0 Eskom	Standard	Technology

Title: **POLE OR GROUND - MOUNTED, SINGLE-PHASE, STEP, AUTOMATIC VOLTAGE REGULATORS STANDARD FOR NOMINAL A.C. VOLTAGES OF 11 KV, 22 KV AND 33 KV**

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Content

Figures

Tables

Executive summary

This standard consists of the following two parts under the general title: Standard for Pole or Ground - Mounted, single-phase, step, automatic, voltage regulators:

- 240-75660124: Part 1 – General and Control requirements
- 240-75660124: Part 2 – Tele-control requirement
- 240-64038621: Remote device communication standard for data retrieval and remote access.

The combined requirements of both parts constitute Eskom's requirements for pole and ground - mounted Automatic Voltage Regulators.

1. Introduction

This document consists of Pole or Ground - Mounted, Single-Phase, Step, Automatic Voltage Regulators Standard

2. Supporting Clauses

2.1 Scope

This standard covers Distribution Group's requirements for outdoor, Pole or Ground - Mounted, single-phase, step type, voltage regulators that have programmable automatic control features and integrated remote operation capability. The regulator is intended for application on rural distribution lines. The standard makes provisions for the following nine voltage regulators:

Item	Description
Normal System Voltage 11 kV	
AVR 1 (Cstl)	VOLT REGULATOR 1 PH 11kV 100A COASTAL
AVR 1 (Inld)	VOLT REGULATOR 1 PH 11kV 100A INLAND
AVR 2 (Cstl)	VOLT REGULATOR 1PH 11kV 200A COASTAL
AVR 2 (Inld)	VOLT REGULATOR 1PH 11kV 200A INLAND
AVR 3 (Cstl)	VOLT REGULATOR 1PH 11kV 300A COASTAL
AVR 3 (Inld)	VOLT REGULATOR 1PH 11kV 300A INLAND
AVR 4 (Cstl)	VOLT REGULATOR 1PH 11kV 400A COASTAL
AVR 4 (Inld)	VOLT REGULATOR 1PH 11kV 400A INLAND
Normal System Voltage 22 kV	
AVR 5 (Cstl)	VOLT REGULATOR 1PH 22kV 100A COASTAL
AVR 5 (Inld)	VOLT REGULATOR 1PH 22kV 100A INLAND
AVR 6 (Cstl)	VOLT REGULATOR 1PH 22kV 200A COASTAL
AVR 6 (Inld)	VOLT REGULATOR 1PH 22kV 200A INLAND
AVR 7 (Cstl)	VOLT REGULATOR 1PH 22kV 300A COASTAL
AVR 7 (Inld)	VOLT REGULATOR 1PH 22kV 300A INLAND
AVR 8 (Cstl)	VOLT REGULATOR 1PH 22kV 400A COASTAL
AVR 8 (Inld)	VOLT REGULATOR 1PH 22kV 400A INLAND
Normal System Voltage 33 kV	
AVR 9 (Cstl)	VOLT REGULATOR 1PH 33kV 200A COASTAL
AVR 9 (Inld)	VOLT REGULATOR 1PH 33kV 200A INLAND

2.1.1 Purpose

Not applicable.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

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] 240-75661213 (34-217), KIPTS Natural ageing and pollution performance test standard for outdoor insulator products. Section 6 – Particular requirements for other insulator products.

[2] 240-170000774, Interim Insulation pollution standards required in place of KIPTS.

[3] SANS 121, 2011 Hot-dip galvanized coatings on fabricated iron and steel articles –Standards and test methods.

[4] 240-64038621. Remote Device Communication for Data Retrieval and Remote Access.

[5] 240-64685228 (DSP 34-2093). Generic standard for protective IED's and tripping relay's.

[6] 240-56364444. Standard minimum requirements for the metering of electrical energy and demand.

[7] 240-85224724: The control of new products and version changes in the technical software, firmware and hardware used in the protection field.

[8] 240-64038621. Remote Device Communication for Data Retrieval and Remote Access.

[9] 240-95836334 (ESP 32-406): Mineral insulating oils (uninhibited and inhibited) Part 1: Purchase, management,

[10] SANS 1091: National colour standards for paint.

[11] ANSI/IEEE C57.15: IEEE Standard Requirements, Terminology, and Test Code for Step-Voltage and Induction-Voltage Regulators

[12] ANSI/IEEE C57.12.20, Section 8: Design test for fault current capability of overhead distribution transformer enclosures

[13] IEC 60076-5: Power transformers – Part 5: Ability to withstand short circuit.

[14] IEC 60085: Thermal evaluation and classification of electrical insulation.

[15] IEC 60529: Degrees of protection provided by enclosures (IP Code)

[16] IEC 60815: Guide for the selection of insulators in respect of polluted conditions.

[17] IEC 61109: Composite insulators for a.c. overhead lines with a nominal voltage greater than 1000 V – Definitions

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
Automatic voltage regulator (AVR)	A mechanical switching device to provide continuous regulating capability by either increasing or decreasing the downstream system voltage at a pre-set voltage and time.
Line drop compensation	To regulate the system voltage at a point remote to the regulating transformer by considering the voltage drop across the line.

Definition	Description
Neutral tap position indication light	A light on the tank or in the controller or both, which is preferred, that is synchronised to the neutral position of the tap-changer.
Operation counter	A switching device to provide continuous counts of every tap operation made by the tap changer.
Reverse control	The operation of the AVR is independent of the side to which the primary source is connected, and it should sense and control the downstream system voltage, regardless of the power flow direction.
Set point voltage	The voltage level to which the regulating control will regulate on the secondary base voltage of the regulator
Tap position indication	An indication in the controller and on the tank of the regulator that is synchronized to the position of the tap-changer.
Time delay	The mean time that the system voltage must remain outside the dead band limit before a tap-change sequence is initiated.
Voltage limiter	A limiter that sets the high and low limits of the output voltage of the regulator in the control unit.

2.3.2 Classification

Controlled Disclosure: Controlled Disclosure to External Parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
AVR	Automatic voltage regulator
FIFO	**F**irst **I**n and **F**irst **O**ut
KIPTS	Koeberg Insulation Pollution Test Station
L	Load
ONAN	Oil natural and air natural cooling
QR	Quick Response
S	Source
SL	Source/Load

2.5 Roles and Responsibilities

Not applicable.

2.6 Process for monitoring

Not applicable.

2.7 Related/Supporting Documents

[1] 240-74148063: Standard for large power transformers up to 132 kV, in the rating range of 1,25 MVA to 160 MVA.

[2] 240-56364444 (DST 34-1024). Standard minimum requirements for the metering of electrical energy and demand.

[3] 240-85224724 (DST 34-465). The control of new products and version changes in the technical software, firmware and hardware used in the protection field.

[4] 240-85224724 (DST_34-462): Standard for distribution protection schemes common requirements.

[5] 240-64038621. Remote Device Communication for Data Retrieval and Remote Access.

3. Pole or Ground - Mounted, Single-Phase, Step, Automatic Voltage Regulators

3.1 Requirements

3.1.1 System and service conditions

3.1.1.1 System conditions

The AVR shall be suitable for use on the following system conditions:

a)	nominal system voltage (Un) (r.m.s.)	-	11 kV, 22 kV or 33 kV;
b)	maximum system voltage (Um) (r.m.s.)	-	12 kV, 24 kV or 36 kV;
c)	system frequency (f)	-	50 Hz;
d)	number of phases	-	1 or 3;
e)	earthing	-	non-effectively and effectively;

3.1.1.2 Service conditions

The AVR shall be suitable for use in the following service conditions and test results must be submitted to verify it:

a)	altitude		-	up to 1800 m
b)	temperature	min ambient	-	-25 °C
		max ambient	-	+55 °C
		max daily variation	-	35 °C
c)	humidity	min ambient	-	0%
		max ambient	-	100%
d)	solar radiation		-	1100 Watt/m2
e)	pollution level		-	very heavy (as defined in IEC 60815)
f)	lightning activity		-	high
g)	cooling requirements		-	ONAN;

3.1.2 General requirements

3.1.2.1 The design of the Automatic Voltage Regulators (AVRs) shall facilitate the following:

3.1.2.2 One regulator can shall be able to regulate a single-phase system (see Figure A.4);

3.1.2.3 Two regulator cans, connected in an open delta configuration, shall be capable of regulating a three-wire three-phase system (see Figure A.5); and

3.1.2.4 Three regulator cans, connected in a closed delta configuration, shall be capable of regulating a three-wire three-phase close delta system (see Figure A.6).

3.1.2.5 The AVR shall be completely self-contained and provide 10% regulation in thirty-two (32) steps (16 boost and 16 buck) of approximately 0,6258 % per step.

3.1.2.6 The tap-changing mechanism shall be motor-driven, quick-break type, and shall be completely oil-immersed.

3.1.2.7 A pressure relief device shall be provided to release excess pressure resulting from temperature variations. Details of the device, including the operating pressure, shall be provided in the tender documentation.

3.1.2.8 The AVR shall be capable of safely withstanding the effects of excessive pressure rise due to an internal fault. Details of how this is achieved shall be provided in the tender documentation.

3.1.2.9 The regulator shall comply with the following temperature rise limits at continuous rated power and the specified service conditions:

- Top oil temperature rise limit – 60 K
- Average winding temperature rise limit – 65 K

3.1.2.10 Solid insulating materials shall be of the appropriate type and temperature class. Their properties and temperature classes shall comply with those recommended in IEC 60085.

3.1.2.11 The insulating oil shall be a mineral oil that complies in all respects with the requirements of ESP 32-406. Oil shall contain no detectable polychlorinated biphenyls (PCBs).

3.1.2.12 A detailed spec sheet for the insulating oil shall be submitted with the tender.

3.1.2.13 The method of cooling shall be oil natural air natural (ONAN).

3.1.3 Ratings

Table 1: Rated values for AVRs @ 11 kV

Clause	Rating	AVR1	AVR2	AVR3	AVR4
	Nominal voltage, phase-to-phase (rms)	12 kV			
	AC 60 sec. wet withstand	28 kV			
	Basic insulation level (BIL)	95 kV			
	Load current (r.m.s.)	100 A	200 A	300 A	400 A
	Short-circuit rating (6 shots at 25 times Ir for 15 cycles)	2.5 kA	5 kA	5 kA	5 kA
	Frequency	50 Hz			

Table 2: Rated values for AVRs @ 22 kV

Clause	Rating	AVR5	AVR6	AVR7	AVR8
	Nominal voltage, phase-to-phase (rms)	24 kV			
	AC 60 sec. wet withstand	50 kV			
	Basic insulation level (BIL)	150 kV			
	Load current (r.m.s.)	100 A	200 A	300 A	400 A
	Short-circuit rating (6 shots at 25 times I_r for 15 cycles)	2.5 kA	5 kA	5 kA	5 kA
	Frequency	50 Hz			

Table 3: Rated values for AVRs @ 33 kV

Clause	Rating	AVR9
	Nominal voltage, phase-to-phase (rms)	36 kV
	AC 60 sec. wet withstand	70 kV
	Basic insulation level (BIL)	200 kV
	Load current (r.m.s.)	200 A
	Short-circuit rating (6 shots at 25 times Ir for 15 cycles)	5 kA
	Frequency	50 Hz

3.1.4 Mounting

3.1.4.1 The AVR shall be suitable for platform or ground mounting. The critical mounting hole dimensions are illustrated in **Figure A.2** of Annex B.

3.1.4.2 Mounting brackets, for station class surge arresters, shall be provided. Three brackets are required on the AVR, adjacent to the S, L and SL bushings. The arrester brackets shall be designed in accordance with **Figure A.3** of Annex B. The arrester brackets shall be manufactured from either stainless steel or hot-dipped galvanised steel. A good electrical connection between the arrester bracket and the AVR tank shall be provided. A drawing of the mounting bracket, indicating the dimensions, shall be provided.

3.1.4.3 A detailed drawing of the AVR mounting arrangement with surge arresters fitted shall be provided using the surge arrester dimensions given in figure A**.3** of Annex B. The minimum phase-to-earth clearances shall be indicated on the drawing.

3.1.4.4 The orientation of the bushings, radiators, control, position indicator, mounting brackets and mounting holes shall be in accordance with figure A**.1** of Annex B.

3.1.4.5 Adequately rated lifting eyes shall be provided on the lid and on the regulator tank. The inside diameter of the eyes shall be a minimum of 30 mm. Warning signs shall be provided at the lifting eyes on the lid to indicate that they are intended for lifting of the active part only and not the entire unit. The lifting eyes on the lid shall be blocked off to reduce the risk of incorrect rigging. Details of how the eyes are blocked off (e.g. plastic cup, or nut and bolt, etc.) shall be provided.

3.1.4.6 The AVR shall be fitted with an external stainless-steel earthing boss. The boss shall be a minimum of 30 mm long, with an M12 thread throughout. The boss shall be fitted with a M12 × 25 mm setscrew, washer, and spring washer. The boss and the setscrew shall be stainless steel of grades 304 or 316. Alternative methods may be accepted, subject to the written approval of the purchaser.

3.1.4.7 The AVR shall have stamped markings on the lid of the regulator for each bushing (i.e. S, L & SL). The same markings shall be reflected in the firmware, software and all documentation.

3.1.4.8 The total mass of the AVR shall not exceed 2 500 kg for pole-mounting only.

3.1.5 Bushings

3.1.5.1 The preferred bushing terminals are smooth, hot-dip tinned, copper cylindrical stems provided with bimetallic clamps that are suitable for accepting aluminium or copper conductors of 6 mm to 15 mm diameter. Alternative terminal systems may be accepted, subject to the written approval of the purchaser.

3.1.5.2 The minimum creepage requirements between phase-to-earth (in per unit of Um) shall be as given in **Figure A.4**. Note that the required creepage is dependent on the type of insulation material.

Table 4: Minimum creepage requirements for Inland and Coastal applications

	Inland application			Coastal application		
IEC 60815 pollution level	Medium			Very heavy		
System voltage	11 kV	22 kV	33 kV	11 kV	22 kV	33 kV
Creepage distance (Insulation material)	240 mm	480 mm	720 mm	372 mm	744 mm	1116 mm
	(Porcelain or Silicone Rubber)					
	300 mm	600 mm	900 mm	(Porcelain or Silicone Rubber)		
	(Cyclo-aliphatic, EPDM or ESP)					

3.1.5.3 Bushing profile characteristics shall comply with the guidelines in Annex D of IEC 60815.

3.1.5.4 Detailed drawings of the bushings and bushing terminals shall be provided.

3.1.6 Material and finishes

3.1.6.1 All support structures and all bolts and nuts associated with these parts, shall be hot-dip galvanized in accordance with SANS 121: 2011.

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

3.1.6.3 The regulator cans and control cabinets intended for coastal applications shall be manufactured from stainless steel of grades 304 or 316. Regulators intended for inland applications shall comply with the coating requirements in accordance with SANS 121: 2011. as a minimum.

3.1.6.4 The colour of the finishing coat for the regulator cans and the control cabinets, intended for inland and coastal applications, shall match colour G35 "Navy light grey" of SANS 1091.

3.1.6.5 In order to easily distinguish between regulators intended for inland and coastal applications, the words “INLAND” or “COASTAL” shall be stencilled on the side of the tank. The markings shall be black and in characters larger than 50 mm. The markings shall be positioned in such a way that it is clearly visible from the ground level, when the base of the regulator is mounted at 3 m above ground level.

3.1.7 Series surge arrester

3.1.7.1 The voltage regulator shall be supplied with a series surge arrester to protect the series winding.

3.1.7.2 The arrester shall be mounted between the terminals of the source bushing and the load bushing. Internal series arresters are acceptable, provided that an unambiguous label is attached to the lid of the regulator (between the S and L bushings).

3.1.7.3 The surge arrester shall be polymer housed and shall be supplied without an explosive disconnecting device.

3.1.7.4 The surge arrester shall comply with the following parameters:

3.1.7.4.1 11kV application:

MCOV:	≥ 2.5 kV
Residual voltage: Ures:	≤ 10.5 kV
Rated discharge current:	10 kA
IEC line discharge:	Class 1
Creepage:	31mm/kV (except if under oil)

3.1.7.4.2 22kV application:

MCOV:	≥ 5 kV
Residual voltage: U_{res}:	≤ 20 kV
Rated discharge current:	10 kA
IEC line discharge:	Class 1
Creepage:	31mm/kV (except if under oil)

3.1.7.4.1 33kV application:

MCOV:	≥ 5 kV
Residual voltage: U_{res}:	≤ 20 kV
Rated discharge current:	10 kA
IEC line discharge:	Class 1
Creepage:	31mm/kV (except if under oil)

3.1.8 Control cabinet

3.1.8.1 Cabinets that house equipment for control purposes shall be mounted independently of the AVR.

3.1.8.2 Suitable ultraviolet-resistant cable, 10 m long, shall be provided for connecting the AVR to the control cabinet. If longer cables are required, the length will be specified in the tender documentation. The maximum achievable separation between the control unit and the AVR shall be stated in the tender documentation.

3.1.8.3 It shall be possible to disconnect the cable at the AVR while the AVR is connected to the energised power system, without causing damage or mal-operation. Care shall be taken to ensure that the current transformers are not open-circuited. A robust, multi-pin, weatherproof connector shall be fitted.

3.1.8.4 Alternatively, the main control unit (e.g. relay) must be removable from the control cabinet. The interface between the control unit and the control cabinet must however be a multi-pin connector.

3.1.8.5 Cabinets shall be adequately sealed, and dust protected and shall be internally treated to prevent moisture condensation. The degree of protection shall be IP 54 or better in accordance with IEC 60529.

3.1.8.6 The supplier shall ensure that the equipment housed in the control cabinet can withstand the heating effect of direct solar radiation without causing failure and/or mal-operation. Details shall be provided in the tender documentation.

3.1.8.7 The cabinet shall make provision for bottom entry of three cables through a pre-punched and hot-dip galvanized gland plate with three 21 mm diameter holes. The holes shall be suitably blanked off with blanking plugs. To ensure that the blanking plugs are not lost during transport, means shall be provided to secure the plugs to the inside of the cabinet.

3.1.8.8 A suitable arrangement shall be provided for the earthing of the gland plate. The supplier shall ensure that both the cabinet and its door are provided with suitable earth studs and shall ensure that good electrical contact is made between the earth, the cabinet and door.

3.1.8.9 The cabinet shall be provided with an external M12 earthing stud with a nut and a serrated washer.

3.1.8.10 The door of the cabinet shall be fitted with a robust fastening arrangement that is capable of being secured by a padlock that has a shackle of 8 mm diameter. Pewter or other brittle metal type handles will not be acceptable.

3.1.8.11 The cabinet shall be easily removable for workshop repair purposes.

3.1.8.12 All terminations shall be made with the tool recommended by the manufacturer of the lugs. Crimping tools shall be of the type which will not release the termination during normal operation until the crimp has been correctly formed. A double die crimping tool shall be used to effect both the lug and insulation support crimp simultaneously.

3.1.8.12.1 Sample crimped ends, selected at random, may be subjected to tests in situ, to prove their mechanical strength. Such tests will consist of an axial pull, equivalent to approximately 60 % of the nominal breaking load of the conductor only, applied by means of a spring balance or similar device. For this standard, the force to be applied when testing crimped terminations on 1,5 mm² and 2,5 mm² cables shall be approximately 270 N. For 0,75 mm² the force shall be approximately 150 N.

3.1.9 Electronic control equipment

3.1.9.1 The controls shall not suffer any damage if one or more phases of the system are open upstream or downstream.

3.1.9.2 Electronic modules shall perform continuous diagnostic monitoring and shall contain hardware and software watchdog checking.

3.1.9.3 Electronic modules shall be suitably protected against voltage surges. Details of the onboard surge protection shall be provided in the tender documentation.

3.1.9.4 The upper limit of the date window shall extend until at least 2050.

3.1.10 Control features

The following features shall be provided:

3.1.10.1 Power control switch

3.1.10.2 The power switch shall have three positions, labelled “INTERNAL”, “OFF” and “EXTERNAL”. The switch shall enable the selection of either the internal supply or an external supply to power the control and tap-changer motor.

3.1.10.3 Reverse power option

3.1.10.4 Functionality shall be provided to ensure fully automatic reverse operation when the source and load voltages are swapped.

3.1.10.5 External power terminals

3.1.10.6 Terminals shall be provided for connection of an external power source to the control and tap-changer motor.

3.1.10.7 Motor control switch

3.1.10.8 The switch shall have three positions labelled “OFF” “MANUAL” and “AUTOMATIC”.

3.1.10.8.1 OFF: The voltage to the tap-changer motor shall be removed when the switch is in the OFF position. Tapping the regulator shall be completely disabled.

3.1.10.8.2 MANUAL: The regulator can be tapped manually with the RAISE/LOWER switch when the motor switch is in the MANUAL position. Automatic tapping by the control relay shall be disabled.

3.1.10.8.3 AUTOMATIC: The regulator's tap-changer is controlled by the control relay when the switch is in the AUTOMATIC position. Only automatic tapping shall be possible, tapping the regulator manually with the RAISE/LOWER switch shall be disabled.

3.1.10.9 Raise / lower control switch

3.1.10.10 The switch shall allow the operator to manually raise or lower the tap-change motor. The switch shall be a three position, two pole switch with a spring-return-to-neutral mechanism. The top and bottom positions of the switch shall be labelled "RAISE" and "LOWER" respectively.

3.1.10.11 Neutral indicator

3.1.10.12 The indicator shall provide the primary indication that the tap-changer is in the neutral position.

3.1.10.13 Voltmeter terminals

3.1.10.14 Terminals shall be provided for the connection of an external voltmeter to measure the regulator output voltage.

3.1.10.15 Fuses

3.1.10.16 Separate fuses shall be provided to protect the tap-change motor and the control panel.

3.1.11 Measurement functions

3.1.11.1 The measurement functions that are provided with the standard AVR shall be clearly defined in the tender documentation.

3.1.11.2 Single phase measurement shall be performed independently for each regulator

3.1.11.3 Quantities to be measured/calculated with specified accuracy's are:

3.1.11.3.1 the r.m.s. phase-to-phase voltages shall be calculated on the load and source side of the automatic voltage regulator rated voltage: ± 2%;

3.1.11.3.2 the r.m.s current per phase, range 0 to 1,1 × Ifull load: ± 2 %;

3.1.11.3.3 single-phase active power in kW: ± 3 %;

3.1.11.3.4 single-phase reactive power in kVAR: ± 3 %;

3.1.11.3.5 total single-phase active energy in kWh: ± 3 %;

3.1.11.3.6 power factor: ± 3 %;

3.1.11.3.7 peak current: ± 2 %;

3.1.11.3.8 peak voltage: ± 2 %;

3.1.11.3.9 maximum demand of items in clauses 4.8.3.3 to 4.8.3.5: ± 3 %.

3.1.11.4 The real power energy and maximum demand measurement shall be integrated with respect to time. Energy values shall be calculated with selectable time integration periods of 15 min, 30 min or 60 min. The integration period shall either start on the hour or the starting time shall be user selectable. The data buffer shall work on the FIFO principle and a minimum size for the data buffer shall store values for 4 months on the 30 min integration period.

3.1.12 Local control and indication

3.1.12.1 Local controls and indications shall be in accordance with table 5

3.1.12.2 All local controls and indications shall be accessible in adverse weather conditions.

3.1.12.3 The AVR tap position indicators shall be clearly visible from ground level. Alternative indication methods shall be subject to approval by the purchaser.

3.1.12.4 Switches used for local control shall be of type described in (i.e. secure or toggled control). Electronic keypad controls shall offer 'quick key' (maximum of one keystroke) access to the controls in **Figure A.5,** if not implemented with switches. Details of available quick keys shall be provided in the enquiry documentation.

Table 5: Minimum requirements for local controls and indications

1	2	3
Item	Features	Remarks
Controls		
Power switch	AVR control power switch ON/OFF	Secure control
Control switch	Auto/remote switch	Secure control
Manual (Raise/Lower)	Manual raise or lower AVR	3.1.10.9
Reverse power	Reverse power selection	Via keypad
Indications		
Neutral light	Tap-changer neutral position indication	Light
Controller not healthy	Controller not healthy	See note 2
Measurements	R.m.s. voltage on source and load side.	Updated continuously
	R.m.s current per phase	
	Power factor	
	Single-phase active power in kW	
	Single-phase reactive power in kvars	
	Total single-phase active energy in kWh	
	Peak voltage	Read-out resetable
	Peak current	
	Maximum demands (3.1.11.3.9)	

Notes:

1) The type of switch used for local control shall not allow for a conflict to exist between the switch position and the function status.

2) The "Controller not healthy" indication shall indicate the control equipment not healthy (watchdog) function operated. It shall not operate during the normal Pole or Ground - Mounted switch operating cycle. This indication should remain active until the unhealthy state that initiated it returns to normal.

3.1.13 Remote controls and indications

The remote controls and indications shall be as specified in 240-7108383 (34-1111): Part 2 – Tele-control requirements.

3.1.14 Remote device communication standard for data retrieval and remote access

The AVR shall be fully compliable to Eskom Standard: 240-64038621, REMOTE DEVICE COMMUNICATION STANDARD FOR DATA RETRIEVAL AND REMOTE ACCESS.

3.1.15 Local engineering

3.1.15.1 The AVR controller shall be equipped with a battery backed up real time clock (RTC) with leap year support. It shall be possible to set the clock from the control panel and via the configuration software to within 1ms of the PC's clock.

3.1.15.1.1 The accuracy of the clock shall be better than 12 (twelve) parts per million across the whole operating temperature range.

3.1.15.1.2 The precision of the clock shall be 1 second or better i.e. CCYY/MM/DD hh:mm:ss.

3.1.15.1.3 The RTC battery shall provide at least 50 days of total standby time. The battery should not need replacing more often than every ten years.

3.1.15.2 A facility for setting the voltage control and operating characteristics shall be locally available in the control cabinet. Password protection against unauthorised changes shall be available.

3.1.15.3 Non-volatile memory storage shall be sized to store an event record containing the following minimum data:

3.1.15.3.1 The last 20 occurrences of local and remote changes to the AVR operating parameters; and

3.1.15.3.2 At least the last five AVR operation events. The actual number available shall be stated in the tender documentation. All events shall be time and date stamped with a resolution of at least 1 s relative to the onboard real time clock.

3.1.15.4 Operation counters shall be provided.

3.1.15.4.1 It shall be possible, under password control, to manually reset the operation counter values. Alternative methods to preserve this information locally with the AVR (to facilitate maintenance) shall be stated in the tender documentation.

3.1.15.4.2 A pointer shall be provided to indicate up to where the data was last read. This will enable regular uploading of the data without re-loading of previously read data. Registers shall not clear automatically after uploading of data. The option to clear the register after uploading shall be provided to the user.

3.1.15.5 The control cabinet shall be equipped with a tamper switch to detect the state of the door (open/closed).

3.1.15.6 Provision shall be made in the control cabinet for isolating the control cabinet electronics from the primary power source.

3.1.16 Configuration software and firmware

3.1.16.1 The AVR control shall be fully configurable from a PC, utilising the controller's configuration software.

3.1.16.2 The configuration software shall be compatible with at least one Microsoft Windows Operating System less than 2 years old and another that is between 2 and 5 years old. Software is regarded as an integral part of the AVR control and should therefore be included as part of the package at no additional cost.

3.1.16.3 It shall be possible to perform future firmware upgrades via the configuration port. Firmware upgrades involving EPROM replacement is not acceptable.

3.1.16.4 Software and firmware updates shall be made available to Eskom at no additional cost for a minimum of 5 years after the delivery of the unit.

3.1.16.5 Software and firmware updates shall be fully backward compatible with all units less than 15 years old.

3.1.16.6 A copy of the configuration software shall be submitted for evaluation.

3.1.17 Power supply

3.1.17.1 The primary supply shall be derived directly from a VT provided in the AVR.

3.1.17.2 The AVR VT shall provide power for the controller, tap-change motor and operation of the communication equipment (e.g. modem).

3.1.17.3 The VT's VA rating shall be indicated in the compliance schedule, as well as the VA that is available to power additional equipment such as a modem or radio.

3.1.18 Rating plate

Each AVR shall have a rating plate of an intrinsically corrosion-resistant material, indelibly marked with the sea-level rating for which the equipment has been type tested. The rating plate shall be indelibly marked with:

a) Manufacturer's name;

b) Equipment product code;

c) Serial number;

d) SAP number

e) Total mass, in kilograms;

f) Date of manufacture;

g) Voltage transformer ratio;

h) CT ratio;

i) Schematic diagram;

j) BIL;

k) Rated voltage;

l) Rated current;

m) Rated kVA and

n) Rated frequency.

o) QR Code must contain the following as a minimum: a, b, c, d, etc.

3.1.19 Additional information

a) All documentation submitted with the tender, shall be in English and shall be submitted on electronic media in accordance with the following requirements:

- All text based documents shall be provided in Microsoft Word (.doc) or Acrobat Reader (.pdf) formats;
- All drawings shall be provided in Acrobat Reader (.pdf) format and dimensions shall be indicated in millimetres.

b) The following drawings shall be submitted:

- General outline and dimensional drawing of the AVR and control;
- Drawing of base plate and mounting holes, indicating the critical dimensions;
- Drawing of the rating plate;
- Dimensional drawing of bushing and terminal clamp;
- Drawing of surge arrester mounting bracket;
- Drawing of the AVR with surge arresters fitted, using the surge arrester dimensions given in figure Figure A.3 of Annex B. The minimum phase-to-earth clearances shall be indicated on the drawing.

- Drawing of control cabinet layout;

c) The following technical manuals shall be submitted:

- Installation, operation and maintenance manual for the regulator;
- Installation, operation and maintenance manual for the control;
- User's guide for the configuration software.

d) Details of AVR's service history shall be submitted:

- How many in service, where and for what period;
- Customer contact names and numbers;

e) The tenderer shall offer comprehensive local support to Eskom. The supplier must provide details on how this support will be provided, as well as a list of support centres and other facilities.

f) An explanation of each digit in the product code shall be submitted.

3.1.20 Maintenance and commissioning

The following shall be provided to facilitate testing and commissioning:

- It shall be possible to perform secondary injection testing.
- It shall be possible to disconnect the AVR and connect a simulator to the control cabinet for testing purposes.
- The AVR shall not malfunction while a radio is transmitting via an antenna in close proximity to the control cabinet while the door is open.
- The regulator shall be designed so that it can be partially or completely untanked for inspection and maintenance without disconnecting any internal electrical or mechanical connection. After the unit is untanked, it shall be possible to operate the regulator mechanism from the control panel (powered from an external source) without any reconnection between the control and the regulator.

3.1.21 Product training

- The supplier shall provide comprehensive training courses to enable Eskom to configure, program, operate, diagnose faults and fully maintain the offered voltage regulators.
- Three training modules, structured in accordance with **Table** 6**,** shall be provided.

Table 6: Training modules per s

1	2	3	4	5	6
Module	**Target group**	**Duration**	**Number of trainees**	**Description**	**Number of training sessions**
1	Protection Engineers & Technicians	1 day	10 per cluster	Details on full functionality and settings	1
2	Telecontrol Engineers & Technicians	1 day	10 per cluster	Details on full functionality and settings	1
3	Operators & Field services engineers	½ day	50 per cluster	Functionality required for operators	5
4	Workshop & maintenance staff	1 day	10 per cluster	Details of maintenance	1

Notes:

- All training must be conducted separately within the boundaries of each of the six clusters.
- The transport and accommodation costs, for Eskom staff, will be for Eskom's account.
- Training venues can be provided by Eskom, if required.

- The cost per training module, structured in accordance with table **Table** 6, shall be provided with the tender.
- Training manuals shall be submitted with the tender.

3.2 Tests

3.2.1 Routine tests

3.2.1.1 The following routine tests shall be carried out as a normal requirement of the contract on each AVR. No additional charge shall be levied for such tests or for the production or presentation of documentation related to routine tests.

a) Resistances measurement;

b) Polarity test;

c) Ratio tests;

d) No-load losses and excitation current;

e) Impedance and load losses;

f) Dielectric tests: Applied voltage test (separate source) and

g) Induced over-voltage test.

3.2.1.2 Copies of routine test certificates shall be supplied together with the equipment when the latter is delivered to the final destination stated in the order.

3.2.2 Type tests

3.2.2.1 Test records (on identical equipment) in the form of validated copies of test certificates issued by a recognized testing authority shall be submitted with the tender documentation.

3.2.2.2 The AVR shall have been type tested in accordance with, and found to comply with, the following requirements of ANSI/IEEE C57.15.

a) Impulse test;

b) Temperature rise;

c) Short-circuit tests;

3.2.2.3 Short-circuit tests conducted on each of the regulator ratings offered is preferred. Tests conducted on similar regulators will however be acceptable, provided that it complies with the definitions of similar transformers as defined in IEC 60076-5, Annex A. A detailed statement, which addresses each of the critical features in Annex A of IEC 60076-5, shall be submitted as proof that the tested unit and the offered unit is similar.

a) Surges withstand capability test.

b) The arc under oil test shall be conducted on the AVR in accordance with ANSI/IEE C57.12.20.

3.2.2.4 Pollution performance tests.

a) The interim Insulation pollution engineering instruction required in place of KIPTS the following, voltage regulator bushing shall be tested in accordance Engineering Instruction 240-170000774.

b) When KIPTS is reinstated, ESKOM reserves the right to subject randomly selected insulators that have been delivered to natural aging and pollution performance tests at KIPTS. Products that were accepted based on the criteria specified in this instruction will be tested at KIPTS at Eskom's own cost. Should unacceptable aging and pollution performance be detected during the KIPTS testing of the product, Eskom reserves the right to withhold further procurement until the defect is corrected by the manufacturer.

3.2.2.5 The voltage regulator's control relay shall be tested in accordance with clause 5 of the Eskom standard 240-85224724 (DST 34-462).

4. Authorisation

This document has been seen and accepted by:

Name and surname	Designation
Mfundi Songo	Senior Manager HV Plant
Eze van Tonder	MV/LV SC Chairperson
Sakkie van Aarde	Senior Advisor Engineering

5. Revisions

Date	Rev	Compiler	Remarks
Sept 2022	**3**	Sakkie Van Aarde	1. ADD 300 and 400 amp 11 and 22 kV options. 2. Critical requirements (#) has been removed from the document. 3. Pollution performance tests has been changed (Engineering Instruction 240-170000774).
April 2017	2	Sakkie Van Aarde	ADD 33 kV regulator
Feb 2015	1	Sakkie Van Aarde	No content changes. Re-format only. This document supersedes document DSP_34-2110
Nov 2012	1	Sakkie Van Aarde	Final Document approved

6. Development team

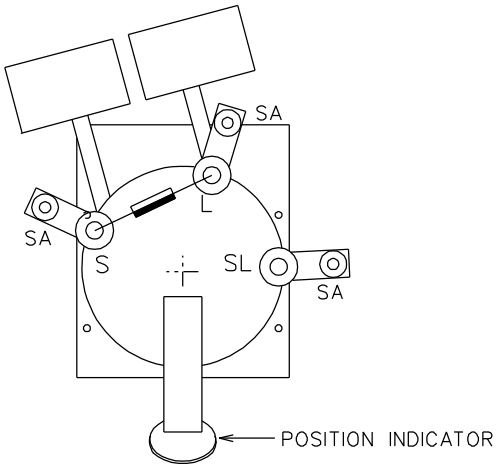
The following people were involved in the development of this document:

- Sakkie van Aarde

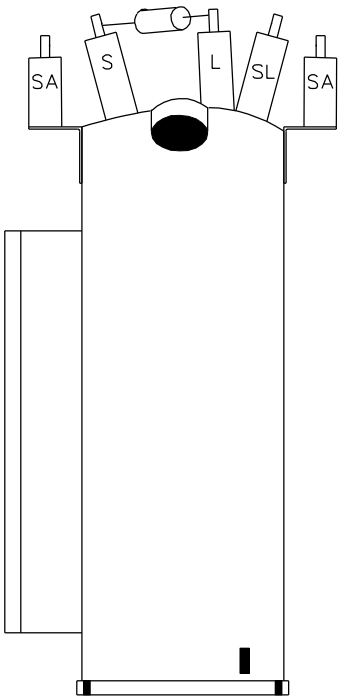
7. Acknowledgements

Not applicable.

Annex A – Drawings

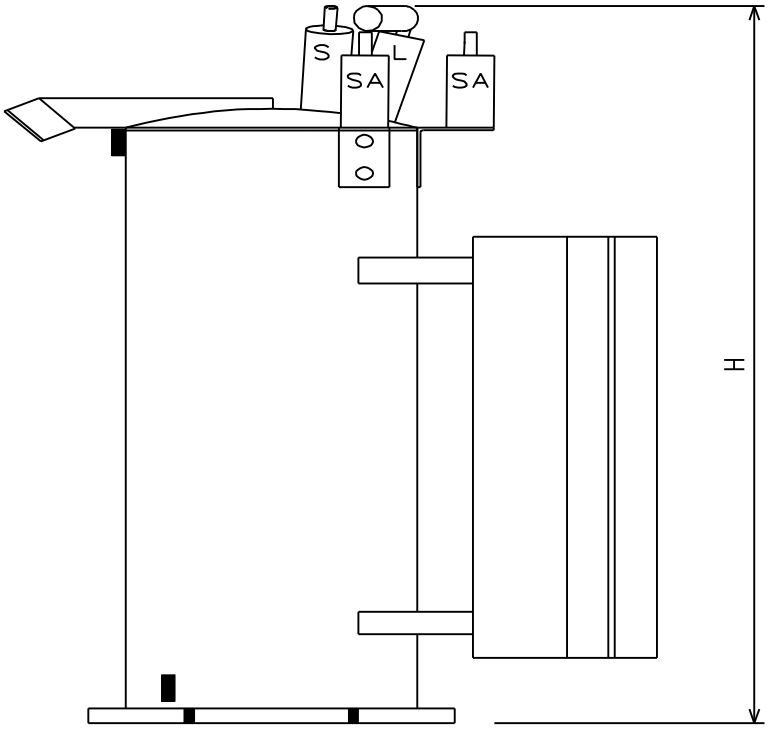


TOP VIEW



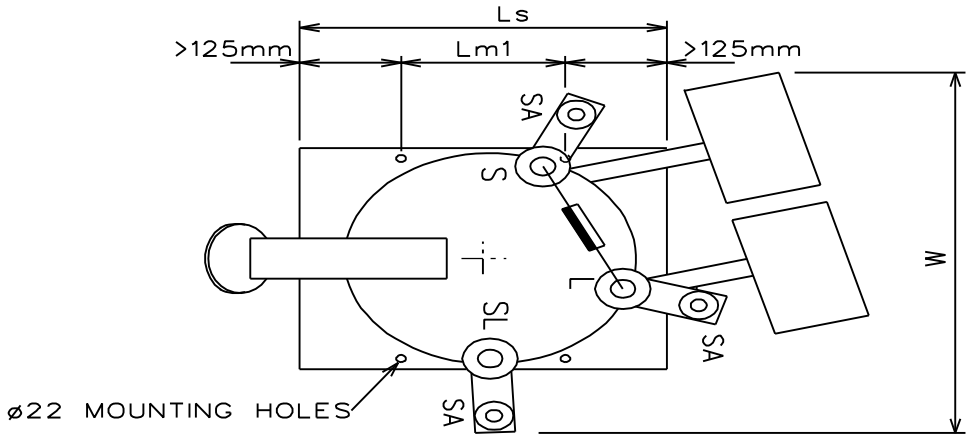
FRONT VIEW

Figure A.1: Voltage regulator layout



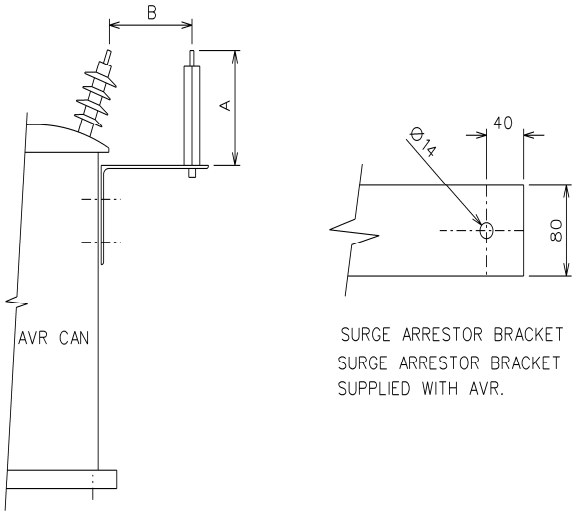
SIDE VIEW

H < 2500mm (Overhall height, including Surge Arrester)
W < 1250mm (Overall width, including Radiators & Arrester brackets)
Ls > 750mm
340mm < Lm1 < 500mm



BOTTOM VIEW

Figure A.2: Outline dimensions and mounting-hole arrangement



SURGE ARRESTER DIMENSIONS			
	11 kV	22 kV	33 kV
A	280-350mm	360-500mm	500-710mm
B (MAX)	200mm	200mm	200mm
C (MIN)	190mm	300mm	410mm

NOTE :
B - SHORTEST DISTANCE BETWEEN SA LINE TERMINAL AND AVR BUSHING.
C - SHORTEST DISTANCE BETWEEN SA LINE TERMINAL AND ANY EARTHED METAL.
* THE SA BRACKET SHALL BE DESIGNED TO ENSURE THAT THE REQUIREMENTS FOR B AND C ARE MET, WHEN AN ARRESTER OF DIMENSION A IS FITTED.

Figure A.3: Requirements for surge arrester mounting bracket

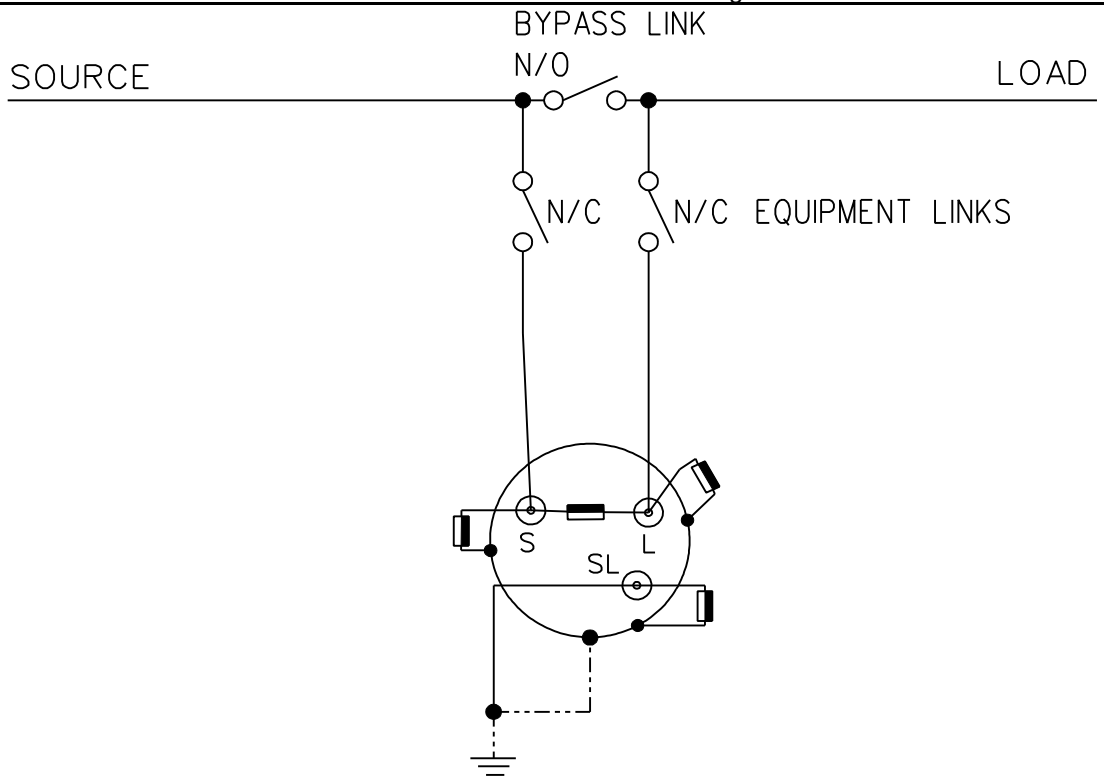


Figure A.4: Single-phase configuration

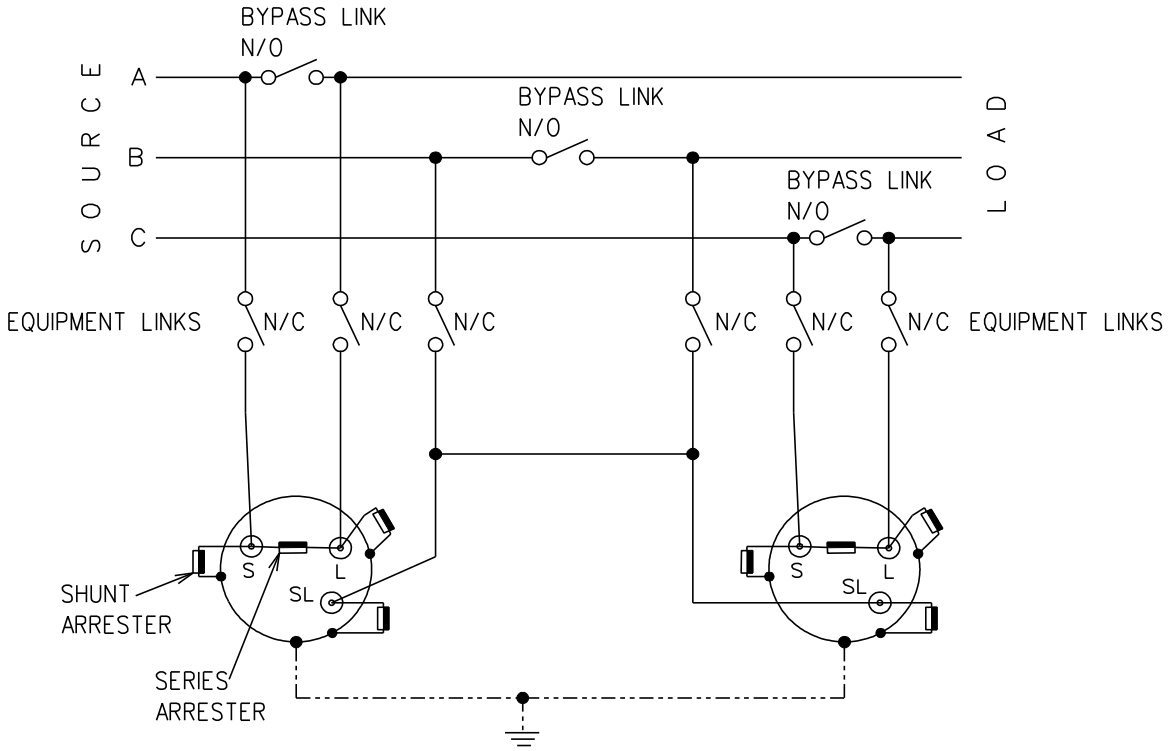


Figure A.5: Open delta, three-phase configuration

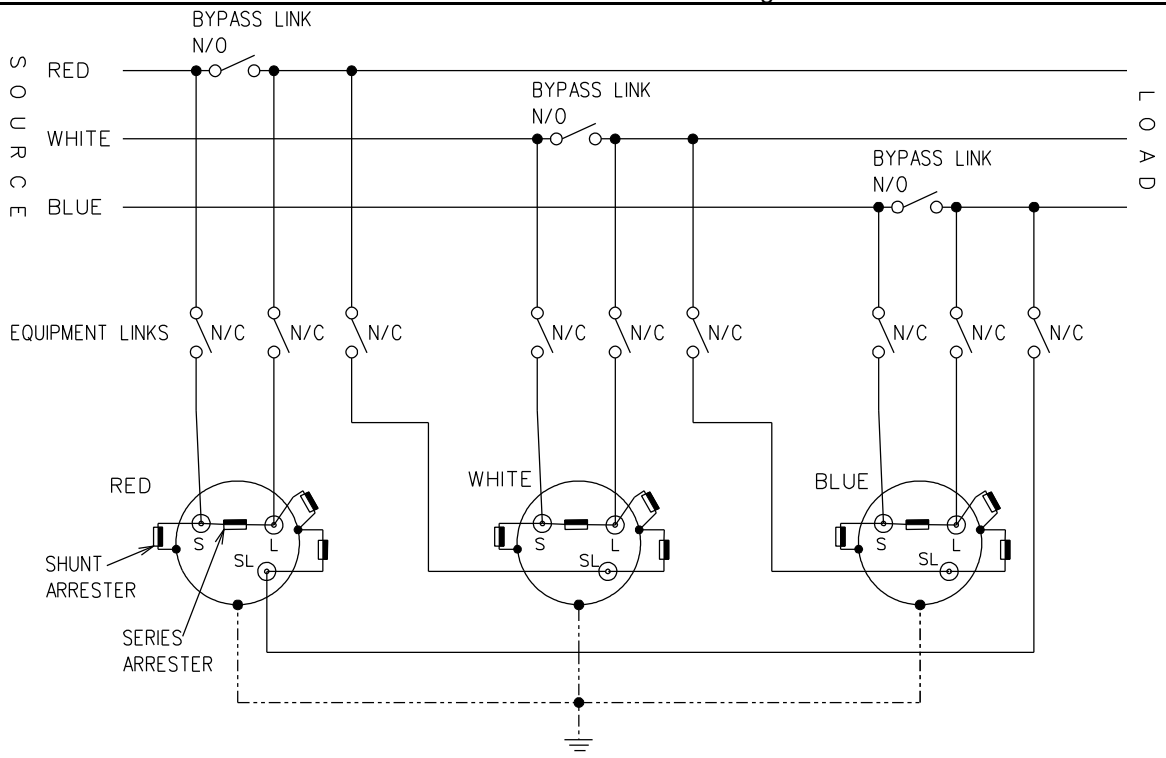


Figure A.6: Closed delta, three-phase configuration

Annex B – - Type test report summary sheet

Supplier's name: ……

Item(s) description: ……

Test		Report no.	Test facility	Comments	Report submitted (Y/N)
a)	Impulse test				
b)	Temperature rise test				
c)	Short-circuit test				
a)	Surges withstand capability test				
b)	Arc under oil test				
3.2.2.5	Control relay tests				

Annex C – Summary of Insulator/bushing Pollution Performance test requirements

Supplier's name: ……

Item(s) description: ……

	Test certificate	**Standards.**	Clause in 240-170000774	Received (Yes/No)	Test authority/Lab accepted (Yes/No	Accepted (Yes/No)
1.	1000 hr salt fog	SANS 61109	4.3			
2.	Pollution performance curve	SANS 60815 Cigre TB 555 Cigre TB 691	4.4			
3.	Material fingerprint analysis	240-100495413	4.5			
4.	Sample	240-100495413	4.6			
5.	Dimension drawing	240-100495413	4.6			

Annex D – Technical schedules A and B

Only one set of technical schedules are provided below, a separate set of technical schedules shall however be completed and submitted for each regulator that is offered. In other words, nine sets must be submitted if the full range of regulators are offered

The relevant tick boxes at the top of the page must be ticked.

Eskom Enquiry no.: _____ Standerd. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 1 of 2

Technical schedules A and B for

Voltage: 11 kV ☐, 22 kV ☐ or 33 kV ☐ (← tick relevant box)

Current: 100 A ☐, 200 A ☐, 300 A ☐ or 400 A ☐ (← tick relevant box)

Application: Inland ☐ or Coastal ☐ (← tick relevant box)

Schedule A: Purchaser's specific requirements

Schedule B: Guarantees and technical particulars of equipment offered

Item	Sub-clause of 240-75660124	Description		Schedule A	Schedule B
		Identification			
		1) Name of manufacturer		xxxxxxxxxxx	_____
		2) Name of supplier		xxxxxxxxxxx	_____
		3) Product code of voltage regulator		xxxxxxxxxxx	_____
		4) Product code of regulator control		xxxxxxxxxxx	_____
		5) Configuration software version		xxxxxxxxxxx	_____
		6) Firmware version		xxxxxxxxxxx	_____
	3.1	Rated requirements			
	3.1.1.1.a)	1) Nominal voltage (phase to phase)	kV	xxxxxxxxxxx	_____
	3.1.3.	2) AC 60 sec. wet withstand	kV	xxxxxxxxxxx	_____
	3.1.3.	3) Basic insulation level (BIL)	kV	xxxxxxxxxxx	_____
	3.1.3.	4) Load current	A	xxxxxxxxxxx	_____
	3.1.3.	5) Short-circuit rating (for 15 cycles)	kA	xxxxxxxxxxx	_____
	3.1.3.	6) Frequency	Hz	50	_____
		7) Nominal rating	kVA	xxxxxxxxxxx	_____
		Losses			
		1) Guaranteed max. load losses	kW	xxxxxxxxxxx	_____
		2) Guaranteed max. no-load losses	kW	xxxxxxxxxxx	_____
		Contact operations			
		1) Min. guaranteed operations at full load before it is necessary to open the regulator.		xxxxxxxxxxx	_____
		2) Min. guaranteed operations at full load until failure, without any maintenance.		xxxxxxxxxxx	_____

Eskom Enquiry no.: _____ Spec. ref. no.: 34-2110 Rev. 0

Manufacturer: _____ Date: _____

Supplier: _____ Page: 2 of 2

Technical schedules A and B for

Voltage: 11 kV ☐, 22 kV ☐ or 33 kV ☐ (← tick relevant box)

Current: 100 A ☐, 200 A ☐, 300 A ☐ or 400 A ☐ (← tick relevant box)

Application: Inland ☐ or Coastal ☐ (← tick relevant box)

Schedule A: Purchaser's specific requirements

Schedule B: Guarantees and technical particulars of equipment offered

Item	Sub-clause of 34-2110	Description		Schedule A	Schedule B
	3.1.5.	Bushings			
		1) Product code of bushing		xxxxxxxxxxx	_____
		2) Insulation material		xxxxxxxxxxx	_____
	3.1.5.2	3) Creepage distance	mm	xxxxxxxxxxx	_____
	3.1.6.3	Material & coating			
		1) Regulator tank		xxxxxxxxxxx	_____
		2) Control cubicle		xxxxxxxxxxx	_____
		Dimensions 11 and 22 kV			
		Overall height (H)	mm	< 2 500	_____
		Overall with (W)	mm	< 1 250	_____
	3.1.4.8	Total mass **11 and 22 kV**	kg	≤ 2500	_____
		Dimensions 33 kV			
		Overall height (H)	mm	xxxxxxxxxxx	_____
		Overall with (W)	mm	xxxxxxxxxxx	_____
	3.1.4.8	Total mass **33 kV**	kg	xxxxxxxxxxx	_____

Deviation schedule

Any deviations from this standard 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 E – Compliance schedules

Guide

A clause by clause statement of compliance is required from the supplier. The attached compliance schedule shall be used for this purpose.

Column 1: The relevant sub-clause of 34-415.

Column 2: Statement of compliance (Yes or No). If not filled in, it will be assumed that the tender does not comply with the specific clause.

Column 3: Stipulate deviations and any other relevant information as required by the standard.

If "Yes" is indicated in column 2, supporting information shall be provided in column 3 as proof that the product complies with the specified requirement. Blank cells in column 3 are not acceptable.

Example

Standard:

a) The control cabinet shall be stainless steel to eliminate corrosion. (critical requirement)

b) The control cabinet shall be lockable. (non-critical requirement)

c) The control cabinet shall have four earth terminals. (non-critical requirement)

Compliance schedule:

1	2	3
Clause	**Comply**	**Comments/Deviation**
1	Yes	A grade 316 cabinet is offered
	No	A glass fibre control cabinet is offered. It is believed that this cabinet will also eliminate corrosion.
	No	A galvanised steel control cabinet is offered. It is believed that this cabinet will also eliminate corrosion.
2	Yes	The cabinet is pad lockable.
3	No	The standard control cabinet have only three earth terminals

Eskom Enquiry no.: _____ Spec. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 1 of 9

Compliance schedule

1	2	3
Clause	Comply	Comments/Deviation
3.1.1.1.a)		
3.1.1.1.b)		
3.1.1.1.c)		
3.1.1.1.d)		
3.1.1.1.e)		
3.1.1.2.a)		
3.1.1.2.b)		
3.1.1.2.c)		
3.1.1.2.d)		
3.1.1.2.e)		
3.1.1.2.f)		
3.1.1.2.g)		
3.1.2.2		
3.1.2.3		
3.1.2.4		
3.1.2.5		
3.1.2.6		
3.1.2.7		
3.1.2.9		
3.1.2.10		

Eskom Enquiry no.: _____ Spec. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 2 of 9

Compliance schedule

1	2	3
Clause	Comply	Comments/Deviation
3.1.2.11		
3.1.2.12		
3.1.2.13		
3.1.3.1.a)		
3.1.3.1.b)		
3.1.3.1.c)		
3.1.3.1.d)		
3.1.3.1.e)		
3.1.3.1.f)		
3.1.3.2.a)		
3.1.3.2.b)		
3.1.3.2.c)		
3.1.3.2.d)		
3.1.3.2.e)		
3.1.3.2.f)		
3.1.3.3.a)		
3.1.3.3.b)		
3.1.3.3.c)		
3.1.3.3.d)		

Eskom Enquiry no.: _____ Spec. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 3 of 9

Compliance schedule

1	2	3
Clause	Comply	Comments/Deviation
3.1.3.3.e)		
3.1.3.3.f)		
3.1.4.1.		
3.1.4.2.		
3.1.4.3.		
3.1.4.4.		
3.1.4.5.		
3.1.4.6.		
3.1.4.7		
3.1.4.8		
3.1.5.1.		
3.1.5.2.		
3.1.5.3.		
3.1.5.4		
3.1.6.1.		
3.1.6.2.		
3.1.6.3		
3.1.6.4.		
3.1.6.5.		

Eskom Enquiry no.: _____ Spec. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 4 of 9

Compliance schedule

1	2	3
Clause	Comply	Comments/Deviation
3.1.7.1.		
3.1.7.2.		
3.1.7.3.		
3.1.7.4.1.		
3.1.7.4.2.		
3.1.7.4.3.		
3.1.8.1.		
3.1.8.2.		
3.1.8.3.		
3.1.8.4.		
3.1.8.5.		
3.1.8.6.		
3.1.8.7.		
3.1.8.8.		
3.1.8.9.		
3.1.8.10.		
3.1.8.11.		
3.1.8.12.		
3.1.8.12.1.		

Eskom Enquiry no.: _____ Spec. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 5 of 9

Compliance schedule

1	2	3
Clause	Comply	Comments/Deviation
3.1.9.1.		
3.1.9.2		
3.1.9.3.		
3.1.9.4.		
3.1.10.1		
3.1.10.2		
3.1.10.3.		
3.1.10.4.		
3.1.10.5.		
3.1.10.6.		
3.1.10.7.		
3.1.10.8.1.		
3.1.10.8.2.		
3.1.10.8.3.		
3.1.10.9.		
3.1.10.10.		
3.1.10.11.		
3.1.10.12.		
3.1.10.13.		

Eskom Enquiry no.: _____ Spec. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 6 of 9

Compliance schedule

1	2	3
Clause	Comply	Comments/Deviation
3.1.10.14.		
3.1.10.15.		
3.1.10.16.		
3.1.11.1.		
3.1.11.2.		
3.1.11.3.1.		
3.1.11.3.2		
3.1.11.3.3		
3.1.11.3.4		
3.1.11.3.5		
3.1.11.3.6		
3.1.11.3.7		
3.1.11.3.8		
3.1.11.3.9		
3.1.11.4.		
3.1.12.1.		
3.1.12.2.		
3.1.12.3.		
3.1.12.4.		

Eskom Enquiry no.: _____ Spec. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 7 of 9

Compliance schedule

1	2	3
Clause	Comply	Comments/Deviation
3.1.15.1.		
3.1.15.1.1.		
3.1.15.1.2.		
3.1.15.1.3.		
3.1.15.2.		
3.1.15.3.		
3.1.15.3.1.		
3.1.15.3.2.		
3.1.15.4.		
3.1.15.4.1.		
3.1.15.4.2		
3.1.15.5.		
3.1.15.6.		
3.1.16.1.		
3.1.16.2.		
3.1.16.3.		
3.1.16.4.		
3.1.16.5.		
3.1.16.6.		

Eskom Enquiry no.: _____ Spec. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 8 of 9

Compliance schedule

1	2	3
Clause	Comply	Comments/Deviation
3.1.17.1.		
3.1.17.2.		
3.1.17.3.		
3.1.18.a)		
3.1.18.b)		
3.1.18.c)		
3.1.18.d)		
3.1.18.e)		
3.1.18.f)		
3.1.18.g)		
3.1.18.h)		
3.1.18.i)		
3.1.18.j)		
3.1.18.k)		
3.1.18.l)		
3.1.18.m)		
3.1.19.a)		
3.1.19.b)		
3.1.19.c)		
3.1.19.d)		

Eskom Enquiry no.: _____ Spec. ref. no.: 240-75660124

Manufacturer: _____ Date: _____

Supplier: _____ Page: 9 of 9

Compliance schedule

1	2	3
Clause	Comply	Comments/Deviation
3.1.19.e)		
3.1.19.f)		
3.1.20.		
3.1.21.		
3.2.1.1.a)		
3.2.1.1.b)		
3.2.1.1.c)		
3.2.1.1.d)		
3.2.1.1.e)		
3.2.1.1.f)		
3.2.1.1.g)		
3.2.2.1.		
3.2.2.2.a)		
3.2.2.2.b)		
3.2.2.2.c)		
3.2.2.3.a)		
3.2.2.3.b)		
3.2.2.4.a)		
3.2.2.4.b)		
3.2.2.5.		