Eskom	Standard	Technology

Title: **STANDARD FOR THE CHOICE OF SINGLE AND THREE MECHANISM CIRCUIT-BREAKERS**

Unique Identifier: **240-68972898**

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This document is **STABILISED.** The technical content in this document is not expected to change because the document covers: *(Tick applicable motivation)*

1	A specific plant, project or solution	
2	A mature and stable technical area/technology	x
3	Established and accepted practices.	x

This letter is for multiple documents:

PCM Reference: **Design Substations**
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1. Introduction

Circuit breakers are either manufactured with a single mechanism in order that all three poles are opened simultaneously when a signal to open is received, or manufactured with a mechanism per pole in order the poles can be opened at different times depending on the application. This document describes the different applications of single and three mechanism circuit breakers.

2. Supporting clauses

2.1 Scope

This document is a standard for the application of single- and three-mechanism circuit breakers in Transmission substations.

2.1.1 Purpose

The purpose of the document is to provide clear instruction as to where single and three mechanism circuit breakers are to be applied.

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] ISO 9001 Quality Management Systems.

[2] Substation Layout Design Guide.

2.2.2 Informative

[3] IEC 60934 Circuit breakers for equipment.

2.3 Definitions

2.3.1 General

Definition	Description
Auto-reclosing – Single Phase	The action of a circuit breaker where a single pole momentarily opens due to an often temporary fault on the phase and then closing after a pre-set time.
Auto-reclosing – Three Phase	The action of a circuit breaker where all three poles momentarily opens due to a temporary fault on any of the phase and then all three closing after a pre-set time.
Circuit Breaker	Mechanical switching device that is capable of making, carrying and breaking currents under normal circuit conditions and of making, carrying for a specified time, and automatically breaking currents under specified abnormal circuit conditions such as those of overcurrent.
Distribution Board	Enclosure that contains electrical equipment for the distribution or control of electrical power, from one or more incoming circuits, to one or more outgoing circuits.

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
A	Ampere
AC	Alternating Current
DB	Distribution Board
DC	Direct Current
MCB	Miniature Circuit Breaker
MVA	Mega Volt Ampere
OLTC	On-load Tap Changer
PB	Plug-box
TDB	Transformer Distribution Board
TRFR	Transformer
VDC	Volts Direct Current

2.5 Roles and responsibilities

Not applicable.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

Not applicable.

3. Single and Three Mechanism Circuit Breakers

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and interrupt current flow. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation.

Depending on the application of the circuit breaker, it may require that the circuit breaker be a three pole switched (single mechanism) or a single pole switched (three mechanisms) device.

3.1 Controlled Switching

Controlled switching is the term used to describe the application of electronic control devices to control the mechanical closing or opening of circuit breaker contacts. It has been a desirable method for stress reduction and in particular for reduction of switching overvoltages, becoming an issue of widespread interest to the utilities and manufacturers. Its benefit and feasibility were presented by CIGRE Task Force 13.00.1, with emphasis on mitigation of switching surges and related economical features due to the reduction of insulation levels of large capacitor banks, elimination of circuit breakers auxiliary chamber, compaction of transmission lines and reduction of arresters rating

Microprocessor based controllers are used for point-on-wave switching (the method is based on a very simple zero crossing algorithm with constraints) of circuit breakers for transient reduction and improved power quality. Controlled switching is used for elimination of harmful electrical transients upon planned switching of mainly capacitor banks, shunt reactors and sometimes power transformers. The method is also gaining acceptance for reenergizing of EHV transmission lines, and replacing traditional pre-insertion resistors.

The live tank circuit breakers are particularly well suited for controlled switching due to their good stability in regards to mechanical operating time and dynamic dielectric behaviour. Some controllers are equipped with a special adaptive control, which compensates for any systematic variations in operating time. Necessary signals for the function are received from existing instrument transformers.

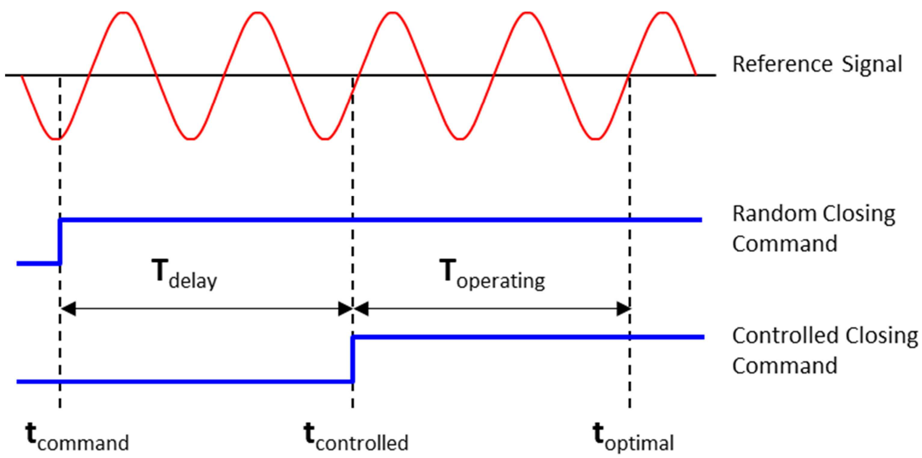

Figure 1: Schematic Controlled Closing Sequence

3.1.1 Shunt Capacitor Banks and Long Cable Connections

In order to completely eliminate the overvoltages and the inrush current produced by the closure of a circuit breaker onto a capacitor bank or capacitive load, it is required that there be a zero voltage difference across the contacts of the circuit breaker at the time where the contacts meet. The circuit breaker is switched on a voltage zero.

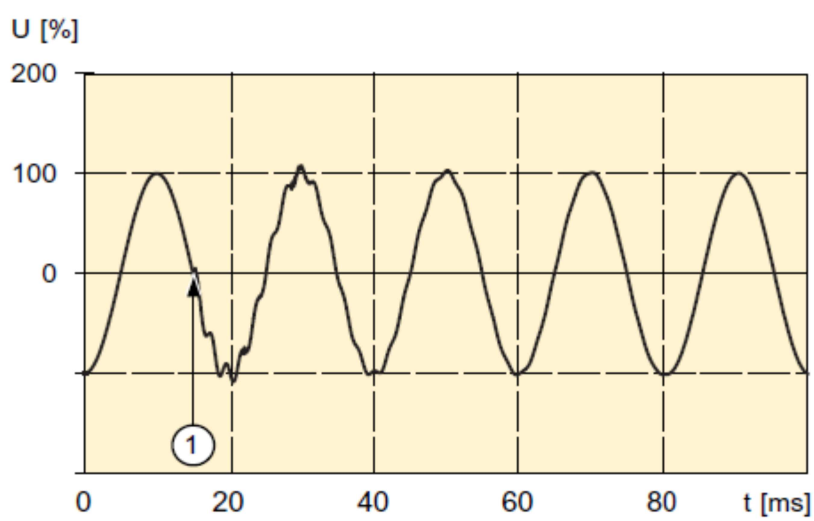

Figure 2: Switching a Capacitive Load on a Voltage Zero

3.1.2 Shunt Reactors

Energisation of a shunt reactor (closing of reactor circuit) involves undesirable inrush current which is in tune of 2-3 times rated current of the reactor. This undesirable inrush current affects the system. This inrush can be avoided by closing the circuit breaker at the peak of the power frequency voltage. For this application, the expected closing time must correspond to a peak of voltage. In order to completely eliminate the overvoltages and the inrush current produced by the closure of a circuit breaker it is required that there be a zero current difference across the contacts of the circuit breaker at the time where the contacts meet.

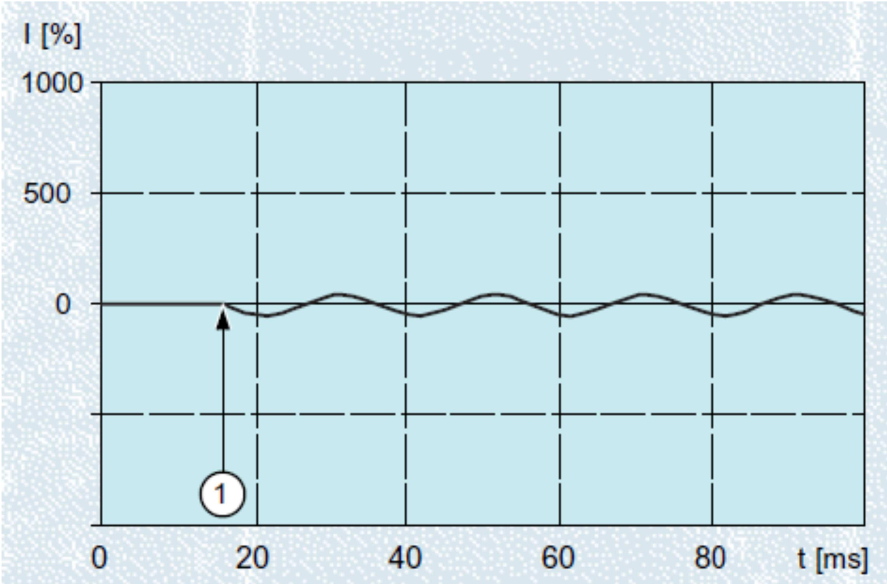

Figure 3: Switching a Reactive Load on a Current Zero

3.2 Auto Reclose

It is well realized that the transient faults which are most frequent in occurrence do no permanent damage to the system as they are transitory in nature. These faults disappear if the line is disconnected from the system momentarily in order to allow the arc to extinguish. After the arc path has become sufficiently deionized, the line can be reclosed to restore normal service. The type of fault could be a flashover across an insulator. Reclosing could also achieve the same thing with semi-permanent faults but with a delayed action, e.g., a small tree branch falling on the line, in which case the cause of the fault would not be removed by the immediate tripping of the circuit breaker but could be burnt away during a time delayed trip and thus the line reclosed to restore normal service. Now should the fault be permanent, reclosing is of no use, as the fault still remains on reclosing and the fault has to be attended personally. It simply means that if the fault does not disappear after the first trip and closure, double or triple-shot reclosing is used in some cases before pulling the line out of service. Experience shows that nearly 80% of the faults are cleared after the first trip, 10% stay in for the second reclosure which is made after a time delay, 3% require the third reclosure and about 7% are permanent faults which are not cleared and result in lockout of the reclosing relay. When a line is fed from both ends, the breakers at the two ends trip simultaneously on occurrence of the fault, the generators at the two ends of the line drift apart in phase, the breakers must be reclosed before the generators drift too far apart for synchronism to be maintained, such a reclosure increases the stability limit considerably.

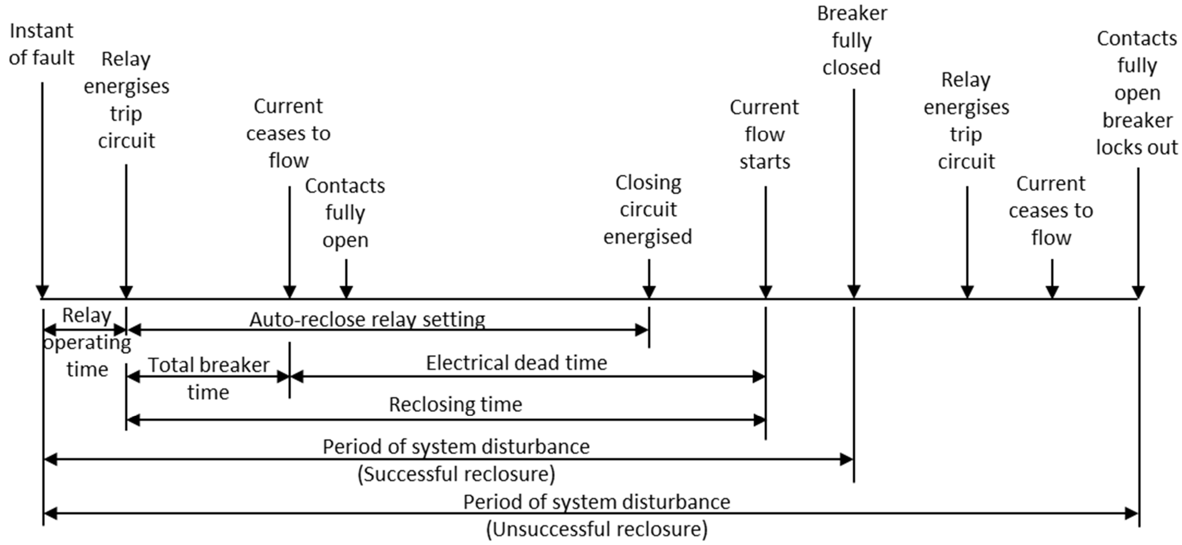

Figure 4: Auto-reclosure Cycle for a Circuit Breaker with a Single Shot Auto-reclose Scheme

3.3 Three Phase verses Single Phase Auto Reclosing

Three-phase auto-reclosure is one in which the three phases of the transmission line are opened after fault incidence, independent of the fault type, and are reclosed after a predetermined time period following the initial circuit breaker opening. For a single circuit interconnectors between two power systems, the opening of all the three phases of the circuit breaker makes the generators in each group start to drift apart in relation to each other, since no interchange of synchronizing power can take place.

On the other hand single-phase auto-reclosure is one in which only the faulted phase is opened in the presence of a single-phase fault and reclosed after a controlled delay period. For multiphase faults, all three phases are opened and reclosure is not attempted. In case of single-phase faults which are in majority, synchronizing power can still be interchanged through the healthy phases.

In the case of single-phase auto-reclosing each phase of the circuit breaker has to be segregated and provided with its own closing and tripping mechanism. Also it is necessary to fit phase selecting relays that will detect and select the faulty phase. Thus single-phase auto-reclosing is more complex and expensive as compared to three-phase auto-reclosing. When single-phase auto-reclose is used the faulty phase must be de-energized for a longer interval of time, than in the case of three-phase auto-reclose, owing to the capacitive coupling between the faulty phase and the healthy conductors which tends to increase the duration of the arc. The advantage claimed for single-phase reclosing is that on a system with transformer neutrals grounded solidly at each substation, the interruption of one phase to clear a ground fault causes negligible interference with the load because the interrupted phase current now flows in the ground through neutral points until the fault current is cleared and the faulted phase reclosed. The main drawback is its longer deionizing time which can cause interference with communication circuits and, in certain cases mal-operation of earth relays in double circuit lines owing to the flow of zero sequence currents.

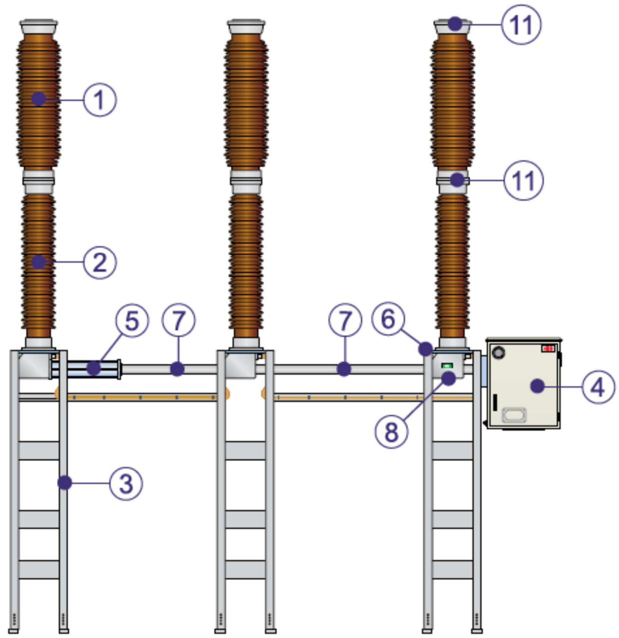

Figure 5: Three-pole Operated Circuit Breaker

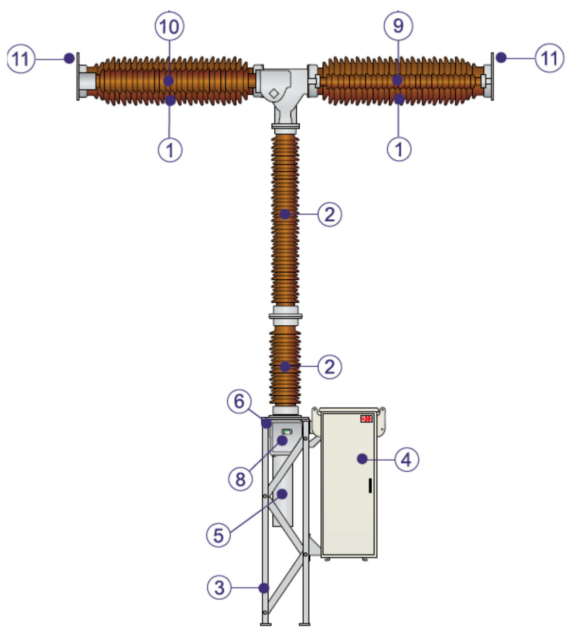

Figure 6: One-pole Operated Circuit Breaker

Table 1 provides a guide as to where single and three mechanism circuit breakers are applied.

Table 1: – Typical Circuit Breaker Allocation

Yard A.C. Loads	Voltage	3-Pole Operation Single Mechanism	1-Pole Operation Three Mechanisms	Reason			
				Controlled Switching	3-Pole Tripping	3-Pole ARC	1-Pole ARC
Shunt Capacitor	All		X	X			
Shunt Reactor	All		X	X			
Feeders	132kV and Below	X				X	
Radial Feeders (where requested)	132kV and Below		X				X
Feeders	220kV and Above		X				X
Transformers	All	X			X		
Generator Transformers	All	X			X		
Bus Coupler used for Bypass and Feeders have 1-Pole Operation	220kV and Above		X				X
Bus Coupler used for Bypass and Feeders have 3-Pole Operation	All	X				X	
Transfer Bus Coupler	220kV and Above		X			X	

4. Authorization

This document has been seen and accepted by:

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5. Revisions

Date	Rev	Compiler	Remarks
Oct 2015	1	AJS Groenewald	First Issue.

6. Development team

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

- Braam Groenewald
- Leon Kotze

7. Acknowledgements

With thanks to all the members of the development team.