	Standard	Technology
Eskom		

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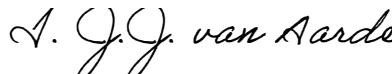
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Content

1. Introduction

This standard consists of the following two parts under the general title: Standard for pole-mounted auto-reclosers:

- 240-71084644 (34-888): Part 1 – General and Protection requirements

- 240-76628305 (34-889): Part 2 – Tele-control requirements

The combined requirements of both parts constitute Eskom's requirements for pole-mounted auto-recloser.

2. Supporting Clauses

2.1 Scope

2.1.1 Purpose

This standard covers Distribution Group requirements for single-phase (SWER) and three-phase, outdoor, pole-mounted auto- recloser that have programmable protection features and integrated remote tele-control operation capability. This auto-recloser are intended for source and down-line duty on rural distribution networks at nominal AC voltages of 6.6 kV, 11 kV, 19 kV, 22 kV and 33 kV.

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

[3] 240-56364444 (DST 34-1024). Standard minimum requirements for the metering of electrical energy and demand.

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

[7] IEC 60044, Instrument transformers.

[8] IEC 60050-441, International Electrotechnical Vocabulary (IEV) - Chapter 441: Switchgear, controlgear and fuses.

[9] IEC 60050-448, International Electrotechnical Vocabulary - Chapter 448: Power system protection.

[10] IEC 60255, Electrical relays.

[11] IEC 60529, Degrees of protection provided by enclosures (IP Code).

[12] IEC 60694, Common standards for high-voltage switchgear and controlgear standards

[13] IEC 60815, Guide for the selection of insulators in respect of polluted conditions.

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[14]   IEC 61000, Control electronic elements immunity withstand capability test.

[15]   IEC 62271-111 (IEEE C37.60), Overhead, pad-mounted, dry vault, and submersible automatic circuit recloser and fault interrupters for alternating current systems up to 38 kV.

[16]   IEC 60255-24 Measuring relays and protection equipment – Part 24: Common format for transient data exchange (COMTRADE) for power systems.

2.2.2   Informative

[1]   240-100495413 (DPC 34-224): KIPTS natural ageing and pollution performance test procedure for outdoor insulator products. Section 0 –General requirements.

[2]   Cigre TB 555: Artificial Pollution Test for Polymer Insulators.

[3]   Cigre TB 691: Pollution Test of Naturally and Artificially Contaminated Insulators

2.3   Definitions

Definition	Description
auto-recloser (AR)	A mechanical switching device that, after opening, closes automatically after a predetermined time.
auto-reclosing	The operating sequence of a mechanical switching device whereby, following its opening, it closes automatically after a predetermined time. [IEV 441-16-10]
bi-directional	The operation of a bi-directional AR is independent of the side to which the primary source is connected.
circuit-breaker	A mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short circuit. [IEV 441-14-20]
cold load pick-up (CLP) feature	A feature that allows modification of the overcurrent protection characteristics in order to prevent relay mal-operation under conditions of system energisation.
data communication equipment (DCE)	Devices that provide the functions required to establish, maintain and terminate a data transmission connection (e.g. radio, modem, etc.).
data terminal equipment (DTE)	Devices acting as a data source, or data sink, or both.
dead time	The time between the instant that the current is interrupted by the AR and the instant the close contact of the AR closes as a result of an automatic reclose operation. [IEV 448-04-09]
definite time lag (DTL) protection element	A protection element with a settable time delay that is constant above the pick-up current setting.
delayed protection operation	The protection functionality enabling delayed circuit-breaker operation, whether this is due to an IDMTL or DTL protection element.
disc reset time	The time required for the disc of an electromechanical IDMTL protection relay to turn back to its original position after it has turned to the position where a protection operation was initiated.
fast curve protection element	A family of curves with operating times approximately constant (slightly inverse) relative to the multiple of pick-up setting.

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Definition	Description
hot line tag (HLT)	A feature that assists live-line work by disabling all closing and reclosing and enabling a user configurable time-current curve for one trip to lockout.
instantaneous protection element	An element with no intentional time delay active above a pre-determined pick-up current setting.
inverse definite minimum time (IDMT) protection element	A protection element of which the minimum operating time is adjustable and is inversely proportional to the fault current.
latched control	A single latching contact that produces one state of a control function when open and the other state when closed. For the purposes of this standard, this definition only refers to that type of Tele-control protocol message, which contains the desired state of the control within the message. This type of control may only be used with integrated devices since physical latched contacts are considered unsafe.
local control	Control of an operation at a point on or adjacent to the controlled switching device. [IEV 441-16-06]
negative phase sequence (NPS) protection	Protection intended to operate when the negative sequence component of the system current phasors is in excess of a predetermined value.
negative sequence component	One of the three symmetrical sequence components which exists only in an unsymmetrical three-phase system of sinusoidal quantities and which is defined by the following complex mathematical expression: $X2 = 1/3(XL1 + a2XL2 + aXL3)$ where a is the 120 degree operator, and XL1, XL2 and XL3 are the complex expressions of the phase quantities concerned, and where X denotes the system current or voltage phasors. [IEV 448-11-28]
pulsed control	A single momentary (normally open, non-latching) contact that produces only one state of a control function. On each closure of the contact the controlled output state is activated. An example of the use of this type of control is a RESET button.
rapid protection operation	The protection functionality enabling rapid circuit-breaker operation, whether this is due to an instantaneous, fast curve, or a definite time delay protection element with relatively short definite time delay.
remote control	Control of an operation at a point distant from the controlled switching device. [IEV 441-16-07]
reset time	The time duration after a circuit-breaker close operation for which the measured currents are below a fault detecting level. On expiry of this time the protection sequence resets.
secure control (local)	A pair of normally open non-latching contacts that each effect only one state of a control function. Each state of the control is activated by momentarily closing the contact allocated to that state. An example of this is a pair of push-buttons, one that opens the circuit-breaker and one that closes the circuit-breaker. If one button is activated repeatedly it only effects that state and does not change the state of the control.
sensitive earth fault (SEF) protection	Protection intended to operate for power system earth faults with very low fault currents.

Definition	Description
single pole tripping	This function allows individual breaker poles to be operated independently by selected protection functions.
supervisory	Remote control and indications of an AR by means of an RTU and a telecommunications link.
system earthing - effective	An earthed system, in which the power-frequency phase-to-earth over-voltages associated with earth faults are limited to 0,8 x Um.
system earthing - non-effective	A system in which the neutral is intentionally connected to the system earth through a current limiting device.
toggle control	A single, normally open, non-latching contact that alternately effects both states of a control function. On each closure of the contact the controlled output state will change.
trip circuit supervision	This function continuously monitors the trip circuit of the breaker in the open and close positions.
zone sequence co-ordination (ZSC)	The feature that allows protection devices to maintain sequence co-ordination for combinations of rapid and delayed protection operations. The upstream device senses the presence of a fault as well as the clearance of that fault (by a downstream device) and proceeds to the next rapid trip operation in its sequence, without tripping itself.

2.3.1   Classification

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

2.4   Abbreviations

Abbreviation	Description
AC	Alternating Current
AR	Auto-recloser
ARC	Auto-reclose Cycle
CLP	Cold Load Pick-up
CPU	Central Processing Unit
CT	Current Transformer
CVT	Capacitive coupled Voltage Transformer
DC	Direct Current
DCE	Data Communication Equipment
DNP	Distributed Network Protocol
DTE	Data Terminal Equipment
DTL	Definite Time Lag
E/F	Earth Fault
EI	Extremely Inverse
EPROM	Erasable Programmable Read-only Memory

Abbreviation	Description
FIFO	First In First Out
HMI	Human Machine Interface
HTL	Hot Line Tag
IDMTL	Inverse Definite Minimum Time
IRTU	Integrated Remote Terminal Unit
KIPTS	Koeberg Insulator Pollution Test Station
LO	Lock Out
NI	Normal Inverse
NPS	Negative Phase Sequence
O/C	Overcurrent
PC	Personal Computer
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SEF	Sensitive Earth Fault
TCC	Time Current Curve
UHF	Ultra High Frequency
VI	Very Inverse
VT	Voltage Transformer
ZSC	Zone Sequence Co-ordination
#	Critical clause

2.5 Roles and Responsibilities

All personnel involved in the procurement of the products specified in this standard shall ensure that the product supplied is in compliance with this standard.

2.6 Process for monitoring

Not applicable.

2.7 Related/Supporting Documents

Not applicable.

2.8 Bibliography

- 240–100495413 (34-224), KIPTS Natural ageing and pollution performance test standard for outdoor insulator products. Section 0 – General requirements
- 240-76628317 (DST 34-1197), Distribution standard; Part 4 - Medium voltage reticulation; Section 8 - Rural reticulation protection; Setting philosophy.
- 240-76628315 (DST 34-1198), Distribution standard; Part 4 - Medium voltage reticulation; Section 7 - Rural reticulation protection; Network philosophy

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- 240-75655504 (DSP 34-1658), Corrosion protection standard for distribution outdoor equipment manufactured from steel.

- IEC 62271-100, High-voltage switchgear and control gear Part 100: High-voltage alternating-current circuit- breakers

3. Standard for Pole-Mounted Auto-Reclosers - Part 1: General and Protection Requirements

An auto-recloser (AR) is considered to consist of two main subcomponents, i.e. a circuit-breaker and a control cabinet. In order to distinguish between the two main subcomponents and the combined product, the following terminology will be utilised in this standard:

- Circuit-breaker – the mechanical switching device, including the bushings and mounting bracket

- Recloser control – the control cubicle and its entire contents, including the control cable

- Auto-recloser – the combination of the circuit-breaker and the recloser control (AR)

3.1 General

3.1.1 Service conditions

The auto-recloser 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 ℃
		max ambient	-	+55 ℃
		max daily variation	-	35 ℃
c)	humidity	min ambient	-	0%
		max ambient	-	100%
d)	solar radiation		-	1100 Watt/m2
e)	pollution level		-	very heavy (as defined in IEC 60815)

3.1.2 Configuration

This standard makes provision for single (SWER), three-phase circuit-breakers and one recloser control, i.e.:

a) Circuit-breaker rated at 19 kV(SWER) and 400 A

b) Circuit-breaker rated at 22 kV and 400 A;

c) Circuit-breaker rated at 33 kV and 400 A;

d) Universal recloser control, configurable for application on 6.6 kV, 11 kV, 19 kV (SWER), 22 kV and 33 kV networks.

3.1.2.1 # It shall be possible to apply standard 22 kV rated circuit-breakers on 6.6 kV and 11 kV networks, without any hardware modifications.

3.1.2.2 # It shall be possible to easily configure the recloser control, by means of user selectable software changes only, for application on 6.6 kV, 11 kV, 19 kV (SWER), 22 kV and 33 kV networks.

3.2 Circuit-breaker

3.2.1 General

3.2.1.1 All metal components of the circuit-breaker shall be electrically bonded. The bonding method shall have a current carrying capability equivalent to that of 16 mm^2, stranded, copper conductor.

3.2.1.2 The circuit-breaker shall be supplied with an external earth terminal.

3.2.1.2.1 The earth terminal shall comprise either of the following:

a)   A M12 x 25 mm (minimum) setscrew, washer and spring washer;

b)   A bolted, clamping arrangement that can accommodate a 16 mm^2, stranded, copper conductor or

c)   The purchaser may accept an alternative terminal system, subject to written approval.

3.2.1.2.2 All the earth terminal components shall be stainless steel of grades 304 or 316.

3.2.1.2.3 Loose bolts that can be replaced shall be utilized. (To enable replacement in the event of seizing, due to galling.)

3.2.1.3 The overall mass of the circuit-breaker (including external voltage sensors, if applicable) shall be less than 500 kg.

3.2.1.4 Details of the insulation medium shall be provided in the tender documentation.

3.2.1.5 Arc-extinguishing shall be performed by vacuum interrupters.

3.2.1.6 Pressure relief facilities shall be provided to enable the circuit-breaker to withstand safely the effects of excessive pressure rise due to an internal fault. Details of how the pressure relief is achieved and how its effectiveness has been proved shall be provided in the tender documentation.

3.2.1.7 #Malfunction of the AR shall not pose a safety hazard to the operator.

3.2.1.8 # The circuit-breaker shall have a low voltage trip coil and it shall be possible to trip and close the circuit-breaker electrically from the recloser control, while the circuit-breaker is not connected to the primary supply.

3.2.1.9 # The circuit-breaker shall be bi-directional.

3.2.1.10 The circuit-breaker shall have phase markings on the breaker tank at each bushing visible from ground level. The same markings shall be reflected in the firmware, software and all documentation.

3.2.1.10.1 It shall be possible to allocate user defined phase identifications, (e.g. C1 = Red or A2 = Blue) in the configuration software and these allocations shall also be reflected in the SCADA database.

3.2.2 Ratings

3.2.2.1 #Rated insulation level

The rated insulation level of the circuit-breaker shall be as specified in Table 1.

Table 1: Insulation levels

1	2	3	4	5
Nominal system voltage (Un) (kV)	Maximum system voltage (Um) (kV)	Power frequency wet withstand (kV)	Lightning impulse withstand (At Standard Atmospheric Conditions) (kV peak)	
			Closed contacts	Open contacts
19 (SWER)	21	40	200	165
22	24	50	150	125
33	36	70	200	165

3.2.2.2 #Rated current

The current rating of the circuit-breaker shall be at least:

a)	Rated continuous current	400 A
b)	Rated short-time (3 s) withstand current (r.m.s.)	4kA (SWER), 12.5 kA (three phase
c)	Rated symmetrical interrupting current	4kA (SWER), 12.5 kA (three phase);
d)	Rated symmetrical making current (r.m.s.)	4kA (SWER), 12.5 kA (three phase);

3.2.2.3 #Rated power-frequency

The rated power-frequency of the AR shall be 50 Hz.

3.2.3 Mounting

3.2.3.1 #The circuit-breaker shall be suitable for both single-pole (SWER only) and H-pole mounting, as typically illustrated in Figure 1. A universal mounting-bracket, which can be easily adopted on site for either a single- pole structure or an H-pole structure, shall be provided.

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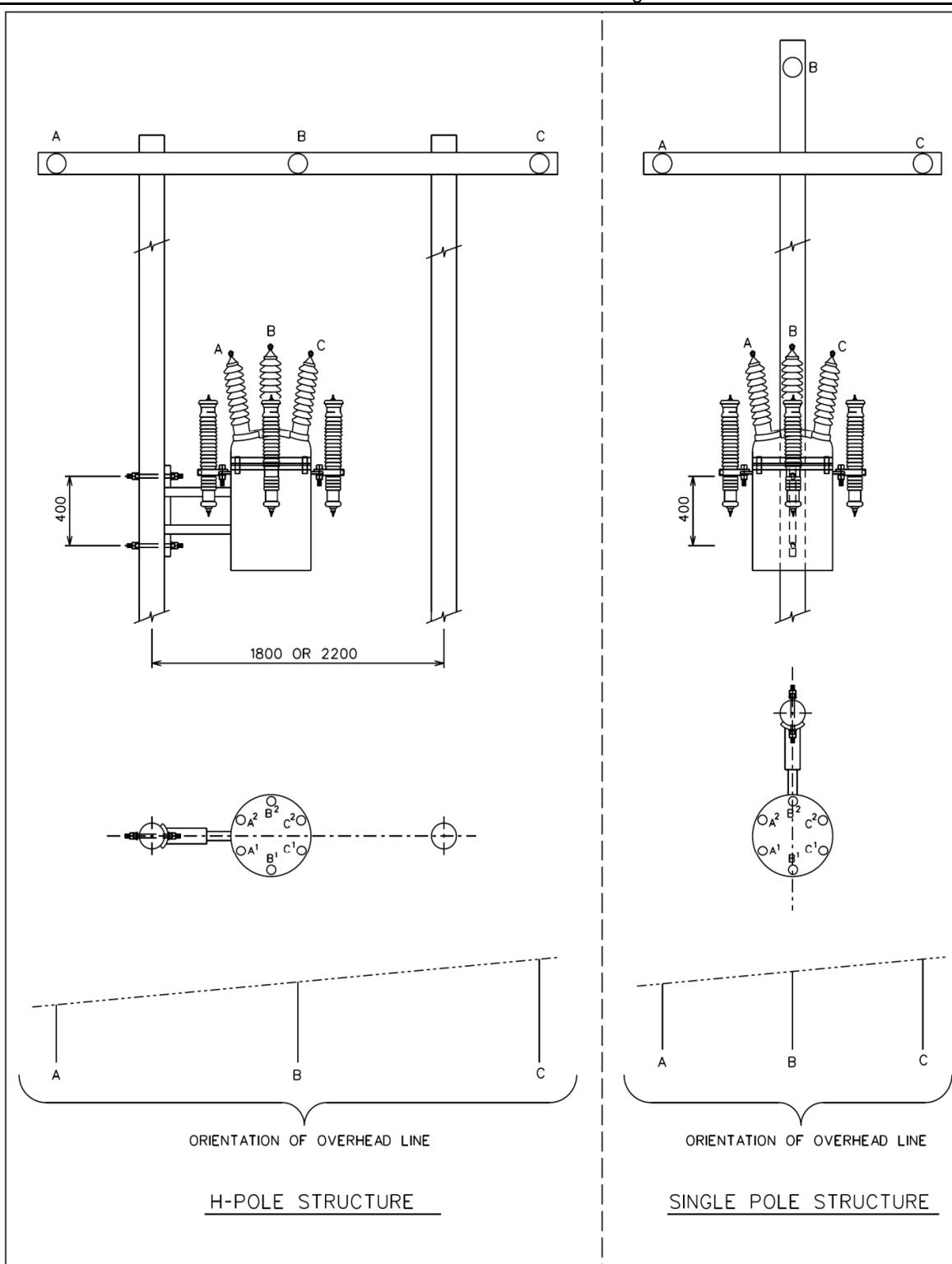
Figure 1: Critical mounting dimensions and illustration of universal mounting bracket.

3.2.3.2 The interface between the pole and the mounting bracket shall have two M20 mounting holes at 400 mm centres.

3.2.3.3 The mounting holes shall be designed such that it will be possible to slide the circuit-breaker into position without having to remove the nuts and washers from the threaded rods. An example of such a design is provided in Figure 2.
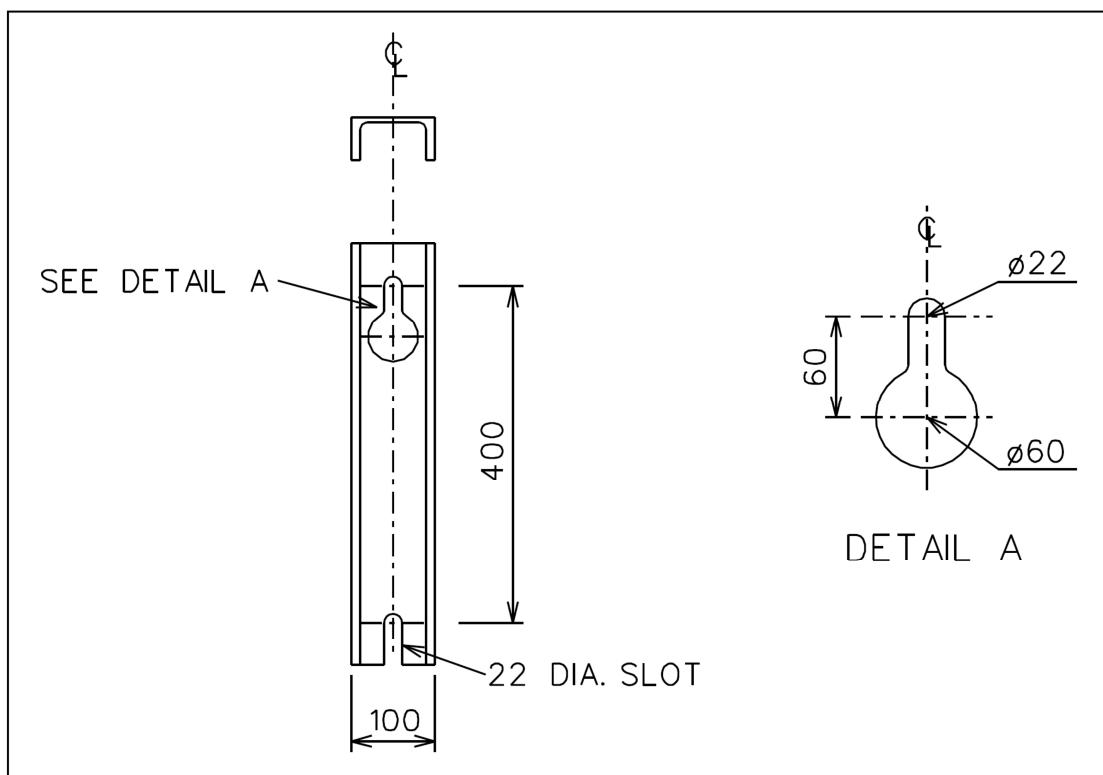
Figure 2: Mounting holes for circuit-breaker mounting bracket.

3.2.3.4 All the required mounting hardware shall be supplied with the circuit-breaker, which shall include two threaded rods (M20 x 450 mm). Each threaded rod shall be supplied with four nuts (M20), one round flat washer (M20 x 36.4 mm diameter x 3 mm) and one curved washer (M20 x 65 mm x 65 mm x 6 mm & curve with 75 mm radius).

3.2.3.5 The threaded rods, nuts and washers shall be hot dipped galvanized.

3.2.3.6 Adequately rated lifting eyes shall be provided to allow the completely assembled circuit-breaker (fitted with surge arresters and external voltage sensors (if applicable)) to be lifted without recourse to a sling spreader. The inside diameter of the lifting eyes shall be a minimum of 30 mm.

3.2.3.7 The mounting bracket shall be designed to ensure that a minimum clearance of 320 mm for 22 kV and 430 mm for 19 kV (SWER) and 33 kV circuit-breakers is maintained between any live terminals (including surge arresters and external voltage sensors s) and the Eskom structure, as indicated with dimension E in Figure 3.

3.2.4 Material and finish

3.2.4.1 All support structures (i.e. mounting brackets for the circuit-breaker, surge arresters, external voltage sensors, etc.) shall be made of stainless steel, or as a minimum be hot-dip galvanized in accordance with SANS 121: 2011.

3.2.4.2 Bolts and nuts associated with the support structures shall be hot-dip galvanized in accordance with SANS 121: 2011.

3.2.4.3 All exposed metal components of the circuit-breaker (excluding the bushing terminals and mounting bracket) shall be manufactured from either an aluminium casting or stainless steel of grades 304 or 316 or. The purchaser may accept alternative materials with similar corrosion resistant properties, subject to written approval.

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

3.2.5 Bushings

3.2.5.1 Terminals

The preferred arrangement for bushing terminals is smooth hot-dip tinned copper cylindrical stems provided with bimetallic clamps that are suitable for accepting aluminium or copper conductors of 8 mm to 15 mm diameter. The purchaser may accept alternative terminal systems, subject to written approval.

3.2.5.2 Material

Details of the external insulation material shall be provided in the tender documentation.

3.2.5.3 #Creepage

3.2.5.3.1 The AR shall be suitable for application in areas with very heavy pollution levels as defined by IEC 60815.

3.2.5.3.2 The minimum creepage requirements between phase and earth shall be as given in 2.

Table 2: Minimum creepage requirements

1	2	3	4
Nominal voltage	22 kV	19 kV	33 kV
Creepage distance	744 mm [31 mm/kV]	1116 mm [31 mm/kV]	1116 mm [31 mm/kV]

3.2.5.4 Profile characteristics

3.2.5.4.1 Bushing profile characteristics shall comply with the guidelines of appendix D of IEC 60815.

3.2.5.4.2 Details of the critical dimensions and ratios, as defined in appendix D of IEC 60815, shall be provided in the tender documentation.

3.2.6 Surge arrester mounting

3.2.6.1 Mounting brackets for surge arresters with the dimensions shown in Figure 3 shall be provided on the source and load side of the circuit-breaker, adjacent to the bushings.

SURGE ARRESTER DIMENSIONS			
	11kV	22kV	33kV
A	200-300mm	300-400mm	370-570mm
B (MAX)	75mm	75mm	75mm
C (MIN)	130mm	130mm	130mm
D (MIN)	200mm	200mm	200mm
E (MIN)	190mm	320mm	400mm
F (MIN)	150mm	150mm	150mm

NOTE :
* D - SHORTEST DISTANCE BETWEEN SA LINE TERMINAL AND CIRCUIT-BREAKER BUSHING.
* E - SHORTEST DISTANCE BETWEEN SA LINE TERMINAL AND ANY EARTHED METAL.
* F - RADIUS SHALL BE CLEAR OF ANY OBJECTS.
* PARAMETERS A, B AND C ARE GIVEN VALUES SPECIFIED BY THE SA MANUFACTURES.
* CIRCUIT-BREAKER SHALL BE DESIGNED TO COMPLY WITH PARAMETERS D, E AND F.

Figure 3: Surge arrester dimensions

3.2.7 Current sensors

3.2.7.1 # The circuit-breaker shall be supplied with one (SWER) or three (one per phase) current sensors (e.g. CTs Rogowski coils, etc.).

3.2.7.2 # The current sensors shall be an integral part of the circuit-breaker.

3.2.7.3 Current sensors with an accuracy of class 0.5, as defined in IEC 60044, shall be preferred.

3.2.7.4 # The current sensors shall be sufficient to ensure that all the Protection and Metering requirements specified in this standard can be achieved in conjunction with the associated recloser control.

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3.2.8   Voltage sensors

3.2.8.1   # The circuit-breaker shall be supplied with two (SWER) OR six voltage sensors (e.g. VTs, CVTs, etc.), one per phase on the source and the load side.

3.2.8.2   Voltage sensors with an accuracy of class 0.5, as defined in IEC 60044, shall be preferred.

3.2.8.3   It is preferred that the voltage sensors are an integral part of the circuit-breaker.

3.2.8.4   Separate voltage sensors will be acceptable, but subject to the following conditions:

3.2.8.4.1 The sensors shall be mounted on, and connected to, the circuit-breaker prior to dispatching the circuit-breaker to Eskom and shall not affect the standard mounting interface, as indicated in 1.

3.2.8.4.2 The sensors shall comply with the insulation requirements as specified in clause 3.2.2.1.

3.2.8.4.3 The external insulation of the sensors shall comply with the creepage and profile characteristic requirements as specified in clauses 3.2.5.3 and 3.2.5.4.

3.2.8.4.4 The necessary documentation shall be provided with the tender documentation to prove compliance with clause 3.2.8.4.

NOTE: It is Eskom's intent is to exclude separate voltage sensors from future revisions of this standard.

3.2.8.5   # The voltage sensors shall be sufficient to ensure that all the Protection and Metering requirements specified in this standard can be achieved in conjunction with the associated recloser control.

3.3   Control cabinet

3.3.1   Mounting

3.3.1.1   The control cabinet shall be easily removable for workshop repair purposes.

3.3.1.2   The cabinet shall be supplied with a mounting bracket.

3.3.1.3   The mounting bracket shall have at least two, vertically spaced, mounting holes. The holes shall be designed such that it will be possible to slide the cabinet into position without having to remove the pole mounting bolts (or coach screws). An example of typical mounting holes is provided in 2.

3.3.1.4   The mounting bracket shall have at least two sets of, vertically spaced, slots for temporary mounting by means of straps.

3.3.2   Material and finish

3.3.2.1   The cabinets shall be manufactured from aluminium or stainless steel of grades 304 or 316.

3.3.2.2   The mounting bracket shall be made of stainless steel, or as a minimum be hot-dip galvanized in accordance with SANS 121: 2011.

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

3.3.2.4   All metal artefacts shall be of a material that is corrosion resistant

3.3.2.5   The housing shall be of durable and vandal proof construction providing adequate protection against mechanical damage

3.3.2.6   All exposed parts shall be UV resistant**.**

3.3.3 Construction

3.3.3.1 The control cabinet shall be separate from the circuit-breaker (i.e. the recloser control and circuit-breaker shall not be integrated into a single device).

3.3.3.2 Cabinets shall be protected from dust and water ingress to achieve an IP rating of IP 54 or better. IP ratings as defined in IEC 60529.

3.3.3.3 Cabinets shall be designed and internally treated to prevent moisture condensation.

3.3.3.4 The cabinet shall be fitted with an external M12 earthing stud with a nut, lock-nut and a serrated washer.

3.3.3.5 All metal components of the control cabinet shall be electrically bonded. The bonding method shall have a current carrying capability equivalent to that of 16 mm2, stranded, copper conductor.

3.3.3.6 Provision shall be made in the cabinet to mount the user's data communication equipment, Unique Identifier 240-71084644 (34-889): Part 2 – Tele-control requirements.

3.3.3.7 The layout of the cabinet shall ensure easy accessibility to the user's communications equipment.

3.3.4 Door

3.3.4.1 The cabinet shall have a hinged door.

3.3.4.2 The door shall be fitted with a robust fastening arrangement which can be locked with a padlock that has a shackle of 8 mm diameter.

3.3.4.3 It shall not be possible to easily force an object such as a crowbar between the door and the cabinet and prise the door open, when the door is closed and padlocked.

3.3.4.4 Means shall be provided to either secure the door in a fully open position (90☐ or more), or to easily remove (without the use of tools) the door completely during maintenance or similar activities.

3.3.4.5 Good electrical contact shall be maintained between the door and the rest of the cabinet at all times (excluding the condition when the door is completely removed).

3.3.4.6 A document pocket shall be provided on the inside of the door for the storage of documentation.

3.3.5 Cable entry

3.3.5.1 The cabinet shall make provision for bottom entry of three cables.

3.3.5.2 This may be achieved with a pre-punched and then hot-dip galvanised gland plate with three 21 mm diameter holes.

3.3.5.3 A suitable arrangement shall be provided to earth the gland plate.

3.3.5.4 The holes in the blanking plate shall be blanked off with blanking plugs that are bolted or screwed into position.

3.3.5.5 The purchaser may accept alternative methods to achieve the bottom cable entry, subject to written approval.

3.3.6 #External antenna connectors

The control cabinet shall be fitted with external antenna connectors in accordance with the requirements specified in 240-71084644 (34-889): Part 2 – Tele-control requirements.

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3.3.7 Control cable

3.3.7.1 # An ultraviolet resistant cable, minimum 5 m long, shall be provided to connect the circuit-breaker to the recloser control.

3.3.7.2 The maximum separation distance that can be achieved between the circuit-breaker and the recloser control shall be stated in the tender documentation.

3.3.7.3 Robust, multi-pin, weatherproof connectors shall be provided on both ends of the control cable.

3.3.7.4 # It shall be possible to disconnect the control cable at the recloser control while the auto-recloser is energised, without causing damage or mal-operation. Care shall be taken to ensure that CTs are not open-circuited.

3.4 Power supplies

3.4.1 General

3.4.1.1 The recloser control shall have an integral power supply.

3.4.1.2 The control system of the AR shall prevented the circuit-breaker from closing if the battery does not have enough stored energy to open the circuit-breaker for a protection trip condition. Details must be stated in the tender documentation.

3.4.1.3 Batteries shall be automatically disconnected at the manufacturer's specified minimum voltage and automatically reconnected when auxiliary power is restored.

3.4.1.4 Adequately rated miniature circuit-breakers shall be provided for individually isolating the recloser control from the following:

3.4.1.5 auxiliary supply and

3.4.1.6 battery backup supply.

3.4.2 Power consumption

3.4.2.1 Steps shall be taken to minimise the device's power consumption. The tenderer shall detail any design elements geared for minimising power consumption.

3.4.2.2 Details of the recloser control's power consumption shall be provided in the tender documentation. The maximum current drain (considering the inputs to be in a "worst case" configuration regarding power consumption) and any inrush current parameters shall be stated.

3.4.2.3 Details of the power requirements for a close operation shall be provided in the tender documentation.

3.4.3 Charger

3.4.3.1 The power supply shall be integrated and of the constant voltage, current limited type. These two parameters shall be settable.

3.4.3.2 The charger shall be rated to power all the electronic modules, operate the AR (tripping and closing) and power the data communication equipment.

3.4.3.3 The charger shall ensure that the battery is optimally charged under the specified operating temperature conditions by employing temperature compensation.

3.4.3.4 The charger shall be capable of recharging the battery from flat to 80% of its rated capacity in a minimum of 15 hours while supplying the AR and the radio.

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3.4.4   Voltage/current excursions

3.4.4.1   The power supply shall include the necessary over-current protection to protect the supply from current excursions.

3.4.4.2   The power supply shall have protection features to protect the connected battery and loads from overvoltage conditions

3.4.4.3   The use of fuses for over-current protection on the auxiliary input circuit(s) is not acceptable.

3.4.4.4   Information on the methods used to protect against transient over-current conditions shall be provided in the tender documentation.

3.4.4.5   The power supply shall include the necessary surge arresters and/or voltage limiting devices to inhibit damage due to voltage surges.

3.4.5   Battery

3.4.5.1   If the offered battery is of the valve regulated lead acid type, it shall comply with the requirements of 240-51999453, Standard specification for Valve-regulated Lead-acid Cells.

3.4.5.2   For any other battery technologies offered, the relevant IEC / SANS standards that it complies with shall be stated and the test certificates provided. In this case an comparative sizing calculation shall be done for using a VRLA battery.

3.4.5.3   The battery shall be rated to keep the connected load equipment powered and ensure that all other required actions can still be supported for a minimum of 24h at the minimum specified operating temperature.

3.4.5.4   The battery shall be able to support the following actions:

a)   10 AR operations

b)   Radio operation

c)   at least five consecutive close operations and five consecutive open operations during the last 50% of useful capacity.

d)   an orderly IRTU shutdown when the battery voltage reaches the manufacturer's specified minimum limit and the shutdown shall be delayed until a shutdown indication is successfully relayed to the master station.

3.4.5.5   Details of the battery capacity calculation shall be provided, showing the load profile on which the calculation was based and also all compensating factors.

3.4.5.6   "Battery Low" indication shall be available locally and remotely. The indication of "Battery Low" status shall occur when 50% of the battery capacity remains. This indication shall have sufficient hysteresis to prevent chatter during AR operations and radio transmissions.

3.4.5.7   The minimum operational battery life expectancy (to 80% of rated capacity) must exceed 4 years. The confidence of this must exceed one in a thousand (i.e.99.9%). Details of the calculations to verify this life expectancy of the battery shall be stated in the tender documentation.

3.4.5.8   The battery to be used with the unit shall be capable of operating in the environment to be found within the pole-mounted enclosure, and shall not be unsafe.

3.4.5.9   All relevant safety and hazard issues pertaining to the use of the battery in a confined enclosure in the pole-mounted environment shall be disclosed by the tenderer.

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3.4.5.10 Due consideration shall be given to the enclosure internal operating temperature for the charging cycle as well as for the battery standby time. Information on how these requirements have been catered for shall be provided in the tender documentation

3.4.5.11 An automatic and manual battery load test should be able to be performed. The frequency and time of day for the automatic test shall be settable via the front port or control software Details of how the test is done shall be stated in the tender documentation..

3.4.5.12 The tenderer shall provide test results of the battery to be used. These tests shall have been conducted in the same environment that the battery will be expected to operate in, and shall conclusively show the expected life and the degradation to be expected with time.

3.4.6   Auxiliary supply

3.4.6.1   The auxiliary supply will be derived from an external power source, which will be provided by Eskom.

3.4.6.2   Provision shall be made to accommodate an external 4 mm^2 cable from the auxiliary transformer eg. Spring loaded terminals etc.

The output voltage of the external power source could be either of the following:

a)   110 V (±20%) AC at a frequency of 50 Hz;

b)   240 V (±20%) AC at a frequency of 50 Hz;

c)   110 V (±20%) DC or

d)   240 V (±20%) DC.

3.4.6.3   The voltage input level of the recloser control's power supply shall be user selectable between those specified in clause 3.4.6.2 a) & b), c) & d).**Error! Reference source not found.** Preference will be given to products that can also be powered from the voltage input levels specified in clause 3.4.6.2. c) and 3.4.6.2.d).

3.4.6.4   The device shall provide a visual indication, on the control panel and in the event log, of the status of the auxiliary supply.

3.4.6.5   An auxiliary supply fail function shall be provided; it shall operate an alarm output with a user selectable delay of 0 s to 300 s, in steps of 1 s to alarm and to reset

3.4.6.6   Loss or restoration of the auxiliary supply voltage, and under-voltage conditions in the auxiliary supply shall not result in damage or spurious operation of the equipment.

3.5   Configuration port

3.5.1   General

3.5.1.1   # A configuration port shall be provided on the front panel of the recloser control to facilitate local configuration

3.5.1.2   # The use of dongles is not acceptable.

3.5.1.3   The configuration port shall be either an Ethernet and USB, or USB and RF link compatible port.s.

3.5.1.4   USB ports shall be in accordance with the following:

3.5.1.5   The configuration port shall be a standard type "B" socket to make provision for the use of a standard USB printer cable with a type "A" connector at the PC and a type "B" connector at the recloser control.

3.6   Electronic control equipment

3.6.1   GPS with antenna

3.6.1.1 The control cabinet shall be fitted with a GPS with external antenna in accordance with the requirements specified in 240-71084644 (34-889): Part 2 – Tele-control requirements.

3.6.2   General

3.6.2.1   The recloser control shall be equipped with a battery backed up real time clock with leap year support.

3.6.2.2   It shall be possible to set the clock via the configuration software and via a DNP3 master simulator (connected locally) to within 1 ms of the synchronisation clock.

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

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

3.6.2.5   The real time clock battery, or other power source, shall provide at least 25 days of total standby time. The power source should not need replacing more often than every ten years.

3.6.2.6   # The controls shall not suffer any damage if one or more poles of the circuit-breaker fail to respond to either a trip or a close command.

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

3.6.2.8   # The CPU shall be monitored by an independent hardware watchdog circuit which must perform a complete reset of the recloser control should the CPU malfunction. The unit must log the occurrence of such a reset.

3.6.2.9   # Trip circuit supervision shall be provided and it shall be monitored in the circuit-breaker open and closed position.

3.6.2.10 Electronic modules shall be suitably protected against voltage surges. Details of the on-board surge protection shall be provided in the tender documentation.

3.6.2.11 The equipment housed inside the control cabinet shall be capable of withstanding the heating effect of direct solar radiation, as specified clause 3.1.1d), without causing failure and/or mal-operation.

3.6.2.12 The maximum expected temperature inside the control cabinet, under the service conditions defined in clause 3.1.1, shall be stated in the tender documentation. An explanation of how this temperature was calculated or estimated shall also be provided.

3.7   Protection characteristics

Note: Overcurrent (O/C) elements not applicable/active in SWER controller, only earth fault (E/F) and sensitive earth fault (SEF).

3.7.1   General

3.7.1.1   #A harmonic current inrush restraint function, approved by the purchaser, shall be supplied. The supplier shall describe the method offered in the tender documentation.

3.7.1.2   The ratio of drop-off current to pick-up current shall be at least 95 % for all protection functions. (Idrop-off / Ipick-up x 100% ≥ 95%)

3.7.1.3 #The E/F and SEF functions shall be equipped with harmonic filtering to prevent operation when harmonics are present in the primary residual earth currents. A low-pass filter shall be supplied, with:

a) 2nd harmonic rejection > 6 : 1; and

b) 3rd harmonic rejection > 50 : 1.

Both the SEF function and its filter shall be described in the tender documentation.

3.7.1.4 #All protection functions, i.e. overcurrent (O/C), earth fault (E/F) and sensitive earth fault (SEF) shall have elements with characteristics that comply with IEC 60255 and IEC 62271-111. Inclusion of the traditional recloser curves will be preferred.

3.7.1.5 #The sequence of trip and auto-reclose characteristics for O/C, E/F and SEF shall be programmable to enable:

a) the selection of any combination of the available elements O/C and E/F for each trip in the trip-and-reclose sequence; and

b) separate trip-and-reclose sequence for SEF.

c) separate trip-and-reclose sequences for O/C, E/F and SEF.

3.7.1.6 #Relays shall be equipped with a function to create user definable curves.

3.7.1.7 #In order to prevent notching of an upstream electromechanical relay, which picked up for the same fault that the downstream recloser did, a disk reset function shall be provided in accordance with the following:

a) Resetting of a picked-up IDMTL or DTL protection function (O/C, E/F and SEF) by simulating the reset time of an electromechanical protection relay.

b) The preferred method of disk reset shall be according to IEC 60255-4 Class A, Class B, Class C, Long-time inverse and Short-time inverse reset curves.

c) An alternative method maybe a user defined DTL reset time (settable between 1s and 20 s).

d) The function shall be user selectable.

3.7.1.8 A zone sequence co-ordination (ZSC) feature shall be provided to ensure trip-close sequence co-ordination for combinations of rapid and delayed protection operations applied to series ARs. ZSC functionality shall be such that:

a) an AR senses the presence of an overcurrent or earth fault, as well as the clearance of that fault by another downstream device and proceeds to the next protection operation in its own sequence; secondly it proceeds in its sequence of rapid protection operations only, allowing the full number of delayed operations to be executed for in-zone conditions.

b) an alternative method maybe for the recloser to advance to a user selected sequence setting within the auto-reclose cycle.

3.7.1.9 Protection Time Current Curves (TCC) shall be selectable from standard IEC and ANSI TCC libraries. The plug setting and the time multiplier shall be selectable from the same window in the User Configuration Software.

3.7.2   Overcurrent function

Note: # Setting ranges negotiable

3.7.2.1 # Delayed protection operation shall be possible by selecting an IDMTL protection element with normal inverse (NI), very inverse (VI) or extremely inverse (EI) curve or a definite time protection element

with time delay from 0,05 s to 10 s, in 0,05 s steps, in accordance with IEC 60255 and IEC 62271-111. Inclusion of the traditional recloser curves is essential.

3.7.2.2 # The overcurrent pick-up setting range shall be selectable from 50 A to at least twice the rated load current of the circuit-breaker in step sizes not greater than 10 A.

3.7.2.3 # Rapid protection operation shall be possible by selecting a fast curve or a DTL protection element.

3.7.2.4 Co-ordination of the rapid protection elements between two devices in series shall be possible either by selecting suitable curves from a family or by addition of a selectable time increment, typically 0,05 s to 3 s, in 0,05 s steps, or any other acceptable solution.

3.7.2.5 # Long protection operating times associated with fault levels marginally above the pick-up setting of the IDMTL protection element shall be avoided by the provision of a Low Set Definite Time element with the following features:

a)   it shall be possible to enable or disable the element. When enabled it shall be active simultaneously as an overlay with all selected elements;

b)   the element shall have the same pick-up current setting as the IDMTL element; and

c)   the time delay shall be selectable from 1 s to 10 s, in 1 s steps. The time delay shall be independent of any curve manipulation.

3.7.2.6 # A High Set Instantaneous element with a selectable time delay shall be provided, with the following features:

a)   it shall be possible to enable or disable the element. When enabled it shall be active simultaneously as an overlay with all selected elements;

b)   circuit-breaker lock-out as a result of an operation due to the High Set Instantaneous element shall be selectable;

c)   the pick-up setting range of this element shall be at least 100 % to 3000 % of the overcurrent setting and shall be independent of any curve manipulation; and

d)   the time delay shall be selectable from instantaneous to 2 s, in 0,01 s steps. The time delay shall be independent of any curve manipulation.

3.7.2.7 # A cold load pick-up (CLP) feature shall be provided that allows user selectable modification of protection element characteristics under conditions of system energization. The CLP function may be provided in one of the following two ways:

a)   The pick-up current setting of the IDMTL O/C element and the Low Set Definite Time O/C element may be modified with a settable factor to increase the pick-up current of these elements for the CLP duration. The rapid O/C element should be blocked for this time.

b)   The rapid O/C element and the Low Set Definite Time O/C element could be blocked for the CLP time duration; and

3.7.2.8 # The CLP function shall have the following characteristics:

a)   the CLP function shall not in any way interfere with any of the other functions/'elements' pick-up current settings except as mentioned above;

b)   the CLP functionality shall be such that the active duration of the CLP is selectable from 0 min to 120 min in 1 min steps; and

c)   the modification factor for the O/C element should be settable from 1 to 2 in steps of 0,1. Alternatively an automatic intelligent method of CLP may be applied whereby previous load and outage time is taken into account when modifying the O/C element dynamically.

3.7.3   Earth fault function

Note: #Setting ranges negotiable)

3.7.3.1   # The earth fault setting range shall detect primary earth fault currents down to 10 A.

3.7.3.2   # Delayed protection operation shall be possible by selecting an IDMTL element with NI, VI or EI curve, or a definite time protection element with time delay from 0,05 s to 10 s, in 0,05 s steps, in accordance with IEC 60255 and IEC 62271-111. Inclusion of the traditional recloser curves is essential.

3.7.3.3   # Rapid protection operation shall be possible by selecting a fast curve or a DTL protection element. Co-ordination of the rapid protection elements between two devices in series shall be possible either by selecting suitable curves from a family or by addition of a selectable time increment, typically 0,05 s to 3 s, in 0,05 s steps, or any other acceptable solution.

3.7.3.4   # A High Set Instantaneous element with a selectable time delay shall be provided with the following features:

a)   it shall be possible to enable or disable the element. When enabled it shall be active simultaneously as an overlay with all selected elements;

b)   circuit-breaker lock-out as a result of an operation due to the High Set Instantaneous element shall be selectable;

c)   the pick-up setting range of this element shall be at least 100 % to 1500 % of the earth fault setting and shall be independent of any curve manipulation; and

d)   the time delay shall be selectable from 0,05 s to 1 s, in 0,05 s steps. The time delay shall be independent of any curve manipulation.

3.7.4   Sensitive earth fault (SEF) function

Note: # Setting ranges negotiable

3.7.4.1   # A primary earth fault current of 3 A (**Preferred 1 A)** to 20 A in steps not exceeding 1 A shall be detectable.

3.7.4.2   # Delayed protection operation shall be possible by selecting a definite time protection element with time delay from 3 s to 25 s, in 1 s steps.

3.7.5   Live Load Blocking

3.7.5.1   # The Live Load Blocking feature shall be user selectable: i.e. available/ not available.

3.7.5.2   # The Live Load blocking shall be switchable: i.e. On/Off

3.7.5.3   # ARs with the Live Load Blocking feature shall be able to define which side is source or load.

3.7.5.4   # The breaker shall not close when voltage is detected at the load side.

3.7.5.5   # Live load primary pick-up setting range shall be selectable from 2000 V to rated voltage of the device in steps of 100 V or better. An alternative method providing a proper live load detection may be accepted upon agreement with purchaser.

3.7.6   Negative phase sequence protection (NPS) (Applicable in three phase only)

3.7.6.1   The primary pick-up setting range shall be selectable from 1 A to 20 A in step sizes not greater than 0,5 A.

3.7.6.2 The time delay shall be a definite time, selectable from instantaneous to 10 s, in steps not greater than 1 s.

3.7.6.3 The NPS function shall be blocked if O/C, E/F or SEF function's starter picks up.

3.7.6.4 The NPS reset time shall be instantaneous.

3.7.6.5 The NPS function shall be user selectable to operate the following outputs:

a)   alarm output only,

b)   trip output only,

c)   both the alarm and the trip outputs.

3.7.6.6 Directional NPS functionality shall be provided.

3.7.7 Hot line tag

3.7.7.1 A hot line tag (HLT) feature shall be provided to assist live-line work.

3.7.7.2 It shall be possible to control HLT via both local and remote control.

3.7.7.3 A local and remote indication of the HLT status shall be provided.

3.7.7.4 The HLT function shall have the following characteristics:

a)   when HLT is activated only a single trip to lockout shall be allowed, but local and remote closing, as well as auto-reclosing shall be disabled;

b)   HLT shall enable a user configurable time-current curve;

c)   it shall be possible to deactivate HLT locally or remotely regardless of which control source activated it. Protection against unwanted deactivation via remote control will be achieved by turning off the Supervisory switch.

d)   the HLT function shall not in any way interfere with any of the other functions except as mentioned above.

3.7.8 Under- and over-frequency protection

Preference shall be given to relays with the following frequency protection functionality.

3.7.8.1 The frequency protection function shall have an over -and an under-frequency setting and a DTL timer.

3.7.8.2 As the power system frequency drops below the set under-frequency level the DTL timer shall start and initiate a trip and lockout on timing out. Similarly, as the frequency exceeds the set over-frequency level a trip and lockout shall be initiated.

3.7.8.3 A user selectable blocking function should be provided that will prevent the breaker from closing when the measured frequency is outside the under- and over-frequency settings,

3.7.8.4 A user selectable auto-reclosing function should be provided that will allow auto-reclosing of the breaker after the frequency has returned to normal, only if the breaker tripped as a result of an under- or over-frequency condition. In addition, a user settable timer should be provided for setting an auto-reclose time delay on return of normal frequency. The time delay shall be settable with a range of 0 s to 300 s in steps of 30 s.

3.7.8.5 The frequency protection function shall comply with the following criteria:

a)   the under frequency setting range shall be between 45 Hz and 50 Hz in steps of 0.05Hz;

b)   the over frequency setting range shall be between 50 Hz and 55 Hz in steps of 0.05Hz;

c)   the definite time delay shall be settable with a range of 0 s to 5 s in steps of 0.02 s;

d)   the frequency function pick-up time shall be better than 0.1 s;

e)   the accuracy of the frequency measurement shall be better than ± 10 mHz;

f)   the reset time shall be instantaneous;

g)   the element shall have a reset difference (i.e. hysteresis) of between 30mHz and 50mHz;

h)   it is preferred that the element shall include under voltage blocking that is settable between 0.3 and 0.9 x Vn;

3.7.9   Under- and over-voltage protection

3.7.9.1 The voltage protection function shall have an over- and an under-voltage setting and a DTL timer.

3.7.9.2 As the power system voltage drops below the set under-voltage level the DTL timer shall start and initiate a trip and/or alarm on timing out. Similarly, as the voltage exceeds the set over-voltage level a trip and/or alarm shall be initiated.

3.7.9.3 The voltage protection function shall comply with the following criteria:

a)   the under- & over voltage pick-up setting range shall be between 0 V and 300 V secondary in steps of 0.1 V; the steady-state pick-up accuracy should be ±2V and ±5% of setting;

b)   the definite time delay shall be settable with a range of 0 s to 300 s in steps of 1 s;

3.7.9.4 The voltage protection function shall be user selectable to operate the following outputs:

a)   alarm output only,

b)   trip output only,

c)   both the alarm and the trip outputs.

d)   breaker close blocking when measured voltage is outside the under- and over-voltage settings,

e)   auto-reclosing of breaker after voltage returned to normal, only if the breaker tripped as a result of an under- or over-voltage condition. In addition, a user settable timer should be provided for setting an auto-reclose time delay on return of normal voltage. The time delay shall be settable with a range of 0 s to 300 s in steps of 30 s.

3.7.10   Auto-reclose operation parameters

3.7.10.1 # The number of sequential trips to reach lockout shall be selectable to be 1, 2, 3 or 4.

3.7.10.2 # The reset time shall be selectable from 5 s to 180s in 1 s steps.

3.7.10.3 # Dead times shall be separately selectable for SEF and the combination of overcurrent and earth fault functions. The dead time between each successive reclosure shall be independently selectable from 0.5 s to 10 s (in steps no greater than 0,5 s) for the first reclosure and from a minimum of 10 s up to a maximum of 1800 s (in steps no greater than 1 s) for subsequent reclosures.

3.7.10.4 # A close instruction initiated locally or remotely during a dead time shall result in lockout if the fault is still present upon closure.

3.7.10.5 ARs with single and three pole tripping capability will be preferred. The ARC functionality for single and three pole tripping shall be user selectable throughout the ARC sequence.

3.7.10.6 ARs with single pole tripping capability shall indicate the contact states such that the Closed bit will be true when one or more of the contacts are closed and the Opened bit will be true when one or more of the contacts are open.

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3.7.11 Loop Automation.

3.7.11.1 Loop Automation feature shall be user selectable: i.e. available/ not available.

3.7.11.2 Loop Automation shall be switchable: i.e. On/Off

3.7.11.3 The breaker shall not close on to a fault while busy with the restoration process.

3.7.11.4 Loop Automation shall be linked to the Auto Reclose On/Off function, if Auto Reclose is switched off Loop Automation must also be Off.

3.8 Measurement functions

3.8.1 The characteristics of the measurement functions shall be as follows:

3.8.1.1 Measurements shall be done using the three-phase four-wire (3P4W) method or single-phase two-wire (1P2W) for SWER. The measurement system shall therefore utilise one/three current sensors to measure line current (red, white, blue phase or single phase (SWER)) and one/three voltage sensors measuring phase-to-neutral voltages (red-to-neutral, white-to-neutral, blue-to- neutral or single phase (SWER).

3.8.1.2 Quantities to be measured/calculated (with accuracy as specified) are:

a)   voltage (r.m.s.) [kV]: - phase-to-phase and phase-to-neutral voltage of all one/three phases on the source and load side of the circuit-breaker;

- magnitude and phase angle shall be indicated;

- accuracy: ± 0.5 % of the circuit-breaker's rated voltage.

b)   current (r.m.s.) [A]: - line current per phase;

- range: 0 to 1.1 ± full load;

- magnitude and phase angle shall be indicated;

- accuracy: ± 0.5 %.

c)   active power [kW]: - per phase and one/three-phase power;

- forward and reverse power flow shall be indicated (e.g. ±);

- accuracy: ± 0.5 %.

d)   apparent power [kVA]: - per phase and one/three-phase power;

- forward and reverse power flow shall be indicated (e.g. ±);

- accuracy: ± 1 %.

e)   reactive power [kVAr]: - per phase and one/three-phase power;

- forward and reverse power flow shall be indicated (e.g. ±);

- accuracy: ± 2 %.

f)   active energy [kWh]: - one/three-phase energy ((see clauses 3.8.1.4 & 3.8.1.5));

- provide separate registers for forward and reverse energy;

- accuracy: class 0.5.

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g) reactive energy [kVArh]: - one/three-phase energy ((see clauses 3.8.1.4 & 3.8.1.5));

- provide separate registers for forward and reverse energy;
- accuracy: class 2.

h) power factor: - leading or lagging magnitude shall be indicated;

- accuracy: ± 3 %.

i) peak current (r.m.s) [A]: - for the quantities in b, as indicated above (see clause 3.8.1.3);

- registers shall be resetable locally and remotely;
- accuracy: ± 3 %.

j) maximum demand: - for the quantities in c and d, as indicated above (see clauses 3.8.1.4 & 3.8.1.5);

- registers shall be resetable locally and remotely;
- provide separate registers for forward and reverse power flow;
- accuracy: ± 3 %.

3.8.1.3   It will be preferred if peak current measurements are recorded when a user selectable threshold value is exceeded. The maximum attained value, the duration that the threshold value was exceeded and the time and date when it occurred should be recorded.

3.8.1.4   The energy and maximum demand measurements shall be integrated with respect to time, with selectable time integration periods of 15 min, 30 min or 60 min. These integrating periods shall not be of a "sliding window" type but will be fixed block intervals starting on the hour.

3.8.1.5   The data buffer for the energy and maximum demand measurements 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.

3.8.1.6   The ability to display (locally and remotely) the following quantities will be preferred, the magnitude and the phase angle should be displayed:

a) positive phase sequence voltage,

b) negative phase sequence voltage (three phase only),

c) zero phase sequence voltage,

d) positive phase sequence current,

e) negative phase sequence current (three phase only), and

f) zero phase sequence current.

3.9 Local controls and indications

3.9.1 The local controls and indications shall be as given in Table 3.

Table 3: Minimum standard of local controls and indications

1	2	3
Item	**Features**	**Remarks**
Local controls (See note 1)	Breaker CLOSE/TRIP & LO	Secure control
	Supervisory ON/OFF	Secure or Toggled control (see note 3)
	ARC ON/OFF	Secure or Toggled control
	SEF ON/OFF	Secure or Toggled control
	E/F ON/OFF	Secure or Toggled control
	Hot line tag ON/OFF	Secure or Toggled control
	Alternative setting groups 0,1, 2 & 3	Toggle or Pulse control
Local indications (See note 1)	Supervisory ON/OFF	See note 3
	ARC ON/OFF	-
	SEF ON/OFF	-
	E/F ON/OFF	-
	Hot Line Tag ON/OFF	-
	Alternative setting groups 0,1, 2 & 3	-
	Breaker OPEN	-
	Breaker CLOSE	-
	ARC LOCKED-OUT	-
	NPS Alarm (three phase only)	-
	NPS Trip (three phase only)	-
	Frequency Trip	-
	Auto frequency restore	-
	Voltage Alarm	-
	Voltage Trip	-
	Auto voltage restore	-
	Protection Pick-up Alarm	-
	Protection operation	
	Controller not healthy	See note 2
	Trip circuit not healthy	See clause 3.7.9
	Gas alarm	If applicable
	Loss of system voltage	See clause 3.8.9
	Auxiliary supply fail	See clause 3.5.6.6
	Battery low	See clause 3.5.5.6
	Charger fail	-

1	2	3
Local indications (continued) (See note 1)	Operation counter	See clause 3.12.5.1 Displayed immediately (i.e. requiring no keystrokes)
	Fault counters	See clause3.12.4.2 Displayed immediately (i.e. requiring no keystrokes)
	Duty cycle record	See clause 3.12.6
Local analogue indications (See note 1) Local analogue indications (continued) (See note 1)	Voltage	As per clause a))
	Current	As per clause b)(2)
	Active power	As per clause c))
	Apparent power	As per clause d))
	Reactive power	As per clause e))
	Active energy	As per clause f))
	Reactive energy	As per clause 0)
	Power factor	As per clause h))
	Peak current	As per clause i))
	Maximum demand	As per clause j))
	Positive phase sequence voltage	See clause 3.8.1.6
	Negative phase sequence voltage (three phase only)	
	Zero phase sequence voltage	
	Positive phase sequence current	
	Negative phase sequence current (three phase only)	
	Zero phase sequence current	

Note 1: The local control and the local indication features on the control panel shall be labelled as presented in column 2, where applicable. The type of switch used for local control shall not allow for a conflict to exist between the switch position and the function status. All quantities, except maximum demand, to be update continuously.

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

Note 3: The switch shall allow the recloser control to be set in the following modes:

1) Supervisory On: In this mode a local operator can trip the AR and change the mode. A remote operator can trip and close the AR and change configuration parameters. All reporting functions are active.

2) Supervisory Off: In this mode a local operator can trip and close the AR and change configuration parameters. A remote operator cannot perform any controls. All reporting functions are active.

3.9.1.1 # The circuit-breaker shall be provided with an external lever to permit manual operation, using an insulated operating stick, to open and automatically lock-out the circuit-breaker from ground level. Where the lever is not solidly connected to the contact mechanism, the position of the external lever must be indicated to the control unit by a micro-switch and this indication must be available in the database as a separate indication.

3.9.1.2 # The circuit-breaker status shall be clearly visible from ground level. "Opened" shall be indicated with a white "O" or "OPEN" on a green background. "Closed" shall be indicated by a white "I" or "CLOSE" on a red background. Alternative indications shall be subject to approval by the purchaser.

3.9.1.3 # Full control and indication shall be immediately available on opening the door of the control cabinet. The local indications may power down if no keystrokes are registered for a period of fifteen minutes. A "wake-up" button that has to be pushed before any controls may be executed is NOT acceptable.

3.9.1.4 It shall be possible to change all the user selectable settings via the local HMI and via configuration software.

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

3.9.1.6 Password protection against unauthorised changes shall be available. Separate passwords for the Protection and Tele-control settings are required.

3.9.1.7 Switches used for local control shall offer the type of control described in Table 3 i.e. secure or toggled control. Electronic keypad controls shall offer 'quick key' (maximum of one keystroke) access to the controls in Table 3 if not implemented with switches.

3.9.1.8 Easily available (i.e. maximum of one keystroke) local indication of protection operation shall be provided for at least the last operation of the AR. The function, the phase involved (indicated by A, B or C) and the magnitude of the measured quantity shall be indicated.

3.9.1.9 A local trip indication, requiring no keystrokes, shall be provided. The trip function (e.g. O/C, E/F, SEF, NPS, etc.) and the phase involved (e.g. A, B or C) shall be indicated and shall remain visible until reset locally or remotely.

3.9.1.10 # The option shall be available to link the SEF and E/F controls as illustrated in Table 4. This linkage shall apply regardless of the source of the control i.e. via Tele-control, via the Operator panel or via the Configuration software.

Table 4: Truth for SEF and E/F Control

1	2	3	4	5
Initial state of controls		**Change state of control (action taken)**	**Required result**	
SEF	E/F		SEF	E/F
OFF	OFF	Switch E/F function ON	OFF	ON
OFF	OFF	Switch SEF function ON	ON	ON
OFF	ON	Switch E/F function OFF	OFF	OFF
OFF	ON	Switch SEF function ON	ON	ON
ON	ON	Switch E/F function OFF	OFF	OFF
ON	ON	Switch SEF function OFF	OFF	ON
In short this table says: "turning SEF ON must also turn E/F ON and turning E/F OFF must also turn SEF OFF"				

3.9.2   ARs using gas, as an insulating medium shall:

3.9.2.1 Provide a low gas pressure indication at a gas pressure that enables safe operation of the AR.

3.9.2.2 Provide a user selectable function to open and lockout the AR under the above described condition.

3.9.2.3 Provide a method to block all trip and close signals in the event of the gas pressure dropping below a safe pressure.

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3.9.2.4 Details of the low gas pressure alarm/block philosophy shall be provided in the tender documentation.

3.9.2.5 A user selectable Local Close Delay (Hit and Run) function shall be provided:

3.9.2.6 The delay will only be initiated when a local close instruction is issued from the front panel.

3.9.2.7 The time delay shall be selectable from 0 s to 20 s, in 1 s steps.

3.10 Remote controls and indications

The remote controls and indications shall be as specified in 240-71084644 (34-889): Part 2 – Tele-control requirements.

3.11 Remote device communication standard for data retrieval and remote access

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

3.12 Local engineering

3.12.1 Up loading of Protection and Tele-control databases

3.12.1.1 The option to upload user selectable segments of the database shall be provided.

3.12.1.2 It shall be possible to upload the Protection and Tele-control databases separately.

3.12.2 Setting file data exchange

3.12.2.1 The auto-recloser settings application software shall provide an import/export facility that will allow protection and communication settings data to be exchanged with a third-party settings management software database. The Purchaser presently uses DigSilent StationWare for this purpose.

3.12.2.2 The Supplier shall demonstrate the bidirectional exchange of protection and communication settings between the auto recloser setting/configuration software and a Microsoft Excel spreadsheet.

3.12.2.3 The file format for settings file data exchange shall be open source and made available to other software developers.

3.12.2.4 Acceptable formats for the data exchange are:

a)   ASCII text file;

b)   *.xml file format with published style sheets;

c)   Microsoft Excel file format;

d)   Extended Relay Interface by Omicron (XRIO) format; and

e)   Comma Separated Value (CSV) file format.

3.12.2.5 The Supplier shall provide Microsoft Excel-based setting sheets for the auto-recloser with separate columns for the setting name, actual setting and setting range and step sizes. The Excel worksheet shall be equipped to export settings into a format suitable for direct import into the auto-recloser setting/configuration software.

3.12.2.6 The Supplier shall provide a setting template for application with DigSilent StationWare settings management software.

3.12.3 Memory storage

Non-volatile memory storage shall be sized to store the following data as a minimum:

a)   all operating, protection and tele-control parameters;

b)   metering data as defined in clause 3.8;

c)   an event record as defined in clause 3.12.4 and

d)   counters as defined in clause 3.12.4.1.

3.12.4 Event record

3.12.4.1 Each AR shall include a sequence of event recorder that can log any settings change; settings group change; protection pickup or trip operation; or change in circuit-breaker and/or input and output status. Local and remote control actions (both manual and automatic) shall be logged.

3.12.4.2 The sequence of event recorder shall be capable of recording the maximum phase and neutral currents associated with over current, earth fault and sensitive earth fault protection "pick-up and trip" and "pick-up and drop-off" events.

3.12.4.3 The signals whose state changes are to be captured in the sequence of event recorder shall be programmable.

3.12.4.4 Events shall be date and time stamped to 1 ms resolution relative to the on-board real time clock and shall be recorded sequentially and chronologically. The year shall be recorded as a four digit number.

3.12.4.5 The naming of the events in the event recorder shall be consistent with those used on the operator panel and those reported via the communications protocol.

3.12.4.6 The AR shall store at least 1 000 events. Events shall be stored using the First In – First Out principle.

3.12.4.7 To enable uploading of the event data without re-loading of previously loaded data, the following is required**:**

3.12.4.8 the default upload standard shall be such that the configuration software shall first establish up to which point the event recorder of the particular device was last read and then only download the more recent events;

a)   the block of events that must be uploaded shall be user selectable with a defined stop and start date;

b)   registers shall not clear automatically after uploading of data

3.12.4.9 It shall be possible to save the sequence of events download from an AR in xml (e.g. COMFEDE as require in IEC 60255-24) and/or text formats. Sequence of events lists which can only be viewed using vendor-proprietary software are not acceptable.

3.12.5 Counters

An operations counter and fault counters shall be provided in accordance with the following:

3.12.5.1 Operation counter

a)   # the operation counter shall provide a record and indication of all mechanical operations, i.e. a summation of all Open operations of the circuit-breaker;

b)   # it shall be possible, under password control, to manually edit the counter and

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c)   the preferred location of the register in which the operation counter's data is stored, is onboard the circuit-breaker.

3.12.5.2 Fault counters

a)   # fault counters shall be provided, per protection function, e.g. O/C, E/F, SEF, etc. ;

b)   # fault counters shall provide a record and indication of all Protection initiated trips, i.e. a summation of all Protection initiated trips, per Protection function and

c)   it shall be possible to reset each fault counters.

3.12.6   Duty cycle record

A duty cycle record shall be provided in accordance with the following:

a)   # the duty cycle record shall provide a record and indication of the life cycle status of the breaker's contacts, taking into account the actual interrupted current, e.g. I2t (details of how the life cycle status is established shall be provided in the tender documentation);

b)   # it shall be possible, under password control, to manually edit the counter and

c)   the preferred location of the register in which the duty cycle record's data is stored, is onboard the circuit-breaker.

3.12.7   External interface module

3.12.7.1 An external interface module, suitable for the receipt of an external trip and close signal, shall be provided as an optional accessory.

3.12.7.2 An external interface module, suitable for the receipt of an external current and voltage signal, shall be provided as an optional accessory.

or

3.12.7.3 an external interface module, suitable for the receipt of an external trip and close, current and voltage signal, shall be provided as an optional accessory.

3.12.7.4 Power for the external interface module must be supplied by the controller. The Aux and battery supply shall be provided on separate spring loaded terminals in the control box to be used as wetting voltages for the external interface module (I/O).

3.12.7.5 The external interface module shall be provided in accordance with the following:

a)   at least one trip and one close input shall be provided, four separate tripping/closing inputs are preferred (e.g. for use in transformer protection applications: winding temperature, oil temperature, Buccholz trips, etc.);

b)   the pick-up time shall be less than 10 ms;

c)   an input modules providing its own wetting supply (e.g. detection of a potential free contact status) is preferred. External wetting supplies (24Vdc - 250Vdc and 110Vac - 230Vac) shall also be accommodated;

d)   local indication of external trips (discrete per input) shall be provided;

e)   external trips shall be logged in the event recorder and

f)   the ability to initiate or lock-out the ARC sequence upon external trip shall be provided.

3.13   Configuration software and Firmware

3.13.1   General

3.13.1.1 # The AR shall be fully configurable from a PC, utilising the configuration software.

3.13.1.2 # Configuration software is regarded as an integral part of the AR and should therefore be included as part of the package at no additional cost.

3.13.1.3 # 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".

3.13.1.4 Configuration software releases shall be fully backward compatible with all auto-reclosers from the same range, which is less than 15 years old.

3.13.1.5 # A copy of the configuration software shall be submitted with the tender documentation.

3.13.1.6 All future updates of configuration software and firmware shall be made available to Eskom at no additional cost.

3.13.1.7 It shall be possible to perform future firmware upgrades via the local communication ports. Firmware upgrades involving EPROM replacement are not acceptable.

3.13.1.8 In the event of a change request being initiated by the supplier, all costs, except for those associated with witnessing/verification by Eskom staff, but including power system simulator testing (where applicable), shall be for the supplier's account.

3.13.1.9 The supplier shall inform Eskom of any firmware or hardware update that becomes available for used by Eskom, specifically where the update relates to a problem or deficiency which may affect its reliable or safe operation.

3.13.1.10 The supplier shall provide the Eskom technical representative with reasons for the change, shall provide details of the change, and shall declare all associated effects (e.g. impact on performance, communications, settings, and interoperability with previous versions).

3.13.1.11 Eskom shall not be obliged to undertake the evaluation of new firmware versions or new versions of hardware for each new version released by the supplier. This decision shall be taken by Eskom's appointed technical representative.

3.13.1.12 Updated firmware or hardware shall not be considered for evaluation by Eskom unless supported by an updated manual describing all new or altered features.

3.13.1.13 The release of future (i.e. after initial evaluation and acceptance) versions of software and firmware to Eskom shall be in accordance with Unique Identifier 240-64685228.#

3.14   Commissioning and fault finding

a)   Wiring of serial cables in the control cabinet shall permit the connection of a temporary protocol monitor.

b)   It shall be possible to perform secondary injection testing while the AR is communicating with the Tele-control master.

c)   The AR shall not malfunction while a radio, which is in close proximity to the AR, is transmitting via an antenna; even if the control cabinet door is open.

d)   It shall be possible to disconnect the circuit-breaker and connect a circuit-breaker simulator to the recloser control for testing purposes. The simulator shall accept three external currents and six voltages from an external test set. The external simulator must have a stop contact to simulate the main breaker contact status.

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e)   If specialized test equipment are required:

1)   the cost of these units shall be provided in the tender documentation and

2)   a detailed drawing of the control cable pin-outs shall be provided.

3.15   Product training

a)   # The supplier shall provide comprehensive training courses to enable Eskom to configure, program, operate, diagnose faults and fully maintain the offered auto-reclosers.

b)   # The language medium for the training courses shall be English.

c)   Three training modules, structured in accordance with Table 5, shall be provided.

Table 5: Training modules per Region

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 town see notes	Details on full functionality and settings	1
2	Telecontrol Engineers & Technicians	1 day	10 per town see notes	Details on full functionality and settings	1
3	Operators & Field services engineers	½ day	50 per town see notes	Functionality required for operators	5
4	Workshop & maintenance staff	1 day	10 per town see notes	Details of maintenance	1

NOTE:

1)   All training must be conducted separately within the boundaries of each of the following cities: Bloemfontein, Cape Town, East London, Johannesburg, Kimberly, Nelspruit, Polokwane (Pietersburg) and Pietermaritzburg.

2)   The transport and accommodation costs, for Eskom staff, will be for Eskom's account.

3)   - Training venues can be provided by Eskom, if required.

d)   The cost per training module, structured in accordance with Table 5, shall be provided with the tender documentation.

e)   Training manuals for each module shall be submitted with the tender documentation.

3.16   Additional information

3.16.1   General

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

b)   All text based documents shall be provided in Microsoft Word (.doc) or Adobe Reader (.pdf) formats;

c)   All drawings shall be provided in Adobe Reader (.pdf) format and all dimensions shall be indicated in millimetres.

3.16.2   Drawings

The following drawings shall be submitted (critical dimensions and specified dimensions shall be clearly indicated):

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3.16.2.1 Circuit-breaker

a)   general outline drawing of the circuit-breaker;

b)   drawing of the circuit-breaker's mounting bracket;

c)   drawing of bushing and terminal clamp/arrangement;

d)   drawing of the circuit-breaker's rating plate;

e)   drawing of surge arrester mounting bracket and

f)   drawing of the circuit-breaker with surge arresters fitted, using the surge arrester dimensions given in 3. The minimum phase-to-earth clearances shall be indicated on the drawing. External voltage sensors shall also be indicated on the drawing, if applicable.

3.16.2.2 Recloser control

a)   general outline drawing of the control cabinet;

b)   drawing of the control cabinet's mounting bracket;

c)   drawing of the control cabinet's rating plate;

d)   drawing of control cabinet's internal layout;

e)   drawing of the front panel layout and

f)   drawing of allocated space for the user's communication equipment

3.16.2.3 Schematics

a)   internal components and wiring diagram of the circuit-breaker;

b)   modules and wring diagram of the recloser control;

c)   module sub-rack and recloser control wiring diagram including functions and designations of the terminal blocks/connectors;

d)   control cable pin-outs;

e)   details of terminals and terminal connectors;

f)   block schematic diagrams showing the functional arrangement of the IRTU system and

g)   functional diagrams showing the overall operation of the equipment.

3.16.3   Technical manuals

The following technical manuals shall be submitted:

a)   installation, operation and maintenance manual for the circuit-breaker;

b)   installation, operation and maintenance manual for the recloser control and

c)   user's guide for the configuration software.

3.16.4   Technical support

3.16.4.1 Successful suppliers shall offer comprehensive local support to Eskom.

3.16.4.2 The following information shall be submitted with the tender documentation:

a)   details on how this support will be provided;

b)   details of local support centres, including testing capabilities, facilities (e.g. offices, workshops, warehousing, etc.), etc.;

c)   details of local support staff, i.e. names, function, qualification, experience, etc. and

d)   details of the process that will be followed to track failed components which are submitted for repair.

e)   Specifies that a detailed spares handling and repair process must be submitted by tenders.

3.16.5 Accessories and spares

A list of recommended accessories, spares and tools shall be submitted with the tender documentation, in accordance with the following:

a)   only components that are unique and deemed to be necessary (i.e. it is expected that Eskom will require the component during the duration of the contract) should be listed;

b)   the product code for each component on the list shall be indicated;

c)   a brief description of the function of each component on the list shall be provided;

d)   prices shall be quoted for each component on the list.

e)   The following is a typical list, items marked with an asterisk shall be included as a minimum:

- *Complete circuit-breaker
- *Complete recloser control
- *Control cabinet enclosure
- *Control cable
- *Battery
- *Bushings or breaker-pole
- *Control relay
- *Internal control modules, if applicable

3.16.6 Service history

Details of the auto-recloser's service history shall be submitted with the tender documentation, in accordance with the following:

a)   how many units are in service, where are they and for what period have they been installed; and

b)   customer names, email addresses and telephone numbers.

3.17   Tests

3.17.1 Type tests

3.17.1.1 Test records (on identical equipment) in the form of validated copies of test reports, issued by a recognised testing authority, shall be submitted with the tender documentation.

3.17.1.2 The AR shall have been type tested in accordance with, and found to comply with, the requirements of IEC 62271-111 (IEEE C37.60) for the following tests:

3.17.1.2.1 Insulation (dielectric) tests:

a)   power frequency withstand voltage test and

b)   lightning impulse withstand voltage test.

3.17.1.2.2 Switching tests:

a) load switching tests;

b) line charging current test and

c) cable charging current test.

3.17.1.2.3 Making current capability (verified with standard operating duty test).

3.17.1.2.4 Rated symmetrical interrupting current tests:

a) interrupting performance (automatic operation);

b) verification of rated symmetrical interrupting current (verified with standard operating duty test) and

c) standard operating duty test (automatic operation).

3.17.1.2.5 Minimum tripping current tests

3.17.1.2.6 Partial discharge (corona) tests (applicable to ARs using non-restoring dielectric as the primary insulation (e.g. solid dielectric)).

3.17.1.2.7 Radio influence voltage tests (applicable to ARs using self-restoring dielectric as the primary insulation (e.g. oil, gas & air)).

3.17.1.2.8 Temperature rise test.

3.17.1.2.9 Time–current tests

3.17.1.2.10 Mechanical duty test

3.17.1.2.11 Control electronic immunity withstand capability test in accordance with IEC 61000:

3.17.1.2.12 Condition of AR after each test of clause 3.17.1.2.2 and clause 3.17.1.2.4.

3.17.1.3 Short–time withstand current test in accordance with IEC 60694.

3.17.1.4 The circuit-breaker shall have been type tested in accordance with **240-75661213 (DPC 34-216)**, KIPTS natural ageing and pollution performance test standard for outdoor insulator products, Section 4 – Particular requirements for other insulator products.

Supplier to provide either a

a) A valid KIPTS certificate (provided that the item on offer is the exact same item that was tested and passed at KIPTS)

   or,

b) A 1000 hour salt fog test as per IEC 62217:

   Reference reports for test certificates from a recognized, independent testing authority indicating compliance with the IEC 61109, "Insulators for overhead lines – Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1 000 V – Definitions, test methods and acceptance criteria", Edition 2 (2008-05), which includes successful 1000 hour salt-fog tracking and erosion test as per IEC 62217, "Polymeric HV insulators for indoor and outdoor use — General definitions, test methods and acceptance criteria", Edition 2 (2012-09),

   and

Pollution Curves as per Approach 2 recommended in IEC TS 60815 – 1:

Reference reports from a recognized, independent testing authority, on test insulator (with identical insulation to that of the insulator to be supplied) pollution $U_{50\%}$ withstand voltage curves at three pollution levels - *SDD* of 0.06; 0.12 and 0.48 mg/cm^2 with *NSDD* of ≥ 0.1 mg/cm^2 performed for polymeric insulators according to the modified Solid Layer test method (with pre-conditioning procedure, and with/without recovery) according to Cigre TB 555, "ARTIFICIAL POLLUTION TEST FOR POLYMER INSULATORS", WG C4.303, (2013-10) and Cigre TB 691, "POLLUTION TEST OF NATURALLY AND ARTIFICIALLY CONTAMINATED INSULATORS", WG D1.44, (2017-07).

The test insulator pollution U50% withstand voltage results above is then converted into flashover stress along the test insulation length HT as $\frac{U_{50\%}}{H_T}$ in kV/m and presented as three point approximated power law curves against pollution level SDD in mg/cm2 as per graph below.
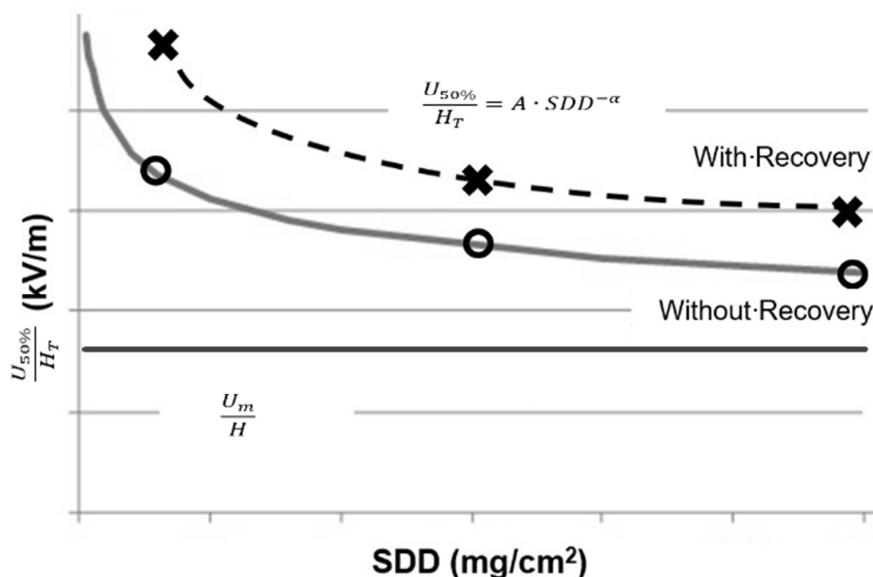
- **Figure 1: Flashover Stress along the test insulation length graph**

$\frac{U_m}{H}$ is calculated in kV/m using its insulation length *H*, and U_m the highest system r.m.s. phase to phase voltage that the insulator to be supplied will be subjected to.

This insulator will be accepted if $\frac{U_{50\%}}{H_T} > \frac{U_m}{H}$ in the *SDD* range:

- 0.12 to 0.48 mg/cm^2 for use in Heavy to Very Heavy environments

Insulator pollution flashover performance curve constants *A* in kV/m and *α* is to be determined for the equation $\frac{U_{50\%}}{H_T} = A \cdot SDD^{-\alpha}$ for use by Eskom along with SPS in the statistical approach as per Annex G "Deterministic and statistical approaches for artificial pollution test severity and acceptance criteria" of IEC TS 60815-1, "Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles", Edition 1 (2008-10) so as to optimise insulation selection.

3.17.1.5 The AR's control relay shall been type tested in accordance with clause 4.2.1, 2, 3, and 4 of the Eskom standard, Unique Identifier 240-64685228. The environmental class shall be C1.

3.17.1.6 All protection curves shall have been type tested in accordance with, and found to comply with, the requirements of the following relevant standards: IEC 60255 and IEC 62271-111.

3.17.2 Routine tests

3.17.2.1 The following routine tests, in accordance with IEC 62271-111 (IEEE C37.60), shall be carried out as a normal requirement of the contract on each AR.

3.17.2.1.1 Calibration

3.17.2.1.2 Control, secondary wiring and accessory device test

3.17.2.1.3 Dielectric withstand test; 1-min. dry power-frequency

3.17.2.1.4 Partial discharge test

3.17.2.1.5 No load mechanical operation test

3.17.2.1.6 Gas leak test (gas-filled ARs only)

3.18 Marking and packaging

3.18.1 Rating plate – circuit-breaker

3.18.1.1 Each circuit-breaker shall bear a rating plate of an intrinsically corrosion-resistant material, indelibly marked with the sea-level ratings for which the equipment has been type tested.

3.18.1.2 The rating plate shall be indelibly marked with the following:

a)   manufacturer's name and/or trademark;

b)   manufacturer's product code to indicate the type/design;

c)   serial number;

d)   date of manufacture;

e)   rated maximum voltage;

f)   rated lightning impulse withstand voltage;

g)   rated continuous current;

h)   rated short-time (3 s) withstand current;

i)   rated symmetrical interrupting current;

j)   rated symmetrical making current;

k)   rated power frequency: and

l)   mass, in kilograms and

m)   coefficient label.

3.18.2 Rating plate – recloser control

3.18.2.1 Each recloser control shall bear a rating plate of an intrinsically corrosion-resistant material, indelibly marked with the sea-level ratings for which the equipment has been type tested.

3.18.2.2 The rating plate shall be indelibly marked with the following:

a)   manufacturer's name and/or trademark;

b)   manufacturer's product code to indicate the type/design;

c)   serial number;

d)   date of manufacture;

e)   rated power frequency;

f)   auxiliary supply voltage:

g)   mass, in kilograms and

h)   coefficient label.

3.18.3 Packaging

3.18.3.1 The packing shall be such as to protect the components against corrosion and damage during normal handling, transportation and storage.

3.18.3.2 Packing shall be such as to permit easy identification of the components without their removal from the packing.

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

a)   product description;

b)   product code or part number;

c)   the gross mass, in kilograms;

d)   name of manufacturer and contact details;

e)   number of components of each type in the container;

f)   address of the destination;

g)   Eskom's purchase order number and

h)   Eskom's material SAP number(s).

3.18.3.4 If the product is supplied by a third party supplier (e.g. importers, agents, etc.) the container shall also bear the following information on the outside of the container:

a)   name of the third party supplier;

b)   contact details of the third party supplier.

4.   Authorisation

This document has been seen and accepted by:

Name and surname	Designation
Sakkie van Aarde	Senior Advisor HV Plant
Eze van Tonder	MV Equipment Care Group Chairperson
Mohamed Khan	MV/LV SC Chairperson
Mfundi Songo	Senior Manager DXOPS Technology

5.   Revisions

Date	Rev	Compiler	Remarks

Date	Rev	Compiler	Remarks
March 2021	3	S van Aarde	The SWER standard were 24075660202 merge into this standard, because the single phase breaker (SWER) use the same control as the three phase breaker.
			Insulation pollution (KIPTS) requirements has been change.
			Control electronic element immunity withstand capability test in accordance with IEC 61000 has been added.
July 2016	2	S van Aarde	The following has been added or revised in this standards:
			1) 3.8.5. Live load blocking
			2) 3.8.11. Loop Automation
			3) 3.12. REMOTE DEVICE COMMUNICATION STANDARD FOR DATA RETRIEVAL AND REMOTE ACCESS
			4) 3.13.2. Setting file data exchange
			5) 3.13.4. Event record
			6) 3.13.7. External interface module
			4.15 Detailed requirements are specified for product training to ensure that comprehensive training is provided and that the cost of training can be compared on an equal basis
			4.2.8 Six voltage sensors, one per phase on the source and the load side, are specified for the circuit-breaker. This requirement is included to cater for bi-directionality and distribution automation. In the previous enquiry more than 50% of the products offered complied with this requirement at no additional cost.
			5.1.2 The latest edition of the specification IEEE C37.60 (IEC 62271-111) is utilised as the reference specification for the type test requirements
			5.1.3 A short-time withstand current test has been added
			5.1.5 Type testing of the control relay in accordance with the Eskom specification ESKASAAO4 has been added. This is a standard Eskom requirement for all Protection relays
			Annex B A type test summary report has been added
			Annex C Technical schedules (A & B) have been added to capture some basic information.
Feb 2015	1	S. van Aarde	Document reformatted, o content change. This document supersedes DSP_34-888
Aug 2012	1	I.J.J. van Aarde	4.15.3 No contents change in document except the training venues has change to towns.

Date	Rev	Compiler	Remarks
Aug 2007	0	DR Theron	The document reference number changed from SCSSCAAQ1 Rev.2 to 34-888 Rev.0, in accordance with the Eskom Corporate Document Centre's requirements.
			The specification is revised in preparation for the technical evaluation of auto-reclosers in 2008
			The specification has been divided into two parts, where Part 1 specifies the general and Protection requirements and Part 2 specifies the Telecontrol requirements.
			Significant changes have been made in Part 1 as far as the structure of the document is concerned. The majority of the clauses has been moved and regrouped under different headings in an effort to make the document more user-friendly. Therefore, although the overall 'look' of the document is significantly different, the actual changes to the requirements are minimal.
			All changes to requirements and new requirements are indicated in red text

6. Development team

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

- Sean van der Nest
- Philip De Jager
- Mohamed Khan

7. Acknowledgements

Not applicable.

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Annex A – Type test report summary sheet

Separate summary sheets should be submitted for each AR offered

Item(s) description					
Test		**Report no.**	**Test facility**	**Comments**	**Report submitted (Y/ N)**
3.17.1.2.1 a)	Power frequency withstand voltage test				
3.17.1.2.1 b)	Lightning impulse withstand voltage test				
3.17.1.2.2 a)	Load switching tests				
3.17.1.2.2 b)	Line charging current test				
3.17.1.2.2 c)	Cable charging current test				
3.17.1.2.4 a)	Interrupting performance				
3.17.1.2.4 c)	Standard operating duty test				
3.17.1.2.5	Minimum tripping current tests				
3.17.1.2.6	Partial discharge (corona) tests				
3.17.1.2.7	Radio influence voltage tests				
3.17.1.2.8	Temperature rise test				

Item(s) description					
Test		**Report no.**	**Test facility**	**Comments**	**Report submitted (Y/ N)**
3.17.1.2.9	Time–current tests				
3.17.1.2.10	Mechanical duty test				
3.17.1.2.11	Control electronic element immunity withstand capability test				
3.17.1.2.12	Condition of AR after each test of clause 3.17.1.2.2 and clause 3.17.1.2.4				
3.17.1.3	Short–time withstand current test				
3.17.1.4	Pollution performance test				
3.17.1.5	Control relay test in accordance with Unique Identifier 240-64685228.				
3.17.1.6	Protection curve tests in accordance with IEC 60255 and IEC 62271-111				

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Annex B – 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 AR that is offered.

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

Technical schedules A and B

for

Voltage: 22 kV , 19 kV   or 33 kV   (tick relevant box)

Schedule A: Purchaser's specific requirements

Schedule B: Guarantees and technical particulars of equipment offered

Item	Clause	Description	Schedule A	Schedule B
1.		**Identification**		
		1) Name of manufacturer	xxxxxxxxxxxxxx	
		2) Name of supplier	xxxxxxxxxxxxxx	
		3) Product code of circuit-breaker	xxxxxxxxxxxxxx	
		4) Product code of recloser control	xxxxxxxxxxxxxx	
		5) Configuration software: name &	xxxxxxxxxxxxxx	
		version	xxxxxxxxxxxxxx	
		6) Firmware version	xxxxxxxxxxxxxx	
2.		**Rated requirements**		
	3.1.2.	1) Nominal voltage (phase to phase) kV	xxxxxxxxxxxxxx	
	3.2.2.1.	2) AC 60 s wet withstand kV	xxxxxxxxxxxxxx	
	3.2.2.1.	3) BIL (open contacts) kV	xxxxxxxxxxxxxxxxxxx	
	3.2.2.1.	4) BIL (closed contacts) kV	xxxxxxxxxxxxxxx	
	3.2.2.2	5) Rated continuous current A	≥ 400 A	
	3.2.2.2	6) Rated short-time (3s) withstand current kA, Three Phase	≥ 12.5 kA	
		or Single Phase (SWER)	≥ 4 kA	
	3.2.2.2	7)Rated symmetrical interrupting current kA, Three Phase,	≥ 12.5 kA	
		or Single Phase (SWER)	≥ 4 kA	
	3.2.2.2	8) Rated symmetrical making current kA, Three Phase	≥ 12.5 kA	
		or Single Phase (SWER)	≥ 4 kA	
	3.2.2.3	9) Frequency Hz	50Hz	
3.		Contact operations		
		Min. guaranteed mechanical operations	xxxxxxxxxxxxxx	
		2) Min. guaranteed operations at rated continuous current	xxxxxxxxxxxxxx	
		3) Min. guaranteed operations at rated symmetrical interrupting current	xxxxxxxxxxxxxx	

Technical schedules A and B

for

Voltage: 22 kV   ,19 kV   or 33 kV   (tick relevant box)

Schedule A: Purchaser's specific requirements

Schedule B: Guarantees and technical particulars of equipment offered

Item	Clause	Description	Schedule A	Schedule B
4.		Bushings		
		1) Product code of bushing	xxxxxxxxxxxxxx	
	3.2.5.2	2) Insulation material	xxxxxxxxxxxxxx	
	3.2.5.3	Creepage distance mm	xxxxxxxxxxxxxx	
5.		Material & coating		
		1) Circuit-breaker tank	xxxxxxxxxxxxxx	
		2) Control cubicle	xxxxxxxxxxxxxx	
6		Miscellaneous		
		1) Battery type	xxxxxxxxxxxxxx	
		2)Battery voltage V	xxxxxxxxxxxxxx	
		3) Control circuit voltage V	xxxxxxxxxxxxxx	
7	**3.5.3.2**	4) Auxiliary supply voltage V	110 & 240 (AC & DC)	
8	**3.2.1.3**	5)Total mass kg	≤ 500 kg xxxxxx	
9		6) Warrantee period	xxxxxxxxxxxxxx	

Annex C – 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 34-888.

- 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:

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

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

3) 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

1	2	3
Clause	**Comply**	**Comments/Deviation**
3.1.1a) #		
3.1.1b) #		
3.1.1c) #		
3.1.1d) #		
3.1.1e) #		
3.1.2.a)		
3.1.2.b)		
3.1.2.c)		
3.1.2.d)		
3.1.2.1 #		
3.1.2.2 #		
3.2.1.1		
3.2.1.2		
3.2.1.2.1a)		
3.2.1.2.1b)		
3.2.1.2.1c)		
3.2.1.2.2		
3.2.1.2.3		
3.2.1.3		
3.2.1.4		
3.2.1.5		
3.2.1.6		
3.2.1.7 #		
3.2.1.8 #		
3.2.1.9 #		
3.2.1.10		
3.2.1.10.1		
3.2.2.1 #		
3.2.2.2a) #		
3.2.2.2b) #		
3.2.2.2c) #		
3.2.2.2d) #		
3.2.2.3 #		
3.2.3.1#		
3.2.3.2		
3.2.3.3		
3.2.3.4		
3.2.3.5		

1	2	3
Clause	**Comply**	**Comments/Deviation**
3.2.3.6		
3.2.3.7		
3.2.4.1		
3.2.4.2		
3.2.4.3		
3.2.4.4		
3.2.5.1		
3.2.5.2		
3.2.5.3.1 #		
3.2.5.3.2 #		
3.2.5.4.1		
3.2.5.4.2		
3.2.6.1		
3.2.7.1 #		
3.2.7.2 #		
3.2.7.3		
3.2.7.4 #		
3.2.8.1 #		
3.2.8.2		
3.2.8.3		
3.2.8.4		
3.2.8.4.1		
3.2.8.4.2		
3.2.8.4.3		
3.2.8.4.4		
3.2.8.5 #		
3.3.1.1		
3.3.1.2		
3.3.1.3		
3.3.1.4		
3.3.2.1		
3.3.2.2		
3.3.2.3		
3.3.2.4		
3.3.2.5		
3.3.2.6		

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Clause	Comply	Comments/Deviation
3.3.3.1		
3.3.3.2		
3.3.3.3		
3.3.3.4		
3.3.3.5		
3.3.3.6		
3.3.3.7		
3.3.4.1		
3.3.4.2		
3.3.4.3		
3.3.4.4		
3.3.4.5		
3.3.4.6		
3.3.5.1		
3.3.5.2		
3.3.5.3		
3.3.5.4		
3.3.5.5		
3.3.6#		
3.3.7.1#		
3.3.7.2		
3.3.7.3		
3.3.7.4#		
3.4.1.1.		
3.4.1.2		
3.4.1.3		
3.4.1.4		
3.4.1.5		
3.4.1.6		
3.4.2.1		
3.4.2.2		
3.4.2.3		
3.4.3.1		
3.4.3.2		
3.4.3.3		
3.4.3.4		

1	2	3
Clause	Comply	Comments/Deviation
3.4.4.1		
3.4.4.2		
3.4.4.3		
3.4.4.4		
3.4.4.5		
3.4.5.1		
3.4.5.2		
3.4.5.3		
3.4.5.4 a)		
3.4.5.4 b)		
3.4.5.4 c)		
3.4.5.4 d)		
3.4.5.5		
3.4.5.6		
3.4.5.7		
3.4.5.8		
3.4.5.9		
3.4.5.10		
3.4.5.11		
3.4.5.12		
3.4.6.1		
3.4.6.2 a)		
3.4.6.2 b)		
3.4.6.2 c)		
3.4.6.2 d)		
3.4.6.3		
3.4.6.4		
3.4.6.5		
3.4.6.6		
3.5.1.1.#		
3.5.1.2 #		
3.5.1.3		
3.5.1.4		
3.5.1.5		

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Clause	Comply	Comments/Deviation
3.6.1.1.		
3.6.2.1.		
3.6.2.2.		
3.6.2.3.		
3.6.2.4.		
3.6.2.5.		
3.6.2.6. #		
3.6.2.7.#		
3.6.2.8.#		
3.6.2.9.#		
3.6.2.10.#		
3.6.2.11.#		
3.6.2.12.#		
3.7.1.1 #		
3.7.1.2		
3.7.1.3 a) #		
3.7.1.3 b) #		
3.7.1.4 #		
3.7.1.5 a) #		
3.7.1.5 b) #		
3.7.1.5 c) #		
3.7.1.6 #		
3.7.1.7 a) #		
3.7.1.7 b) #		
3.7.1.7 c) #		
3.7.1.7 d) #		
3.7.1.8 a)		
3.7.1.8 b)		
3.7.1.9		
3.7.2.1 #		
3.7.2.2 #		
3.7.2.3 #		
3.7.2.4		
3.7.2.5 a) #		
3.7.2.5 b) #		
3.7.2.5 c) #		

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3.7.2.6 a)		
3.7.2.6 b) #		
3.7.2.6 c) #		
3.7.2.6 d) #		
3.7.2.7 a) #		
3.7.2.7 b) #		
3.7.2.8 a) #		
3.7.2.8 b) #		
3.7.2.8 c) #		
3.7.3.1 #		
3.7.3.2 #		
3.7.3.3 #		
3.7.3.4 a) #		
3.7.3.4 b) #		
3.7.3.4 c) #		
3.7.3.4 d) #		
3.7.4.1		
3.7.4.2		
3.7.5.1 #		
3.7.5.2 #		
3.7.5.3 #		
3.7.5.4 #		
3.7.5.5 #		
3.7.6.1		
3.7.6.2		
3.7.6.3		
3.7.6.4		
3.7.6.5 a)		
3.7.6.5 b)		
3.7.6.5 c)		
3.7.6.6		
3.7.7.1		
3.7.7.2		
3.7.7.3		

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3.7.7.4 a)		
3.7.7.4 b)		
3.7.7.4 c)		
3.7.7.4 d)		
3.7.8.1		
3.7.8.2		
3.7.8.3		
3.7.8.4		
3.7.8.5 a)		
3.7.8.5 b)		
3.7.8.5 c)		
3.7.8.5 d)		
3.7.8.5 e)		
3.7.8.5 f)		
3.7.8.5 g)		
3.7.8.5 h)		
3.7.9.1		
3.7.9.2		
3.7.9.3 a)		
3.7.9.3 b)		
3.7.9.4 a)		
3.7.9.4 b)		
3.7.9.4 c)		
3.7.9.4 d)		
3.7.9.4 e)		
3.7.10.1#		
3.7.10.2#		
3.7.10.3#		
3.7.10.4#		
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3.7.10.6		
3.7.11.1		
3.7.11.2		
3.7.11.3		
3.7.11.4		
3.8.1.1		

1	2	3
Clause	Comply	Comments/Deviation
3.8.1.2 a)		
3.8.1.2 b)		
3.8.1.2 c)		
3.8.1.2 d)		
3.8.1.2 e)		
3.8.1.2 f)		
3.8.1.2 g)		
3.8.1.2 h)		
3.8.1.2 i)		
3.8.1.2 j)		
3.8.1.3		
3.8.1.4		
3.8.1.5		
3.8.1.6 a)		
3.8.1.6 b)		
3.8.1.6 c)		
3.8.1.6 d)		
3.8.1.6 e)		
3.8.1.6 f)		
3.9.1.		
3.9.1.1#		
3.9.1.2#		
3.9.1.3#		
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3.9.1.5		
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3.9.1.7		
3.9.1.8		
3.9.1.9		
3.9.1.10#		
3.9.2.1		
3.9.2.2		
3.9.2.3		
3.9.2.4		
3.9.2.5		
3.9.2.6		
3.9.2.7		

1	2	3
Clause	**Comply**	**Comments/Deviation**
3.12.1.1		
3.12.1.2		
3.12.2 1		
3.12 2.2		
3.12.2 3		
3.12.2 4a)		
3.12.2 4b)		
3.12.2 4c)		
3.12.2 4d)		
3.12.2 4e)		
3.12.2 5		
3.12.2 6		
3.12.3.a)		
3.12.3.b)		
3.12.3.c)		
3.12.3.d)		
3.12.4.1		
3.12.4.2		
3.12.4.3		
3.12.4.4		
3.12.4.5		
3.12.4.6		
3.12.4.7		
3.12.4.8a)		
3.12.4.8b)		
3.12.4.9		
3.12.5.1a) #		
3.12.5.1b) #		
3.12.5.1c) #		
3.12.5.2a) #		
3.12.5.2b) #		
3.12.5.2c) #		

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3.12.6.a) #		
3.12.6.b) #		
3.12.6.c) #		
3.12.7.1		
3.12.7.2		
3.12.7.3		
3.12.7.4		
3.12.7.5 a)		
3.12.7.5 b)		
3.12.7.5 c)		
3.12.7.5 d		
3.12.7.5 e)		
3.12.7.5 f)		
3.13.1.1.#		
3.13.1.2.#		
3.13.1.3.#		
3.13.1.4.		
3.13.1.5. #		
3.13.1.6.		
3.13.1.7.		
3.13.1.8.		
3.13.1.9.		
3.13.1.11		
3.13.1.12		
3.13.1.13		
3.14.a)		
3.14.b)		
3.14.c)		
3.14.d)		
3.14 e)		
3.15 a)#		
3.15 b)#		
3.15 c)		
3.15 d)		
3.15 e)		

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Clause	Comply	Comments/Deviation
3.16.1 a)		
3.16.1 b)		
3.16.1c)		
3.16 2.1 a)		
3.16 2.1 b)		
3.16 2.1 c)		
3.16 2.1 d)		
3.16 2.1 e)		
3.16 2.1 f)		
3.16.2.2 a)		
3.16.2.2 b)		
3.16.2.2 c)		
3.16.2.2 d)		
3.16.2.2 e)		
3.16.2.2 f)		
3.16.2.3 a)		
3.16.2.3 b)		
3.16.2.3 c)		
3.16.2.3 d)		
3.16.2.3 e)		
3.16.2.3 f)		
3.16.2.3 g)		
3.16.3. a)		
3.16.3. b)		
3.16.3. c)		
3.16.4.1.		
3.16.4.2. a)		
3.16.4.2. b)		
3.16.4.2. c)		
3.16.4.2. d)		
3.16.4.2. e)		
3.16.5. a)		
3.16.5. b)		
3.16.5. c)		
3.16.5. d)		
3.16.5. e)		

1 Clause	2 Comply	3 Comments/Deviation
3.16.6. a)		
3.16.6. b)		
3.17.1.2.		
3.17.1.2.1a)		
3.17.1.2.1b)		
3.17.1.2.2a)		
3.17.1.2.2b)		
3.17.1.2.2c)		
3.17.1.2.3		
3.17.1.2.4a)		
3.17.1.2.4b)		
3.17.1.2.4c)		
3.17.1.2.5		
3.17.1.2.6		
3.17.1.2.7		
3.17.1.2.8		
3.17.1.2.9		
3.17.1.2.10		
3.17.1.2.11		
3.17.1.2.12		
3.17.1.3		
3.17.1.4 a)		
3.17.1.4 b)		
3.17.1.5		
3.17.1.6		
3.17.2.1.		
3.17.2.1.1		
3.17.2.1.2		
3.17.2.1.3		
3.17.2.1.4		
3.17.2.1.5		
3.17.2.1.6		

1	2	3
Clause	**Comply**	**Comments/Deviation**
3.18.1.1		
3.18.1.2 a)		
3.18.1.2 b)		
3.18.1.2 c)		
3.18.1.2 d)		
3.18.1.2 e)		
3.18.1.2 f)		
3.18.1.2 g)		
3.18.1.2 h)		
3.18.1.2 i)		
3.18.1.2 j)		
3.18.1.2 k)		
3.18.1.2 l)		
3.18.1.2 m)		
3.18.2.1		
3.18.2.2.a)		
3.18.2.2.b)		
3.18.2.2.c)		
3.18.2.2.d)		
3.18.2.2.e)		
3.18.2.2.f)		
3.18.2.2. g)		
3.18.2.2 m)		
3.18.3.1		
3.18.3.2		
3.18.3.3 a)		
3.18.3.3 b)		
3.18.3.3 c)		
3.18.3.3 d)		
3.18.3.3 e)		
3.18.3.3 f)		
3.18.3.3 g)		
3.18.3.3 h)		
3.18.3.4 a)		
3.18.3.4 b)		