Saudi Electricity Company	الشركة السعودية للكهرباء

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SPECIFICATIONS

FOR

POWER FACTOR CORRECTION FOR

LOW VOLTAGE POWER SYSTEMS

CONTENTS

1.0 SCOPE

This specification outlines the minimum technical requirements for the design, installation of Power Factor Correction capacitors intended to be used with low voltage equipment. Such equipment shall be utilized for the improvement of power factor and/or mitigation of harmonics in AC electrical power systems. This is in addition to the requirements specified in 01-SDMS-01- Specification for General Requirements for All Equipment/Material.

2.0 APPLICABLE CODES AND STANDARDS

The latest revision/ amendments of the following codes and standards shall be applicable for the equipment / materials covered in this specification.

2.1 IEC 60831-1 Capacitor units and capacitor banks intended to be used, particularly, for power-factor correction of A.C power systems having a rated voltage up to and including 1000 V and frequencies 60 Hz. Guidelines for performance, rating and testing. Safety requirements, Guide for installation and operation.

2.2 IEC 60529 Classification of degree of protection provided by enclosures.

2.3 IEC 61557-1 Electrical safety in low voltage distribution systems up to 1000VAC

2.4 ISO 2063 Metallic coatings-protection of iron and steel against corrosion-metal spraying of zinc and aluminum.

2.5 IEC 60439-1 Low-voltage switchgear and controlgear assemblies-type tested and partially type tested assemblies.

2.6 IEEE 18 Standard for Shunt Capacitor

3.0 DESIGN OF CAPACITORS

3.1 Capacitor type

The capacitors shall be dry-type units, which is the most efficient and economical for PFC intended for low voltage equipment. The thickness of the dielectric differs as a function of voltage rating. The metallization and edge enhancement with extra junctions or cross profile metallization play a significant role in achieving high current handling and stable capacitance at high operating temperatures.

3.2 Self healing

The capacitors shall have self healing ability, where a damage of some part of the dielectric due to a microscopic flaw in the dielectric film, caused by over-voltage, can be self-healed quickly and returned to normal state. So the reliability is much higher.

3.3 Overpressure disconnector

The capacitors shall be protected by a high quality system, incorporating overpressure disconnectors to switch off the capacitor if internal fault occurs and the pressure rises to unsafe levels. To ensure full functionality of an overpressure disconnector, its elastic elements must not be hindered, i.e.

- Connecting lines must be flexible leads.
- There must be sufficient space for expansion above the connections.

4.0 CONSTRUCTION REQUIREMENTS

4.1 General

The power capacitors shall be operable on 60 Hz and shall meet or comply with industry standards, in particular IEC 60831-1, IEC 60439 and IEC 61557-1. They shall be sited in cool ventilated locations away from other heat radiating elements. Capacitors shall contain no PCB material to avoid the risk of fire due to spurting or leaking oil and will be non polluting, non toxic and environmentally friendly.

Except for capacitors directly connected to the motor terminals, all capacitor banks shall be provided with a switching device equipped with an automatic trip.
The mounting arrangement of capacitors shall allow visual inspection and maintenance access, while allowing an individual capacitor to be removed without disconnection or removal of adjacent capacitors. Power capacitors shall also be capable of being mounted in an upright or horizontal position.

Additionally, adequate protection shall be provided against dust and direct solar radiation.

4.2 Inrush current

The PFC capacitors shall be capable of withstanding high inrush currents caused by switching operations (>100*I_R). For capacitors connected in parallel i.e. as banks, an inrush current 200 times the rated current can occur. Proper measures shall be taken to avoid such a condition.

The capacitors shall incorporate the following to limit the inrush current.

- Contactors with pre charging resistors
- Serial air coils

4.3 Over current and short circuit protection

4.3.1 HRC fuses or MCCBs shall be used for short circuit protection. The connecting cables and circuitry shall be selected so that 1.3 times the rated capacitor current can be permanently handled.

4.3.2 The maximum admissible over current of 1.3*I_R to IEC standard 60831 shall be maintained by all capacitors. Thermal/Thermal magnetic or electronic over current relays shall be used for over current protection. HRC fuses do not protect against overload.

4.3.3 The HRC fuse rating should be 1.6 to 1.8 times nominal capacitor current.

4.3.4 HRC fuses shall not be used for switching because of the risk of arcing.

4.4 Capacitor Contactors/Thyristors modules

Depending on the requirements either capacitor contactors or electronically controlled thyristors shall be used for switching PFC capacitors. For very fast and frequent switching thyristors shall be employed that have a switching time of only a few milliseconds.

Contactors along with damping resistors shall be used where there is a possibility of high inrush peak current to reduce it to <70*I_R. The capacitor contactors shall be weld resistant up to a possible peak inrush current of 200 * I_R

4.5 Enclosure

Capacitor bank enclosures for both indoor and outdoor applications shall be frame construction made out of cut and welded sheet steel angles and shall comply with standard IEC 60529. Either Alu-zinc or GI sheets o4 2mm to 3mm as the case may be shall be used. Where necessary ribs /reinforcements shall be used to prevent excessive wobbling especially on the doors. Welded structures and fabricated components shall be pretreated and then powder coated to give protection against environment. The degree of protection shall be IP 20 to IP 54 depending on the requirement.

5.0 HARMONICS

Capacitors shall be positioned so as to avoid the occurrence of resonance. The same value of kVAR installed at high voltage rather than low voltage can eliminate a resonant condition. One or more of the following solutions shall be adopted to avoid harmonics as much as possible.

5.1 Position the non linear loads upstream in the system

Electrical loads that have a non linear voltage/current characteristic (rectifiers, inverters for drives, welding apparatus and uninterruptible power supplies), shall be connected as far upstream as possible so as to avoid overall harmonic disturbances that increase as the short circuit power decreases.

5.2 Non linear load grouping

Non linear devices shall be grouped together and separated from the others. The two groups of devices shall be supplied by different sets of bus bars. Wherever possible the two groups shall be supplied by a source via separate transformers. For significant 3^{rd} harmonic distortion, a DY connection of the transformer shall be used. For 5^{th} and 7^{th} harmonic DYD connection shall be made.

5.3 Filter reactors

Filter reactors shall be used in series with the power capacitors for cases where resonance is most likely to occur. This arrangement will ensure the reduction of harmonic distortion and avoidance of series/parallel resonance that can lead to

- Overloading of capacitors
- Overloading of transformer and transmission equipment
- Interference with metering and control systems

- Resonance elevation i.e. amplification of harmonics
- Voltage distortion

5.3.1 Detuned filtering (PFC-DF)

Capacitors with detuned filtering technique shall be employed to correct power factor while avoiding the risk of resonance condition. This shall be performed by shifting the resonance frequency to lower values where no harmonic currents are present, by introducing a filter reactor in series with the capacitors, such that the capacitor/reactor combination is inductive at the dangerous frequencies but capacitive at fundamental frequency.

The reactors shall be selected taking into account the inductance value of the feeding line so as to get the desired tuning frequency and the current capability high enough for the harmonic current absorption that can be expected.

Filter reactors shall be designed to give an inductive voltage drop of about 5 to 10 %, thus protecting the capacitors from harmonics.

The following steps shall be performed to estimate the harmonic content of the system.

I. The presence of harmonic currents in the main feeder cable of the system without capacitors shall be measured at all possible load conditions. The frequency and maximum amplitude for every existing harmonic that could exist shall be measured to get the Total Harmonic Distortion of Current, THD-I.

II. The presence of harmonic voltages coming from outside the system shall be measured, if possible the HV side to get the Total Harmonic Distortion of Voltage, THD-V.

III. For harmonics present (THD-I>10% OR THD-V>3 %), the following procedure shall be adopted

- If there is 3rd harmonic content present, capacitors shall be used with Detuning Factor ‘p’ =14%. If there is no 3rd harmonic content capacitors shall be used with ‘p’=7% or 5.67%
- If THD-V is 3-7% capacitors shall be used with ‘p’=7 %
- If THD-V >7 % capacitors shall be used with ‘p’ =5.67%

5.4 Harmonic filtering

For elimination of harmonics from the system, real LC filters shall be installed. The bank shall be divided into several series filters, each tuned to the harmonic frequency that is supposed to be eliminated.
Industrial installations where a set of non linear loads (variable speed drives, UPS, rectifiers, etc.) representing more than 200kVA shall be equipped with passive filters. The LC circuit, tuned to each harmonic order shall be installed with the non linear load that will function to absorb the harmonics, thus avoiding their flow in the distribution network.
Commercial installations where the non linear load represents less than 200kVA, shall be connected with active filter circuits comprising power electronics and installed in series or parallel with the load.

6.0 POWER FACTOR CONTROLLER

All capacitor units shall be controlled by a PFC controller, responsible for monitoring the reactive and active components of the network through the current and the voltage path. The capacitor stages shall be switched in and out depending on the deviations of the actual power factor from the set value as calculated by the controller.
The controller shall be automatically programmed with a LCD display to indicate the harmonics, current, voltage, frequency, power factor, active and the reactive powers.

7.0 TYPES OF CAPACITORS FOR COMPENSATION

The capacitors provided shall be supplied in either the fixed or automatically switched configuration depending on their configuration i.e. PFC, detuned systems, UPS, wind turbines, transformers and harmonic filtering.

7.1 Fixed capacitors

The capacitors to be used at the terminals of inductive devices such as motors and transformers or where the level of load is reasonably constant, shall be fixed type to form a continuous level of compensation. Control shall be either manual or semi automatic.

7.2 Automatic capacitor banks

Where the active power or reactive power variations are relatively large or the kvar rating of the capacitors is more than 15 % of the supply transformer, automatic

capacitor banks shall be used to provide automatic control of compensation maintaining the power factor within close limits around a selected level.

8.0 PLACEMENT OF COMPENSATION CAPACITORS

8.1 Global compensation

When the load is stable and continuous global compensation shall be applied where the capacitor bank is connected to the busbars of the main LV distribution board for the installation.

8.2 Compensation by sector

Compensation by sector shall be employed for extensive installations where the load/time patterns differ from one part of the installation to another. The capacitor banks shall be connected to each local distribution board.

8.3 Individual compensation

When the power of the motor is significant with respect to the declared power requirement (KVA) of the installation, individual compensation shall be applied, thereby confining the reactive power to the smallest possible segment of the network. The kvar rating of the capacitor bank shall be in the order of 25 % of the kW rating of the motor.

9.0 SAFETY REQUIREMENTS

9.1 Power capacitors shall be installed in a cool and well ventilated location and not close to objects that dissipate heat, like filter circuit reactors and furnaces or in direct sunlight.

9.2 Enough space shall be left on top of the capacitor to allow for longitudinal expansion of the can and proper functioning of the overpressure disconnectors. A minimum spacing of 20mm is necessary between capacitors to ensure proper cooling.

9.3 If harmonics are present detuned capacitor banks shall be installed.

9.4 Discharge reactors or resistors shall be incorporated to protect against electric shock hazards. Functioning of these resistors/reactors shall be tested by powering the capacitor up and down. The voltage across the terminal must fall to <50 V within 60s.

9.5 Good and effective grounding for capacitor enclosures shall be provided.

9.6 Means shall be provided to isolate a faulty component/bank.

9.7 Capacitors shall not be stored in a corrosive environment especially where chloride gas, sulfide gas or similar substances are present.

10.0 INSPECTION AND TESTING

Tests shall be performed at the manufacturer's works in accordance with the relevant IEC standards.

The tests shall include:
Routine tests for capacitor bank :

- Inspection for conformity with specifications.
- Dielectric test: 2.5KV 1 minute.

During inspection, routine test shall be carried out only on some sample(2 or 3 capacitor banks).

Routine tests for capacitor :

- Voltage withstand test.
- Capacitance measurement.
- Loss angle measurement on similar capacitor.

Type tests :

Type testing shall be supplied for loose capacitors on similar capacitor. Type test certificate shall be issued by an independent test station of international repute.

11.0 CURRENT TRANSFORMERS

The current transformer shall comply with IEC 60044 and shall be of 5 A output, class 1.5 VA minimum.

12.0 GROUNDING

All units shall be star connected provided with a ground terminal with a 10 mm hole.

13.0 HANDLING

A shock control shall be placed on the package of the capacitor bank. If the bank falls, this control will be broken.
The equipment shall be provided with lifting rings, or provided with provision for using a forklift truck for handling.
For Installation, a 100 mm space shall be provided at the back of the bank in order to have an optimal position of the bank for good ventilation.

14.0 CERTIFICATION

The three phase capacitor shall be designed and manufactured in an ISO 9001 and ISO 14001 certified plants. Certificates shall be available on demand.

15.0 WARRANTY/DISCLAIMERS

15.1 The switched capacitor assembly shall be warranted by the manufacturer to be free from defects for a period of 18 months from factory shipment or a period of one year after the unit is energized, whichever occurs first.

15.2 The manufacturer shall not be held liable for improper operation of the switched capacitor assembly due to harmonic resonance conditions that may result from application of the capacitor assembly to a system that contains harmonic currents and/ or voltages.

16.0 TECHNICAL DATA SCHEDULE

REF. SEC	DESCRIPTION	SEC SPECIFICATION VALUE		VENDOR PROPOSED VALUE
1	**GENERAL**			
1.1	Nominal System Voltage	380 V	127 V	
2	**DESIGN AND CONSTRUCTION REQUIREMENTS**			
2.1	Frequency (HZ)	60		
2.2	Maximum Ambient Temperature	55 °C		
2.3	Minimum Ambient Temperature	-5 °C		
2.4	Switching Operation Counter	Required		
2.5	Current Transformer	Required		
3	**MARKING**			
3.1	Nameplate marking as per the specs.	Required		
4	**INSPECTION AND TESTING**			
4.1	Meet all sub clauses in specifications	Required		
4,2	Meet all tests required in specification	Required		