Guide Form Specification for Medium Voltage Metal-Enclosed Power Filter Banks

(Chemical – Large Rectifier Application)

Brown text is related to arc flash hazard mitigation features that strive to either minimize the level and exposure to an arc flash event or reduce the probability that an arc flash event will occur. Consult NEPSI's technical note for more information about arc flash hazard mitigation at www.nepsi.com.

1 General

1.1 This specification is for a medium voltage three phase metal-enclosed automatic harmonic filter bank consisting of _____ steps of _____ kvar at _____ kv, tuned to the _____ harmonic(s). The kvar specified in the preceding sentence is the output kvar of the filter step(s) at the specified voltage and not the installed kvar.

The harmonic filter bank shall be designed for automatic power factor correction and harmonic filtering for a large rectifier system. Filtering capacity shall also account for the balance of the plant load, which consist of medium voltage variable speed drives. Consideration should be given to partial loading as well as full-load conditions of the rectifier. Provisions shall be provided for harmonic damping of high frequency harmonics due to stray capacitance.

Note: For large chemical plants that use large rectifier system, multi-tuned stages of various types, tuning, and reactive power may be required. In such cases, consider using a table similar to the following (else delete it).

Branch | Stage Detail

Branch/ Stage	Filter Type Type	Tuning (Harmonic #)	Output kvar	Harmonic Current Rating (RMS Amps)	Damping Resistor Rating* Resistance (Ohms)	Damping Resistor Rating* Watt Rating (kW)
	Select					
1	Select					
2	Select					
3	Select					
4	Select					
5	Select					
6	Select					
7	Select					
8	Select					
9						

10	Select					

** Damping Resistor should only be specified for HP and C-HP Filter Branches*

All controls, switching devices, and protection features shall be supplied and enclosed in an all-welded compartmentalized steel enclosure. The filter bank shall come fully assembled and ready for interconnection. All exceptions to this specification shall be clearly stated with your bid. If no exceptions are taken, the bid should include the phrase "no exceptions have been taken".

1.2 The ratings of the filter bank and associated switchgear, switching devices, capacitors, fuses, and all other applicable components shall have ratings designed for application on the following system:

Nominal System Voltage, (Kv)…… _____
Maximum System Voltage, (Kv)…… _____
System BIL, (Kv)……..…….._____
Three Phase Short Circuit Rating at Capacitor
Bank (RMS Symmetrical Amps)……_____
Line-Ground Short Circuit Rating at Capacitor
Bank (RMS Symmetrical Amps)……_____

(Optional – Arc Flash Hazard Mitigation) For Arc Flash Hazard Mitigation – Consider increasing equipment BIL by one step. A higher BIL will provide more strike distance and creep distance at a fraction of the cost of the equipment and will result in equipment that is less likely to flash over or fail. Metal-enclosed banks are limited to 200kV BIL, and therefore this mitigation option is only available to 170kV BIL.

1.3 Ambient Air Temperature for design shall be as follows:

Average annual temperature……..…….Min_____/Max_____ (degrees C)
Average Daily variation …… _____ (degrees C)
Design temperature ……Min. _____/Max_____ (degrees C)

1.4 Relative Humidity for design shall be as follows:

Monthly Average Relative Humidity ……..…….Min._____/Max_____ (%)
DesignRelative Humidy ……..……Min. _____/Max_____ (%)

1.5 Solar radiation for design purposes shall be as follows:

Average annual solar radiation …… _____ (kW/m^2)

1.6 Precipitation for design shall be as follows:

Average annual precipitation ……_____ (mm)

1.7 Snow Load for design shall be as follows:

Maximum design snow load ……..……_____ (kG/m^2)

1.8 Wind for design shall be as follows:

Basic wind speed (V) ……_____ (km/h)
……corresponding to a 3 second gust speed
…….. Standard height of 10m above ground

Prevailing winds …… _____ (N, S, E, W, etc)

1.9 Seismology for design shall be as follows:

All building, structures, and components shall be designed for earthquake forces according to the _____. Note the following data as it pertains to this location:

2 Compliance with Standard & Codes

The metal enclosed harmonic filter bank shall conform to or exceed the applicable requirements of the following standards and codes:

- UL-347, High Voltage Industrial Control Equipment
- UL-508, Industrial Control Panels, Issue Number : 2, October 1993
- UL-50, Standard for enclosures for Electrical Equipment
- ANSI Z535.4 Product Safety Label Standard July 1, 2002.
- Applicable portions of Article 710 in the National Electrical Code
- Article 460 of the National Electrical Code
- ANSI C57.12.28-1988 – Pad Mounted Equipment Enclosure Integrity
- ANSI C37.20.2 – Guide for Enclosure Categories and Related Requirements (delete this line if the filter bank is going to be placed in a public accessible area)
- IEEE Std. 1036-1992, IEEE Guide for Application of Shunt Power Capacitors
- Optional – Arc Flash Hazard Mitigation, IEEE C37.20.7-2007, IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38kV for Internal Arcing Faults
- CP-1 NEMA Standard on Shunt Capacitors
- NESC Standards

3 Product Listing

3.1 The filter bank control panel shall be UL508A Certified for both Canadian and US products.

3.2 The filter bank shall be “listed” per OSHA (in the USA) and the Standards Council of Canada (in Canada) to the following standards.

- For products shipping to the United States, IEEE C37.20.3-2001
- For products shipping to Canada, C22.2 No. 190-M1985+GI1 + GI2 (R2004)

A copy of the NRTL Certificate showing compliance with the above shall be included with the bid.

4 Enclosure Construction

4.1 The manufacturer of the enclosure shall also be the assembler of the harmonic filter bank. This is to ensure the highest degree of control with respect to critical enclosure manufacturing processes such as cleaning and surface preparation, welding, priming, and painting. Verification of enclosure manufacturing by supplier (on-site visit, photos, raw material invoices) may be required. No exceptions allowed.

4.2 The filter bank shall consist of a single compartmentalized enclosure with NEMA 3R (IP64), NEMA 12 (IP65), NEMA 4X (IP66) (specify one, delete the other two) construction that will house all components, including fuses, capacitors, switches and associated controls. All components shall be accessible and removable from the front of the enclosure. Bolted panel construction, transclosure style, and switchgear cubicle style enclosures will not be allowed and will be rejected. For Arc Flash Hazard Mitigation it is recommended that the equipment be placed outside in switchgear yard. Arc blast dissipates at a rate which approximates the inverse-square rule for distance. Keeping workers away from the equipment is an easy way to ensure worker safety. Save on E-house/switchgear room space, put metal-enclosed harmonic filter banks outdoors.

4.3 The enclosure shall be fabricated from 11-gauge cold rolled galvaneal steel (or specify 12-gauge stainless steel, type 304, 316, or 409). The roof shall be cross-kinked or gabled to allow for watershed.

4.4 The doors shall be flush and removable in the open position. They shall be equipped with stainless steel hinges and hinge pins, and 3-point latching handles. The handles shall be pad lockable. All doors providing access to high voltage compartments shall be equipped with door stays to hold doors in the open position.

4.5 (Optional – Arc Flash Hazard Mitigation) The doors shall be capable of withstanding the effects of an internal arcing fault.

4.6 The compartment containing the incoming air disconnect switch and ground switch (if supplied) shall be equipped with an internal hinged barrier door to guard against inadvertent entry to the terminals of the load-interrupter switch. Access to any portion of the air disconnect switch shall be blocked by the protective door while allowing access main fuses (if supplied) and capacitor compartments.

4.7 (Optional – Arc Flash Hazard Mitigation) The internal hinged protective barrier door shall be key interlocked with the upstream feeder breaker to ensure the incoming breaker is disconnected and racked out before entry into compartment is allowed.

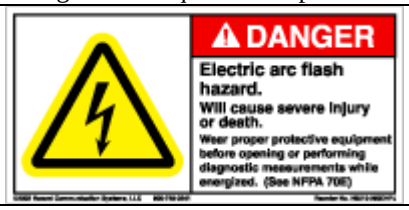
4.8 The base of the enclosure shall be equipped with C4x5.4 structural steel channel. Removable steel lifting plates consisting of 1/2" steel shall be located at each corner. Formed channel bases will not be accepted.

4.9 All ventilation louvers shall be located on the front, (you may also specify back or sides) of the enclosure and shall be equipped with 2” (5.08 cm) 20x20x2 MERV 5 Fiberglass filters. Filters shall be removable while bank is energized. Live parts shall not be accessible while filters are removed.

4.10 All fasteners and associated hardware, inside and out, shall be stainless steel. Externally accessible hardware shall not be used for support of high-voltage components or switch-operating mechanisms within the filter bank.

4.11 Thermostatically Controlled Strip Heaters shall be supplied in all non-ventilated compartments. When determined by the manufacturer, a thermostatically controlled fan or ventilator shall be supplied.

4.12 Each door of the enclosure shall be equipped with self-adhesive vinyl warning signs that comply with ANSI Z535.4 Product Safety Label Standard dated July 1, 2002. The Incoming Compartment sign shall state

Warning Label Requirements per above section	
	
Electric arc flash hazard. Will cause severe injury or death. Wear proper protective equipment before opening or performing diagnostic measurements while energized. (See NFPA 70E)	*HAZARDOUS VOLTAGE. Contact may cause electric shock or burn. Turn off and lock out system power before servicing.*

4.13 The filter bank shall be name plated with a riveted anodized steel nameplate containing the following information:

- Nominal System Voltage
- Maximum System Voltage
- Number of Steps, Stages, and Switching Sequence
- kvar per step, kvar of each stage, tuning point, and harmonic current rating in amps
- BIL
- Manufacturers phone number, address, and phone number for technical assistance

4.14 The enclosure shall have a continuous 1/4" x 2" Tin-plated (you may specify Silver) ground bus that spans the full width of the enclosure.

4.15 The enclosure shall be prepared and painted with a high-solid epoxy coating as specified below. The paint shall be ANSI gray 61 – Munsell No. 8.3G 6.10/0.54, ANSI Gray 70 – Munsell No. 5BG 7.0/0.4 or Green - Munsell No. 7Gy 3.29/1.5(or specify another Munsell number).

Surface Preparation:
All steel surfaces shall be prepared per SSPC-SP2, 3, 6, 7, 10, 11 or the paint manufacturer's recommendations. Exceptions to the manufacturer's requirements shall be approved by the paint manufacturer and provided with the submittal documents.

Inaccessible Surfaces:
Prepare and coat steel surfaces inaccessible to preparation and coating after fabrication with all coats before fabrication. Inaccessible surfaces shall be considered Zone 2A per SSPC specifications.

Paint Specification:
All surfaces, inside and out, shall be top coated with a High-Solid Epoxy Siloxane Marine paint with a dry film thickness of 2 to 3 mils.

The paint utilized shall have the following properties:

- Salt Spray (ASTM B117) 5500 Hours with no face blistering
- Humidity (ASTM D2247) 5500 Hours with no face corrosion or blistering
- Gloss retention (ASTM G53) QUV-B bulb: Greater than 50% gloss retention at 26 weeks.
- Elongation (ASTM D5222) 14%
- Abrasion resistance (ASTM D4060) 1kg load/1000 cycles, CS-17 wheel: 53 mg weight loss.
- Impact resistance (ASTM D2794): Direct 24 in.lb and Reverse 6 in.lb.
- Adhesion, elcometer (ASTM D4541): 2700 PSI
- NFPA Class A Qualification

Paint shall also provide excellent chemical resistance to splash, spillage, fumes and weather for acidic, alkaline, salt solutions (acidic, neutral, and alkaline salt solutions), fresh water, solvents and petroleum product environments.

Upon request, the manufacturer shall provide supporting documents (surface preparation procedures as well as paint manufacturer's paint specifications) showing the above requirements are met. Failure to comply with this request will be cause for cancellation of order.

4.16 (Optional – Arc Flash Hazard Mitigation) Infrared Sightglasses shall be provided for viewing internal components of all medium voltage compartments of the metal-enclosed harmonic filter bank. At least one sightglass shall be provided for every 3 linear feet (1 meter) of enclosure length. Sightglasses shall be arc-flash tested to a maximum of 40kA in accordance with IEEE and IEC standards, and shall be NEMA Type 3/12 (IP65) rated.

4.17 (Optional – Arc Flash Hazard Mitigation) Ultrasound Inspection Ports shall be provided on each door for consistent and quality acoustic data identifying potentially hazardous faults such as arcing, tracking, and corona before they occur.

4.18 (Optional – Arc Flash Hazard Mitigation) The enclosure shall be of an arc resistant design and shall include integral (specify back or top – NEPSI recommends back for outdoor gear with a fenced off protective zone and top for indoor gear) pressure release flaps to facilitate a controlled release of arc created overpressures, smoke, and gasses. (For indoor applications, an enclosed arc-chamber with arc duct exit shall be provided. Field assembly of the arc chamber and arc-duct shall be by the installation contractor. Where venting is intended to penetrate an external wall, the vent shall be covered such that it meets all specified environmental requirements (e.g., rain-tight, dust-tight, vermin-proof)). Arc exhaust location shall be shown on equipment drawings.

Arc Resistant Construction Types (specify one):

- Type 1 – gives the equipment arc resistant protection on the front only.
- Type 2 – gives the equipment arc resistant protection on the front, rear, and sides of the gear.
- Type 1D-SR-SL – gives the equipment arc resistance protection on the front, right side, and left side. The rear of the enclosure will shall be considered a prohibited zone and be fenced off with restricted access.

4.19 Doors providing access to air disconnect switches shall be provided with a wide-view window

constructed of an impact-UV-resistant material, to facilitate checking of switch position without opening the door.

The main incoming fuse compartment (if supplied) shall be equipped with a wide-view window constructed of an impact-UV-resistant material, to facilitate checking of the main fuses without opening the door or de-energizing the bank.

The capacitor compartment shall be equipped with a wide-view window constructed of an impact-UV-resistant material, to facilitate checking of capacitors and capacitor fuses without opening the door or de-energizing the bank.

5 Incoming Air Disconnect Switch

5.1 The filter bank shall be supplied with an external chain operated air disconnect switch. The switch shall be rated at 135% of the banks nominal current rating and shall have a 40-kA RMS momentary asymmetrical rating. This disconnect switch shall be interlocked with the stage switches to prevent it from being opened while the stages are energized. The switch shall be pad-lockable in either the open or closed position.

5.2 The Air Disconnect Switch shall be located in a separate compartment that is isolated from the capacitor/reactor/resistor compartments, and the low voltage control compartment by a steel barrier. In addition to the exterior enclosure doors, a protective hinged barrier door (behind the exterior door) shall be provided before access to the switch terminals is allowed. The hinged barrier door shall be equipped with signage stating the danger of the possibility of live terminals and to confirm the upstream source is disconnected before proceeding.

5.3 The air-disconnect compartment shall also consist of 2 line-to-line connected CPT's for the purpose of voltage sensing and local control power. CPT's shall be 3kVA rated and shall be equipped with primary weak-line fuses and a secondary breaker.

5.4 (Optional – Arc Flash Hazard Mitigation) The air disconnect switch shall be equipped with a motor operator for remote electrical opening and closing.

5.5 (Optional – Arc Flash Hazard Mitigation) The air disconnect switch terminals or shall be equipped with medium voltage indicators that flash when voltage is present.

6 Incoming Fix-Mounted Circuit Breaker (optional)

6.1 The harmonic filter bank shall be equipped with an incoming fixed mounted circuit breaker for the purpose of short circuit protection of the harmonic filter system. The breaker shall be located on the load side of the incoming disconnect switch and shall be completely isolated from the disconnect switch compartment.

6.2 The incoming breaker shall be equipped with an appropriate 3-phase over-current relay, lockout relay, and breaker control switch. The breaker shall be form an integral part of the filter system key interlock system, protection system, and control system.

7 Ground Switch

7.1 An externally operated ground switch shall be provided to ground the load-side terminals of the incoming air disconnect switch. The ground switch shall be pad-lockable in either the open or closed position. The ground switch must be tested in accordance with ANSI/IEEE standards. Test reports shall be furnished upon request.

7.2 The ground switch shall be interlocked with the Air Disconnect Switch to prevent closing of the ground switch when the air disconnect switch is in the closed position.

8 Lightning/Surge Arresters

8.1 The filter bank shall be shall be equipped with Station Class Lightning Arresters. The rating of the lightning arrester shall be recommended by the filter bank supplier. The lightning arresters shall be located in the incoming compartment.

9 Capacitor Switching Device

9.1 The filter bank stages shall be controlled by single phase solenoid operated vacuum switches (or SF6 Switches) that have been tested for capacitor switching. Capacitor switches shall be tested in accordance with ANSI Standard C37.66.

9.2 The switches shall be controlled by an on/off/auto switch. In the auto position, the switches shall accept control from the digital power factor controller. In the on/off position, the switches will be forced on or off, regardless of the power factor controller output signal.

9.3 The control system shall prevent the stage switches from operating more than once in a 5-minute period.

9.4 The stage switches shall be interlocked with the bank's air-disconnect switch and ground switch (and fixed mounted breaker if provided).

(Optional – Arc Flash Hazard Mitigation) Proper choice of vacuum switches is critical for restrike free operation. NEPSI always recommends the switch voltage rating be rated above the systems maximum voltage.
Additionally, the switch should be rated 135% of the banks RMS current rating at 110% voltage and maximum harmonic level.

10 Capacitors

10.1 The harmonic filter bank shall be equipped with all-film, low loss, harmonic rated double-bushing capacitors. The capacitors shall be designed, manufactured, and tested to meet and/or exceed all applicable NEMA and ANSI/IEEE standards. Capacitors must be manufactured by Cooper, GE, or ABBEach capacitor shall contain an internal discharge resistor to reduce the stored voltage to 50 volts or less within 5 minutes from disconnection.

10.2 The capacitor's voltage ratings shall be increased for harmonic filter duty with the following considerations (data to support choice of capacitor voltage rating and kvar output of each step shall be provided with Bid):

- Harmonic current peaks having 100% coincidence
- Nominal system over-voltage of 5%
- Ambient voltage distortion equal to the limits set forth by IEEE 519 (at the PCC) or values obtained during measurement

- Adherence to IEEE/ANSI peak (crest) and RMS voltage ratings.

10.3 The capacitors shall be connected in ungrounded split-wye. The neutral between the wye-connected filter banks shall be equipped with a 50/5 current transformers. The current transformer secondary leads shall be terminated in the control compartment onto a CT shorting block or shorting switch for connection to fuse protection relays.

10.4 The capacitors shall be located in a compartment that is separate from the main incoming compartment, control compartment, and damping resistor compartment (if provided). One Capacitor Compartment shall be provided per stage.

10.5 Capacitors shall be mounted on C4x5.4 structural steel channel. The capacitors shall be removable from the front of the enclosure.

(Optional – Arc Flash Hazard Mitigation) Consider using capacitors that have an extra 10% voltage margin on them from your harmonic design at maximum voltage and maximum harmonic for increased reliability.

11 Capacitor Protection

11.1 Each capacitor shall be protected by current limiting fuse that is equipped with a blown fuse indicator. Fuses shall be clip mounted to allow for easy change-out and shall be visible and accessible from the front of the enclosure.

11.2 Each capacitor fuse shall be supplied with a micro switch that allows for supervision of the fuse by means of a flexible non-conductive Bowden cable. During fuse operation, the fuse striker pin transmits mechanical force through the Bowden cable to the micro switch. The NC contact for all capacitor fuse micro switches on each stage shall be connected in series and wired to a terminal block within the control compartment for customer monitoring of fuse status.

11.3 Fuses shall be manufactured by SIBA. No exceptions allowed.

(Optional – Arc Flash Hazard Mitigation) Where neutral unbalance protection is to be specified, NEPSI recommends the use of a neutral CT in the neutral of a split-wye capacitor bank in lieu of a neutral PT. NEPSI and others have documented an increased probability of capacitor switch/breaker restrike when a neutral PT is used. Additionally, NEPSI always recommends the use of direct fuse sensing as provided by SIBA as this system also protects against fuse failure. Neutral unbalance protection can be added as a secondary / primary protection means.

12 Iron-Core Filter Reactors

12.1 The harmonic filter bank shall be equipped with single-phase iron-core dry-type reactors. They shall have Copper windings and a 220°C insulation system with a 115°C temperature rise over a 40°C ambient.

12.2 The reactors shall be Vacuum Pressure Impregnated (VPI) with EPIC TC-0118 Epoxy. The iron laminations shall be a hi-grade magnetic steel. To reduce gap magnetic losses and extraneous magnetic fields, a distributed gap design shall be utilized.

12.3 All gaps shall be cemented to reduce noise levels.

12.4 The rector current ratings and design shall be based on the following considerations:

- The reactor core will not saturate for currents less than 250% of the fundamental current rating of the filter bank or filter bank stage.
- Peak flux density of the core shall be less than 1.2 – 1.4 Tesla assuming all harmonic current peaks are 100% coincident (Core design shall not be based on RMS current rating of reactor).
- Reactor currents are based on computer simulations. Results of such simulations shall be provided with the approval drawings. Where the necessary data for doing the simulations are not been provided, the following minimum current spectrum in amps should be utilized.
  - I_1 = 1.21 x Fundamental Current Rating of the Stage (for multi-stage banks) or Bank at the Nominal System Voltage.
  - $I_{Tuned\ Frequency}$ = 0.5 x Fundamental Current Rating of the stage (for multi-stage banks) or Bank at the Nominal System Voltage.

If proper data has not been provided to do the simulations, the vendor shall submit their bid utilizing the above minimal current ratings. The vendor will be required to submit a data request upon issue of an order so that computer simulations can be conducted to check for proper reactor ratings. Results of harmonic simulations shall be provided with the approval drawings.

(Optional – Arc Flash Hazard Mitigation) – Over-rating iron-core reactors beyond calculated current ratings is a good way to improve reliability of the harmonic filter bank and reduce the probability of failure and possible arc flash event.

13 Iron-Core Reactor Protection

13.1 A three-phase digital overload relay shall be provided to protect the reactors from harmonic current overload. The overload protection shall account for the increased heating effects of higher order harmonic currents. The relays shall be field adjustable. The relays shall have the following minimum protection features:

- Thermal Overload (over current greater than time dial and current pickup setting)
- Under Current (filter drew less than undercurrent setting for 3 seconds)
- Phase Failure (one or more phases lost for 3 seconds)
- Phase Unbalance (one or more phases unbalanced by 50% for 5 seconds)
- Long-Time Over-Current (the filter drew short-time high current for 5 seconds)
- Short-Time Over-Current (the filter drew short-time high current for 0.5 seconds)
- The relay shall display actual current for each phase during operation and shall provide a latch indicator as to the cause of the overload trip.

13.2 An overload temperature relay shall be provided as backup protection for the Iron-Core Reactors and also to protect against fan failure.

14 High-Pass Filter Resistor Modules (Damping Resistors)

15 Stainless steel grid resistor modules shall be utilized for the harmonic filter stages that are specified as C-High-Pass or Standard High-Pass filter branches.

16 The resistors shall have a _____ kW/Phase rating and resistance of _____

ohms/phase.The resistor modules shall come fully assembled and ready for installation on the roof of the harmonic filter bank. All interconnection cables, through-roof bushings, and lugs shall be provided with the equipment. The resistor modules shall be easy to install and to interconnect with the main filter branches.

16.1 The resistors modules shall consist of a stainless steel, self-ventilated, unpainted enclosure.

16.2 Resistors shall be protected from overload with an overload protection relay. The relays shall be field adjustable. The relays shall have the following minimum protection features:

- Thermal Overload (over current greater than time dial and current pickup setting)
- Long-Time Over-Current (the filter drew short-time high current for 5 seconds)
- Short-Time Over-Current (the filter drew short-time high current for 0.5 seconds)
- The relay shall display actual current for each phase during operation and shall provide a latch indicator as to the cause of the overload trip.
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(Optional – Arc Flash Hazard Mitigation) – Over-rating resistor watt ratings beyond calculated watt losses is a good way to improve reliability of the harmonic filter bank and reduce the probability of failure and possible arc flash event. NEPSI usually recommends a least a factor of 2.0.

17 Phase and Ground Bus

17.1 All phase and ground bus shall be Tin-plated (or Silver plated) for maximum conductivity and corrosion resistance. Bolted bus-to-bus connections shall be made with 3/8" – 13 stainless-steel bolts with two stainless steel flat washers, one under the bolt head and one under the nut and with a stainless steel split lockwasher between the flat washer and the nut. The bus shall not have a current density greater than 1200 amps/in^2. Where expansion capability is required, the bus shall be rated for the maximum capacity of the bank.

17.2 The ground bus shall be located near the front base of the enclosure to allow for placement of field installed ground clamps. The bus shall run the full width of the enclosure and shall be pre-punched for connection of equipment ground conductor(s) and cable shield wires. The ground bus shall connect to stainless steel ground pads located on the ends of the enclosure to allow for external connection to the substation ground grid.

17.3 The bus supports, bus, and interconnections shall withstand the stress associated with the available short-circuit current at the filter bank.

17.4 (Optional – Arc Flash Hazard Mitigation) All main phase bus shall be insulated with heavy wall anti-track heat shrinkable tubing designed for insulating medium voltage bus bar. Insulation must be tested to ANSI C37.20.2 standards.

18 Interlocks

18.1 The filter bank shall be equipped with a keyed interlock system to prevent unauthorized and out of sequence entry into the filter bank.

18.2 The interlock scheme shall include the upstream protective device (where necessary), the filter banks air disconnect switch, ground switch, and the doors of the enclosure. The interlock scheme shall function as follows:

1) Turn all filter stages off manually with the on/off/auto switches.
2) Upon a waiting period of 5 minutes (beyond the time that all stages have been turned off), key "A1" shall be released. (Note: This key shall be held captive until all stages have

been de-energized for 5 minutes).

3) Use the “A1” key to unlock the air disconnect switch. Open the Air-Disconnect Switch and close the mechanically interlocked Ground Switch.
4) Remove the “A2” key from the Ground Switch (Removing of the “A2” key shall lock ground switch in closed position” and proceed to the Air-Disconnect Switch External Compartment Door. Unlock the Air-Disconnect Switch Compartment Door and remove the “A3” key from the lock. (Note: Access to Air-Disconnect Switch terminals is prevented by the interior compartment door. This door can be interlocked with upstream breaker or load interrupter if desired. This would prevent access to terminals of switch unless upstream device was locked out.)
5) Use the “A3” key to open the first door that has access to the capacitor compartment. (Upon turning of the “A3” key, the vacuum switches shall close to ground all components on the load-side of the vacuum switches.) Remove the “A4” key from the first filter bank compartment door and proceed to the second filter bank compartment door.
6) Open the second filter bank compartment door, and proceed with the released key (if one is present) to the next door.
7) The above procedure is repeated until all doors are open.

18.3 The keyed interlocks on the door shall be mounted behind the enclosure doors with the key-holes protruding through the doors. The locks shall be equipped with stainless steel spring covers. The keyed interlock system shall allow all doors to be opened at one time. Master Key interchanges or externally mounted key interlocks shall not be provided.

19 Controls

19.1 All low voltage controls (where practical) shall be isolated from the high voltage compartments. All controls shall be accessible while the bank is energized. The control compartment shall form an integral part of the enclosure (no externally mounted control compartments shall be allowed). The control compartment shall allow for bottom or top entry of customer control wires without having to enter the medium voltage compartment. The controls compartment shall be equipped with a swing out panel to allow access to panel mounted controls.

19.2 The automatic harmonic filter bank shall be equipped with a power factor controller that will automatically switch the filter bank stages in or out to regulate a facilities power factor to a preset value. The controller shall consists of the following features:

- Display of power factor, number of steps, switching counter and duty cycles, Network technical data,: I, U, S, P, Q, Total harmonic voltage distortion, Alarm log, step status, step capacitance monitoring, total harmonic current distortion, Voltage and current harmonic spectrum.
- Alarms for low power factor, Hunting, Abnormal power factor display, low voltage, overcompensation, wrong frequency, overcurrent, overvoltage, over temperature, voltage distortion, capacitor overload.

19.3 The complete control circuit shall be protected by a main circuit breaker.

19.4 Each stage shall be equipped with on/off/auto switches, stage on indicator (green) and stage off indicator (red). An interposing on-delay relay shall be provided to prevent the energization of a capacitor bank in less than 5 minutes. The manufacturer of the bank shall confirm that when going from the “Manual” position to the “Auto” position on any stage, that the corresponding stage will not be energized in less than 5-minutes.

For Arc Flash Hazard Mitigation, there shall be a 10 second delay before switching when switching from the off to the on position or the on to the off position to allow workers to move outside the arc flash danger zone.

19.5 The bank shall be equipped with a control power transformer that has both primary and secondary overcurrent protection. The control power transformer shall be connected between phases B and C.

19.6 The Capacitor Bank Compartment, Control Compartment, and Air-Disconnect Switch Compartment shall be equipped with lights that are controlled by an on/off switch located in the control compartment.

19.7 (Optional – Arc Flash Hazard Mitigation) The control and protection system shall be remotely mounted from the main equipment enclosure. The remote enclosure shall be NEMA 1 rated for indoor application. All interconnection wiring shall be supplied by the installing contractor. Terminal blocks in the main equipment enclosure shall be located in a marshalling cabinet. Remote I/O blocks may be used when required in the marshalling cabinet.

19.8 (Optional – Arc Flash Hazard Mitigation) The harmonic filter bank shall be equipped with an ABB UFES (Ultra Fast Earthing Switch) that will provide active arc fault protection for the entire capacitor bank. The UFES system shall be supplied complete with electronic detection and tripping unit, primary switching element, arc sensors and trip cables. The system shall be installed and ready for operation. A transfer trip must be wired out to terminal blocks for tripping upstream feeder breaker in event of fault.

19.9 (Optional – Arc Flash Hazard Mitigation) The control system shall be equipped with a "maintenance switch" that enables instantaneous settings on the harmonic filter bank feeder breakers (and stage breakers when present) to reduce trip times when workers are near the equipment. The switch shall also inhibit all stage switching to reduce the probability of arc flash event from switch failure or switch restrike while workers are nearby.

19.10 (Optional – Arc Flash Hazard Mitigation) The filter bank shall be equipped with an arc flash detection relay that provides high speed tripping of the filter bank feeder breaker in the event of an arc flash fault. The relay and optics shall be installed and tested at the factor before shipment. The fast trip relay output shall be wired to terminal blocks for connection to capacitor bank feeder breaker.

19.11 A 15-amp GFI Convenience outlet shall be provided in the control compartment.

19.12 The Medium Voltage Capacitor Bank Control System shall be listed under UL 508A for Industrial Control Panels.

19.13 UL Rated Control Power Circuit Breakers shall be utilized in the control circuit for switching and protection of key control components.

The following optional requirements can be specified on the main as well as on each stage:

19.14 A three-phase panel meter shall be provided. This meter shall receive its voltage and current signals from three current transformers and two potential transformers located inside the filter bank. The meter shall be pre-programmed at the factory and shall have the following features:

- Voltage, per phase & average

- Current, per phase & average
- Real Power, per phase & total
- Apparent Power, per phase & total
- Power Factor, per phase and total
- Voltage & Current Unbalance
- Frequency
- Imported, exported, absolute and net kWh & kVARh
- Accumulated kVAh
- Sliding Window, Predicted, & Thermal Demand on kW, kVAR, kVA, & I average
- Minimums and Maximums are stored for Voltage, Current, kW, kVAR, kVA, Power Factor, Frequency, & Sliding Window Demand for kW and kVA
- Individual and Total Harmonic Distortion on Voltage & Current Inputs up to 15th harmonic
- The meter shall have 4 digital outputs that can be wired for relay control based on any of the measured values above.
- Communication requirement: (Modbus, DNP, Profibus, IEC 60870, IEC 61850)

20 Supplier Quality System

20.1 Supplier shall have third party certification by an internationally recognized accreditation body to ISO 9001:2008. The certification certificate shall be provided with the quote.

20.2 Supplier shall be authorized to label equipment as compliant with IEEE C37.20.3-2001 "Standard for Metal-Enclosed Switchgear" and C22.2 No. 190-M1985 "Capacitors for Power Factor Correction". The certification certificate shall be provided with the quote.

20.3 Supplier shall be factory certified through periodic inspection by UL to apply UL and C-UL labels on their control panels. The certification certificate shall be provided with the quote.

20.4 Supplier shall have on staff, experienced, licensed professional engineers (PE's) with degrees in Power Engineering (preferably with advanced degrees) as evidence of technical proficiency.

20.5 Supplier must provide a medium voltage metal enclosed customer list with contact information for the purpose of reference checks. The customer lists shall be provided with the quote.

20.6 Supplier must allow factory audits to occur at mutually agreed upon dates between the customer and supplier.

21 Submittals

21.1 Upon issue of a purchase order, the supplier shall provide 3 copies of approval drawings. The submittals shall include:

- Installation Instructions
- Single Line and three line diagrams
- Pad and cable entry drawings
- Drawings showing component layout
- Data sheets for all internal components
- Material listing

22 Bid Requirements

22.1 Supplier must provide an Inspection Test Plan (ITP) detailing all tests, tests reports, and certifications and their schedule for submission from date-of-award.

22.2 Supplier must provide a Supplier Document List (SDL) detailing all submittal and close-out documentation that will be provided, along with a submittal schedule (in weeks after award).

22.3 Supplier must state all exceptions in the Bid. If no exceptions are taken, the supplier must state that there are no exceptions.

22.4 Supplier must have optional extended warranty and field service agreements available. These policies shall be provided with the bid.

22.5 Supplier must provide product, quality, and UL certifications and customer list with Bid.

22.6 Quotes are to be FOB factory, freight allowed.

23 Testing and Test Reports

23.1 All components shall be tested in accordance with the relevant standards. Tests to be conducted shall be included in an Inspection Test Plan (ITP), and provided with the bid. At a minimum, the tests included in this section shall be included in the ITP.

23.2 A Power-Frequency Withstand Test and a Lightning-Impulse Withstand Test shall be conducted by the assembler in accordance with IEEE C37.57-2003 (2010), IEEE C37.20.3, and IEEE Std. 4 - 2013. The Test Voltages shall be in accordance with C37.20.3-2013 Table 1. Multiple test shall be conducted to demonstrate insulation levels under various operating modes, i.e. main switch open, main switch closed, capacitor stage switch open, capacitor switch stage close.

23.3 All relays and control devices shall be programmed, tested, and calibrated prior to shipment. The results of the calibration shall be issued with the test report. Relay and control settings shall be documented and included with the equipment installation, commissioning, and maintenance instructions.

23.4 Air Disconnect Switch shall include the following test: Contact Resistance Test, HiPot Test (1 min) at standard voltage per applicable standard, and operation test.

23.5 Lightning Arresters shall include the following test: Reference Voltage, Residual / Discharge Voltage, Partial Discharge Test, Power Frequency Test.

23.6 Instrument Transformers shall include the following: Turns Ratio Test, Polarity Check, Insulation Test, and Excitation Test per IEEE Std. C57.13.

23.7 Capacitors shall include the following test: Leak test, low voltage capacitance test, ground test over-voltage, capacitance and loss measurement, discharge resistor measurement, and visual inspection for damage.

23.8 Southern States CapSwitcher shall include the following test: Hi-Pot Testing, Timing Test, Resistance Check, Heater Wattage Check, SF6 Leak Check, Slow Close Operation Test, Wiring Check, Gas Density Switch Check (when applicable).

23.9 SF6 Circuit Breaker shall include the following test: Mechanical Operation Tests, Power Frequency Voltage Voltage Withstand Test, Contact Resistance Test, Operating Time Test.

23.10 The equipment shall be fully assembled and tested prior to shipment. Certified test reports in accordance with the vendors inspection test plan (ITP) shall be issued and approved prior to shipping.

23.11 The client reserves the right to witness any and all tests performed at no additional cost. Sufficient notification shall be given to allow client's representative(s) to be present for the tests. A minimum of 15 working days shall be allowed.

24 Acceptable Product & Suppliers

24.1 Suppliers must offer a minimum 1-year warranty and have available extended warranty programs.

24.2 Supplier must be able to meet testing requirements.

24.3 The supplier must have a current ISO 9001 certification and be certified by an independent ISO accredited firm. The ISO 9001 certificate shall be provided with the bid.

24.4 Supplier must have a licensed professional engineer on staff that has a post graduate degree in electric power engineering. Credentials shall be supplied upon request.

24.5 Supplier must show that they are a regular supplier of medium voltage automatic metal-enclosed filter banks. Product literature and a list of customers that have purchased similar products shall be supplied upon request.

24.6 Suppliers must be able to provide performance guarantee in regards to harmonics and power factor.

24.7 Acceptable Suppliers are as follows:

Northeast Power Systems, Inc.
66 Carey Road
Queensbury, NY 12804

Phone: 518-792-4776
Fax: 518-792-5767

Webpage: www.nepsi.com
Quote request: sales@nepsi.com