# SECTION [26 35 33.16][16340]

## POWER FACTOR CORRECTION

### Square D VarSet™ by Schneider Electric

Schneider Electric Editor's Note:

This guide specification is written in accordance with the Construction Specifications Institute (CSI) Master Format. This section must be carefully reviewed and edited by the architect or the engineer to meet the requirements of the project. Coordinate this section with other specification sections within the Contract Documents and Drawings.

To properly use / edit this document, show formatting and hidden text by selecting ¶ on the menu or by typing (Ctrl+*) simultaneously. Except for these introductory and closing paragraphs, green hidden text will not print. Text in red is optional. Red text in [brackets] denotes multiple options where one or more should be chosen. All red text should be edited and changed to black for final project conformation. In addition, these introductory paragraphs should be deleted or changed to hidden text.

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for power factor correction equipment (also identified as automatic capacitor banks, PFC equipment) as required for the complete performance of the Work, as shown on the Drawings, as specified herein.

B. Related Sections: Related sections include, but shall not be limited to, the following:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
2. Applicable general requirements for electrical Work specified within Division 26 Specification Sections apply to this Section.
3. Refer to specification Section 26 13 09 Electrical Power Management System for additional requirements.

### 1.2 REFERENCES

A. General, Publications: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. American National Standards Institute (ANSI)
   a. ANSI C37.51, "Switchgear Metal Enclosed Low Voltage AC Power Circuit Breaker Switchgear Assemblies Conformance Test Procedures."
2. American Society for Testing and Materials (ASTM)
   a. ASTM E 329, "Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction."
3. Canadian Standards Association (CSA)
   a. C.22.2 No. 190, "Capacitors for Power Factor Correction."
   b. C22.1, "Canadian Electrical Code, Part I" (CEC)
   c. Z462, "Workplace Electrical Safety"
4. National Electrical Manufacturers Association (NEMA)
   a. NEMA 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)"

5. National Fire Protection Association (NFPA)
    a. NFPA 70, "National Electrical Code" hereinafter referred to as NEC.
    b. NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces"
6. Underwriters Laboratories, Inc. (UL)
    a. UL 508a, "Industrial Control Panels"
    b. UL 810, "Standard for Capacitors."

## 1.3 DEFINITIONS

A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.
    1. PFC: Power Factor Correction

## 1.4 SUBMITTALS

A. General: Submittals shall be in accordance with the requirements of Section [01 33 00][01300] Submittals and Section [26 00 10][16010] Electrical Requirements, in addition to those specified herein.
    1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.
    2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.

## 1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 20 years.
    1. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
    2. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis.

B. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing low voltage automatic capacitor banks similar in type and scope to that required for this Project.

C. Inspecting and Testing Agency Qualifications: To qualify for acceptance, an independent inspecting and testing agency hired by the Contractor or manufacturer to test products shall demonstrate to the Architect/Engineer's satisfaction that they are qualified according to ASTM E 329 to conduct testing indicated.

D. All work performed and all materials used shall be in accordance with the National Electrical Code, and with applicable local regulations and ordinances. Process controllers, assemblies, materials, and equipment shall be listed and labeled by Underwriter's Laboratories or by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### 1.6 DELIVERY, STORAGE AND HANDLING

A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.

B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.

C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

### 1.7 WARRANTY

A. General: Refer to [Section 01 77 00 - Closeout Procedures] [Section 01770 - Closeout Procedures].

B. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

### 1.8 SPECIAL TOOLS AND SPARE PARTS [NOT USED]

A. The Contractor shall provide a recommended spare parts list with the following information provided as a minimum:

1. Contact information for the closest parts stocking location to the Owner.
2. Critical spare parts shall be identified as those parts being associated with long lead times and/or those being critical to the unit's operation.
3. Maintenance spares shall be identified as being those parts required to regularly perform scheduled maintenance on the furnished equipment. These spares shall include, but shall not be limited to, consumable spares that are required to be exchanged during scheduled maintenance periods.

B. Spare parts shall be provided for each type and size of unit furnished. At a minimum, the following shall be provided:

1. Provide the minimum spare parts recommended by the manufacturer.
2. Provide [1] set of each type of power and control fuse installed within equipment

C. Spare parts shall be properly marked and packaged for long term storage. Printed circuit boards shall be provided in separate anti-static containers.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. [Basis-of-Design Product: Subject to compliance with requirements, provide Square D VarSet, by Schneider Electric.]

B. Acceptable Products: PFC equipment specified herein shall be the product of a single manufacturer. Products and manufacturers specified are to establish a standard of quality for design, function, materials, and appearance. Products shall be modified as necessary by the manufacturer for

compliance with requirements. Provide the following specified product and manufacturer without exception, unless approved as a substitute by addendum to the Contract Documents prior to the bid date:

1. Square D VarSet by Schneider Electric
2. [2nd manufacturer and model]
3. [3rd manufacturer and model]

## 2.2 GENERAL REQUIREMENTS

A. Capacitor bank shall be able to select a target power factor, adjustable to any value between 0.80 lagging and unity. When the power factor differs from the target setting for more than 1 to 30 seconds, capacitor bank shall bring the corrected circuit power factor to the closest target setting.

B. Electrical Components, Devices, and Accessories: Electrical components, devices, and accessories shall be listed and labeled as defined in NEC, Article 100, by an inspecting and testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. The complete equipment shall be manufactured per UL 508, and CSA 22.2 No. 190.

D. Capacitor equipment shall be suitable for the following conditions:

1. Operating ambient temperature range shall be 23 °F ( 5 °C) to 104 °F (40 °C) maximum.
2. Highest mean over any period of 24 hours shall be 104 °F (40 °C).
3. Highest mean over one year shall be 95 °F (35 °C).
4. Maximum Altitude: 6562 feet (2000 m).
5. Humidity: 0 percent to 95 percent, non-condensing.

## 2.3 POWER FACTOR CORRECTION UNITS

### A. Equipment Size / Ratings

1. Operating voltage shall be [480 volts] (line to line), three phase, [60] hertz.
2. Rated capacitor cell voltage shall be minimum of [575 volts for 480 Volt networks].
3. Total kVAR rating of the capacitor bank shall be [_____] kVAR at [480V].
4. Capacitor steps shall be [_____] kVAR for [480V] networks.
5. If the incomer has terminal lugs, then the same shall be of copper and all copper buswork shall be braced to withstand fault level at either 25 kA RMS amperes symmetrical plus 10 percent for four cycles per ANSI C37.51. [If the incomer is a circuit breaker, then the same shall be rated to withstand a fault level of 65 kA at 480 volts. The main circuit breaker shall be rated for a minimum of 135 percent of the capacitor system full load current at operating voltage.]

B. Enclosure:

1. Enclosure(s) shall be freestanding / wall mounted, and shall be constructed of sheet steel, including, but not limited to a hinged door, ground lug, and removable lifting eyes, finished with standard [ANSI/ASA 49 gray][ANSI/ASA 61 gray][ RAL 7035] paint.
2. Enclosure(s) shall meet NEMA 250 Type 1 for indoor application.
3. Enclosure door(s) shall be full height, key lockable with door mounted controller, to comply with NFPA70E requirements.

C. Capacitors

1. Internal capacitor cells shall be UL and CSA recognized in compliance with UL 810 and CSA22.2, No. 190.

2. Liquid filled or impregnated capacitors are not acceptable. Individual capacitor elements shall be of a self-healing design utilizing a low loss metalized film dielectric system with a pressure sensitive circuit interrupter. Electrical losses, including, but not limited to, contribution of discharge resistors, shall average less than 0.5 watts per kVAR.

3. Capacitor shall be able of continuous operation at 135 percent of the rated rms current, including fundamental and harmonic currents, and be suitable for continuous operation at terminal to terminal voltage (rms including harmonics) equals to 110% of the rated voltage.

4. Capacitor elements shall be delta connected at rated voltage. Wye connected capacitor elements shall not be acceptable.

5. Capacitor shall incorporate a 3-phase pressure switch disconnector for protection against internal faults, over pressure, etc. The pressure switch disconnector must isolate all the three phases simultaneously in the event of fault.

6. Discharge resistors shall be provided to meet UL/CSA requirement (reduce voltage on the cells to 50 volts or less within one minute after the capacitor has been switched off).

D. Internal Overcurrent Protective Device: Thermal magnetic molded case current limiting circuit breaker shall be provided on the line side of each contactor. Circuit breaker shall be UL/CSA listed, shall have inverse time current element for low level overloads, and shall have adequate short circuit current interrupting rating.

E. Contactors:

1. For applications with gradual load variation, electromagnetic contactors shall be used. The electromagnetic contactors shall be three poles; rated for the repetitive high inrush switching duty in the capacitor application. Contactors shall be designed for capacitor switching duty, UL / CSA listed and rated 600 volts AC with 120 volts AC operating coils.

2. For applications with dynamic load variation or electronic loads that are sensitive to transient over voltages, transient free switching shall be used. Transient free switching with (solid state capacitor switching module) shall enable a 1 second response time. The thyristors in the switching module shall be rated to 200 amperes RMS nominal current per phase up to 600V, and shall be rated for 2400 PIV. Up to 3 stages can grouped in a single switching module for effective thermal management. The switching module shall be protected by thermal protection device to prevent overheating. The air flow through the heat sink shall be external to the capacitor bank. Losses from the heat sink, shall not add to the temperature rise internal to the capacitor bank.

F. De-Tuning Reactors:

1. Tuning reactors for each capacitive stage shall be selected such that filter tuning of each stage shall be equal to 4.2 x 60 hertz equivalent to a 252 Hz tuning.

2. Reactor shall be constructed of EI laminated low hysteresis core with a controlled air gap and three aluminum windings.

3. Reactor insulation shall be rated for 180 °C, class H.

4. Center leg of tuning reactor shall have an embedded thermistor wired to a thermistor relay for the stage to deenergize the associated contactor in the event of reactor overheating.

G. Control Power Requirements:

1. 120 volt AC control circuit transformer shall be provided within the enclosure.

2. Major components, including, but not limited to, both primary and secondary winding of the transformer, shall be fused.

H. Power Factor Controller:

1. The PF controller shall be a programmable unit with a single current input and single line to line voltage input. The controller shall be suitable for operation with energy import and energy export

(4 quadrant operations). The controller shall measure power factor in the distribution system, and per the programmed control logic, shall connect or disconnect the required amount of capacitor stages needed to maintain the preset power factor.

2. The controller shall utilize a switching logic that shall optimize the use of capacitor elements and contactors in the bank. Three switching logics shall be available; Automatic (Best Fit), LIFO & Progressive.
3. A backlit LCD display shall be provided to view the system condition and gain access to all the menus. Indication of actual Power Factor, Alarms, stage energization and inductive/capacitive condition shall be provided.
4. Backlit LCD display shall light up when the controller is being access.
5. The controller shall be equipped with a quick set up menu to allow for simple and quick startup of the Automatic Capacitor bank.
6. The controller shall also be equipped with an expert setup menu allowing password controlled access to advanced parameters like: measurement, maintenance, controls, capacitor data, alarms and Modbus communication.
7. When overriding the automatic mode for maintenance, a ten minutes maximum override time shall be provided with an automatic return to automatic mode of operation.
8. A common alarm dry contact shall be provided to signal an alarm status.
9. The controller shall automatically select the system frequency (50 hertz or 60 hertz).
10. An automatic step detection and an automatic voltage and current input wiring connection must be provided to reduce risks of bad connection. CT ratio, position and polarity shall be adjustable by the controller.
11. The controller shall monitor all connected steps and provide the real-time power in kW, kVAR and kVA. The controller shall also monitor remaining step kVAR capacity as a percentage of the original reactive power and the PFC system hours of operation since commissioning.
12. The controller shall permit programming of the switching stage response time, number of stages (12 maximum), and various adjustment parameters depending on system design.
13. The controller shall be equipped with a Modbus RTU (RS 485, 2 wires) communication port. Furthermore, communication via Ethernet TCP/IP shall be possible when an Ethernet gateway (Link 150) is added to the automatic capacitor bank.
14. A digital input shall be provided to activate the Cosphi #2 for application with back-up generator.
15. The controller shall allow the following settings and readings.
    a. Automatic initialization and stage rating detection
    b. Any step sequence detection (User definable step sequence)
    c. Measurement of capacitance per stage
    d. Cap bank over load current ratio
    e. THD Voltage
    f. 4 Quadrant operation
    g. Active, reactive and apparent power
    h. Record of the Max temp internal of the capacitor bank since reset
    i. RS485 interface.

I. The controller shall initiate alarms and warnings in the following events.
1. Temperature limit is exceeded
2. Insufficient capacitor output
3. Overload current ratio limit is exceeded
4. Under voltage, Over voltage

5. THDU limit is exceeded

## 2.4 EXTERNAL CURRENT TRANSFORMER (CT):

A. A current transformer to be installed upstream of where the automatic capacitor is attached to the electrical distribution system, shall be provided with a ratio of [____] amperes to [1][5] amperes. The field installable CT shall be split core type with an opening large enough to facilitate installation around the cables or bus.

B. A shorting terminal shall be provided for two incoming current transformer wires.

## 2.5 ELECTRICAL POWER MANAGEMENT SYSTEM [NOT USED]

A. The Capacitor bank shall provide the necessary communications connectivity and functionality required to support the functionality of an Electrical Power Management System (EPMS). This shall include, but not be limited, to the following:

1. Communications connectivity using the specified Ethernet network and protocols of the EPMS and related EPMS connected equipment necessary to provide functionality. Equipment may be connected through a communications gateway as shown or specified; otherwise Ethernet and protocol connectivity shall be provided within the equipment.
2. Compliance with Cyber security requirements.
3. Remote EPMS application functionality for equipment configuration [ and operational control]; electrical power monitoring; power quality monitoring, compliance and correction; and alarm monitoring with event log.
4. Refer to the Electrical Power Management System specification section for additional requirements.

B. Native software compatibility shall be fully factory-tested, and shall include the following characteristics.

1. Capability for pre-engineered, interactive graphical display screens to view and analyze real-time device data. Data displayed shall include the following
   a. Power factor (target, measured total, measured displacement)
   b. Total Power values (kW, kVAR, and kVA)
   c. Average Current
   d. Step settings & status of each step (whether closed, faulty, whether step type is automatic or fixed)
   e. Step capacity for each step (initial, present and percentage remaining)
   f. Device status information (line-to-line voltage, average current, temperature)
   g. Device maintenance warnings & alarms (step broken, step power loss, hunting, over-under compensation, temperature alarms, operating hours exceeded, switching cycles exceeded etc.)
   h. Device diagnostic data (operating hours, ambient temperature, overload current ratio, fan relay status etc.)
   i. Device configuration settings (control sensitivity, step switch interval, discharge time etc.)
2. Pre-mapping of registers to standard measurement names without the need for additional configuration or internal device registers.
3. Automatic collection and logging of device data by EPMS software without additional configuration. Historical data logged shall include the following.
   a. Average current
   b. Ambient Temperature
   c. Power Factor (total, apparent, reactive, real).

## 2.6 MARKINGS AND LABELING

A. All identification and warning labels and nameplates exterior to the AHF shall be resistant to weather, UV, and their intended installation environment.

B. Each AHF shall be provided with an engraved nameplate identifying the project specific equipment tag and service description.

C. Warning labels and nameplates shall be present at access locations to advise personnel of possible hazards. The AHF shall be marked in accordance with UL, NFPA 70 NEC, NFPA 70E, and other applicable standards.

# PART 3 - EXECUTION

## 3.1 GENERAL

A. In addition to the requirements specified herein, execution shall be in accordance with the requirements of Specification Section [26 00 10][16010] and Drawings.

B. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.

C. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

D. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

E. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.

F. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory trained manufacturer's representative field service engineer. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment. Report to the Engineer any discrepancies or issues with the installation.

G. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

## 3.2 FACTORY ACCEPTANCE TESTING [NOT USED]

A. Standard tests shall be performed in the factory to confirm proper operation of the capacitor bank, including, but not limited to, operation of control circuits, functioning of the PF controller, confirming of kVAR rating at rated voltage and high pot testing per UL / CSA requirements.

## 3.3 FUNCTIONAL DEMONSTRATION TESTING

A. The contractor shall certify in writing prior to scheduling functional demonstration testing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations and is ready for operation.

B. The contractor shall demonstrate the functional and operational features of the capacitor bank along with the PF Controller.

END OF SECTION [26 35 33.16][16340]



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