. Pole spacing: 5.90”
           4. Impulse level 75kV BIL and 60Hz 1 minute withstand level 26kV
           5. Momentary Withstand & Fault Close Rating: 40kA Asymmetrical
           6. Short time Fault Withstand Rating: 25kA Symmetrical for 3 seconds
           7. Switch opening time 40 – 60 ms
        3. 15KV Class Capacitor Bank Main Switch Ratings:
           1. Maximum rated voltage 17KV.
           2. 600A Continuous Current [200A and 1200A rated switches available when specified or required by design].
           3. Pole spacing: 9.25”
           4. Impulse level 110kV BIL and 60Hz 1 minute withstand level 50kV
           5. Momentary Withstand & Fault Close Rating: 40kA Asymmetrical
           6. Short time Fault Withstand Rating: 25kA Symmetrical for 2 seconds
           7. Switch opening time 40 – 60 ms
     2. Ground switch
        1. Ground switch shall be provided in the incoming section to ground the 3 phases to ground.
        2. Ground switch shall be rated for 40kA Momentary Withstand rating.
        3. Ground switch shall be 3-pole switch interlocked with the main switch.
        4. Ground switch shall have externally operable handles with padlocking and kirk key interlocking provisions.

* 1. CAPACITOR unit
     1. Capacitor unit shall be mounted upright with bushings on top. Bushings for 1-phase tanks shall be porcelain glazed for high strength and durability. Bushings shall be hermetically sealed to the capacitor tank. Bushings for 5kV Class 3-phase tanks can be porcelain or non-porcelain.
     2. Capacitor unit shall be stainless-steel tank with light gray finish. The tank shall have stainless-steel mounting brackets. The underside of each bracket shall be unpainted for positive grounding.
     3. Capacitor units shall be constructed with all-film, extended-foil elements, solderless connections, and laser-cut aluminum foil.
     4. Capacitor units shall be low dielectric loss 0.05 watt/kvar. All 1-phase, 2-bushing capacitor units shall be rated 95kV BIL. For 5kV Class the 3-phase capacitor units may be rated 60kV BIL.
     5. Each capacitor unit shall be equipped with internal discharge resistors to reduce terminal voltage to 50 volts or less within five minutes after the capacitor has been disconnected.
     6. Each capacitor unit shall have a stainless-steel nameplate and a blue non-PCB decal.
     7. Capacitor units shall be de-rated for high altitude and high ambient temperature conditions. Capacitor unit rated nameplate voltage and continuous overvoltage capability shall be selected such that the capacitors can withstand overvoltage conditions due to system contingencies, system over-voltages, switching transients and capacitor bank unbalance conditions.
     8. Capacitor units shall be manufactured at an ISO 9001 certified facility. Capacitor units shall be designed, manufactured, and tested per the latest IEEE Standard 18.
     9. capacitor specifications for “non-filtered” banks:
        1. Capacitor shall be suitable for continuous operation at 115% of system nominal voltage and 135% of full load current.
        2. For 5kV Class the capacitors shall be connected in Delta configuration. For 15kV Class the capacitor shall be connected in Wye (Star) configuration.
        3. Each capacitor case shall be grounded to the enclosure ground bus.
        4. Capacitor units for non-filtered applications can be 1-phase/2-bushing or 3-phase/3-bushing.
        5. Capacitor unit short circuit fault handling capability shall be coordinated with the available short circuit current and the capacitor unit protection fuses. The capacitor unit duty shall be selected to withstand the available system fault current.
     10. capacitor specifications for “harmonic filter” banks:
         1. Capacitor shall be suitable for operation at 125% of rated nameplate voltage, and 135% of rated nameplate current minimum.
         2. For 5kV Class the capacitors shall be connected in Delta configuration. For 15kV Class the capacitor shall be connected in Wye (Star) configuration.
         3. Each capacitor case shall be grounded to the enclosure ground bus. Capacitors for harmonic filter applications shall be heavy duty, -50°C to +55°C temperature rating, 125% continuous over-voltage capability above rated nameplate, 15kA fault handling capability, 100KA transient current withstand capability, and meet IEEE Std. 18, NEMA and IEC standards.
         4. Capacitor units for filter applications shall be 1-phase/2-bushing.

The capacitor shall be sized per the harmonic filter design duty. Continuous current and voltage rating of the capacitor bank shall be based upon the harmonic current spectrum specified.

* 1. bus, CABLE & TERMINALS
     1. Main and Ground bus shall be silver or tin platted.
     2. Main bus shall be provided and properly sized to handle continuous current rating of capacitor bank as well as a minimum of 25% (If future expansion required, specify \_\_\_\_\_\_ KVAR future expansion).
     3. Ground bus shall be provided in each section for the entire length of the capacitor bank. A ground pad with holes shall be provided on each end for landing external ground cables.
     4. The copper bus shall have rounded edges.
     5. Copper bus shall be braced for the available system short circuit current at the capacitor bank bus.
     6. Main bus support insulators shall be 95kV BIL.
     7. All live copper connections shall be made using long barrel compression lugs with minimum double crimping on each lug. Mechanical type cable terminations shall not be allowed for any current carrying terminals.
     8. All live terminations shall be with bolts, nuts, flat washers and Belleville washers.
     9. All power cables shall be 15kV Class, 90°C, EPR insulation. The conductors shall be tin coated soft annealed copper and flexible bunch with high standing. The insulation thickness shall be 210 Mils.
  2. Vacuum contactors
     1. Vacuum contactors shall be rated for capacitive switching.
     2. Vacuum contactors shall be rated 7.2kV / 3-pole for 5kV systems and 15kV / 1-pole for 15kV systems.
     3. Each vacuum contactor shall be grounded to the enclosure ground bus.
     4. contactors shall be rated for switching of capacitors by the contactor manufacturer.
     5. 5kv class application:
        1. The vacuum contactor shall be rated 7.2KV, 3-pole, \_\_\_160A/ \_\_200A/ \_\_\_320A/ \_\_\_400A/ \_\_\_800A.
        2. Vacuum contactor shall meet NEMA/ANSI ICS 3, UL 347 recognized, KEMA tested, and CSA certified.
        3. Vacuum Contactor Interrupting Rating: 4500A for up to 320A rated continuous and 8500A for up to 800A rated continuous.
        4. Vacuum Contactor making/breaking capacity shall be 4000A
        5. Vacuum Contactor Short Term withstand rating shall be 2400A for 30 sec / 6000A for 1 sec
        6. Vacuum Contactor Momentary Withstand rating shall be 63,000A peak for 0.5 cycle (8.7ms).
        7. Vacuum Contactor mechanical life shall be 2,500,000 operations
        8. Vacuum Contactor electrical life shall be 300,000 operations
        9. Vacuum Contactor BIL rating shall be 60kV.
        10. Vacuum Contactor 60Hz dielectric strength shall be 20kV for 1 minute.
        11. Vacuum Contactor shall be electrically held type.
        12. Vacuum Contactor closing time shall be 80 ms.
        13. Vacuum Contactor opening time shall be adjustable from 30 to 300 ms.
     6. 15kv class application:
        1. The vacuum contactor shall be rated 15KV, 1-pole\_\_200A/ \_\_\_400A.
        2. Vacuum contactor shall meet ANSI Standard C37.66.
        3. Vacuum Contactor high frequency transient making capacity shall be 12000A
        4. Vacuum Contactor Short Term withstand rating shall be 4500A for 1 sec / 6000A for 0.5 sec.
        5. Vacuum Contactor Momentary Withstand rating shall be 9,000A Asymmetrical.
        6. Vacuum Contactor mechanical life shall be 10,000 operations
        7. Vacuum Contactor BIL rating shall be 95kV.
        8. Vacuum Contactor 60Hz dielectric strength shall be 35kV for 1 minute dry.
        9. Vacuum Contactor shall be motor operated mechanically latched type.
  3. fuSES
     1. Main and capacitor fuses shall be rated for full system voltage with 50kA interrupting rating.
     2. All fuses shall be sealed and current limiting type with silver element in a sand medium. The fuse components shall be housed in a fiberglass reinforced resin tube or high strength filament wound glass & epoxy tubes with plated copper contact caps. All fuses shall have a blown fuse indicator for visual indication.
     3. Main fuses shall be double helix configuration with pure silver elements and filled with high purity silica sand of controlled grain size.
     4. Capacitor fuses shall be sized to withstand transient inrush currents associated with back-to-back capacitor bank switching.
     5. Fuses shall be sealed and no external expulsion gases & materials shall be produced during interruption.
  4. reaCTORS
     1. Air Core Reactors for “non-filtered” capacitor bank:
        1. The reactors for non-filtered capacitor bank shall be air core type for current limiting and back-to-back switching.
        2. The reactors shall be minimum 40uH, 125A, 1-pole, 95kV BIL. The air core reactors for each stage shall be sized according to the required current limiting based on the capacitor bank KVAR switching size.
        3. Air core reactor coils shall be 100% copper.
     2. Iron core reactors for tuned & de-tuned (4.2H/4.4H/4.6H/4.7H) harmonic filter capacitor bank:
        1. The reactors for harmonic filter capacitor banks shall be iron core type.
        2. The reactors shall be rated 115°C temperature rise with 220°C Nomex insulation system.
        3. The reactors shall be vacuum pressure impregnated with varnish. The varnish color shall be light brown.
        4. The reactors shall be manufactured using high quality steel for the core.
        5. Iron core reactors coils shall be 100% copper.
        6. The reactor shall be (specify: de-tuned/ anti-resonant / tuned) to the (specify: 4.2nd/ 4.4th/ 4.6th/ 4.7th) harmonic.
        7. Reactors shall be open frame construction. For 5kV class the reactors shall be rated 60kV BIL. For 15kV class the reactors shall be rated 95kV BIL.
        8. Reactors shall be sized MINIMUM 160% of full load amps. Reactors shall be sized for the current harmonic spectrum I1=\_\_\_A; I5=\_\_\_A; I7=\_\_\_A; I11=\_\_\_A; I13=\_\_\_A; I17=\_\_\_A.
  5. Key Interlock System
     1. Key Interlock system shall be using Kirk Key Company locks.
     2. Unit main disconnect shall have Kirk Key Co. lock that, when switch is open, key is removable to unlock opened position on ground switch.
     3. The ground switch can then be closed and shall have key interlocks that can be removed in closed position to allow for unlocking doors.
     4. The ground switch cannot close unless the disconnect switch is locked open. The ground switch cannot open unless all the capacitor section doors have been locked closed.
     5. Optional: Time delay entry interlocking can be provided if specified.
     6. Optional: Open vacuum contactors before opening man switch interlock can be provided if specified.
     7. Each door handle shall be heavy duty with padlocking provisions and shall have a keyed lock in the handle.
     8. Kirk key lock covers shall be stainless-steel and shall be installed with stainless-steel bolts.
  6. Nameplates
     1. Capacitor bank rating nameplate shall be provided on the main section on the outside and inside.
     2. The rating nameplate shall have the following information:

Voltage, Full load amps, Frequency, Fluid volume, Serial number, Part number, Eaton order number, Number of stages, Number of enclosure sections, Main disconnect switch rating, Main fuse current rating, & Main fuse interrupting rating.

* + 1. Each section shall be identified with section # and stage #.
    2. Each section shall have a 9” x 5” high voltage danger sign.
    3. Each section shall a caution sign for disconnect before serving and wait 5 minutes before opening enclosure.
    4. The main switch and ground switch shall be identified with engraved nameplates.
  1. Control Section
     1. Construction
        1. The control panel shall be flush mounted on the main incoming section door.
        2. The control panel shall have a clear lexan window such that all the indicating lights and meters are visible without opening the control panel door.
        3. The control panel shall have a thermostatically controlled cooling fan.
        4. The control panel front and rear panel shall be white color.
        5. All devices shall be identified with a device tags.
        6. All front panel devices shall have engraved nameplates.
     2. Power Factor Controller (For automatic capacitor banks):
        1. Power factor controller shall have LCD with backlit and shall be rated for -20°C to +70°C ambient operating temperature and 98% humidity.
        2. Programmable set points for all functions. Power factor controller shall have password protection. All alarms shall be displayed on the LCD.
        3. High harmonic content (>5% THD voltage) alarm.
        4. Power factor controller shall have the following alarm options which can be programmed by the Customer: over/under compensation, no current signal, step fault, step warning, 20X switching time outside limit, voltage harmonic limit, current harmonic limit, and over/under voltage.
        5. Power factor controller shall have field adjustable phase compensation so that the user can connect the current and voltage measurement signals in any phase orientation so that the user does not have to physically rotate the power cable and/or CT leads to achieve a particular phasing between current and voltage.
        6. Power factor controller shall have individual discharge time programmable for each step. Controller shall be capable of programming two target power factors. Controller shall have an adjustable switch interval time delay between switching steps in regulation. The controller shall have an adjustable step exchange switch interval time delay for switching-off an active step and switching-in the next step to achieve better power factor.
        7. Controller shall have control halt and control sleep on/off settings for each control alarm.
        8. Controller shall have a digital relay output in addition to the alarm output. All output contacts shall be rated 5A/250Vac.
        9. Controller shall have programmable switch cycle balancing, step exchange and control sensitivity settings.
        10. Controller shall have the option of turning on/off the automatic step recognition feature. Controller shall the capability to program the actual rated KVAR of each stage.
        11. Controller shall display current, voltage, Current THD, Voltage THD, KVA, KW, KVAR, Power Factor, Hz, current & voltage harmonics.
        12. Controller shall be UL recognized.
     3. Multifunction Meter & Relay:
        1. Each stage shall have a digital multifunction meter/relay (MMR) for 3-phase True RMS current, voltage, & KVAR sensing and display.
        2. The multifunction meter/relay (MMR) shall provide current unbalance, current overload, & overvoltage protection functions for each stage.
        3. The MMR trigger parameters shall include adjustable pick-up, drop-out, on delay and off delay settings.
        4. The MMR I/O shall have 2 digital outputs and 4 digital inputs. The relay DIO contacts shall be rated 250V/5A.
        5. The MMR sampling rate measurement shall be 128 samples per cycle.
        6. The MMR shall have bright 3-row LED display.
        7. The MMR shall have 2-wire RS-485 communications port with Modbus RTU, DNP3 and ASCII communications protocol.
        8. The MMR shall be suitable for 60°C ambient temperature and 95% humidity.
        9. The MMR current input shall be rated to withstand 15A RMS continuous and 300A RMS for 1 sec.
     4. Other:
        1. Adjustable stage anti-cycling timers. Manual-Off-Auto toggle switches shall be provided for operation of the switched steps.
        2. Vacuum contactors shall be controlled using interposing control relays with contacts rated 10A/120Vac.
        3. All alarm/trip/status indicating lights shall be 120Vac LED.
        4. Each stage shall have Manual-Off-Auto switches, stage on indicator, and counter. The control scheme shall be such that when switching from “Manual” position to “OFF” to “AUTO” or “MAN” position on any stage, that the corresponding stage will not be energized in less than 5 minutes. An interposing timing relay shall be provided to prevent energization of the capacitor stage in less than 5 minutes.
        5. Control panel shall be designed for future addition for \_\_\_ stages (If future expansion required, specify).
        6. Over-temperature alarm LED & trip shall be provided for each stage for harmonic filter capacitor banks.
        7. Space heater circuit shall be such that the customer can bring external power source if needed to power space heaters during storage.
        8. Control panel shall have 120V circuit breaker for disconnecting and over-current protection of control wiring. Separate control circuit breakers shall be provided for control circuit, vacuum contactor control, space heater circuit, and cooling fan circuit. All control circuit breakers shall be rated 10kAIC,120Vac.
        9. The control shall have on delay timers as protection against upstream utility reclosers opening and closing to clear distribution line faults. The start timer shall be adjustable.
        10. All timers and settings shall be field adjustable.
        11. All alarms and trips shall be wired to an adjustable on-delay alarm timer relay. One common alarm dry contact shall be wired out to terminal blocks for Customer’s remote alarm. One common wetted 120Vac alarm contact shall be wired out to terminal blocks for Customer’s use. Loss of control power alarm shall be wired to the capacitor bank common alarm. Loss of vacuum contactor power and cooling fan power shall be wired to the capacitor bank common alarm and indicated on the front panel LED indicating light.
        12. All control wiring shall be minimum #14AWG, SIS, XLPE, 600V, FT2, 125°C, UL/CSA Listed. All wire terminations shall be identified with wire markers.
        13. All control wires in control panel shall be routed in wire-ways with covers.
        14. All terminal blocks shall be rated 50A, 600V.
        15. Shipping split control wiring shall have locking type male/female plugs rated 19A, 600Vac.
  2. capacitor Bank Protection
     1. Capacitor bank main bus shall be protected with current limiting full voltage rated fuses with blown fuse indication. Fuses shall be 50kAIR rated for the full system voltage class.
     2. Current transformer shall be provided for each phase to monitor each stage of capacitor bank current. Current transformers shall be multi-ratio with 10 ratio taps so that the ratio can be adjusted for future expansion.
     3. Current limiting capacitor fuses with current and voltage ratings appropriate for the capacitor shall protect the stage and capacitors.
     4. Capacitor rated fuse shall be provided per each capacitor tank unit.
     5. Current unbalance and current overload protection trip shall be provided for each stage.

1. **testinG, quality control & shipping**
   1. component production testing
      1. All capacitors shall be tested in compliance with IEEE requirements for capacitance, dissipation factor, terminal to terminal and terminal to case dielectric strength, and oil leaks. All capacitor cells shall be traceable through construction and testing.
      2. All iron core reactors shall be tested for inductance by applying voltage and measuring current at fundamental.
      3. All power transformers shall be tested for ratio and accuracy.
      4. All multifunction meters shall be tested for operation and accuracy.
   2. assemblies production testing
      1. The power factor capacitor correction capacitor bank shall be tested for proper operation prior to leaving the factory.
      2. The following checks, measurements, and operations must be confirmed and recorded:
         1. Wire connections
         2. Torque connections
         3. Operation of contactors, heaters, & cooling fans
         4. Phase to Phase resistance checks
         5. Phase to Phase capacitance checks
         6. Controller operation, manual operation
         7. Controller operation, automatic operation
         8. Insulation resistance Megger test Phase-to-Phase and Phase-to-Ground
         9. DC Hi-pot test (DC Hi-pot Level = 2 x System Voltage + 2500V)
         10. Test all CT ratios and circuits with primary current injection on main bus.
      3. The certified record of these tests shall become part of the permanent documentation package that travels with the automatic capacitor bank
   3. Quality control
      1. Quality assurance checklist shall be completed for each unit.
      2. The equipment shall be manufactured in an ISO 9001 certified facility.
   4. shipping
      1. Each shipping section shall be shipped on heat treated wood pallets.
      2. All shipping sections shall be identified & labeled.
      3. All shipping split hardware shall be included with the equipment.
      4. All shipping sections shall be wrapped in heavy duty plastic.
      5. The shipping pallets shall allow 8” clear space all around the enclosure to prevent scratching & damage during shipping, transportation, handling, and installation.
      6. Manufacturer shall provide shipping & handling instructions and MSDS prior to shipping the equipment.

END