Technical Specification

COMPLETE SET OF AUTO RECLOSER 33KV

(As per stated in TNB Technical Specification KEJ05295:2021, Rev 2)

33kV 3-POLE OUTDOOR AUTOMATIC CIRCUIT RECLOSER FOR MV OVERHEAD LINE SYSTEM

Tech Spec: KEJ05295:2021, Rev 2

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TECHNICAL SPECIFICATION

SCADA-READY 33kV 3-POLE OUTDOOR AUTOMATIC CIRCUIT RECLOSER FOR MEDIUM VOLTAGE OVERHEAD LINE SYSTEMS

Specification No.	KEJ05295:2021	Revision No.	2
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Approved by	TNB, Distribution Network Division Technical Committee Dated 23rd June 2021		

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1.0 SCOPE

1.1 This specification covers the general requirement of design, construction, electrical ratings and testing for a SCADA-Ready 33kV 3-pole outdoor automatic circuit recloser (SR-ACR) to be used in TNB medium voltage overhead line systems.

1.2 The SR-ACR and all related components and accessories shall be suitable for use in a tropical zone with high relative humidity of approximately 0% to 95% RH, heavy rainfall, ambient temperature of between 28°C to 45°C, solar radiation of 1200 W/m^3 and an average isokeraunic level of 200 thunder-days per annum.

1.3 The preferred operational altitude is up to 2,500 m above sea level.

2.0 ELECTRICAL SYSTEM

The SR-ACR shall be designed for continuous operation on a 3-phase 3-wire 33kV, 50Hz distribution overhead line systems with the star-point of the source-end transformer earthed through an arc suppression coil or neutral earthing resistor.

3.0 STANDARDS

3.1 Unless otherwise specified, this specification shall make reference to and comply with the relevant requirements of the following standards, or equivalent, together with all latest editions and/or current amendments thereof: -

a)	IEEE C37.60	:	High-voltage switchgear and controlgear – Part 111: Automatic circuit reclosers and fault interrupters for alternating current systems up to 38 kV
b)	IEC 62271-111	:	High-voltage switchgear and controlgear – Part 111: Automatic circuit reclosers and fault interrupters for alternating current systems up to 38 kV
c)	IEC 60044-2	:	Instrument transformers – Part 2 : Inductive voltage transformers
d)	IEC 61643-11	:	Surge protective devices connected to low voltage power distribution systems – Requirements and test methods

e)	IEC 61643-331	:	Components for surge protective devices – Test specification for metal oxide varistors
f)	IEC 60815-1	:	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles
g)	BS EN ISO 1461	:	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods
h)	TNB Technical Specification - KEJ08237:2013 (Rev. 01)	:	Insulating covers for 33kV pole-mounted substations
i)	TNB Technical Specification - KEJ05285:2020	:	10kA polymeric metal oxide gapless surge arrestor (Station Low) for use in 33kV overhead line systems

3.2 Other internationally recognized standards that are equivalent to the abovementioned standard can be considered provided that an English version of such standards shall be submitted to TNB for further reference.

4.0 SCADA-READY AUTOMATIC CIRCUIT RECLOSER RATINGS

a)	Nominal Voltage	33kV
b)	Rated System Voltage	36 kV
c)	Rated Continuous/Normal Current	Not less than 400A & up to 630A
d)	Rated Frequency	50 Hz
e)	Rated Short Circuit Making Current	≥ 31.5 kA_{peak}
f)	Rated Interrupting / Breaking Current	≥ 12.5 kA_{rms}
g)	Rated Short-Time Withstand Current	≥ 12.5 kA_{rms} / 3s
h)	Lightning Impulse Withstand Voltage (peak)	170 kV
i)	Power Frequency Withstand Voltage (rms)	
	✓ Dry @ 1 minute	70kV
	✓ Wet @ 10 seconds	60kV
j)	Average Ambient Temperature (Maximum)	28°C (45°C)
k)	Humidity Range	0 – 95%
l)	Preferred Altitude Requirement	Up to 1,800m
m)	Preferred Mechanical Operations	≥ 10,000 operations

n) Bushing Insulators		
✓ Total Creepage Distance	min.	576 mm
	max.	900 mm

5.0 DESIGN AND CONSTRUCTION

5.1 General

5.1.1 The SR-ACR shall be gas-insulated or with solid insulation designed for outdoor use and shall not contain any self-combustible material such as insulating oil.

5.1.2 The SR-ACR shall be hermetically sealed permanently, compact, lightweight, maintenance free, corrosion free, compatible and can be easily mounted either on H-poles or gantry structures.

5.1.3 The SR-ACR shall be packaged complete with its own self-contained operating mechanism, self-supporting control unit housed in a water-proof and dust-proof stainless steel cubicle having an IP54 degree of protection, a multi-ratio single phase 2-pole potential transformer to provide sufficient power supply for its operations, backed-up by rechargeable sealed lead acid battery, and its low voltage supply shall be effectively protected from voltage surges due to lightning.

5.1.4 Moreover, the SR-ACR shall be equipped with SCADA functionalities and shall comprise of microprocessor-based control unit for protection, metering, fault and event recording. The recording shall include date, time and value of the fault current and shall be stored in a non-volatile memory.

5.1.5 The SR-ACR shall also come with a counter to record its operations.

5.1.6 The overall design of the SR-ACR shall demonstrate ability to withstand mechanical and electrical endurance with the use of superior tropicalized materials.

5.1.7 To facilitate installation of the SR-ACR, it shall be provided with permanent lifting means and shall be equipped with integral surge arrester mounting brackets on both the SOURCE and LOAD sides.

5.1.8 The SOURCE side and LOAD side of the SR-ACR shall be indelibly marked at a suitable location to provide easy identification.

5.1.9 All steel and iron parts, if provided, shall be galvanized to protect from corrosion as per BS EN ISO 1461.

5.1.10 All non-metal parts, such as gas seals, bushings, and insulating materials, shall be UV resistant.

5.2 Operation

5.2.1 The arc interrupter contacts shall operate in vacuum and shall be sufficiently insulated by SF_6 gas or approved solid insulation and isolated from live parts for the safety of the operator.

5.2.2 The arc interrupter contacts shall be designed to withstand heavy arcing when load breaking is required or when breaking / making during a fault

5.2.3 The mechanical life of the arc interrupter shall be able to withstand a minimum of 10,000 operations.

5.2.4 The main current carrying contacts shall be so designed to ensure good electrical conductivity and to minimize pitting during operation. The design shall also ensure that a constant pressure is applied uniformly between the moving and fixed contacts.

5.2.5 The design and position of the main contacts shall avoid the accumulation of decomposed by-product and shall be maintenance-free.

5.2.6 The OPEN or CLOSE position of the SR-ACR shall be easy to see from ground level even under adverse weather condition by having a reliable, light reflecting, color-coded indicating device of the position of the arc interrupter. The words “OPEN” and “CLOSE” shall be used together with the color-coded indicator.

5.2.7 The SR-ACR shall be capable of performing the duty cycle as tabulated below:

% of Interrupting Capacity	X/R Ratio	No. of Unit Operations
15 – 20	4	44
45 – 55	8	56
90 – 100	15	16
Total Number of Unit Operations		116

5.2.8 The SR-ACR shall have adequate mechanical strength on its terminal to withstand the total forces, including wind loading and electromagnetic forces, related to its application and rating, without reduction of its reliability or current carrying capacity once it has been installed on the H-poles or gantry structures.

5.2.9 A tagging facility and/or padlocking facility shall be provided during OPEN position to avoid accidental CLOSE during maintenance.

5.2.10 The general operating requirement shall be as follows:

a. the SR-ACR shall be equipped with low voltage solenoid or magnetic actuator operating mechanism for its closing and opening operations;

b. a single-stored energy operating mechanism shall operate all phases simultaneously and that independent operations of each pole, irrespective of the state of the other poles, is not permitted;

c. the correct contact opening and closing speeds shall be achieved by mechanism design and shall be independent of the method of operation used

5.2.11 Manual closing and opening facilities shall also be provided for maintenance purpose.

5.2.12 The SR-ACR shall be designed to prevent unwanted operations such that:

5.2.12.1 the SR-ACR OPEN or CLOSE position shall remain constant despite:

a. forces arising from gravity, vibration or reasonable shock;

b. accidental touching of the connecting rods or operating devices;

c. electromagnetic forces

5.2.12.2 the SR-ACR shall have provisions to prevent unauthorized operations

5.3 Protection and Control Requirement

5.3.1 The control panel shall include control, protection and communication module.

5.3.2 The control and protection module shall comprise of a microprocessor-based control unit for protection, control, measurement, fault disturbance and event recording. The control module shall be powered up from an external source of supply (240 V AC) and backed-up by the battery (12 V DC).

5.3.3 The SR-ACR shall be provided with SCADA facilities for monitoring and control from Regional Control Centers (RCC).

5.3.4 Control and Protection Panel

5.3.4.1 The control panel shall be a weatherproof cabinet with a door that can be pad lockable. The operating temperature range of the control panel shall be 0°C to +50°C, ambient with an average of +30°C; relative humidity shall be up to 95%.

5.3.4.2 The control panel shall have an Ingress of Protection at least **IP54** and shall be designed for ease of mounting at the bottom of the pole.

5.3.4.3 A control cable of not less than **15 meters** in length shall be provided for this connection.

5.3.4.4 The LV supply to the control panel shall be protected by a surge protection device which is to be located at the incoming LV supply (separated from Power Supply Module).

5.3.4.5 The firmware and software provided shall be tested and proven in the market.

5.3.4.6 The control panel shall be equipped with the following standard features (not limited to):

a) For any operations related to protection functions and setting configurations shall be password protected.

b) Fault targets and SR-ACR status shall be conspicuously indicated at the front panel by LED indicators.

c) SR-ACR interrupter duty monitor

d) Load profile monitor

e) Demand current metering

f) Event recorder for at least 50 last historical events

g) Sequence coordination

h) Heater with thermostat control. Standard range of temperature shall be within 20-40 degree.

i) SR-ACR retry

j) Data port for connection to the computer for programming and downloading of data.

k) Dedicated data port shall be provided for external communication (i.e. SCADA).

5.3.4.7 The front panel shall have capabilities to perform manual operations (not limited to):

a) Close

b) Open

c) Protection function ON/OFF (key lock password protected)

d) Reclosing function ON/OFF (key lock password protected)

e) Remote / Local

f) Battery test

g) Navigation menu button

5.3.4.8 The control panel shall have an LCD display and/or LED indicator located on the front panel to provide local indication of the following conditions (not limited to):

a) SR-ACR Open

b) SR-ACR Close

c) Overcurrent (O/C)

d) Earth Fault (E/F)

e) Fault Current (scrolling)

f) Lockout

g) Number of reclosing

h) Current Above Minimum Trip

i) Non-Reclosing Active

5.3.4.9 Moreover, the control panel shall be equipped with an LCD display and/or LED indicator located on the front panel to provide malfunction indication of the following conditions (not limited to):

a) Failed operation (primary)

b) Internal failure

c) SF_6 gas low (if applicable)

d) AC fail

e) DC fail

f) Low battery voltage

5.3.4.10 The electronic control panel shall have the following salient features:

a) LCD with high degree of resolution and legibility, valid for life span of the SR-ACR. In the event of faulty LCD, provision to replace without replacing the whole module is possible.

b) The printed circuit board (PCB) for all modules shall be conformal coated to prevent oxidation and external short circuit.

5.3.5 Protection Functions

The SR-ACR shall be provided with the following protection functions (not limited to):

a) Over current with reclose function
b) Earth fault with reclose function
c) Sensitive Earth fault with reclose function
d) Broken conductor without reclose function. (I2/I1)
e) Directional OCEF
f) Sync checks facility
g) In-rush blocking
h) Cold Load Pickup (optional)

5.3.6 Protection Settings and Configurations

5.3.6.1 The trip settings shall be programmable within the ranges as below (not limited to):

a) Over current (O/C) - 20A to 1600A
b) Earth Fault (E/F) - 5A to 800A

5.3.6.2 The over current and earth fault time current curves shall be selectable and can be modified through:

a) Vertical shift multiplier value

b) Minimum response time delay

c) Constant time adder

d) High current trip

e) High current lockout

5.3.6.3 The following settings shall be programmable via software and accessories (communication cables) to be supplied with every SR-ACR:

a) Number of operations to lockout (1, 2, 3, 4), independently selectable for Overcurrent (O/C) and Earth Fault (E/F)

b) Recloser interval / Dead Time (0.6 to 30 sec.), independently selectable for each operation

c) Reset interval / Reclaim Time (3 to 45 sec.), after successful reclosing

d) Cold load pick-up TCC, independently selectable for both Overcurrent (O/C) and Earth Fault (E/F)

e) All protection function i.e.: overcurrent (O/C), earth fault (E/F), sensitive earth fault (SEF), broken conductor shall have elements with characteristics that comply with IEC 60255 or other relevant standards

f) All protection function shall be able to be enabled or disabled individually

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

h) All protection settings shall be stored in a non-volatile memory

i) Preferably, Time Delay for manual closing is to be provided.

5.3.7 Event / Disturbance Recorder and Measurement

5.3.7.1 Event Recorder

Any activities related to protection settings, configuration and operation of the SR-ACR shall be kept in the non-volatile memory. Event Recorder feature shall record and store at least 500 most recent events in non-volatile memory.

The event recorder shall include information on the time and date of the event occurrence, the event type and the circuit currents on all three phases and ground (this includes the fault current for an overcurrent trip event). The events recorded shall include the following:

a) Over current and earth fault trip

b) Reset

c) Close/open by manual control switch

d) Close/open by supervisory control

e) Lockout by protection operation

f) Loss of ac voltage

g) Restoration of ac voltage

h) Sequence coordination operation

All the data shall remain in the memory in the event of AC and/or DC fail.

5.3.7.2 Disturbance Recorder

a) The SR-ACR shall be able to store disturbance recorder (fault waveform) for every protection pickup or tripping.

b) Minimum requirement for each recording of the disturbance recorder shall be of 150 cycles (3 second).

c) Disturbance recording shall be recorded in the form of both report and waveform.

d) Software provided shall have the capability to extract and display fault waveform.

5.3.7.3 **Analogue Measurement**

The control panel shall have metering features, which measures and displays the following current values for three phases and ground current (not limited to):

a) Instantaneous phase currents

b) Instantaneous phase voltages

c) kWh and kVARh

d) Power factor (calculated)

e) Integrated phase current values, with a programmable integration

f) Interval of 5 or 15 minutes (settable) – load profile

g) Peak integrated demand values

5.3.8 **Interrogation Tools**

a) Personal computer (PC) interfacing accessories shall be provided together with each control panel.

b) A suitable data port to be located on the control front panel shall be provided for temporary connection with a Data Reader or personal computer.

c) A personal computer (PC) can be connected to the control temporarily via the front panel data port and used for data acquisition and also for sending new settings to the control module.

d) Software for the interrogation and configuration including for SCADA requirement such as communication port settings (enable/disable CTS, DTS, DCD, timeout, delays, etc) shall be usable for TNB's users' notebooks and compatible with the latest Microsoft Windows Operating System.

5.3.9 SCADA Indication Points

The SR-ACR shall be able to provide point lists which cover analog measurement, recloser status, control, protection alarms and recloser alarms for SCADA facilities as below (not limited to):

Type	Indication	Alarm Description
Control	Dummy Control	Dummy Control Open
		Dummy Control Close
	Automatic Circuit Recloser	Auto-recloser Open
		Auto-recloser Close
Analog	Red Phase Current	R-phase Amps
	Yellow Phase Current	Y-phase Amps
	Blue Phase Current	B-phase Amps
	Red Phase Voltage	R-phase Volt
	Yellow Phase Voltage	Y-phase Volt
	Blue Phase Voltage	B-phase Volt
	L-L Voltage (Source)	L-L Voltage (Source)
	L-L Voltage (Load)	L-L Voltage (Load)
SR-ACR Status	Dummy Control Status	Dummy Open
		Dummy Close
	Open	Auto-Recloser Open
	Close	Auto-Recloser Close
	Lockout	Auto-Recloser Lockout
	Remote	Auto-Recloser Remote
	Local	Auto-Recloser Local

Type	Voltage free indication	Alarm Description
Protection Alarms	Open (OC1) Open (OC3) Open (EF1)	Overcurrent (IDMT) Overcurrent (Hi Set) Earth Fault
	Protection Enabled	Protection On Protection Off
	Ground Enabled	Earth Fault On Earth Fault Off
	Auto-Recloser Alarms	Auto-Recloser Enabled Auto-Recloser Disabled Auto-Recloser Disconnected
	Auto- Recloser Conductor Alarm	Auto-Recloser Broken Conductor
Automatic Circuit Recloser Status	AR Open	AR Open
	AR Close	AR Close
Alarm	System Warning	Warning
	AC/DC supply	AC Failed
		Battery Failed
	Gas Pressure alarm (if applicable)	SF_6 Gas Pressure Low
	Control & Protection Module/Card	Card Alarm

5.3.10 Voltage Supply

a) A multi-ratio single phase 2-pole potential transformer of 33kV-22kV-11kV/0.24kV AC shall be supplied together with the SR-ACR to provide auxiliary power supply to the control device and shall be backed-up by rechargeable sealed lead acid battery.

b) The battery shall be capable of operating the control for a minimum of 48 hours after loss of the primary supply.

c) After this time, if the primary supply has not been restored, the control shall shut down automatically.

d) There shall be local indication and contacts for remote alarm to indicate loss of operating power.

e) Rechargeable battery shall have life span not less than 2 years and can cater external load e.g. radio or modem.

f) Three pin power supply socket single phase shall be provided according to MS standard.

5.3.11 SCADA Communication Requirements

a) The SR-ACR Controller shall support at least one of the SCADA Protocols listed below:

1. IEC 60870-5-101 in Unbalance Mode with
   i. Link Address Size = 2 Octet
   ii. Common Address Size = 2 Octet
   iii. Object Address Size = 2 Octet
   iv. COT Size = 1 Octet

2. DNP 3.0 with
   i. Minimum of Application Layer Protocol Level 2
   ii. Support for Unsolicited RBE Reporting

b) The SR-ACR Controller shall be equipped with at least one RS-232 Serial Communication Interface for SCADA purposes, fully configurable port settings (enable/disable CTS, DTS, DCD, timeout, delays, etc).

c) This serial port will be used to connect to TNB's SCADA Master System via TNB-issued Modem/DTU.

d) Tools for configuration and maintenance of the SR-ACR shall include diagnostic cables, software etc.

e) All the points available to SCADA shall have their Addresses (Information Object Address/Object Index) to be user configurable.

f) All the points available to SCADA shall have the option to be ENABLED or DISABLED by the user.

g) The SR-ACR Controller shall have a 12 V_{dc} auxiliary power ready for Modem / Data Transmission Unit and its power requirement.

h) The complete Protocol of Inter-operability Matrix / Slave Device Profile shall be provided and is subject to modification with respect to TNB's Protocol of Inter-operability Matrix for the Master side. TNB's matrix will be provided to the successful Tenderer.

i) All monitored information shall be of the Time-Tag type.

j) All control commands shall be of the Select-Before-Execute type.

5.3.12 SR-ACR Control Panel Design for SCADA Communication Requirements

a) The SR-ACR Control Panel shall be equipped with 2 numbers of Heavy-Duty Interposing Relays (HDIR) - Single Pole for the purpose of testing Trip and Close functions (dummy control) from Control Centers. The relevant status change signals shall be made available to Control Centre as stated in the SCADA Indication Points.

b) The SR-ACR Control Panel shall have a space for Modem / DTU installation. The space shall be able to accommodate Modem / DTU with dimensions of 110 mm x 180 mm x 50 mm. A dedicated hole with a diameter of 2 cm shall be provided for mounting of the modem antenna. The manufacturer shall provide the necessary material to seal the hole after installation in order to comply with Ingress of Protection at least **IP54**.

c) The SR-ACR Control Panel shall be provided with DIN rail connector type complete with terminal blocks for mounting of Power Supply, Communication wires (from modem to AR Controller) and Earthing terminals.

d) The maximum power consumption of the modem is **5 Watt**.

5.3.13 **Accessories (Optional)**

a) Portable Test Set

1. Portable test set shall be provided for ease testing and commissioning.

2. The control shall be capable of being tested by a portable test set, capable of testing all control functions with or without connections to a recloser.

3. The control shall have ability to accomplish the following functions, including local, supervisory I/O and digital communications for each function. Local indication and verification shall be included with each function.

4. Manufacturers shall propose their own portable test set.

b) Spare part

1. A comprehensive list of manufacturer's recommended spare part shall be included.

2. Quantity offered shall be adequate for first 5 years of operation.

3. Spare supply shall be packed to provide long storage without deterioration and shall be clearly marked and labeled.

5.4 Grounding

5.4.1 A grounding terminal stud preferably with a minimum size of M12 shall be provided for the grounding of the operating mechanism. The terminal shall be marked with the "earth" symbol.

5.4.2 A grounding terminal shall also be provided for bonding the SR-ACR metal parts and mounting frame to the local grounding.

5.5 Bushing Insulators and Connectors

5.5.1 The material for the bushing or housing insulator shall be of silicon rubber with suitable connectors, preferably of universal four-bolt clamp type connectors, able to accommodate connection and termination of the overhead line conductor to the SR-ACR.

5.5.2 The design of the bushings and connectors shall be such that the overhead line conductor can be properly connected and terminated to the SR-ACR.

5.5.3 The connectors shall be compatible with both stranded copper and aluminum conductor.

5.5.4 The bushings and connectors shall be covered such that there shall be no exposed parts between the SR-ACR and the overhead line conductor.

5.5.5 The material and testing for the bushing and connector cover shall comply with TNB Technical Specification **KEJ08237:2013 (Rev. 01)**.

5.5.6 Bushing type current transformers of ratio 1000:1 shall be installed on bushing number 1, 3 and 5 to sense the line current on all three phases.

5.6 Multi-Ratio Single Phase 2-Pole Potential Transformer

5.6.1 The design and performance of the Potential Transformer (PT) shall conform to the latest edition and/or amendments of IEC 60044-2: Instrument transformers – Part 2: Inductive voltage transformers.

5.6.2 The PT shall be non-flammable and of solid insulation. Oil-immersed PT is not acceptable.

5.6.3 The PT shall be installed to provide power supply to the SR-ACR to enable the SR-ACR operations and functionalities.

5.6.4 The PT shall be suitable to be energized via 11kV, 22kV or 33kV overhead line system with selectable secondary winding providing 240V and 500VA of burden irrespective of the primary voltage.

5.6.5 The PT shall be designed for operation as follows:

No.	Parameter	Unit	Requirement
1.	Rated Primary Voltage	kV	33 / 22 / 11
2.	Rated Secondary Voltage	kV	0.240
3.	Rated Frequency	Hz	50
4.	Rated Burden	VA	500 (irrespective of primary voltage)
5.	Rated Voltage Factor; Rated Time	-	1.9; 8 hours
6.	No of Phase	-	Single Phase; 2 Pole
7.	Accuracy Class	-	6P
8.	Rated Power Freq. Withstand Voltage (rms)	kV	70 @ 36kV
9.	Rated Lightning Impulse Withstand Voltage (peak)	kV	170 @ 36kV

5.6.6 The PT shall be designed and come complete with all mounting accessories, line terminal studs and earth terminal studs to enable mounting on H-Poles or gantry structures.

5.6.7 The PT shall have a rating plate which shall be legible and durable containing the following minimum information:

a. Manufacturer's Name / Model No. / Serial No.
b. IEC Standard
c. Date of Manufacture
d. Primary / Secondary Voltage
e. Frequency
f. Insulation Level
g. Burden
h. Accuracy Class
i. Wiring Tapping Arrangement for Selection of 11 / 22 / 33kV Primary Voltage

5.6.8 The PT shall have been type-tested according to IEC 60044-2.

5.7 AC Surge Protection Device for Control Unit LV Power Supply

5.7.1 The Surge Protection Device (SPD) for the SR-ACR shall come together with an auto-resetting Earth Leakage Circuit Breaker (ELCB) that shall be housed in a stainless-steel compartment.

5.7.2 The SPD shall be of DIN-rail type to protect the SR-ACR control unit from in-flowing surge and instantaneous overcurrent.

5.7.3 The auto resetting ELCB shall have the capability to reset the power supply in case of momentary leakage, overcurrent or overvoltage.

5.7.4 The SPD and auto-resetting ELCB modules shall be so designed to be detachable for ease of replacement should the SPD or auto-resetting ELCB become faulty.

5.7.5 The SPD shall have indicators to check the status of the protection capability and shall be equipped with a dry contact for remote monitoring preferably as follows:

SPD Condition	Indicator Status	Dry Contact Status for Remote Monitoring
Normal	Green	Open
Fail	Red	Short Circuit

5.7.6 The SPD shall be designed with a MOV-type built-in fuse circuit for thermal runaway prevention.

5.7.7 The preferred electrical rating of the SPD shall be as follows:

No.	Classification	Specification
1.	Standard	IEC 61643-331 Class II
2.	Rated Voltage	240 V
3.	Maximum Continuous Operating Voltage	275 V
4.	Maximum Discharge Current	40 kA
5.	Nominal Discharge Current	20 kA
6.	Modes of Protection	L – N, N – PE, L - PE
7.	Voltage Protection Level	L – N, N – PE: ≤ 1.5kV
8.	Temporary Overvoltage Characteristics	L – N: 319 V / 5 sec.
9.	Operating Temperature	Up to 80°C @ 95% RH

5.7.8 The connection configuration shall be so designed to be parallel.

5.7.9 The auto resetting ELCB shall come with a selection button to allow operators to switch between automatic and manual operation.

5.7.10 A status indicator shall also be available to indicate the operational status of the auto resetting ELCB preferably as follows:

5.7.11 A reset button shall also be made available to reset the status indicator and the auto-resetting facility.

5.7.12 The auto-resetting ELCB shall come equipped with an in-built motor and shaft to realize the auto-resetting function of the ELCB.

5.7.13 A test button shall be made available on the auto-resetting ELCB to allow operators to check for tripping due to leakage current and to test the auto-resetting functionality after the connection has been made.

5.7.14 The preferred electrical rating of the auto resetting ELCB shall be as follows:

No.	Item	Classification	Specification
1.	Input	Rated Voltage	240 Vac
2.		Rated Current	30 A
3.		Rated Frequency	50 Hz
4.		Surge Operation	6 kV / 2.5 kA
5.	Output	Rated Voltage	240 Vac
6.		Rated Current	30 A
7.		Rated Frequency	50 Hz
8.		Rated Breaking Capacity	2.5 kA
9.		Rated Sensitivity Current	300 mA
10.		Residual Current Off-Time	0.1 sec
11.		Auto-Reset Type	Time Checking
12.	Temperature	Operating Temperature	Up to 80°C @ 95% RH

5.7.15 The drive motor rotating shaft shall be powered by 12Vdc.

5.7.16 The reset frequency shall be 3 times preferably as follows:

a. 1st reset after 10 seconds
b. 2nd reset after 10 seconds
c. 3rd reset after 60 seconds
d. After the 3rd reset, should the fault is still not cleared, the operator shall reset the auto-resetting facility of the ELCB manually using the reset button as mentioned in 5.7.11 above

5.7.17 The SPD system shall be type tested as per IEC 61643-11.

5.8 SR-ACR Tank

5.8.1 The SR-ACR tank, if exposed, shall be made of stainless-steel material, shall be robust in construction, and shall comply with the design requirements for pressurized gas compartment.

5.8.2 The SR-ACR tank shall be designed preferably in accordance to IP67 degree of protection.

5.8.3 A security valve or safety membrane shall be provided to counteract internal arc fault to enable safe release of internal overpressure that exceed the tank safe design limit

5.8.4 The position of the security valve or safety membrane shall be such that the high-pressured gas will burst in a direction away from the operator.

5.8.5 Gas seals shall be designed to prevent leakage of gas or water ingress throughout the service life of the SR-ACR.

5.9 Surge Arrestor and Associated Materials & Requirement

5.9.1 The SR-ACR shall be supplied with six (6) surge arrestors to be aptly placed near the incoming and outgoing terminal bushings of the SC-ACR.

5.9.2 The surge arrestors shall comply with the latest TNB Technical Specification **KEJ05285:2020** – *10kA Polymeric Metal Oxide Gapless Surge Arrestor (Station Low) For Use in 33kV Overhead Line Systems*.

5.9.3 Each surge arrestor shall come with one (1) PVC-covered aluminum jumper with a cross-sectional area of 150 mm^2 or copper equivalent cross-sectional area with a length of 500 mm or sufficiently required length to enable proper connection of the surge arrestor to the SC-ACR terminal bushing.

5.9.4 Each surge arrestor shall also come with one (1) flexible copper braid with an equivalent cross-sectional area of 35 mm^2 with a length of 500 mm or sufficiently required length to enable proper connection of the surge arrestor tail to the ground terminal of the SC-ACR tank.

5.9.5 The SC-ACR tank shall be equipped with built-in brackets properly positioned for optimum placement of the surge arrestors to ensure effective protection of the SC-ACR from lightning impulse as mentioned in clause 5.1.7.

5.9.6 The exposed live parts of the surge arrestor terminals shall be covered by providing insulating covers with suitable openings/holes for cable entrances. These insulating covers shall comply with requirements in the latest TNB Technical Specification **KEJ08237:2013 (Rev. 01)** – *Insulating Covers for 33 kV Pole-Mounted Substations*.

6.0 MARKINGS

Each SR-ACR shall be provided with a stainless-steel rating plate that shall be placed on the lower part of the tank and shall be clearly marked as follows:

i. Manufacturer's name or trademark, model no. and serial no.

ii. Date of Manufacture

iii. Standards i.e. IEC, IEEE etc.

iv. Rated Voltage, Continuous Current, and Frequency

v. Rated Short Circuit Making Current (peak)

vi. Rated Interrupting / Breaking Current (r.m.s)

vii. Rated Short-Time Withstand Current (r.m.s)

viii. The acronym "TNB"

ix. TNB Contract Number

7.0 INSPECTION AND TESTING

7.1 General Requirements

It is the responsibility of the manufacturer to ensure that the product is inspected and tested at all stages of manufacturing in accordance with the requirements as stipulated in this specification.

7.1.1 The approval or passing of any such tests and inspections shall not prejudice the right of TNB to reject the product if it does not comply with this specification when installed or if it does not give complete satisfaction in service. This condition shall apply only if the causes of the above-mentioned situations are due to any deficiency or wrong action on the part of the manufacturer towards the fulfillment of the requirements of this specification.

7.1.2 The manufacturer shall allow the representative of TNB or its appointed Quality Agents access to all production facilities necessary for the manufacture of this product, at all reasonable times. The manufacturer is responsible to maintain all Quality and Test records for a minimum period of five (5) years. TNB and / or its appointed agents reserve the right to inspect these records as and when deem necessary.

7.1.3 During such inspection, any corrective actions necessary shall be complied with within the scope of this specification.

7.1.4 The tests shall be carried out in accordance to the standards as stipulated in Clause 3.0 and any additional requirements as stated in this specification.

7.2 Type Test

7.2.1 The product shall have successfully passed the type tests in accordance to IEEE C37.60 and/or IEC 62271-111 and its other related amendments, if any.

7.2.2 In the event that modifications to the design of the product are made in which in the opinion of TNB that it will affect the performance of the product, the relevant type tests shall be repeated at the expense of the manufacturer. TNB engineers or its appointed Quality Agent shall select samples for the purpose of these tests.

7.2.3 The type tests as mentioned in Clause 7.2.1 above are to be conducted at any national or international laboratory accredited to ISO/IEC 17025 by the National Accreditation Body. The tests to be conducted shall be within the scope of accreditation of the laboratory and shall cover the appropriate capacity limit for the specified tests.

7.2.4 TNB shall reserve the rights to witness the conduct of the said tests if deemed necessary through its engineers or appointed representatives.

7.3 Routine Tests

Routine tests shall be carried out by the manufacturer on all products in the finished state or, where appropriate, during the manufacturing processes. The routine tests on the SR-ACR shall be in accordance to IEEE C37.60 and/or IEC 62271-111 and its other related amendments, if any:

a. Reclosing and Overcurrent Trip Calibration Tests
b. Control, Secondary Wiring and Accessory Device Test
c. Dielectric Withstand Test – 1-minute dry @ power frequency
d. Mechanical Operation Test

7.4 Product Inspection / Factory Acceptance Test

7.4.1 For each contract, a schedule for the implementation of acceptance testing shall be agreed between the manufacturer and TNB in order that acceptance testing may be carried out on a regular basis.

7.4.2 The product inspection / factory acceptance test shall be as follows (but not limited to):

a. Physical and dimensional checks
b. Reclosing and Overcurrent Trip Calibration Tests
c. Control, Secondary Wiring and Accessory Device Test
d. Dielectric Withstand Test – 1-minute dry @ power frequency
e. Mechanical Operation Test

7.4.3 The sampling rate for the product inspection / factory acceptance test shall be referred to the tender document.

8.0 TRAINING

Training shall be given by the manufacturer/supplier on installations, operations, and maintenance of the SR-ACR prior to delivery.

9.0 SAFETY

9.1 Safety Information

The equipment must be accompanied by instructions and safety information in a language understood by the end-user. Such instructions and safety information, as well as any labeling, must be clear, understandable and intelligible.

9.2 Protection Against Third Party

The manufacturer shall take technical measures to ensure that the public both persons and animals are adequately protected against the danger of physical injury or other harm, which might be caused by direct or indirect contact with the equipment.

10.0 TECHNICAL DATA

Full technical information, drawing, and data on the design and construction of the product as well as the type test reports conducted by an ISO/IEC 17025 accredited testing laboratory, in the format of **Appendix A**, shall be submitted for technical evaluation and test purposes. A VCD or DVD containing a video representation of the standard operating procedures of the SR-ACR shall also be submitted for technical evaluation.

Appendix A

No.	MANDATORY REQUIREMENT	TNB Requirement	Supplier Offer
1	Company / Model Name & No. / Manufacturer	Company	
		Model Name & No.	
		Manufacturer	
2	Country of Manufacturer		
3	Rated System Voltage	36 kV	
4	Rated Frequency	50 Hz	
5	Number of Phases	3	
6	Rated Continuous/Normal Current	Not Less Than 400A Up to 630A	
7	Rated Short Circuit Making Current	$\geq$ 31.5 kA_{peak}	
8	Rated Interrupting / Breaking Current	$\geq$ 12.5 kA_{rms}	
9	Rated Short-Time Withstand Current	$\geq$ 12.5 kA_{rms} / 3 sec	
10	Lightning Impulse Withstand Voltage (peak)	170 kV	
11	Power Frequency Withstand Voltage (rms) Dry @ 1 minute Wet @ 10 seconds	 70 kV 60kV	
12	Average Ambient Temperature (Maximum)	28°C (45°C)	
13	Humidity Range	0 – 95% RH	
14	Preferred Altitude Requirement	Up to 1,800 meters	
15	Preferred Mechanical Operations Requirement	$\geq$ 10,000 operations	
16	Bushing Insulators	Silicone Rubber	
17	Total Creepage Distance Min.	576 mm	
	Max.	900 mm	

Appendix A (cont.)

No.	MANDATORY REQUIREMENT	TNB Requirement	Supplier Offer
18	Insulation of Automatic Circuit Recloser	Gas / Solid Insulated	
19	Designed with Permanent Hermetically Sealed Tank	Yes	
20	Designed with Self-Contained Operating Mechanism	Yes	
21	Self-Supporting Control Unit in Stainless Steel Control Cubicle Provided	Yes	
22	Multi-Ratio 33-22-11 / 0.240 kV Single Phase 2-Pole Potential Transformer Provided	Yes	
23	Independent Surge Protection Device with Auto-Resetting ELCB for Low Voltage Supply Provided	Yes	
24	SCADA Features & Functionalities of Microprocessor-Based Control Unit for Protection, Metering, Fault & Event Recording Provided for Remote Monitoring and Control	Yes	
25	Non-Volatile Memory Storage for Fault & Event Recording Facility Available	Yes	
26	Operation Counter Available	Yes	
27	Designed with Permanent Lifting Means	Yes	
28	Surge Arrestor Mounting Brackets on Both LOAD & SOURCE Sides Provided	Yes	
29	LOAD & SOURCE Sides Indelibly Marked	Yes	
30	Designed with Vacuum Arc Interrupter	Yes	
31	OPEN & CLOSE Position Visible from Ground, Color Coded and Sufficiently Labelled	Yes	

Appendix A (cont.)

No.	MANDATORY REQUIREMENT	TNB Requirement	Supplier Offer
32	Capable of Performing Duty Cycle as per Clause 5.2.7	Yes	
33	Tagging and/or Padlocking at OPEN Position for Safety Provided	Yes	
34	Designed with LV Solenoid or Magnetic Actuator Mechanisms for Simultaneous 3-Phase Opening and Closing	Yes	
35	Manual Closing & Opening for Maintenance Purpose Provided	Yes	
36	Facilities to Prevent Unauthorized Operations Provided	Yes	
37	Control & Protection Modules Power Supply	Main from 240 Vac Back-Up by 12 Vdc Battery	
38	Control Panel Cubicle Coding	IP54	
39	Length of Control Cable Provided	15 meters	
40	Firmware & Software Provided Sufficiently Tested & Proven	Yes	
41	Standard Features for Control Panel as per Clause 5.3.4.6	Yes	
42	Front Panel Capabilities as per Clause 5.3.4.7	Yes	
43	Control Panel LCD Display as per Clause 5.3.4.8 and 5.3.4.9	Yes	
44	Protection Functions Provided as per Clause 5.3.5	Yes	
45	Protection Settings and Configurations as per Clause 5.3.6	Yes	

Appendix A (cont.)

No.	MANDATORY REQUIREMENT	TNB Requirement	Supplier Offer
46	Event / Disturbance Recorder and Measurement Requirement as per Clause 5.3.7	Yes	
47	Interrogation Tools Provided with Features as per Clause 5.3.8	Yes	
48	SCADA Indication Points Provided as per Clause 5.3.9	Yes	
49	Voltage Supply Requirements as per Clause 5.3.10	Yes	
50	SCADA Communication Requirements as per Clause 5.3.11	Yes	
51	Control Panel Design for SCADA Communication Requirements as per Clause 5.3.12	Yes	
52	Grounding Terminal Provided with "Earth" Symbol	Yes	
53	Preferred Minimum Size of Terminal Stud	M12	
54	Bushing Type	Silicone Rubber	
55	Preferred Terminal Connector	Universal 4-Bolt Clamp Type	
56	Terminal Connector Suitable for Stranded Copper & Aluminum Conductor	Yes	
57	Bushings & Connectors Provided with Covers	Yes	
58	Material & Testing of Bushing & Connector Covers Compliance	TNB Technical Specification KEJ08237:2013 (Rev. 01)	
59	Bushing-Type Current Transformer (CT) Ratio	1000:1	

Appendix A (cont.)

No.	MANDATORY REQUIREMENT	TNB Requirement	Supplier Offer
60	Bushing-Type CT Provided at Bushing Nos 1, 3 & 5	Yes	
61	Multi-Ratio Single Phase 2-Pole Potential Transformer (PT) as per IEC 60044-2 Provided	Yes	
62	PT Suitable to be Energized at 11, 22 & 33kV	Yes	
63	PT Designed with Selectable Secondary Winding Providing 240Vac Supply	Yes	
64	PT Rated Burden	500 VA	
65	PT Burden Irrespective of Primary Voltage	Yes	
66	PT Rated Voltage Factor / Rated Time	1.9 / 8 Hours	
67	PT Accuracy Class	6P	
68	PT Rated Power Frequency Withstand Voltage (rms)	70kV	
69	PT Rated Lightning Impulse Voltage Withstand Voltage (peak)	170kV	
70	PT Rating Plate Requirement as per Clause 5.6.7	Yes	
71	PT Type Tested as per IEC 60044-2 & Type Test Documentation Submitted	Yes	
72	Independent DIN-Rail Type AC Surge Protection Device (SPD) for Control Unit LV Power Supply Provided	Yes	
73	SPD Designed with Auto-Resetting ELCB	Yes	

Appendix A (cont.)

No.	MANDATORY REQUIREMENT	TNB Requirement	Supplier Offer
74	Provision for Dry Contacts for SPD Remote Monitoring via SCADA	Yes	
75	MOV-Type SPD Designed with Built-In Fuse Circuit for Thermal Runaway Prevention	Yes	
76	Preferred Electrical Rating of SPD as per Clause 5.7.7	Yes	
77	Auto-Resetting ELCB Requirements as per Clauses 5.7.9 – 5.7.13	Yes	
78	Preferred Electrical Rating of Auto-Resetting ELCB as per Clause 5.7.1.14	Yes	
79	Auto-Resetting ELCB Provided with 12Vdc Motor Rotating Shaft for Reset Operations	Yes	
80	Reset Frequency for Auto-Resetting ELCB	3 Times	
81	Preferred Auto-Resetting ELCB Reset Frequency Requirements as per Clause 5.7.16	Yes	
82	SPD System Type Tested to IEC 61643-11 & Type Test Documentation Submitted	Yes	
83	Preferred Automatic Circuit Recloser Tank IP Coding	IP67	
84	Automatic Circuit Recloser Type Tested as per IEEE C37.60 / IEC 62271-111 Submitted	Yes	
85	Type Tests Done at ISO/IEC 17025 Certified Laboratory	Yes	
86	Technical Documentation on Information of Design, Drawings & Data Submitted for All Product Components & Accessories	Yes	
87	Six (6) Surge Arrestors Provided	Yes	

Appendix A (cont.)

No.	MANDATORY REQUIREMENT	TNB Requirement	Supplier Offer
88	Surge Arrestors Comply with the Latest TNB Technical Specification **KEJ05285:2020**	Yes	
89	Each Surge Arrestor Provided with: One (1) PVC-covered aluminum jumper with a cross-sectional area of 150 mm^2 or copper equivalent CSA with a length of 500 mm or sufficiently required length	Yes	
90	Each Surge Arrestor Provided with: One (1) flexible copper braid with an equivalent cross-sectional area of 35 mm^2 with a length of 500 mm or sufficiently required length	Yes	

LIGHTNING ARRESTER
33kV

Tech Spec: KEJ05285:2020

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TECHNICAL SPECIFICATION

10kA POLYMERIC METAL OXIDE GAPLESS SURGE ARRESTER (STATION LOW) FOR USE IN 33kV OVERHEAD LINE SYSTEMS

Specification No.	KEJ05285:2020	Revision No.	1
Prepared by	Ir. Mohd Faris bin Ariffin Specialist (Overhead Line Systems Design & Diagnostics) Engineering Services Asset Management Department TNB, Distribution Network Division		
Approved by	TNB, Distribution Network Division Technical Committee Dated: 1st October 2020		

(WAN NAZMY BIN WAN MAHMOOD)
Head (Asset Management)
Distribution Network, TNB

1.0 SCOPE

1.1 This specification covers the design, construction, electrical characteristics, and test requirements for 10 kA Polymeric Metal Oxide Gapless Surge Arrester (Station Low) that is intended to be used in the 33kV Overhead Line Systems.

1.2 The surge arrester shall be suitable for outdoor use in the Tropical Zone with relative humidity of approximately 95%, heavy rainfall, ambient temperature of 28^0C to 45^0C, solar radiation of 1200 W/m^2 and an average of isoceraunic level of approximately 200 thunder-days per annum. The operational altitude is preferably up to 1800 meters from sea level.

2.0 FUNCTIONS

2.1 The surge arrester shall be designed for outdoor service conditions abovementioned and shall be used as an accessory for TNB 33kV overhead line systems.

2.2 The surge arrester shall be capable of providing the 33kV overhead line equipment and installations with protection against lightning and shall itself be able to withstand voltage surges due to lightning.

3.0 SYSTEM PARAMETERS

The surge arrester shall be designed for continuous operation as specified under the following conditions: -

No	Conditions	33 kV
i.	Rated Frequency	50 Hz
ii.	Number of Phases	3
iii.	Nominal Voltage	33 kV (rms)
iv.	Rated Voltage	36 kV (rms)
v.	Prospective Short-Circuit Current	$I_{sc} \geq 25$ kA
vi.	Grounding System	Neutral Earthing Resistor

4.0 CONFORMITY WITH STANDARDS

4.1 Unless otherwise specified, the specification for the 10kA Polymeric Metal Oxide Gapless Surge Arrester (Station Low) shall include but is not limited to the following standards as reference and for compliance together with all current amendments: -

a. IEC 60099-4 (2014) : Surge Arresters – Part 4: Metal oxide surge arresters without gaps for a.c. systems

b. IEC 60099-5 (2018) : Surge Arresters – Part 5: Selection and application recommendations

c. IEC 61109 (2008) : Insulators for overhead lines - Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1000 V - Definitions, test methods and acceptance criteria

4.2 Other internationally recognized standards that are compatible to the abovementioned standards can be considered provided that an English version of such standards shall be submitted to TNB for further reference.

5.0 TECHNICAL REQUIREMENT

No	Item	Requirement
1.	Arrester Classification	Station Low (SL)
2.	Standard Nominal Discharge Current (8/20μs)	I_n = 10 kA_{peak}
3.	High Current Impulse Withstand (4/10μs)	I_{hc} = 100 kA_{peak}
4.	Thermal Energy Rating (W_{th}) @ U_r	≥ 4.0 kJ/kV
5.	Repetitive Charge Transfer Rating (Q_{rs})	≥ 1.0 Coulombs
6.	Nominal Voltage; kV	33.0
7.	Rated Voltage; kV (U_r)	36.0
8.	Maximum Continuous Operating Voltage (MCOV); kV (U_c)	28.8
9.	Maximum Residual Voltage @ I_n	≤ 127.5
10.	Insulation Withstand Voltage	
a.	Lightning Impulse Withstand Voltage (Dry); kV_{peak}	170
b.	Power Frequency Withstand Voltage (Wet); kV	≥ 70
11.	Minimum Creepage Distance; mm	≥ 720
12.	Minimum Cantilever Strength; Nm	≥ 250

6.0 DESIGN AND CONSTRUCTION

6.1 The surge arrester shall be connected between phase and earth across distribution medium voltage overhead line equipment and switchgears such as pole top transformers, automatic circuit reclosers, and load break switches to protect these equipment and switchgears against voltage surges due to lightning.

6.2 The surge arrester metal oxide blocks shall be housed in a hermetically sealed silicone housing to prevent ingress of moisture.

6.3 The design of the silicone-housed surge arrester shall be so designed to minimize accumulation of contaminant and shall be such that the stresses due to expansion and contraction in any part of the silicone housing shall not lead to deterioration.

6.4 The construction of the surge arrester housing shall also be so designed such that the silicone is directly molded onto the metal oxide blocks to ensure that no void is present between the metal oxide blocks and the silicone rubber housing to avoid any formation of air bubble or allow moisture ingress.

6.5 The surge arrester shall be provided with a disconnecting device without any explosive cartridge to ensure that damaged or failed surge arrester in service is isolated from the system to prevent it from causing persistent fault to the system. The surge arrester disconnector shall also be so designed such that it will be able to give a visible indication that the surge arrester has damaged or failed.

6.6 The surge arrester shall come complete with the following accessories to ensure secured and safe mounting on the overhead line installations:

6.6.1 Line terminal clamps of suitable material to connect both aluminum and copper conductors;

6.6.2 Earth connection lead or earthing terminal clamps suitable to connect 50mm^2 copper conductor;

6.6.3 Both line terminal and earthing terminal studs shall be of M12 size;

6.6.4 Mounting clamps of mechanically strong and corrosion-resistant material. Iron or steel parts shall be hot-dipped galvanized;

6.6.5 Insulating bracket that is robust to be used for mounting the surge arrester to the overhead line system installations;

6.6.6 Insulating cover as per TNB Technical Specification **KEJ08237:2013 Rev. 1** – *Insulating Covers for 33kV Pole-Mounted Substations* for the surge arrester to protect its exposed terminals from direct contact with animal or vegetation encroachment

6.7 The surge arrester shall be free from sharp edges, burrs, flash, or surface projections that could cause damage to the conductor or inflict injury to the installer or user. It shall also be so designed that in normal use its performance is reliable and without danger to persons or surroundings.

6.8 Bidders may propose alternative designs based on the conceptual design described in paragraph 6.1 - 6.7 and the functional requirements outlined in paragraph 2.0 above. Relevant design drawings and documentation complete with the dimensions and descriptions shall be submitted.

6.9 The surge arrester shall be manufactured according to and its safety features and operations shall be tested to the standards mentioned in Clause 4.0 of this specification.

6.10 The surge arrester shall have adequate electrical and mechanical strength for the functions mentioned in Clause 2.0 of this specification and shall comply with the relevant standards as mentioned in Clause 4.0 of this specification.

7.0 MARKING AND IDENTIFICATION

The markings on the surge arrester shall comply with Clause 4.1 of IEC 60099-4 and shall be legible and durable containing the following minimum information: -

- Manufacturer's Name and Date of Manufacture
- Make and Model No.
- Arrester Classification
- Maximum Continuous Operating Voltage (MCOV); U_c
- Rated Voltage; U_r
- Rated Frequency; Hz

- Nominal Discharge Current; I_n
- Repetitive Charge Transfer Rating; Q_{rs}
- The Acronym "TNB" & TNB Contract Number
- Reference Standard i.e. IEC 60099-4

8.0 INSPECTION AND TESTING

8.1 General Requirements

8.1.1 It is the responsibility of the manufacturer to ensure that the product is inspected and tested at all stages of manufacturing in accordance with the requirements as stipulated in this specification.

8.1.2 The approval or passing of any such tests and inspections shall not prejudice the right of TNB to reject the product if it does not comply with this specification when installed or if it does not give complete satisfaction in service. This condition shall apply only if the causes of the above-mentioned situations are due to any deficiency or wrong action on the part of the manufacturer towards the fulfillment of the requirements of this specification.

8.1.3 The manufacturer shall allow the representative of TNB or its appointed Quality Agents access to all production facilities necessary for the manufacture of this product, at all reasonable times. The manufacturer is responsible to maintain all Quality and Test records for a minimum period of five (5) years. TNB and / or its appointed agents reserve the right to inspect these records as and when deemed necessary.

8.1.4 During such inspection, any corrective actions necessary shall be complied with within the scope of this specification

8.1.5 The tests shall be carried out in accordance with the standards mentioned in Clause 4.0 above and other related amendments, and any additional requirements as stated in this specification.

8.2 Type Test

8.2.1 The product shall have successfully passed the type tests for polymer-housed surge arrester in accordance with IEC 60099-4 (2014) and its other related amendments, if any:

a. Insulation withstand tests (Clause 10.8.2) ~ *switching impulse test not required*
b. Residual voltage tests (Clause 10.8.3)
c. Test to verify long term stability under continuous operating voltage (Clause 10.8.4)
d. Test to verify the repetitive charge transfer rating, Q_{rs} (Clause 10.8.5)
e. Heat dissipation behavior of test sample (Clause 10.8.6)
f. Operating duty tests (Clause 10.8.7)
g. Power frequency voltage-versus-time test (Clause 10.8.8)
h. Tests of arrester disconnector (Clause 10.8.9)
i. Short-circuit tests (Clause 10.8.10)
j. Test of the bending moment (Clause 10.8.11)
k. Weather ageing test (Clause 10.8.17)

8.2.2 In the event that modifications to the design of the product are made in which in the opinion of TNB that it will affect the performance of the product, the relevant type tests shall be repeated at the expense of the manufacturer. TNB engineers or its appointed Quality Agent shall select samples for the purpose of these tests.

8.2.3 The type tests as mentioned in Clause 8.2.1 above are to be conducted at any national or international independent laboratory accredited to ISO/IEC 17025 by the National Accreditation Body. The tests to be conducted shall be within the scope of accreditation of the laboratory and shall cover the appropriate capacity limit for the specified tests.

8.2.4 TNB shall reserve the rights to witness the conduct of the said tests if deemed necessary through its engineers or appointed representatives.

8.3 Routine Tests

8.3.1 Routine tests shall be carried out by the manufacturer on all products in the finished state or, where appropriate, during the manufacturing processes. The routine tests that shall be made on the products as per Clause 9.1 of IEC 60099-4 (2014) are: -

a. Measurement of reference voltage, U_{ref} (Clause 9.1.a)
b. Residual voltage test (Clause 9.1.b)
c. Internal partial discharge test (Clause 9.1.c)

8.4 Product Inspection / Factory Acceptance Test

8.4.1 The manufacturer shall carry out product inspection / factory acceptance tests on sample of products in the finished state. The sampling tests that shall be made on the products as per Clause 9.2 of IEC 60099-4 (2014) are: -

a. Visual inspection on markings
b. Physical and visual verification of the dimensions and construction
c. Measurement of power-frequency voltage on the arrester at the reference current (Clause 9.2.1.a)
d. Lightning impulse residual voltage on the arrester at nominal discharge current if possible or at a current value chosen according to Clause 8.3 of IEC 60099-4 (2014) (Clause 9.2.1.b)
e. Internal partial discharge test (Clause 9.2.1.c)
f. Bending moment and tensile load tests (Clause 9.2.1.d)

8.4.2 The sampling rate for the product inspection / factory acceptance test shall be referred to the tender document.

9.0 TECHNICAL DATA

Technical drawings and technical data pertaining to the design and construction of the product shall be submitted in the format as shown in Appendix A.

APPENDIX A

TECHNICAL DATA INFORMATION

No	TECHNICAL REQUIREMENTS		TENDERER OFFER	TNB REQUIREMENT
1	Type No. / Trademark / Manufacturer			
2	Nominal Voltage	kV		33 kV
3	Rated Voltage (U_r)	kV		36 kV
4	Rated Frequency	Hz		50 Hz
5	Prospective Short Circuit Current	I_{sc}		≥ 25kA
6	Arrester Classification			SL
7	Standard Nominal Discharge Current (8/20 µs)	I_n		10 kA_{peak}
8	High Current Impulse Withstand (4/10µs)	I_{hc}		100 kA_{peak}
9	Thermal Charge Transfer Rating @ U_r	W_{th}		≥ 4.0 kJ/kV (U_r)
10	Repetitive Charge Transfer Rating	Q_{rs}		≥ 1.0 C
11	Maximum Continuous Operating Voltage (MCOV)	U_c		28.8 kV
12	Maximum Residual Voltage @ I_n	kV		≤ 127.5 kV
13	Lightning Impulse Withstand Voltage (Dry)	kV_{peak}		170 kV
14	Power Frequency Withstand Voltage - Wet (kV)	kV		≥ 70 kV
15	Minimum Creepage Distance	mm		≥ 720 mm
16	Minimum Cantilever Strength	Nm		≥ 250
17	Material of Insulator Housing			Silicone Rubber
18	Construction of Insulator Housing			Directly Molded / Mold-in-Place onto MO Blocks

APPENDIX A (continued)

TECHNICAL DATA INFORMATION

No	TECHNICAL REQUIREMENTS	TENDERER OFFER	TNB REQUIREMENT
19	Arrestor Disconnecting Device Provided	Yes/No	Yes
20	Line Terminal Clamps with M12 Stud for Aluminum/Copper Conductor Provided	Yes/No	Yes
21	Earth Terminal Clamps with M12 Stud for 50mm^2 Copper Conductor Provided	Yes/No	Yes
22	Mounting Clamps Provided	Yes/No	Yes
23	Insulating Bracket Provided	Yes/No	Yes
24	Insulating Cover for Arrester Provided	Yes/No	Yes
25	Drawings of Design and Construction	Enclosed / Not Enclosed	Enclosed
26	Type Test Reports as per IEC 60099-4 (2014) Submitted:		
a.	Insulation withstand tests	Yes/No	Yes
b.	Residual voltage tests	Yes/No	Yes
c.	Test to verify long term stability under continuous operating voltage	Yes/No	Yes
d.	Test to verify the repetitive charge transfer rating, Q_{rs}	Yes/No	Yes
e.	Heat dissipation behavior of test sample	Yes/No	Yes
f.	Operating duty tests	Yes/No	Yes
g.	Power frequency voltage-versus-time test	Yes/No	Yes
h.	Tests of arrester disconnector	Yes/No	Yes
i.	Short-circuit tests	Yes/No	Yes
j.	Test of the bending moment	Yes/No	Yes
k.	Weather ageing test	Yes/No	Yes

INSULATING COVER FOR SURGE ARRESTER

Tech Spec: KEJ08237:2013 Rev No.1

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TECHNICAL SPECIFICATION

INSULATING COVERS FOR 33 kV POLE-MOUNTED SUBSTATIONS

Specification No.	KEJ08237:2013	Revision No.	1.0
Prepared by	Hannah Ahmad Rosli Senior Engineer (Substation) Engineering Services Unit TNB Distribution Sdn. Bhd		
Approved by	TNB, Distribution Division Technical Committee Dated: 18th April 2013		

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TNB, Distribution Division

1.0 INTRODUCTION

This specification describes the design, construction, tests, and packaging of insulating covers to be used at 33 kV pole-mounted substations. The insulating covers must be designed to protect live parts from flashovers due to contact by animals such as squirrels and birds.

There are 5 types of insulation covers described in this specification:

a) Transformer bushing cover
b) Drop-out fuse cover
c) Lightning arrester cover
d) Conductor cover
e) Animal guard

2.0 SITE AND SERVICE CONDITIONS

The insulating covers shall be suitable for the following conditions:

a) Application: Outdoor Tropical Zone
b) Maximum temperature: 40°C
c) Average annual temperature: 30°C
d) Average maximum relative humidity: 95%
e) Heavy rainfall throughout the year

3.0 REFERENCES

This specification shall make reference to the following standards and specifications of these revisions and the latest revisions hereafter unless otherwise stated:

a) KEJ04203:2001 - TNBD Technical Specification for 33000/433V Dyn11 50Hz ONAN Distribution Transformer

b) KEJ04202:2001 - TNBD Technical Specification for 22000/433V Dyn11 50Hz ONAN Distribution Transformer

c) TNBD Technical Specification for 1500 KVA 33/11kV Dyn11 50 Hz ONAN Transformer

d) KEJ05238:2003 - TNBD Technical Specification for 33 kV and 22 kV Single Phase Expulsion Type Drop-Out Fuse Assembly

e) KEJ02209:1998 - TNBD Technical Specification for 36 kV Polymeric Metal Oxide Gapless Surge Arrester

f) KEJ02228:2002 - TNBD Technical Specification for 19/33 kV Cross-linked Polyethylene (XLPE) Insulated, Aluminium Conductor, PVC Sheathed ABC

g) TNBD Technical Specification for Conductor Aluminium Alloy 19/.137' "ASH"

4.0 ELECTRICAL SYSTEM

The insulating covers shall be designed for continuous operation in the following electrical system:

a) Operating voltage: 33 kV

b) Rated frequency: 50 Hz, 3 phase

c) Rated voltage: 36 kV

5.0 DESIGN

5.1 Dimension

	Insulating cover	Usage	Size	Other features
1	Transformer bushing cover	To cover the entire exposed live part of the high and low voltage bushing terminals of 33/11 kV, 33/0.433 kV, 22/0.433 kV distribution transformers with suitable openings/ holes for cable entrances	o Please refer to technical drawings in Appendix 1	
2	Drop-out fuse cover	To cover the entire exposed live part in **both** the upper and lower terminals of 33 kV 100 A drop-out fuse assemblies with suitable openings/holes for cable entrances	o To accommodate a post insulator with core diameter of 90 mm and shed diameter of 145 mm o Please refer to technical drawings in Appendix 2	Does not hinder the intended operation of the drop-out fuse
3	Lightning arrester cover	To cover the entire exposed live part of the arrester terminal of 36kV, 10kA, class 2, polymeric housed, metal oxide gapless lightning arresters with suitable openings/holes for cable entrances	o To accommodate a post insulator with core diameter of 80 mm and shed diameter of 109 mm o Please refer to technical drawings in Appendix 3	
4	Conductor cover	To cover conductors	o fit conductors with diameter ranging from 12 mm - 20 mm (0.5" – 0.8")	Flexible to allow installation on tight bends
5	Animal guard	To be installed on a disconnecting link/switch bushing to prevent animals, such as squirrels, from bridging the phase-to-ground clearance	o A rigid piece of sheet with thickness > 3mm o To fit between the sheds of post insulators and equipment with core diameters from 25 mm to 115 mm (1"-4.5") o The radius of the animal guard shall be 290 mm - 350 mm	

All the insulating covers shall be made of materials with the following properties:

a) Tracking-resistant

b) Hydrophobic

c) UV radiation-resistant and weather-resistant

d) Non-halogen

e) Long term reliability even at high operating temperature

The insulating covers shall have the following installation features:

a) Simple and quick (example: slip-on)

b) Easily removed for maintenance and re-enterable/reusable

c) Do not require special installation tools

d) Openings/holes for cable entrances are pre-fabricated or can be made by cutting/trimming in the field during installation

e) Covers must be held securely in place

The word '33 kV' must be indelibly marked on each individual cover for differentiation from the 11 kV insulating covers.

5.2 Shelf Life

The insulating covers shall be stable and could be stored not less than thirty (30) months in TNB stores without any degradation in the quality of the material. In addition, the material shall not require any special storage conditions when stored within the range of 20 °C to 40 °C, and under the relative humidity of 95% throughout the year.

6.0 Packaging and Product Identification

The complete component shall be packed into a suitable packaging effectively sealed against ingress of moisture, dirt, vermin, and adequately protected against mechanical damage during handling and transit to TNB warehouses and to work sites.

The following identification shall be indelibly marked on the packaging of the finished goods:

a) The acronym 'TNB'
b) TNB catalogue numbers
c) TNB contract number
d) Product identification model numbers
e) Manufacturer's name and logo
f) Manufacturing month and year
g) Voltage rating
h) Range of size

For each packaging, the manufacturer shall furnish the following items in English and Bahasa Malaysia:

a) Complete list of parts
b) Installation instruction with graphical representation

7.0 Inspection and Testing

7.1 General Requirement

It is the responsibility of the manufacturer to ensure that all products are inspected and tested at all stages of manufacturing in accordance to requirements as stipulated in the manufacturer's own quality manual and requirement of this specification. The cost for all inspections and tests shall be borne by the manufacturer and shall be deemed to be included in the tender price.

The approval or passing of any such tests and inspections shall not prejudice the right of TNB to reject the product if it does not comply with this specification when installed or if it does not give complete satisfaction in service. This condition shall apply only if the causes of the above-mentioned situations are due to any deficiency or wrong action on the part of the manufacturer towards the fulfillment of the requirements of this specification.

The manufacturer shall allow the representative of TNB or its appointed Quality Agents access to all production facilities necessary for the manufacture of the product at all reasonable times. The manufacturer is responsible to maintain all Quality and Test Records for a minimum period of five (5) years. TNB and/or its appointed agent reserved the right to inspect these records as and when deemed necessary.

During such inspection, any corrective actions necessary shall be complied with within the scope of this specification.

7.2 Type Tests

The insulating covers shall have passed the following list of mandatory type tests and fulfilled the corresponding minimum requirements.

Test	Test method	Pass Criteria
AC voltage withstand (not applicable to animal guard)	Please refer to 7.2.1	No flashover or breakdown at ≥ 20 kV phase to earth for 1 min
Tracking resistance	IEC 60587: Electrical insulating materials used under severe ambient conditions - Test methods for evaluating resistance to tracking and erosion	Minimum Class 2A 3.0
UV resistance	ASTM G53: Standard Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV- Condensation Type) for Exposure of Nonmetallic Materials	*Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after duration of exposure ≥ 1000 hours
Thermal withstand	Please refer to 7.2.2.	*Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after 168 hours at 120 °C

* Tensile strength and ultimate elongation measurements shall be in accordance to ASTM D638: Standard Test Method for Tensile Properties of Plastics

Compliance to other type tests having similar characteristics and providing equivalent or better performance and/or quality to those specified may be proposed.

All Test Reports shall be furnished in English for the tests issued and must clearly indicate the manufacturer's name and address, particulars of samples tested and the relevant standards/test methods applied.

7.2.1 AC voltage withstand test

The test methods vary according to the insulating covers being tested.

7.2.1.1 Conductor cover

A conductor cover sample is wrapped/installed around a bare conductor of diameter 12-28 mm. A solidly grounded copper mesh of approximately 100 mm wide is tightly wrapped around the conductor cover. This acts as the ground electrode. Refer to Fig 1.

The power frequency voltage of 20 kV phase to earth voltage is applied to the conductor for 1 minute.

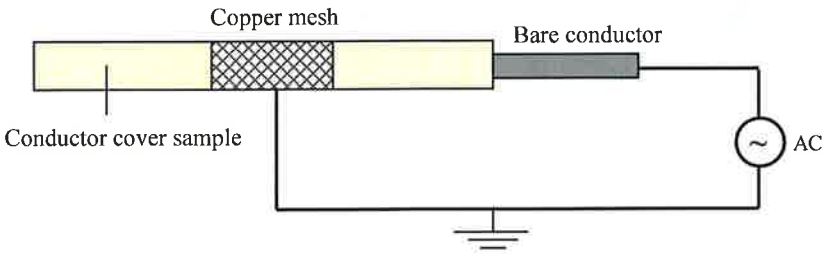


Fig 1. Test set up for a conductor cover

7.2.1.2 Transformer bushing cover, drop-out fuse cover and lightning arrester cover

Insulating covers are to be mounted on test terminals that resemble the respective dimension and connection of the actual equipment terminal to be covered. Please refer to Appendix 1, 2 and 3 for the technical drawings of these actual equipment.

The ground electrode shall be a metallic probe that is placed at the cable entrances of the covers. Refer to example test set up in Fig 2. If the design of the covers is such that it is possible to wrap a copper mesh around them, then a copper mesh shall be used as the ground electrode.

The power frequency voltage of 20 kV phase to earth voltage is applied to the test terminal for 1 minute.

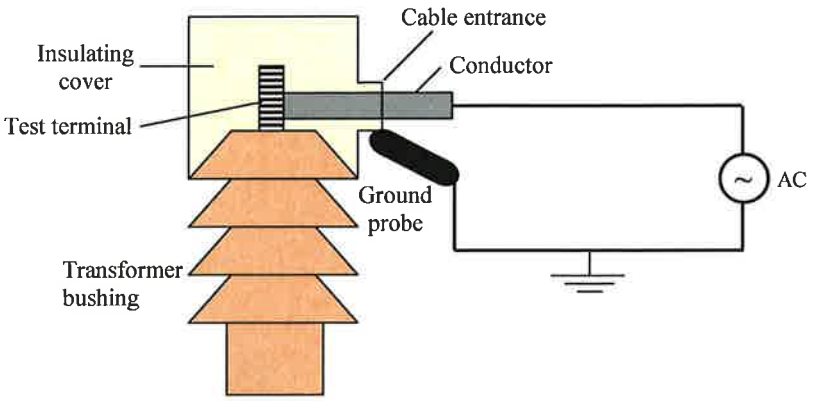


Fig 2. Example test set up for a transformer bushing cover

7.2.2 Thermal withstand test

5 samples prepared from the insulating covers are hung in a convection oven and maintained continuously at 120 °C for 168 hours. After allowing the samples to cool to room temperature, they are to be visually examined and tested for tensile strength and ultimate elongation. The tensile strength and ultimate elongation measurement are to be conducted according to ASTM D638: Standard Test Method for Tensile Properties of Plastics

7.3 Product Inspection

For each contract, a schedule for product inspection shall be agreed between the manufacturer and TNB in order for the inspection to be carried out on a regular basis. Product inspection shall be carried out before the finished products are delivered to TNB warehouses. The inspection shall consist of the following:

a) packing list check
b) physical dimension check of all components
c) physical condition check of all components
d) packaging check (labeling/marking)
e) marking '33 kV' on each product

On the passing of the inspection, security labels shall be affixed to each box in the lot in order to signify approval at factory.

Please refer to the tender documents for sampling and passing criteria.

7.4 Guarantee Period

The guarantee period for the insulation covers shall be 5 (five) years. If the cover is damaged within the guaranteed period, the manufacturer shall promptly investigate, repair or replace it within 60 days after first being informed.

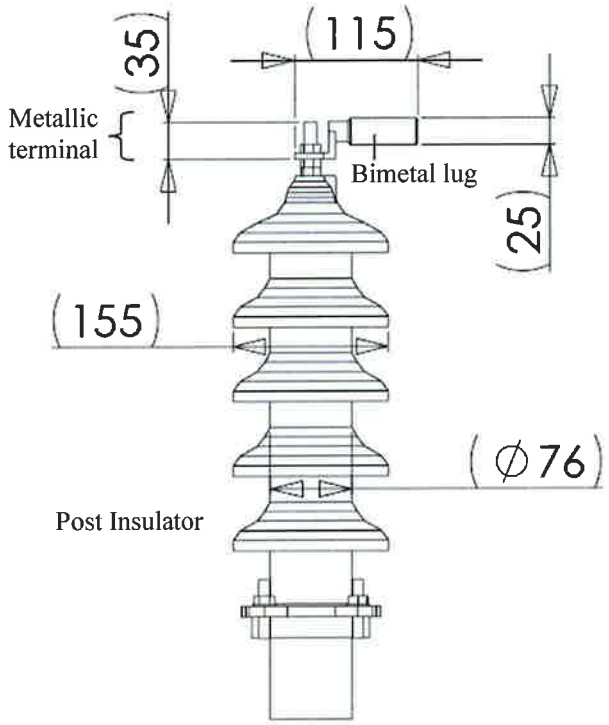
7.5 Product Demonstration and Training

The manufacturer shall provide comprehensive demonstration and training on the correct installation procedure of the insulation covers to TNB personnel in arranged sessions to be scheduled with TNB. The installation procedure shall be documented in video format and made available on CD's.

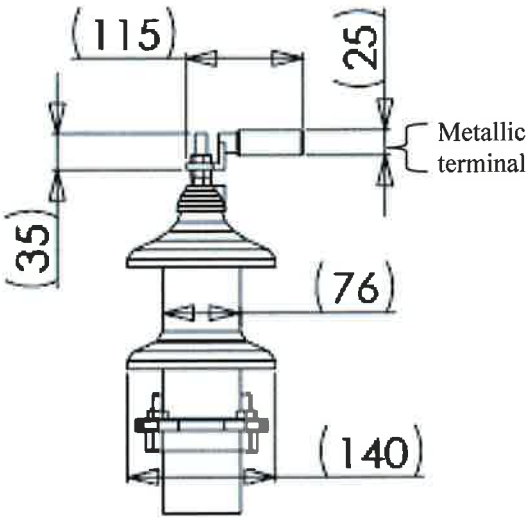
-END-

APPENDIX 1: TECHNICAL DRAWINGS OF TRANSFOR MER BUSHINGS

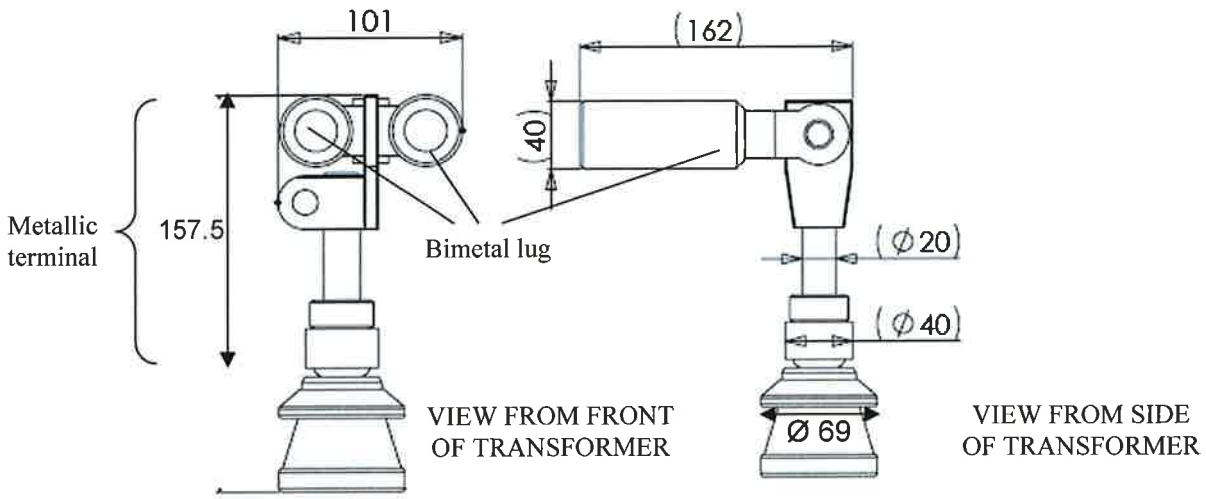
HV BUSHING OF 33/11 kV 1.5 MVA TRANSFORMER



LV BUSHING OF 33/11 kV 1.5 MVA TRANSFORMER

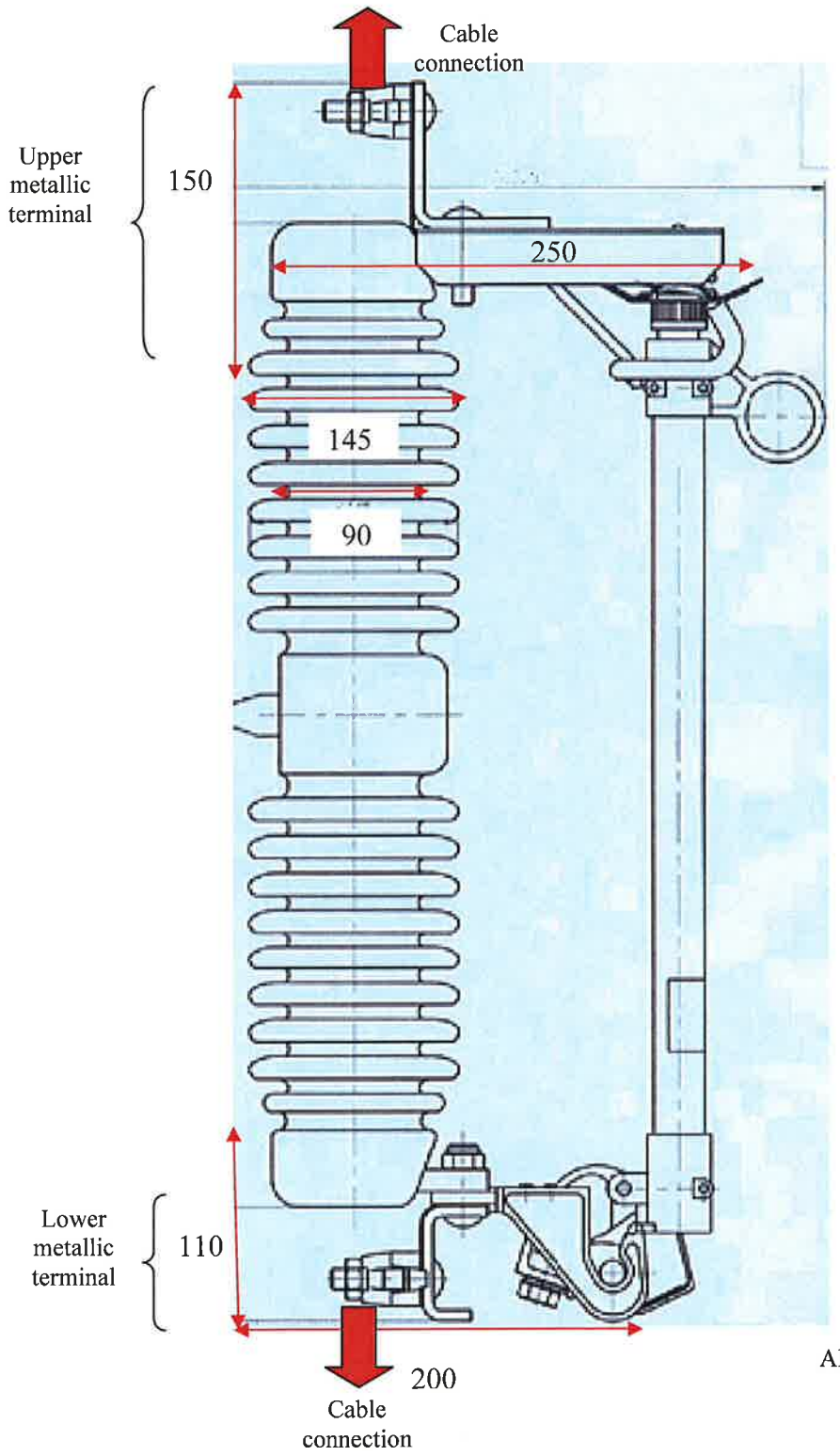


LV BUSHING OF 33/0.433 kV TRANSFORMER



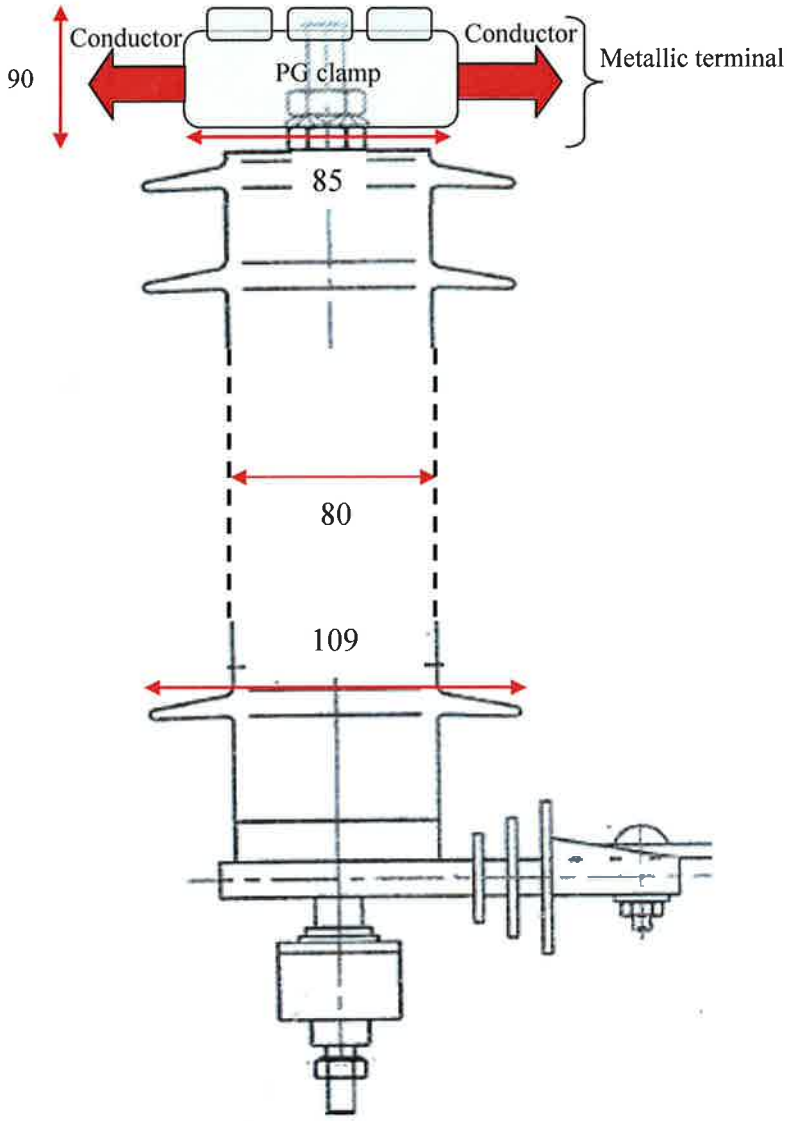
All measurements in mm

APPENDIX 2: TECHNICAL DRAWINGS OF 33kV DROP-OUT FUSE



All measurements in mm

APPENDIX 3: TECHNICAL DRAWINGS OF 33kV LIGHTNING ARRESTER



1. All measurements in mm
2. Connection of conductors to the lightning arrester terminal is made using Parallel-Groove (PG) clamp

APPENDIX 4: TECHNICAL EVALUATION CRITERIA FOR TRANSFORMER BUSHING COVER

NO	TECHNICAL REQUIREMENTS	TECHNICAL DATA/COMPLIANCE
1	Electrical system o Operating voltage (kV) o Rated frequency (Hz) o Rated voltage (Hz)	
2	Dimension o Cover the entire exposed live part of high voltage and low voltage bushing terminals of 33/11 kV, 33/0.433 kV, 22/0.433 kV distribution transformer o Suitable openings/holes for cable entrances	
3	The word '33 kV' indelibly marked on each cover	
4	Material o Tracking-resistant o Hydrophobic o UV radiation-resistant o Non-halogen	
5	Installation o Simple and quick (example: Slip on) o Easily removed and re-enterable/reusable o No requirement for special installation tools o Opening/holes for cable entrances are pre-fabricated or can be made by cutting/trimming in the field during installation	
6	Type Tests o AC voltage withstand test: Min 20 kV phase to earth for min 1 minute o Tracking resistance Min Class 2A 3.0 o UV resistance test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after duration of exposure ≥ 1000 hours o Thermal withstand test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after 168 hours at 120 °C o Test reports in English enclosed	
7	Guarantee Period	

APPENDIX 5: TECHNICAL EVALUATION CRITERIA FOR DROP-OUT FUSE COVER

NO	TECHNICAL REQUIREMENTS	TECHNICAL DATA/COMPLIANCE
1	Electrical system o Operating voltage (kV) o Rated frequency (Hz) o Rated voltage (Hz)	
2	Dimension o Cover the entire exposed live part in the upper and lower terminal areas of 33 kV 100 A drop-out fuse assemblies o Suitable openings/holes for cable entrances o Able to accommodate a post insulator with core diameter of 90 mm and shed diameter of 145 mm	
3	Design o Must not hinder the intended operation of drop-out fuse	
4	The word '33 kV' indelibly marked on each cover	
5	Material o Tracking-resistant o Hydrophobic o UV radiation-resistant o Non-halogen	
6	Installation o Simple and quick (example: Slip on) o Easily removed and re-enterable/reusable o No requirement for special installation tools o Opening/holes for cable entrances are pre-fabricated or can be made by cutting/trimming in the field during installation	
7	Type Tests o AC voltage withstand test: Min 20 kV phase to earth for min 1 minute o Tracking resistance Min Class 2A 3.0 o UV resistance test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after duration of exposure ≥ 1000 hours o Thermal withstand test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after 168 hours at 120 °C o Test reports in English enclosed	
8	Guarantee Period	

APPENDIX 6: TECHNICAL EVALUATION CRITERIA FOR LIGHTNING ARRESTER COVER

NO	TECHNICAL REQUIREMENTS	TECHNICAL DATA/COMPLIANCE
1	Electrical system o Operating voltage (kV) o Rated frequency (Hz) o Rated voltage (Hz)	
2	Dimension o Suitable to cover the entire exposed live part of the arrester terminal area of 36 kV, 10 kA, class 2, polymeric housed, metal oxide gapless lightning arrester o Suitable openings/holes for cable entrances o Diameter or width (mm) o Length or height (mm)	
3	The word '33 kV' indelibly marked on each cover	
4	Material o Tracking-resistant o Hydrophobic o UV radiation-resistant o Non-halogen	
5	Installation o Simple and quick (example: Slip on) o Easily removed and re-enterable/reusable o No requirement for special installation tools o Opening/holes for cable entrances are pre-fabricated or can be made by cutting/trimming in the field during installation	
6	Type Tests o AC voltage withstand test: Min 20 kV phase to earth for min 1 minute o Tracking resistance Min Class 2A 3.0 o UV resistance test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after duration of exposure ≥ 1000 hours o Thermal withstand test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after 168 hours at 120 °C o Test reports in English enclosed	
7	Guarantee Period	

APPENDIX 7: TECHNICAL EVALUATION CRITERIA FOR CONDUCTOR COVER

NO	TECHNICAL REQUIREMENTS	TECHNICAL DATA/COMPLIANCE
1	Electrical system o Operating voltage (kV) o Rated frequency (Hz) o Rated voltage (Hz)	
2	Dimension o Able to fit conductors with diameter ranging 12 mm - 20 mm (0.5" – 0.8")	
3	The word '33 kV' indelibly marked on each cover	
4	Material o Tracking-resistant o Hydrophobic o UV radiation-resistant o Non-halogen o Flexible	
5	Installation o Simple and quick (example: Slip on) o Easily removed and re-enterable/reusable o No requirement for special installation tools	
6	Type Tests o AC voltage withstand test: Min 20 kV phase to earth for min 1 minute o Tracking resistance Min Class 2A 3.0 o UV resistance test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after duration of exposure ≥ 1000 hours o Thermal withstand test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after 168 hours at 120 °C o Test reports in English enclosed	
7	Guarantee Period	

APPENDIX 8: TECHNICAL EVALUATION CRITERIA FOR ANIMAL GUARD

NO	TECHNICAL REQUIREMENTS	TECHNICAL DATA/COMPLIANCE
1	Electrical system o Operating voltage (kV) o Rated frequency (Hz) o Rated voltage (Hz)	
2	The word '33 kV' indelibly marked on each cover	
3	Dimension o Thickness of sheet (mm) o Able to fit between the sheds of post insulators and equipment with core diameters from 60 mm to 115 mm (1.0"-4.5") o The radius of the animal guard shall be 290 mm - 350 mm	
4	Material o Tracking-resistant o Hydrophobic o UV radiation-resistant o Non-halogen	
5	Installation o Simple and quick (example: Slip on) o Easily removed and re-enterable/reusable o No requirement for special installation tools	
6	Type Tests o Tracking resistance Min Class 2A 3.0 o UV resistance test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after duration of exposure ≥ 1000 hours o Thermal withstand test: Tensile strength ≥ 8 MPa & Ultimate elongation ≥ 25% after 168 hours at 120 °C o Test reports in English enclosed	
7	Guarantee Period	