Saudi Electricity Company	الشركة السعودية للكهرباء

SEC DISTRIBUTION MATERIALS SPECIFICATION	43-SDMS-04 Rev. 00
	DATE: 12-11-2014G

43-SDMS-04

REV. 00

SPECIFICATIONS

FOR

SHUNT CAPACITOR BANK
13.8 kV THROUGH 69 kV
FOR
PRIMARY DISTRIBUTION SUBSTATIONS

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1.0 SCOPE

This SEC Distribution Material Specification (SDMS) specifies the minimum technical requirements for design, engineering, manufacture, inspection, testing and performance of outdoor shunt capacitor bank, 13.8kV through 69kV, three-phase, 60 Hz, intended to be used in the Primary Distribution Substations Systems of the Distribution Sector of Saudi Electricity Company.

2.0 CROSS REFERENCES

This Material Standard Specification shall always be read in conjunction with SEC General Specification No. 01-SDMS-01, titled "General Requirements for All Equipment/Materials", which shall be considered as an integral part of this SDMS.

This SDMS shall also be read in conjunction with SEC Purchase Order or Contract Schedules for project, as applicable.

3.0 APPLICABLE CODES AND STANDARDS

The latest revision/amendments of the following Codes and Standards shall be applicable for the equipment/material covered in this SDMS. In case of conflict, the vendor/manufacturer may propose equipment/material conforming to one group of Industry Codes and Standards quoted hereunder without jeopardizing the requirements of this SDMS.

3.1	IEC 60137	Insulated Bushings for Alternative Voltage above 1000V
3.2	IEC 60273	Characteristics of Indoor and Outdoor Post Insulators for Systems with Nominal Voltage greater than 1000V
3.3	IEC 60549	High-voltage Fuses for the External Protection of Shunt Power Capacitors
3.4	IEC 60867	Insulating Liquids-Specification for Unused Liquids Based on Synthetic Aromatic Hydrocarbons
3.5	IEC 60871-1	Shunt Capacitors for a.c. Power Systems having a Rated Voltage above 1000V- Part I : General
3.6	IEC TS 60871-2	Shunt Capacitors for a.c. Power Systems having a Rated Voltage above 1000V – Part 2 : Endurance Testing

3.7	IEC 60871-4	Shunt Capacitors for a.c. Power Systems having a Rated Voltage above 1000V- Part 4 : Internal fuses
3.8	IEEE 18	Standard for Shunt Power Capacitor
3.9	IEEE C57.19.00	General Requirements and Test Procedure for Outdoor Power Apparatus Bushings
3.10	NEMA C29.9	Wet Process Porcelain Insulators-Apparatus, Post Type
3.11	IEEE C37.99	Guide for the Protection of Shunt Capacitor Banks
3.12	IEEE 1036	Guide for Application of Shunt Power Capacitors
3.13	ASTM D-2296	Standard Specification for Continuity of Quality of Electrical Insulating Polybutene Oil for Capacitors

4.0 DESIGN AND CONSTRUCTION REQUIREMENTS

4.1 Design Criteria

Shunt capacitor bank is intended to be used for reactive power compensation and/or as voltage regulators at 13.8 kV through 69 kV and for power (harmonic) filtering circuits as specified in the data schedule.

4.1.1 Capacitor bank/individual capacitors shall be of manufacturer's standard design and shall meet, or exceed the requirements of this Specification in all respects.

4.1.2 Unless otherwise specified, Capacitors in the bank shall be connected in double star with ungrounded neutral for 13.8kV through 34.5kV and single star with grounded neutral above 34.5kV. Capacitor bank shall be suitable for switching with dedicated automatic switching equipment.

4.1.3 Capacitor bank shall consist of individual capacitors, internally/externally fused separately (as specified in the data schedule), racked and grouped to make a three phase complete system, as required. The equipment shall include a common support structure for stacking, base insulators and all necessary accessories to complete the capacitor bank installation.

4.1.4 Shunt Capacitor bank shall be designed per IEC 60871-1 or IEEE 18, but subject to requirements of this specification. Unless otherwise specified in the

data schedule, the number of parallel groups per phase in series and number of individual capacitor in each parallel group per phase shall be per IEEE 1036.

4.1.5 Shunt capacitor bank for reactive power compensation shall be connected in the existing electrical system as a single (isolated) bank or back-to-back as specified in the data schedule.

4.1.6 Ratings of the current limiting/damping/tuning air-core reactor (if any), connected in series in each phase of the capacitor bank, as stated in the data schedule shall be considered for designing the capacitor bank. Calculations shall be furnished to show that the magnitude and frequency of both in-rush and out-rush currents of the capacitor bank is limited within the withstand capability of the associated switching devices.

4.1.7 For shunt capacitor bank for power (harmonic) filtering circuits additional requirements as mentioned in Annex B of IEC 60871-1 shall be applicable. Unbalance conditions of the capacitor bank because of mismatching of capacitance value per phase shall also to be considered for power filtering application.

4.1.8 Capacitor bank shall be provided with fence and gate. Further necessary electro mechanical interlock shall be provided so that the gate can be opened only after complete discharge of the capacitor bank. Fence height and gate dimension and other requirements shall be per SOW/TS.

4.2 Ratings

4.2.1 Ratings of the capacitor bank shall be as specified in the data schedule.

4.2.2 The rated voltage of the capacitor bank shall be as specified in the data schedule. For calculating the maximum voltage rise at the capacitor terminals in power (harmonic) filtering circuits maximum reactor tolerance of 5% shall be used. The capacitance of the capacitor units or banks shall not differ from the rated capacitance by more than the tolerances specified in IEC 60871-1 measured at 30°C internal dielectric temperature.

4.2.3 The residual voltage on the capacitor units prior to energize shall not exceed 10% of the rated voltage. On energizing, the capacitor units shall be able to withstand a transient over voltage, the first peak of which shall not exceed $2\sqrt{2}$ times the applied rms voltage for a maximum duration of ½ cycle; and the associated peak transient over current shall not exceeding 100 times the rated current of the capacitor units.

4.2.4 Capacitors shall be capable of continuous operation at:

a. rms current of 1.30 times the current that occurs at rated sinusoidal voltage and rated frequency and at ambient temperature specified in 01-SDMS-01, excluding transients. Depending on actual capacitance value which can be maximum of 1.1 times rated capacitance of Capacitor ($1.1C_N$) the maximum current can reach 1.43 times rated current (I_N).

b. 110% of rated voltage, including harmonics but excluding transients.

4.2.5 In the capacitor bank where no series connection of the units is used, the BIL of the capacitor units shall be equal to the bank BIL. Capacitor units where series connection is made may have lower BIL, but the external BIL shall conform to the full insulation level (BIL) of the bank.

4.3 **Capacitor Bank Assembly**

4.3.1 The capacitor bank shall be of stack type design and each phase of the bank shall consist of capacitor units arranged in a vertical stack and mounted horizontally on a common elevated rack using base and spacing insulators. The capacitors shall be placed so that there is adequate dissipation by convection and radiation of the heat produced by the capacitor losses.

4.3.2 The arrangement of the capacitor bank shall be such that adequate access for replacement of fuses or capacitor units shall be provided. The common capacitor bank neutral bus shall be provided with adequate insulated supports.

4.3.3 The capacitor bank assembly shall include series-parallel combinations of standard voltage capacitors per IEEE 18 or equivalent IEC standard, connectors, provision for mounting of necessary current and potential transformers for capacitor bank protection and measurements, internal/external fuses for capacitor units, surge arrestors and all necessary accessories for complete installation of the capacitor bank.

4.3.4 Manufacturer shall supply data on expected lifetime of minimum 20 years for the capacitor bank(s) at rated service conditions.

4.3.5 The base, phase/fuse-bus and spacing insulators shall be made of electrical grade wet processed porcelain per relevant IEC or equivalent NEMA

standards, as listed under clause 3.0. Calculations shall be furnished to justify the mechanical characteristics of the insulators.

4.4 **Capacitor Unit**

4.4.1 Individual capacitor unit shall be made of all (poly-propylene) film and aluminum foil.

4.4.2 Capacitor unit shall consist of a stainless steel or corrosion resistant aluminum tank in which one or more capacitors are connected together in parallel or series as required to achieve the appropriate voltage capability and capacitance. Mounting bracket and provision for lifting shall be provided with the capacitor tank. In coastal areas capacitor tank shall be painted per 01-SDMS-01.

4.4.3 Capacitor leads shall be brought out and terminated at porcelain bushings, which shall be hermetically sealed with the tank cover.

4.4.4 Discharge resistor shall be connected across the capacitor leads and located inside the capacitor tank.

Unless otherise specified discharge resistor shall reduce the residual voltage of the capacitor unit to the limiting value of 50 volts or less in 5 minutes for capacitor bank complying with IEEE 18 or 75 volts or less in 10 minutes for capacitor banks complying with IEC stanard after the capacitor has been disconnected from the source of supply.

4.4.5 Capacitors shall be of a sealed construction to prevent breathing and the absorption of moisture.

4.4.6 Capacitor dielectric fluid shall be synthetic oil per ASTM D-2296 or IEC 60867 Sheet 1 Class-III and shall not contain Polychlorinated Biphenyl (PCB) substance. Synthetic oil per Sheet 4 of IEC 60867, or other type of synthetic oil having similar or superior electrical and chemical characteristics to IEC 60867 sheet 1 with minimum 5 years of proven field experience can also be offered for review and final acceptance by SEC.

4.4.7 Calculations for selection of the rating of the internal/external fuse of the capacitor and capacitor tank rupture curve showing safe and unsafe zones shall be furnished.

4.5 **Capacitor Bushing**

Bushings shall be electrical grade wet processed porcelain per IEEE C57.19.00 or IEC 60137 and withstand a washing pressure of 3500kPa without permitting water ingress in to the capacitor unit. Bushing color shall be brown or grey.

4.6 **Terminals**

4.6.1 Capacitor terminal connectors shall be tin plated, parallel groove clamp or threaded studs type, as specified in data schedule, and shall be suitable for connection of copper or aluminum conductors. Connectors shall be sized to accommodate conductor sizes as specified in data schedule.

4.6.2 The neutral terminal for capacitor bank and mid-point terminals in each phase (if required) with grounded single or double star connection shall be 4-hole NEMA pad type.

4.6.3 Bird-proof terminal caps shall be provided when specified in data schedule.

4.7 **Grounding**

4.7.1 Capacitors shall have grounding provision for effective electrical connection of the case to the mounting rack.

4.7.2 Grounding of the capacitor bank neutral(s) shall be in accordance with recommendations given in IEEE C37.99.

4.7.3 One(1) each grounding pad shall be provided on two diagonally opposite legs of the elevated rack. The grounding pad shall be sized to accommodate connectors suitable for bare stranded copper conductor of size up to 2x240mm^2.

4.8 **Capacitor Racks**

4.8.1 Capacitor racks shall be constructed in a way to hold a complete 3-phase capacitor assembly taking into consideration spacing and base insulators, series-parallel combinations of capacitors, and complete fusing of capacitor units. The minimum height of the elevated rack shall be 2440mm.

4.8.2 Racks shall be made of a corrosion resistant aluminum or structural steel (hot dip galvanized), welded or bolted together. Racks, if not galvanized shall be

painted. Welding shall be in accordance with SEC standards. Painting/galvanization shall be per 01-SDMS-01.

4.9 **Capacitor Protection**

4.9.1 Individual Capacitor Unit Protection

a. Each capacitor unit in the bank shall be protected by an internal/external fuse. The internal fuse shall be current limiting type and external fuse shall be either expulsion type or current limiting type and rated to meet the requirements derived from data given in data schedule.

b. The performance requirements of the fuse shall be per IEC 60871-4 or IEC 60549 or equivalent IEEE Standard.

4.9.2 Capacitor Bank Protection

Capacitor bank protections and its schemes etc. shall be per respective project scope of work.

4.10 **Nameplate**

4.10.1 Each capacitor unit shall bear a nameplate which shall be written in English containing the information listed in IEC 60871-1 or ANSI/IEEE 18, plus additional information as follows:

a. The words "_____kV Capacitor".
b. SEC Purchase Order Number or Contract/J.O. No.
c. Design Ambient Temperature
d. 43-SDMS-01, REV.01

4.10.2 Another nameplate, giving similar details of complete capacitor bank shall be provided and fixed on the top of the middle phase elevated rack of the capacitor bank and the same shall be readable from the ground. This nameplate shall be English and Arabic.

4.10.3 The nameplate material shall be stainless steel and fastened to the equipment.

5.0 TESTS

All test results shall be provided for review and approval by SEC.

5.1 Type (Design) Tests

All Type (Design) tests prescribed in the relevant IEC or equivalent IEEE standards, as listed under clause 3.0, shall be performed on the first unit of every new design, rating and size of capacitor to be supplied to SEC.

Certified test reports of Type (Design) tests performed on identical capacitor acceptable to SEC may be submitted for review and acceptance in lieu of the required Type (Design) tests.

For measurement of the tangent of the loss angle (tan δ) of the capacitor at elevated temperature Type Test, capacitor loss (tan δ) value shall be submitted by the manufacturer in the data schedule with applicable tolerance for SEC review.

5.2 Special (Endurance) Test

Endurance test (Overvoltage cycling and ageing test) per IEC TS 60871-2 shall be performed on the first unit of every new design, rating and size of capacitor to be supplied to SEC.

5.3 Routine (Production) Tests

All Routine (Production) tests prescribed in the relevant IEC or equivalent ANSI/IEEE standards, as listed under clause 3.0, shall be performed on each capacitor unit.

For measurement of the tangent of the loss angle (tan δ) of the capacitor routine test, loss values shall be submitted by the manufacturer in the data schedule for SEC review.

5.4 Tests for Insulators, Bushings and Fuses etc.

Tests for base and spacing insulators shall be per relevant IEC or NEMA/IEEE or equivalent standards, as listed under clause 3.0. Tests for capacitor bushings, internal/external fuses of the capacitor units etc. shall be per applicable standards, as listed under clause 3.0 and relevant Industry Standards.

6.0 TECHNICAL DATA SCHEDULE

(SHUNT CAPACITOR BANK)
(Page 1 of 8)

SEC Enquiry/Tender No. _____ Item No. _____

SEC Ref.	Description	Unit	SEC Specified Values	Vendor Proposed Values
3.0	**APPLICABLE CODES AND STANDARDS**			
	Applicable Industry Standards		*	
4.0	**DESIGN AND CONSTRUCTION REQUIREMENTS** **Mean altitude from sea level**			
4.1	**Design Criteria** Type of connection of Capacitor Bank (single star or double star with grounded neutral) Type of Capacitor bank Neutral grounding Type of application (Reactive power compensation or harmonic filtering) Type of bank switching (isolated or back to back Capacitors (internally or externally fused)			
4.2	**Ratings** Nominal system voltage (kVrms) Capacitor bank rated voltage (kVrms) 3- Phase reactive power rating at the rated voltage (MVAR) Bank insulation level, BIL (kV $_{peak}$)			

6.0 TECHNICAL DATA SCHEDULE

(SHUNT CAPACITOR BANK)
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SEC Enquiry No. /TENDER NO._____ Item No. _____

SEC Ref.	Description	Unit	SEC Specified Values	Vendor Pro-posed Values
Conti--nued 4.2	**Rated Power frequency withstand voltage**			
	Design ambient temperature of capacitor bank (◦C)			
	Temperature range of operation (◦C)			
	Harmonic filter			
	Tuned harmonic frequency (Hz)			
	Type of filter (band pass/ high pass)			
	Rated Continuous current (A_{rms})			
	System fault level (k A_{rms})			
	Capacitor tolerance (%)			
	Power network single line diagram provided?)			
4.3	**Capacitor bank assembly**			
	Model designation of Capacitor bank			
	Expected life time of the bank (years)			

6.0 TECHNICAL DATA SCHEDULE

(SHUNT CAPACITOR BANK)
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SEC Enquiry No. /Tender No._____ Item No. _____

SEC Ref.	Description	Unit	SEC Specified Values	Vendor Proposed Values
Continued 4.3	Maximum terminal voltage rating including harmonics (kV rms)			
	Maximum continuous current rating including harmonics (Arms)			
	No. of parallel capacitors per group			
	No. of Parallel groups in series per phase			
	Total no. of capacitors / phase			
	Air core series reactor (if any) inductance per phase.(mH)			
	Peak maximum inrush current (kV peak)			
	Peak maximum outrush current (kV peak)			
	Frequency of inrush current (Hz)			
	Frequency of outrush current (Hz)			
	Rate of change of inrush /outrush current (kA/ micro S			
	Capacitance per phase (micro F)			
	Base and spacing insulator (Furnish detail dimensions and mechanical rating)			
	Capacitor bank assembly drawings provided ?		Yes/no.	

6.0 TECHNICAL DATA SCHEDULE

(SHUNT CAPACITOR BANK)
(Page 4 of 8)

SEC Enquiry No. /Tender No. _____ Item No. _____

SEC Ref.	Description	Unit	SEC Specified Values	Vendor Proposed Values
4.4	**Capacitor unit**			
	Model designation of capacitor unit (capacitance micro F)			
	Capacitor unit rated voltage (kV rms)			
	Capacitor unit power ratings (kVAR)			
	Maximum continuous operating current (A rms)			
	BIL of capacitor unit (kV peak)			
	Rated power frequency withstand voltage (kV rms)			
	Tank material of Capacitor unit			
	Weather the tank is to be painted		Yes/No.	
	Internal discharge resistance (ohm)			
	Standard for capacitor dielectric fluid (furnish complete data of dielectric fluid)			
	Capacitor tank rupture curve provided ?			
	Temperature coefficient of capacitor (micro F / ◦C)			

6.0 TECHNICAL DATA SCHEDULE

(SHUNT CAPACITOR BANK)
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SEC Enquiry No. /Tender No._____ Item No. _____

SEC Ref.	Description	Unit	SEC Specified Values	Vendor Proposed Values
4.5	**Capacitor bushing**			
	No. of bushings per capacitor unit			
	Maximum voltage rating (kV rms)			
	Wet (10 sec.) Power frequency withstand voltage (kV rms)			
	Dry (1 min.) Power frequency withstand voltage (kV rms)			
	Basic Impulse withstand voltage BIL (kV rms)			
	Color of porcelain Creepage distance (mm)			
	Striking distance (mm)			
	Permissible safe contilever loading at external terminal (kG)			
	Facilities required for making capacitance measurement and Power Factor test?			
4.6	**Terminals**			
	Type(parallel groove clamp or threaded studs)			
	For conductor size (mm sq.)			

6.0 TECHNICAL DATA SCHEDULE

(SHUNT CAPACITOR BANK)
(Page 6 of 8)

SEC Enquiry No. _____ Item No. _____

SEC Ref.	Description	Unit	SEC Specified Values	Vendor Proposed Values
Continued)				
4.6	For conductor material (Al orCu) Bird proof terminal caps required? Type for neutral and mid point			
4.8	**Capacitor rack** Complete dimensional details and weight to be provided.			
4.9.1	Individual Capacitor unit protection Fuse Type & designation Fuse element ,fuse-bus & Fuse element supporting assembly material Maximum voltage rating including harmonics (kV rms) Maximum continuous current rating including harmonics (A rms) Current rating of the Fuse-bus/base (A rms) Cold resistance of the fuse-tank (Ω) & percentage tolerance of Resistance value			

6.0 TECHNICAL DATA SCHEDULE

(SHUNT CAPACITOR BANK)
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SEC Enquiry No. _____ Item No. _____

SEC Ref.	Description	Unit	SEC Specified Values	Vendor Proposed Values
Continued 4.9.1	External creepage distance along the fuse link for current limiting fuse (mm)		*	
	Interrupting asymmetrical current (A)		*	
	Discharge energy interrupting rating (Joule)			
	Time -current characteristics provided?		*	
	Capacitor bank protection data provided?		*	
	Other general information		*	
	Approximate shipping dimensions of capacitor bank/unit (mm)		*	
	Approximate shipping weight of capacitor bank unit (kG)		*	
	List parts that will be dismantled and shipped separately		*	
5.1	Capacitor Loss (tan δ) value at elevated temperature during measurement of the tangent of loss angle type test)		*	
5.3	Capacitor loss (tan δ) value during measurement of tangent of loss angle routine test		*	

6.0 TECHNICAL DATA SCHEDULE

(TERMINAL BLOCKS)

(Page 8 of 8)

SEC Enquiry No: _____ **Item No: _____**

A) Additional technical information or features specified by SEC.

B) Additional supplementary data or features proposed by Vendor/Supplier.

C) Other particulars to be filled up by Vendor/Supplier.
(Use separate sheet if needed).

Address	Manufacturer	Vendor/Supplier
Name of the Company		
Location & Office Address		
Authorized Name & Signature		
Date		
Official Seal / Stamp		