

 Eskom	Standard	Technology
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CAPACITOR UNITS**

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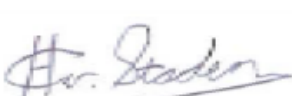


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1. Introduction

Capacitor units are used widely throughout Eskom in shunt and series capacitor banks and HVDC applications. The banks are usually found in substations with shunt, SVC or series capacitor installations on the EHV transmission lines.

This specification can be utilised for the purchasing of capacitor units for a new project or for units to be used as spares for a shunt or series capacitor bank, as mentioned above, for application throughout Eskom.

2. Supporting clauses

2.1 Scope

This specification covers Eskom's requirements for capacitor units, intended for application in shunt, filter and SVC capacitor banks in substations at a nominal A.C. and DC voltage range of 11 kV to 765 kV as well as series banks on 400kV and 765kV transmission lines. This specification will not cater for capacitors used in the Generation division.

A user guide is provided in Annex B to assist the purchaser and supplier with this specification.

2.1.1 Purpose

This specification aims to standardize on the size and ratings of capacitor units used throughout Eskom in its shunt and series capacitor banks. This will, in future, ease the process of buying new capacitor units for a project/refurbishment or ordering spares for failed units.

2.1.2 Applicability

This document shall apply throughout the Transmission and Distribution divisions of Eskom Holdings SOC Limited.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] ISO 9001 Quality Management Systems.
- [2] IEC 60071-1: Insulation co-ordination – Part 1: Definitions, principles and rules.
- [3] IEC 60076-1: Power transformers – Part 1: General.
- [4] IEC 60076-2: Power transformers – Part 2: Temperature rise.
- [5] IEC 60076-3: Power transformers – Part 3: Insulation levels and dielectric tests.
- [6] IEC 60529: Degrees of protection provided by enclosures (IP Code).
- [7] IEC 60871-1: Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V, Part 1: General performance, testing and rating - Safety requirements – Guide for installation and operation.
- [8] IEC 60871-2: Shunt capacitor for a.c. power systems having a rated voltage above 1000 V, Part 2: Endurance testing.
- [9] SANS 60815 or IEC 60815: Guide for the selection of insulators in respect of polluted conditions.
- [10] SANS 61109 or IEC 61109: Composite insulators for a.c. overhead lines with a nominal voltage greater than 1000 V – Definitions, test methods and acceptance criteria.
- [11] 32-333: Standard for electronic protection and fault monitoring equipment for power systems.

- [12] 34-1658: Corrosion protection specification for new indoor and outdoor distribution equipment manufactured from steel.
- [13] 34-224: KIPTS natural ageing and pollution performance test procedure for outdoor insulator products. Section 0 – General requirements.
- [14] IEC 610071: Capacitors for Power Electronics

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

The following definitions, as well as the definitions provided in IEC 60871-1, apply.

Definition	Description
capacitor bank	An assembly of parallel and series connected capacitor units.
capacitor unit (or can)	An assembly of parallel and series connected capacitor elements, each element consisting of dielectric and electrodes.
discharge device	A device connected across the terminals of a capacitor which reduces the capacitor voltage to below a specified level within a specified time after the capacitor has been disconnected from an electric source.
externally fused	each capacitor unit is fused external to the unit
Fused	The practice where either a capacitor unit or a capacitor element is equipped with a fuse protection device
internally fused	each capacitor element in a parallel group is fused internal to the unit

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
AC	Alternating Current
BIL	Basic insulation level
EHV	Extra High Voltage (above 132kV)
HV	High Voltage (Any voltage above 1000V)
IEC	International Electro-technical Commission
ISO	International Organization for Standardization
kV	kilo Volt
kVAr	kilo Volt Ampère reactive

2.5 Roles and responsibilities

It is the responsibility of the appointed HV Capacitor specialist to ensure that the requirements of this document are met by successful tenderers and the responsibility of tendering parties to implement as per the requirements.

2.6 Process for monitoring

Technical Evaluation, Factory Acceptance Testing and Site Acceptance Testing.

2.7 Related/supporting documents

Not applicable.

3. Requirements

3.1 General Requirements

3.1.1 Operating conditions

Table 1 shows the operating conditions applicable to capacitor units.

Table 1: - Operating Conditions

Condition	Parameter	Value
Altitude	Meters above sea level	Up to 1800m
Temperature	Min ambient	-25°C
	Max ambient	+55°C
	Max daily variation	35°C
Humidity	Min ambient	0%
	Max ambient	100%
	Average	30% - 90%
Solar radiation		1100 Watt/m ²
Pollution level	Very heavy (as per IEC 60815)	31 mm/kV
Lightning activity	Low, Medium, High	High
Nominal System Voltage		11 kV – 765 kV

3.1.2 Rating Plate

The capacitor units shall each have a rating plate of an intrinsically corrosion-resistant material, indelibly marked with the sea-level ratings at which the equipment has been type tested. The rating plate shall be individually marked with the following minimum information:

- Manufacturer's name;
- Capacitor unit type and relevant IEC standard number;
- Equipment product code and serial number;
- Date of manufacture;
- Rated Capacitance, Cn
- Rated continuous voltage, Un
- Rated Output, Qn

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- h) Fusing Type
- i) Insulation fluid/medium
- j) Internal arrangement of elements, Si/Pi
- k) Discharge device (resistor) fitted internally (Y/N) and size

Additional to the rating plate, the following information shall be included in a separate document to be supplied with the capacitor unit:

- Internal arrangement of capacitor elements
- Unit Dimensions
- Fuse ratings (externally fused units only)
 - a) Type of fuse (expulsion and/or current limiting)
 - b) Current rating
 - c) Fuse characteristic (i.e. T, K)

3.1.3 Packaging

All equipment shall be carefully packed to prevent damage or deterioration during normal transportation, handling and storage.

Each container shall bear the following information on the outside of the container:

- The address of the destination
- The gross mass, in kilograms
- The name of the manufacturer
- The purchaser's order number and port of destination

3.2 Capacitor Units

3.2.1 General

All capacitor units shall be manufactured in an ISO 9000 certified facility.

Capacitors shall be single-phase units.

Capacitors can be fuse-less, internally fused or externally fused.

Capacitors shall be provided with internally mounted discharge resistors having characteristics in accordance with clause 21 of IEC 60871-1. (Reduce the voltage across the unit to 50V or less within 5 minutes of de-energization)

The chemical properties of the insulating fluid used in capacitor units shall be such that contamination of the environment with regard to biodegradability, toxicity and bio-concentration will be minimal in the event of accidental spillage. Polychlorinated biphenyls (askarels, pcb) are not acceptable as an insulating medium.

3.2.2 Bushings

Single-phase capacitors shall have a two bushing construction, except for the case of single bushing, externally fused units.

Bushings shall be welded or soldered to the containers (tanks). The use of alternative attachment methods shall be subject to approval by the purchaser and shall be stated in the tender documentation.

The capacitor bushings shall be fitted with bolted conductor clamps. Each clamp shall be capable of accommodating two conductors with diameters ranging between 6 mm and 10 mm.

Bushing profile characteristics shall comply with the guidelines in annex D of SANS 60815 (or IEC 60815).

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The minimum bushing creepage distance from phase-to-earth (in mm) shall be as given in Table 1. Note that the required creepage distance is dependent on the type of insulation material. The capacitor bushings shall be fitted with bolted conductor clamps. Each clamp shall be capable of accommodating two conductors with diameters ranging between 6 mm and 10 mm.

Bushing profile characteristics shall comply with the guidelines in annex D of SANS 60815 (or IEC 60815).

The minimum bushing creepage distance from phase-to-earth shall be standardised as 31 mm/kV for inland and coastal applications. Preferred insulation materials include polymer, silicone-rubber or porcelain.

3.2.3 Capacitor Units Ratings

The rated voltage of the capacitor shall be 110% of the nominal system voltage.

Capacitors shall be capable of continuous operation at 1.3 times the current (I nominal) that occurs at rated sinusoidal voltage and rated frequency, excluding transients.

3.2.4 Mounting brackets

Two mounting brackets shall be provided, in accordance with figure 1 of annex A. Each bracket shall have a 12 mm, slotted hole. Metric sizes only.

In the case where existing 25 mm/kV units needs to be replaced, the exact position of the mounting bracket must be calculated and the drawing changed accordingly before it is handed to the manufacturer. This must be done in order to ensure that the increased bushing length of the new standard 31mm/kV bushing does not result in mechanical or electrical clearance problems when installing the new units in the existing bank.

This parameter has been added to the order sheet in Annex B. Mounting particulars must also be added to the technical schedules, as shown in Annex B.

3.2.5 Field Performance and Reference Listing

The capacitor units will have a field failure rate of not more than 0,05% of the installed base over a minimum of a 5 year period measured as an average field failure rate. The reference listing of similar or exact capacitor unit designs installed to be provided together with the field failure rates experienced.

3.2.6 Materials and Finishes

Capacitor units shall be manufactured from 3CR12 or stainless steel of grades 304 or 316.

All interior and exterior 3CR12 surfaces shall be treaded in accordance with coating specification DS6 as defined in 34-1658. Over coating of 304 and 316 stainless steel is not required, suitable precautions shall be implemented to prevent a shiny surface.

Suitable precautions shall be implemented to prevent corrosion due to the use of dissimilar materials.

3.2.7 Additional information

All documents and drawings shall be in English and shall be available in Adobe Acrobat 9.xx or later format.

The following drawings shall be submitted:

- a) outline drawing showing overall and interfacing dimensions;
- b) drawing of rating plate detail;
- c) drawing of bushing showing details of the bushing profile and the terminal connector
- d) schematic of internal layout.

The following documents shall be submitted:

- a) product catalogue of the complete product range with details on product ratings and product codes;
- b) explanation of product code numbering system and

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- c) handling and installation instructions.

3.2.8 Capacitor Unit Tests

Tests shall either be conducted on capacitors of a design identical to that of the offered capacitor, or on capacitors of similar design. Designs are considered to be similar if they do not differ in any way that might influence the properties that are checked by the particular type test. Supporting documentation must be submitted to prove that designs are similar. Type testing certificates and reports of similar designs that are most relevant to the manufacturing process and design and not older than 3 years will be considered.

3.2.8.1 Type Tests

The type tests shall be performed in accordance with IEC 60871 on one capacitor unit of each type and rating. The following type tests shall be performed in accordance with IEC 60871-1:

- a) thermal stability test;
- b) measurement of the tangent of the loss angle ($\tan \delta$) of the capacitor at elevated temperature;
- c) AC voltage test between terminals and container;
- d) lightning impulse test between terminals and container;
- e) short-circuit discharge test;
- f) over voltage endurance testing according to the IEC 60871-2 and
- g) pollution performance tests are presently under consideration. Preference will be given to products that have been subjected to some form of pollution performance test e.g. 34-224 or SANS 61109 (or IEC 61109) annex C.

3.2.8.2 Special Tests (Endurance testing)

The endurance testing shall be carried out after the contractual agreement between the *Contractor* and the Project Manager. The endurance testing shall be performed in accordance with IEC 60871-2 on one capacitor unit of each type and rating.

3.2.8.3 Routine Tests

A copy of a set of routine test certificates shall be submitted with the tender documentation.

A copy of routine test certificates shall be supplied with the equipment when delivered to the final destination stated in the order.

The following routine tests shall be performed, in accordance with IEC 60871-1 (A.C), and IEC 610071 (D.C) on each capacitor unit before dispatch:

- a) A.C. voltage test between terminals and container;
- b) 10s voltage test between terminals (the test voltage shall be either a.c. 2 U_n or d.c 4 U_n at 20 °C;
- c) Capacitance measurement before and after AC voltage test;
- d) Tan delta measurement before and after AC voltage test - the results obtained shall be referred to an ambient temperature of 20 °C;
- e) Test of internal discharge device; and
- f) Sealing test or leak test.

3.2.8.4 Site Tests

All capacitor units shall be subjected to the following tests on site:

- a) Capacitance measurement;

- b) Capacitance test on multi-unit rack assemblies.
- c) Visual inspection
- d) Insulation resistance
- e) Clamps contact resistance
- f) Tightness torque checks
- g) Vermin proof checks

The method of capacitance measurement shall be discussed with the *Employer*.

3.2.8.5 Test records

Test records in the form of validated copies of test reports issued by a recognized testing authority shall be submitted with the tender documentation. Test reports shall be in English.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Neels van Staden	PDE, Senior Consultant, Power Electronics
Vuyani Masuku	PDE, Senior Engineer, Power Electronics
Mogale Sekgobela	PDE, Engineer, Power Electronics
Bheki Ntshangase	PDE, HV Plant Manager

5. Revisions

Date	Rev	Compiler	Remarks
Aug 2020	2	Neels van Staden	Revision
May 2014	1	JS Bezuidenhout	New Specification.
June 2020	2	Neels van Staden	Addition of HVDC requirements Field failure rate and reference listing requirement added

6. Development team

The following people were involved in the development of this document:

- Vuyani Masuku
- Sakkie van Aarde
- Neels van Staden

7. Acknowledgements

Not applicable

Annex A – Drawings

WORKS ORDER	03ZB	CAPACITANCE	25.2 μ F	TEMP CAT	-25/+50
CUSTOMER	ESKOM-TR	RATED VOLTAGE	7277 V	A =	580
ORDER NUMBER	HECTOR SUBSTATION	RATED OUTPUT	420 kVAr	B =	394
ORDER DATE	08-Aug-95	UNIT WEIGHT	67 kG	C =	245
DELIVERY DATE	31-Mar-96	INSULATION	28 / 150 kV	D =	605
QUANTITY	288	PHASES	1	E =	194
SPARES	4	BUSHINGS	2	F =	484
STYLE NUMBER	SMB592V	INTERNAL CONN.	1 (1 PHASE)	G =	448
TOLERANCE	-5.0/+5.0 %	DISCHARGE RES.	2.1 MOHM	H =	850
IMPREGNANT	NON PCB	SERIES GROUPS	4	I =	440
DIELECTRIC	ALL FILM	PARALLEL GROUPS	3	J =	267
FUSES	NONE	SPECIFICATION	IEC 871-1	K =	- / -

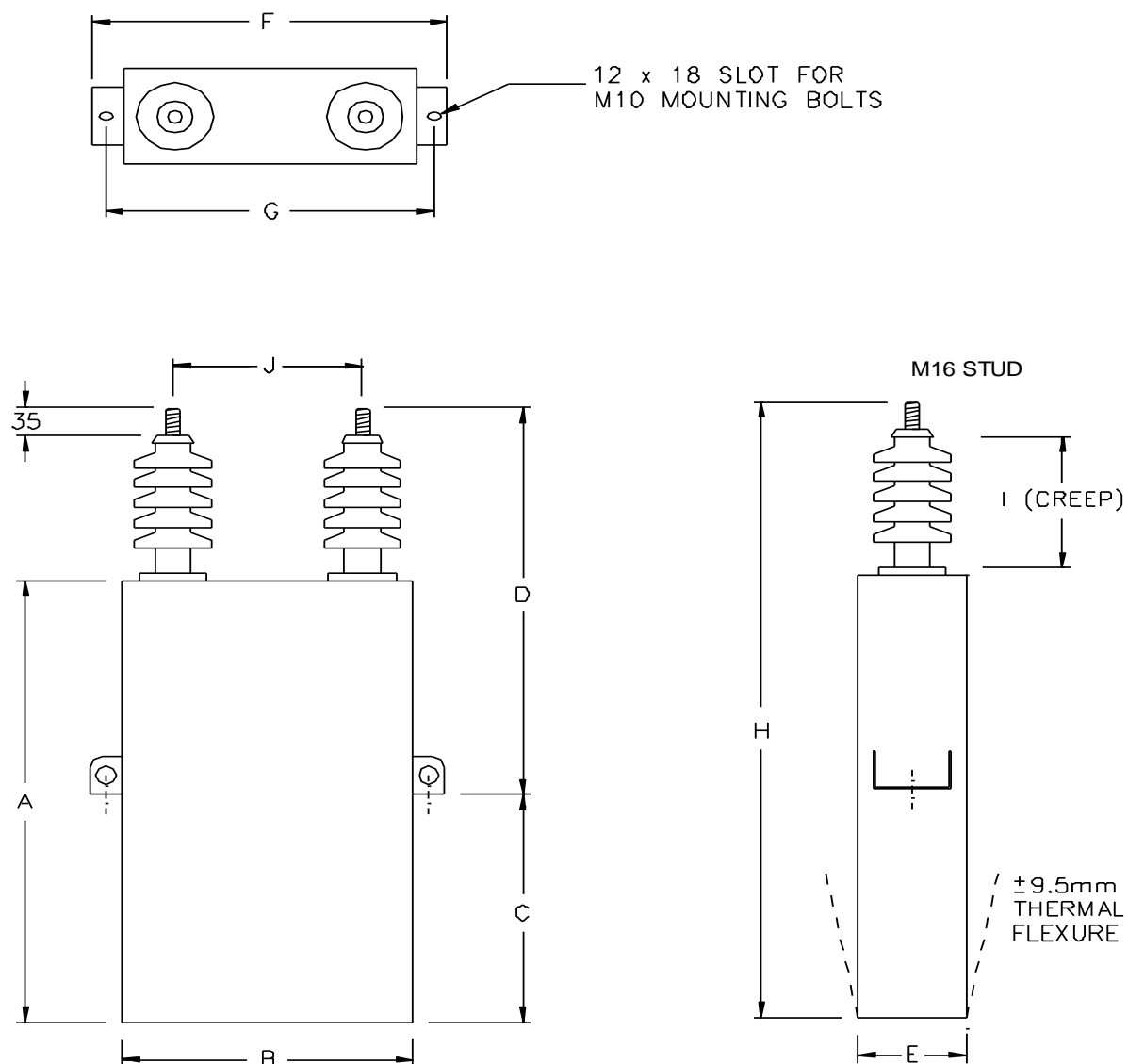


Figure A.1: Critical dimensions and parameters of a capacitor unit (Example details)

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Annex B – User Guide and Technical Schedules

The following is a user guide to assist the purchaser, as well as the supplier, in understanding and utilising this specification correctly.

The specification can therefore be utilised for the purchasing of capacitor units to be used for a new project or as spares (strategic stock) for an existing capacitor bank installation. The order sheets in table B1 should be completed by the purchaser and included in the enquiry document. The intention with the order sheet is to clearly indicate to the supplier which items are to be tendered on for a particular enquiry.

Ordering of capacitor units

The order sheet in table B1 should be utilised to order capacitor units. This is a short version of the technical schedules provided in this annexure. The schedules must be completed by the purchaser and supplier in order to ensure compliance with this specification.

The purchaser is required to indicate the fusing arrangement, the system voltage at which the unit will be installed as well as the required output (kVAR) of the unit. The purchaser must also indicate whether any mounting bracket modification will be needed in order for a 31mm/kV bushing to fit in a bank consisting of capacitor units with 25mm/kV bushings. This will only be applicable to the buying of spares. All new units ordered shall be 31mm/kV.

This specification caters for 70 standard (currently installed) capacitor unit sizes, see table 2. All units shall be single phase. Other installed units, not listed here, may be added to the specification via the relevant channels and processes.

The number of units that are required of a particular type and size can also be indicated on the order sheet. Separate order sheets must be completed if capacitor units of different types and sizes are required.

Table B.1: - Order sheet for capacitor units

Parameter	Value
Rated Voltage (Un)	
Rated output (kVAR @ Un)	
Mounting Bracket Modification Details	
Fusing type [select (✓) 1 of the 3 options]	Fuseless
	Externally Fused
	Internally Fused
Capacitance	
Internal Arrangement	
Tolerance	
Dimensions (WxLxH)	
BIL	
Number of units required	
Notes:	

Schedule A: Purchaser's specific requirements

Schedule B: Particulars of equipment to be supplied

Item	Sub clause of 240- 76429758	Description	Schedule A	Schedule B
1		Identification		
		a) Supplier	xxxxxxxxxx	_____
		b) Manufacturer	xxxxxxxxxx	_____
		c) Product code	xxxxxxxxxx	_____
2		System conditions of service		
		a) Nominal voltage (U_n) r.m.s. kV	_____	xxxxxxxxxx
		b) Maximum voltage (U_m) r.m.s. kV	_____	xxxxxxxxxx
		c) Earthing	_____	xxxxxxxxxx
		d) Frequency Hz	50	xxxxxxxxxx
3	3.2.1	General		
		a) Capacitor type	_____	_____
		b) Internal fuses	_____	_____
		c) Supplied with discharge resistor	Yes	_____
		d) Polychlorinated biphenyls	None	_____
4	3.2.2	Bushings		
		a) Number of bushings	_____	_____
		b) Attachment to can (soldered or welded)	xxxxxxxxxx	_____
		c) Terminals:		
		Bolted connectors supplied	Yes	_____
		Conductor range taking capability of (Diameter in mm)	6 – 10	_____
		b) Bushing profile comply with IEC 60815	Yes	_____
		c) Creepage distance mm	31mm/kV	_____
		d) Bushing material	xxxxxxxxxx	_____

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Schedule A: Purchaser's specific requirements

Schedule B: Particulars of equipment to be supplied

Item	Sub clause of 240- 76429758	Description	Schedule A	Schedule B
5	3.2.3	Rated requirements a) Rated voltage ($1.1 \times U_{n \text{ system}}$): 1-phase units V b) Rated continuous current ($1.3 \times I_{\text{nominal}}$) A c) BIL kV d) AC wet withstand (60 sec) kV e) Frequency Hz f) Effective output at $U_{n \text{ system}}$ kVA h) Capacitance (terminal-to-terminal) μF	 xxxxxxxxxx 50 	
6	3.2.4	Mounting a) Critical dimensions: W: max. width including thermal flexure mm h: distance between bracket and lid mm L: distance between mounting holes mm b) Provided with two mounting brackets with 12 mm slots	 Yes	
7	3.2.5	Material and finishes a) Capacitor tank material	xxxxxxxxxx	
8	3.2.7	Type Tests Provide report number for type test reports submitted with tender documentation a) Thermal stability test b) Tan δ measurement c) AC voltage test d) Lightning impulse test e) Short-circuit discharge test f) Endurance testing g) Pollution performance test i) Over voltage test	 xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx	

Deviation schedule

Any deviations from this specification shall be listed below with reasons for deviation. In addition, evidence shall be provided that the proposed deviation will at least be more cost-effective than that specified by Eskom.

Item	Clause	Proposed deviation

Annex C – Impact Assessment

(Normative)

Impact assessment form to be completed for all documents.

1) Guidelines

- All comments must be completed.
- Motivate why items are N/A (not applicable)
- Indicate actions to be taken, persons or organisations responsible for actions and deadline for action.
- Change control committees to discuss the impact assessment, and if necessary give feedback to the compiler of any omissions or errors.

2) Critical points

2.1 Importance of this document. E.g. is implementation required due to safety deficiencies, statutory requirements, technology changes, document revisions, improved service quality, improved service performance, optimised costs.

This document is a revision of DISSCABH6 and transferred into the new DT document format.

2.2 If the document to be released impacts on statutory or legal compliance - this need to be very clearly stated and so highlighted.

No impact on statutory requirements.

2.3 Impact on stock holding and depletion of existing stock prior to switch over.

This is a specification and as such has no impact on stockholding.

2.4 When will new stock be available?

See 2.3 above.

2.5 Has the interchangeability of the product or item been verified - i.e. when it fails is a straight swap possible with a competitor's product?

This is exactly the reason for this specification.

2.6 Identify and provide details of other critical (items required for the successful implementation of this document) points to be considered in the implementation of this document.

None.

2.7 Provide details of any comments made by the Regions regarding the implementation of this document.

None, this is an existing document transferred into the new DT format.

3) Implementation timeframe

3.1 Time period for implementation of requirements.

Immediately

3.2 Deadline for changeover to new item and personnel to be informed of DX wide change-over.

None

4) Buyers Guide and Power Office

4.1 Does the Buyers Guide or Buyers List need updating?

No, this is a specification, not an item or product.

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4.2 What Buyer's Guides or items have been created?

None

4.3 List all assembly drawing changes that have been revised in conjunction with this document.

None

4.4 If the implementation of this document requires assessment by CAP, provide details under 5

4.5 Which Power Office packages have been created, modified or removed?

None

5) CAP / LAP Pre-Qualification Process related impacts

5.1 Is an ad-hoc re-evaluation of all currently accepted suppliers required as a result of implementation of this document?

N/A

5.2 If NO, provide motivation for issuing this specification before Acceptance Cycle Expiry date.

N/A

5.3 Are ALL suppliers (currently accepted per LAP), aware of the nature of changes contained in this document?

N/A

5.4 Is implementation of the provisions of this document required during the current supplier qualification period?

N/A

5.5 If Yes to 5.4, what date has been set for all currently accepted suppliers to comply fully?

N/A

5.6 If Yes to 5.4, have all currently accepted suppliers been sent a prior formal notification informing them of Eskom's expectations, including the implementation date deadline?

N/A

5.7 Can the changes made, potentially impact upon the purchase price of the material/equipment?

No

5.8 Material group(s) affected by specification: (Refer to Pre-Qualification invitation schedule for list of material groups)

N/A

6) Training or communication

6.1 Is training required?

No

6.2 State the level of training required to implement this document. (E.g. awareness training, practical / on job, module, etc.)

N/A

6.3 State designations of personnel that will require training.

None

6.4 Is the training material available? Identify person responsible for the development of training material.

N/A

6.5 If applicable, provide details of training that will take place. (E.G. sponsor, costs, trainer, schedule of training, course material availability, training in erection / use of new equipment, maintenance training, etc).

N/A

6.6 Was Technical Training Section consulted w.r.t module development process?

N/A

6.7 State communications channels to be used to inform target audience.

Change Control

7) Special tools, equipment, software

7.1 What special tools, equipment, software, etc will need to be purchased by the Region to effectively implement?

N/A

7.2 Are there stock numbers available for the new equipment?

No

7.3 What will be the costs of these special tools, equipment, software?

None

8) Finances

8.1 What total costs would the Regions be required to incur in implementing this document? Identify all cost activities associated with implementation, e.g. labour, training, tooling, stock, obsolescence

Comment:

None, other than the Change Control process.

.....
.....

Impact assessment completed by:

Name:

Designation: