

**TECHNICAL SPECIFICATION  
for 4160V AUTOMATIC and FILTERED AUTOMATIC POWER FACTOR CORRECTION BANKS**

**1. Design Verification**

Manufacturer shall design equipment within IEEE-519 guidelines and / or local utility guidelines, whichever is more stringent. Guidelines met shall include  $I_{thd}$ ,  $V_{thd}$  and  $I^*T$ . Using the data on the attached table, manufacturer shall provide the information in the table below with their quotation. Proposals without this information will not be accepted.

The starting values refer to the “present site conditions”. The resulting values refer to the “conditions following the installation of the proposed power factor correction and / harmonic filtering equipment. Data for calculating the values is attached.

Description	Starting Values	Resulting Values
Power Factor (total load)		
$V_{thd}$ - primary (total load)		
$V_{thd}$ - secondary (total load)		
$I_{thd}$ - pri & sec (total load)		
$I^*T$ (total load)		

**2. Equipment Size / Ratings**

System operating voltage (line-to-line): 4160V, 3 phase, 60Hz. Capacitors shall be rated minimum 4160V for unfiltered banks. For filtered banks, the minimum capacitor voltage shall be 4800 V.

Total kVAR required at system voltage at present: \_\_\_\_\_

Total kVAR required at system voltage for future: \_\_\_\_\_

Maximum kVAR per step: \_\_\_\_\_

**3. Capacitors**

The minimum capacitor voltage required to avoid excessive current and voltage overload shall be quoted. The successful bidder shall be prepared to provide documentation showing the minimum capacitor voltage required to avoid overload due to both import and export harmonics. This information may be required immediately following receipt of an order. Vendors which can not supply this data will not be considered for the supply of the equipment. Buyer reserves the right to cancel the purchase order and order the equipment from another source if the vendor can not supply this data immediately after purchase order release.

Individual capacitors shall be CSA approved, 1 or 3 phase, liquid filled, and of a self-healing design utilizing a low loss metallized film dielectric system. Single phase capacitors must be 2 bushing design - live casings are not acceptable. Capacitor casing shall be of a stainless steel design. Electrical losses shall be less than 0.2 watts per

kVAR. Dielectric fluid shall be high flash point, biodegradable, non-toxic and contain no PCB's.

Capacitors shall be equipped with either internal element fusing or external fuses. Expulsion fuses are not acceptable. Fuses must be coordinated to clear before a 10% probability of capacitor case rupture. Capacitor fuses shall not clear during inrush. Capacitors with external fusing are not acceptable if grounding switches are required. Only internal element fusing will be considered.

Capacitor mounting feet shall have an unpainted area for grounding connection of the capacitor casing.

Capacitors shall be rated for a minimum of 180% continuous current overload and 110% continuous voltage overload based on the rated voltage of the capacitors (4160 V for unfiltered units, 4800 V for filtered units). For capacitors with internal element fusing the minimum continuous current overload shall be 135%.

Where possible use standard size capacitors in the most cost effective combinations as possible. One size of capacitor is preferred to keep replacement parts requirements to a minimum.

Capacitors shall be suitable for -40°C to +45°C ambient temperature or have suitable heating / ventilation to provide the -40°C to +45°C rating.

Capacitor connection can be either delta or wye.

#### **4. Discharge Resistors**

Adequate discharge resistors shall be provided inside each capacitor casing to reduce the capacitor terminal voltage to 50 Volts or less in five minutes after disconnection of supply voltage.

#### **5. Inrush Current Limiters**

*Where harmonic filters are not required in order to meet IEEE-519 and local utility guidelines or avoid harmful harmonic resonance.*

Inrush current limiters shall be included for each step in the capacitor bank assembly. Inrush current limiters shall be single phase air core type c/w aluminum windings. Inductance shall be a minimum of 40  $\mu$ H per phase. Inrush current limiter amperage and voltage ratings shall be sized to match the maximum continuous current rating of the capacitors.

#### **6. Harmonic Filtering Reactors**

*Where harmonic filters are required in order to meet IEEE-519 and local utility guidelines and harmful harmonic resonance.*

Multiple tuning frequencies as required for meeting the guidelines are acceptable.

Harmonic filtering reactors shall be three phase iron core complete with one "+" tap and one "-" tap per phase for field adjustment of inductance. Reactors insulation shall be rated at 220°C. The maximum temperature of the reactor at maximum continuous rms amperage shall be no higher than 145°C with a 45°C ambient. Reactor maximum continuous rms amperage shall be sized to match the maximum continuous rms amperage of the capacitors.

Reactors shall be equipped with snap action thermostats which trip at 145°C to provide continuous overcurrent tripping.

**7. Contactors**

Contactors shall be 3 phase vacuum type and rated for capacitor switching. Contactors must be capable of handling 135% of the nominal amperage of the capacitors being switched and 110% of the capacitor rated voltage. For units equipped with harmonic filters the contactors shall be capable of switching 135% of the rated amperage of the capacitors (4800 V rating). Contactors must be capable of handling the short circuit let through current of the step fuses.

Control input to the contactor shall be 120 Volt, 60 Hz.

**8. HRC Fusing**

A set of HRC fusing shall be included on the line side of each contactor. HRC fuses shall be sized as a minimum to handle the maximum continuous current of the capacitors. The fuse clearing time shall be coordinated to prevent damage to components during short circuit conditions.

**9. Grounding Switch**

Grounding switched shall be 4 pole gang operated when wye connected capacitors are used and 3 pole gang operated when delta connected capacitors are used. Ground switch handles shall be located on the outside of the enclosure.

A grounding switch shall be provided for each contactor. Using the step contactors as a safety device is not acceptable. An interlock shall prevent operating the grounding switches when the disconnecting means for the capacitor bank is closed. Keylocks are to be provided by the vendor and keyed to the disconnect keylock.

Externally fused capacitors are not acceptable when grounding switches are required, internal element fusing is mandatory.

“Wait 5 minutes after disconnecting supply before operating this switch” labels shall be provided for each ground switch handle.

Grounding switches required: Yes \_\_\_\_\_ No \_\_\_\_\_

**10. Wire and Bus Bar**

As a minimum 7500 Volt EPDM wire shall be used. All bus bar shall be tin plated copper. Suitable bracing shall be included.

## **11. Current Transformer**

A solid core current transformer of adequate size, ratio, and burden shall be supplied. Sizing and ratio to be determined after order release.

## **12. Potential Transformer**

A potential transformer of suitable VA rating shall be provided for the measuring voltage for the controller. Two fuses shall be provided on the potential transformer. Adequate discharge resistors shall be included on the load side of the PT to prevent nuisance fuse clearing while energizing the PT under no load conditions.

## **13. Termination**

A termination section shall be included in the enclosure. NEMA 2 hole patterns shall be provided on tin plated copper bus bar for crimp lug connections. Ground terminals shall also be provided for ground wire termination in the termination enclosure.

The termination enclosure shall be suitable for both bottom and top cable entry.

A separate control enclosure shall be provided with room for termination of the required 120 Volt supplies and Current Transformer wiring.

Adequate grounding provisions shall be provided on each corner of the enclosure for grounding.

## **14. Controls**

A thermostat shall be located in each enclosure compartment to turn on ventilation fans when the temperature inside the enclosure reaches 40°C. Another thermostat shall be located in each enclosure to provide an alarm which trips and locks out the associated contactor for the step compartment which is overheated.

600 Volt rated CT's of adequate VA and frequency measuring range shall be supplied for each phase of each step and shall be wired to overload relays in the control box. Harmonic filters with multiple tuning frequencies shall have a set of CT's and an overload relay for each tuning frequency for each step. Terminals for the CT's must be located in the control box to allow exterior metering to be connected to monitor actual step amperage and individual filter amperages. A shorting link shall be provided for each CT installed and for the main incoming CT.

Overload relays shall be changeable from automatic reset to manual reset. When an overload relay is tripped the associated contactor shall be switched off and locked out.

Thermostats from harmonic filtering reactors shall be wired to a monitoring system which switches off and locks out the associated contactor for the overheated reactor.

Alarm indicating lights on the exterior of the enclosure shall indicate which step has tripped and shall indicate the type of alarm. A master reset push-button reset located on the control door shall reset all alarms. Integral time delays shall not permit reswitching of the alarmed steps within five minutes of pressing the master reset.

120 Volt supplies shall be provided by the buyer to operate the controls, heaters, ventilation etc.

## 15. Digital Microprocessor Controller

The digital microprocessor controller shall be a minimum 12 step controller, which includes the following features:

- a) adjustable target power factor from 0.85 lagging to -0.95 leading
- b) circular or linear switching modes
- c) automatic or manual switching of steps
- d) switching ratios of 1:1:1:1:1, 1:1:2:2:2, 1:1:2:2:4, 1:1:2:3:3, 1:1:2:4:4, 1:1:2:4:8, 1:2:2:2:2, 1:2:3:3:3, 1:2:3:4:4, 1:2:3:6:6, 1:2:4:4:4, 1:2:4:8:8
- e) switches up to 12 steps for each switching ratio
- f) option of selecting switched steps as fixed steps
- g) adjustable capacitor current to current transformer ratio (c/k value or sensitivity) from 0.025A to 1.5A.
- h) selectable switching on and off delays of 10, 30, 60, 120, 180, 300, and 500 seconds and an option to have the controller automatically adjust the switching on and off delay between 2-500 seconds as a function of reactive load.
- i) selectable re-switching blocking delay of 20, 60, 180, and 300 seconds
- j) choice of automatic, semi automatic, or manual determination of CT ratio and position, c/k ratio, step switching ratio, and step quantity.
- k) memorization of CT position after the first startup in automatic startup mode.
- l) measuring voltage range of 58 - 690 Volt without potential transformer
- m) displays capacitor step current based on CT ratio without having to use multipliers
- n) displays fundamental and rms current on the main bus bar without having to use multipliers
- o) displays individual harmonic current distortion on the main bus bar for the 3rd, 5th, 7th, 11th, 13th, and 17th harmonics
- p) temperature sensor adjustable from 25 to 50°C.
- q) alarm relay for temperature above set point, individual harmonic current distortion above set point, total harmonic current distortion above set point, power factor below target set point, measuring voltage missing, excessive CT secondary current, CT secondary current too low.
- r) selectable step switching feature in alarm conditions which provides anti-resonance features
- s) selection of activation or deactivation of individual alarms.
- t) display shows symbols for alarms when in alarm status and dry alarm contact closes in alarm condition
- u) no voltage release switches out all capacitors in case of interruption of supply voltage
- v) monitors and displays quantity of individual step operations for determining contactor wear.
- w) displays a fault when any step current is reduced to zero indicating faulty step components.
- x) communications via RS232 as a standard with price adder for RS485 MODBUS RTU using DOS or Windows software
- y) key board locking feature to prevent unauthorized tampering
- z) watchdog continuously monitors processor and indicates a fault if the processor malfunctions.

## 16. Enclosure

Enclosures shall be of at least the minimum gauge galvanized steel as required by code. Hot dipped galvanized floor mounting sills shall be provided to bolt down the enclosure. Sills shall raise the enclosure 2" above floor height.

All doors must be both lockable with a key and boltable. All components must be suitably mounted to provide ease of replacement. All enclosure mounting hardware and framework shall be either galvanized steel or zinc plated steel for grounding continuity. Painted mounting hardware and framework with paint removed for grounding is not acceptable. All enclosure parts other than mounting hardware and framework shall be powder coated ASA 61 Grey.

Enclosures shall be suitable for the location installation. Suitable ventilation shall be provided to operate throughout the ambient temperature range. Ventilation louvres shall be equipped with removable screens which can be replaced from the outside of the enclosure without danger to site personnel. As a minimum each louvre kit shall have a washable aluminum mesh screen to prevent accidental entry of metal objects.

Enclosure rating required: NEMA \_\_\_\_\_

Ambient Temperature range: \_\_\_\_\_ °C to \_\_\_\_\_ °C

## **17. Labelling**

A "Wait five minutes after disconnection from supply" label shall be located on the enclosure door. A "Wait five minutes after disconnection from supply" label shall be provided loose for the disconnecting device. Both labels shall be worded as per code requirements.

Appropriate "Danger High Voltage" labelling shall be provided to each door which provides access to the high voltage compartments.

The control box door shall have "Caution more than 1 live circuit" labelling. All components, terminals, fuses etc within the control box shall be labelled.

"Warning - short circuit CT before disconnecting" labels shall be applied where applicable.

## **18. Testing**

Testing shall be performed as per CSA standards. For filtered units a confirmation of the filter tuning frequencies must be performed prior to shipment to minimize on site tap adjustments.

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