CIRCUIT-BREAKERS

This document is for Relevant Electrical Standards document only.

TABLE OF CONTENTS

PURPOSE AND SCOPE

This document describes the technical requirements for User's equipment directly connected to the England and Wales Transmission system and located within NGET's busbar protection zone operating at nominal voltages of 400 kV, 275 kV, 132 kV and 66 kV unless otherwise agreed with the user as defined in the Bilateral agreement. The principles of this document applies to equipment connected at other voltages".

This document defines the technical requirements for circuit-breakers connected to the National Grid Electricity Transmission System at 400kV, 275kV, 132kV, 66kV. The principles of this document also apply to equipment connected at other voltages.

PART 1 – PROCEDURAL

1 GENERAL REQUIREMENTS

1.1 General Requirements for Circuit-breakers

1.1.1 All mandatory requirements of IEC 62271-100 and IEC 62271-1 shall be met for the specified rating in an effectively earthed neutral system.

1.1.2 The circuit-breakers shall satisfactorily complete all initiated close and open operations.

1.1.3 In the event of a failure to latch in the closed position the circuit-breaker shall open fully and shall be capable of performing all switching and fault interrupting duties during this opening operation.

1.1.4 In the event of opening immediately following a close operation and a continuous close signal being maintained there shall not be repeated attempts to close the circuit-breaker.

1.1.5 All circuit-breakers shall be fitted with a robust and reliable indicating drive system capable at all times of giving a clear and unambiguous representation of the position of the main contacts of the device. The indicating system shall be positively driven in both directions.

1.1.6 The density of the arc extinguishing and insulating media shall be monitored and two discrete alarm levels shall be set as follows;

- A Falling gas alarm to signify the gas density of the arc extinguishing and insulating media has fallen below the normal/rated operating density but is still within operational limits. Opening will still be possible and a close may still be possible, depending on the circuit breaker design.

- A Low gas alarm to signify the gas density of the arc extinguishing and insulating media has fallen to the minimal functional pressure.

Where applicable, the low gas alarm for the arc extinguishing and insulating media shall coincide with an open and close lockout to prevent the circuit breaker being opened and closed. The open and close lockout is often referred to as a Trip Lockout.

A separate close lockout may also be required at an operating density of the arc extinguishing and insulating media between the normal and low alarm level at which it can no longer perform a close and subsequent immediate open operation. With agreement this lockout may coincide with the falling alarm level, or the falling alarm level may be set to coincide with the required close lockout density. A close lockout is typically not required where the density of the insulating and interrupting medium is not depleted during the closing operation,

Informative: Where the insulation media is different to the arc extinguishing media and evidence exists that the insulation medium can be operated at 0barg, assuming the arc extinguishing media is at an acceptable level, i.e. vacuum interrupters in SF^6, the requirement for low density open and close lockout can be waived provided it can be demonstrated that any associated switching transients, lightning transients or normal steady state voltages do not result in the insulation media being overstressed.

1.1.7 Monitoring systems shall be such that any closing operations are only permitted if a subsequent opening operation remains possible. These requirements may be modified where a requirement for forced tripping is identified. This can apply to both operating mechanisms and interrupters.

1.1.8 Provision shall be made for falling density, low density, close lockout and open lockout levels, as appropriate, to be remotely alarmed.

1.1.9 The circuit-breaker in its normal operational state (i.e. with all access doors etc closed) shall meet the pollution performance criteria associated with a degree of protection of IP54.

1.1.10 Where isolation facilities are provided between the main volume of any insulating or arc extinguishing media and the associated monitoring equipment this isolation shall fail to safety and it shall not be possible to put the circuit-breaker into service with the monitoring isolated and unable to monitor the main volume.

1.1.11 Circuit breakers shall be designed to be controlled and operate as a synchronous three phase device, with the exception of devices utilising controlled switching (Point on Wave) where the operation of each phase is intentionally staggered by a defined amount. When intentionally switching non simultaneously the condition of each phase shall be considered as per the logic in Appendix A before allowing operation of the circuit breaker.

Informative: It is recognised that the circuit breaker logic and wiring may be different where controlled switching is implemented as the circuit breaker is no longer switched as a

complete three phase device. The circuit breaker should only be allowed to operate if all three phases are in a condition that would allow it to operate.

Informative: Where a complete circuit breaker comprises fewer or greater than three phases the same logic as described above shall apply.

1.2 General Requirements for Mechanisms and Stored Energy Systems

1.2.1 Circuit-breakers shall be arranged for three pole operation by powered mechanism or mechanisms.

1.2.2 The rated operating sequence in accordance with IEC 62271-100 shall be O - 0.3s - CO - 3 min - CO.

1.2.3 Provision shall be made for local and remote indication that the stored energy system has less than the specified minimum stored energy for a normal operating cycle, close-open (CO). The close lockout shall be initiated. This 'stored energy system incorrect' indication shall not be initiated due to normal operation of the circuit-breaker, including any recharging activity to replenish the minimum stored energy level.

1.2.4 Provision shall be made for local and remote indication that the stored energy system has less than the specified minimum stored energy for normal opening. The open lockout or, where required, a forced open operation, shall be initiated. This 'stored energy system incorrect' indication shall not be initiated due to normal operation of the circuit-breaker.

1.2.5 Operating system lockouts shall be arranged such that if it is possible to close the circuit-breaker normally then opening is not prevented as a result of the energy consumed during the preceding close operation.

1.2.6 In satisfying clause 1.2.5 the maximum tolerance on setting of monitoring devices and an allowance for drift and short time adiabatic change together with either an ambient temperature change of up to 10°C or the normal loss of stored energy during a two hour period, whichever has the greater effect, shall be taken into account.

1.2.7 Where a hydraulic system utilises a compressed gas for energy storage, the pre-charge pressure of this gas related to the ambient temperature at the time of pre-charging shall be sufficient to prevent the initiation of a low gas alarm under normal operating conditions when the ambient temperature falls to the minimum specified in TS 1(RES). Where such systems initiate lockouts following loss of the pre-charge they shall also initiate appropriate alarms indicating the conditions.

1.2.8 The operating level of safety/relief valves fitted to replenishment systems shall be set with sufficient margin above the system replenishment cessation level to accommodate an ambient temperature rise of 10°C.

1.2.9 Means shall be provided to allow the stored energy system to be charged and discharged when the circuit-breaker is either closed or open without causing operation of, or damage to, the circuit-breaker. This requirement is waived for springs connected directly to moving contacts, such as opening springs.

1.2.10 Loss of stored energy from the mechanism shall not cause the primary contacts to part.

1.2.11 Stored energy systems shall not be released due to vibration caused by normal operation or other normal service phenomena.

1.2.12 Mechanisms incorporating springs for energy storage shall be provided with an unambiguous indication of spring state (charged or discharged).

1.3 General Requirements for Control Schemes and Circuitry

1.3.1 Where individual poles have separate operating releases the control scheme shall be such that the requirements of clause 1.3.7 are met.

1.3.2 If the opening circuit is initiated the closing circuit shall be rendered inoperative.

1.3.3 Operating mechanisms shall be provided with facilities for closing and opening and for selection of local/remote control

1.3.4 In the event of a failure to complete a closing operation involving poles having independent drive mechanisms provision shall be made for automatic opening of poles which have closed. Provision for a remote alarm indicating non-simultaneity of poles shall be provided. This requirement shall take account of any intentional non-simultaneity of poles.

1.3.5 In the event of a failure to complete an opening operation involving poles having independent drive mechanisms, provision shall be made for an alarm indicating non-simultaneity of poles. This requirement shall take account of any intentional non-simultaneity of poles.

Informative: It is noted this can be implemented by the on site control scheme instead of by the circuit breaker.

1.3.6 300 kV and 420 kV circuit-breakers shall be provided with two opening releases per operating mechanism. The opening releases shall be arranged for supply from independent battery systems and shall have segregated circuits such that failure of one device in a circuit does not prevent opening of the circuit-breaker. The logic diagrams in Appendix A illustrate the requirements.

1.3.7 If the D.C. power supply is removed from either opening circuit of a circuit-breaker control scheme or one of the Trip Circuit Supervision systems detects a fault with one of the two trip circuits, an alarm shall be raised and it shall still be possible to close the circuit breaker. If the D.C power supply is removed from both opening circuits of a circuit breaker control scheme, the remote closing circuit or mechanism shall be rendered inoperative and a suitable alarm raised to signify the breaker is now inoperative.

1.3.8 Circuit-breaker opening coils and their associated opening circuits shall be suitable for continuous supervision which is functional regardless of the state of the circuit-breaker (open or closed).

The alarm output shall not operate due to normal circuit-breaker operations. The system shall be self-monitoring and failure of a single component shall not cause the circuit-breaker to operate. Isolation facilities shall be provided for circuit-breaker opening coils. These shall be labelled appropriately. These facilities shall be such that the open circuit supervision system shall detect isolation of the opening coils. In addition, the isolation facilities shall be such that they can be secured against unauthorised reinstatement, preferably by a lock and removable key system.

1.3.9 Electrical connectors used within the mechanism cabinet of a circuit-breaker shall be suitable for the mechanical duty imposed upon them and their integrity shall not be compromised by operation of the mechanism.

2 PERFORMANCE REQUIREMENTS

2.1.1 Electronic equipment shall comply with the relevant requirements of NGTS 3.24.15(RES).

2.1.2 When switching capacitive currents within declared rating the circuit-breaker shall exhibit a very low probability of re-strike as defined by Class C2 of IEC 62271-100.

2.1.3 The short-circuit ratings specified apply to both three phase and single phase fault conditions including the relevant arc duration considerations.

2.1.4 The maximum short-circuit break time required to comply with TS 1(RES) is 50 ms for 420 kV circuit-breakers, 60 ms for 300 kV circuit-breakers and 70 ms for 145 kV circuit-breakers. This break time shall be determined as described in IEC 62271-100 with due regard to the rated voltage of the operating releases as defined in TS 2.2 (RES).

Informative: The IEC defines the break time as "the interval of time between the beginning of the opening time of a mechanical switching device and the end of the arcing time". Since the break time depends heavily on the current being interrupted the term short circuit break time is used to clarify the particular conditions under which the break time is critical i.e. under short circuit conditions for reasons of system stability etc.

2.1.5 The circuit-breaker opening and closing times at the maximum, rated and minimum operating voltage of the opening and closing releases shall be declared.

2.1.6 The maximum Make-Break time shall be 80 ms for 420 kV circuit-breaker, 100 ms for 300 kV circuit-breakers and 120 ms for 145 kV circuit-breakers.

2.1.7 The minimum Make-Break time at rated conditions shall be declared and it shall be demonstrated that the circuit-breaker can perform all switching and fault interrupting duties under these conditions.

2.1.8 Operating tolerances, including those for simultaneity of poles, shall be as specified in IEC 62271-100

2.1.9 Circuit-breakers for intentionally non-simultaneous pole operation shall be designed and tested in accordance with IEC 62271-302.

3 TEST REQUIREMENTS

3.1 Control System Test Requirements

3.1.1 Control system testing shall be in accordance with the requirements of TS 3.24.15 (RES).

3.2 Type Test Requirements for Circuit-Breakers

3.2.1 For general application, asymmetrical current short-circuit interruption tests shall be undertaken with a time constant of 45ms or greater.

3.2.2 145kV circuit-breaker shall also be demonstrated to be capable of operation at a dc time constant of 135ms.

Informative: 135ms may be required at bulk supply points and a coincident reduction in RMS current rating e.g. from 40kA to 31.5kA may be acceptable.

Note re 3.2.1 & 3.2.2: If other nominal and short circuit current ratings are applicable to users this is acceptable provided the equipment is fit for purpose. . As per IEC6227-1, 120ms will be accepted where it is adequate for site specific conditions.

3.2.3 Short-circuit testing shall be demonstrated at the minimum operating conditions (lockout) appropriate to the commencement of the duty, i.e. C, O or O-0.3sec-CO. This demonstration shall confirm the interrupting ability, at open lockout conditions, throughout the full range of arc durations related to single phase fault conditions.

3.2.4 Short-circuit testing shall be demonstrated at the minimum (lockout) conditions of arc extinguishing and insulating media

3.2.5 Demonstration of ability against the non-mandatory and Out of Phase requirements of IEC 62271-100 is required.

3.2.6 General purpose circuit-breakers shall be tested for overhead line and cable switching duties in accordance with IEC 62271-100. These tests shall demonstrate that the circuit-breaker can be categorised as having a very low probability of re-strike (Class C2). The voltage factor during testing shall be 1.4 for overhead line application and 1.0 for cable applications. Cable switching testing may be waived where circuit-breakers are separately tested for capacitor bank switching.

Informative: Capacitive current switching tests shall preferably be performed using full pole, direct test methods.

3.3 Routine Tests

3.3.1 Routine testing shall comply with IEC 62271-100.

3.4 Site Commissioning Tests

3.4.1 The Supplier shall provide a schedule of site commissioning tests, broadly in accordance with, and sufficient to show compliance with, IEC 62271-100. The site commissioning programme shall include a complete functional check of the control features.

4 FORMS AND RECORDS

None.

PART 2 - DEFINITIONS AND DOCUMENT HISTORY

5 DEFINITIONS

General purpose circuit-breaker	A circuit-breaker for application or connection to NGET's transmission system operating in a normal system role covered by the requirements of IEC 62271-100. Typically this refers to circuit-breakers applied to lines, cables, transformers, bus sections and bus couplers.
Special purpose circuit-breaker	A circuit-breaker for application to a particular part of NGET's network requiring special consideration and testing in excess of that for general application. Typically this refers to shunt capacitor banks, shunt reactors and series reactors.
Controlled switching	A method whereby the timing of the operation of a circuit-breaker is precisely controlled in relation to the power frequency supply. Also known as "point-on-wave" switching.
Controlled switching system	The combination of a circuit-breaker, controller (relay) and control scheme which, in combination, achieves controlled switching.

6 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
1	October 2014	New document	Mark Waldron/ Richard Poole	GCRP
2	February 2018	Re-defined alarms produced due to falling and low insulation and interruption media and mechanism stored energy Changes to logic diagrams for insulation/interruption medium falling level and close lockout conditions and no longer require both trip coil circuits to be available to allow a close operation. Various clarifications and amendments	Matthew Iles	GCRP

6.1 Procedure Review Date

5 years from publication date.

PART 3 - GUIDANCE NOTES & APPENDICES

7 REFERENCES

7.1 Noise at Work Regulations 1989

7.2 IEC 62271-1 High-voltage Switchgear & Controlgear – Part 1: Common Specifications

7.3 IEC 62271-100 High-voltage Switchgear & Controlgear – Part 100: AlternatingCurrent Circuit-breakers

7.4 IEC 62271-110 High-voltage Switchgear & Controlgear – Part 110: Inductive Current Switching.

7.5 IEC 62271-302 High Voltage Switchgear & Controlgear – Part 302: Alternating Current circuit-breakers with intentionally non-simultaneous poleoperation

7.6 BS 381C Specification for Colours for Identification, Coding and Special Purposes.

7.7 TS 1(RES) Ratings and General Requirements for Plant, Equipment & Apparatus for the National Grid system

7.8 TS 2.2(RES) Switchgear

7.9 TS 3.24.15(RES) Environmental and Test Requirements for Electronic Equipment

APPENDIX A - OPENING AND CLOSING RELEASE LOGIC DIAGRAMS

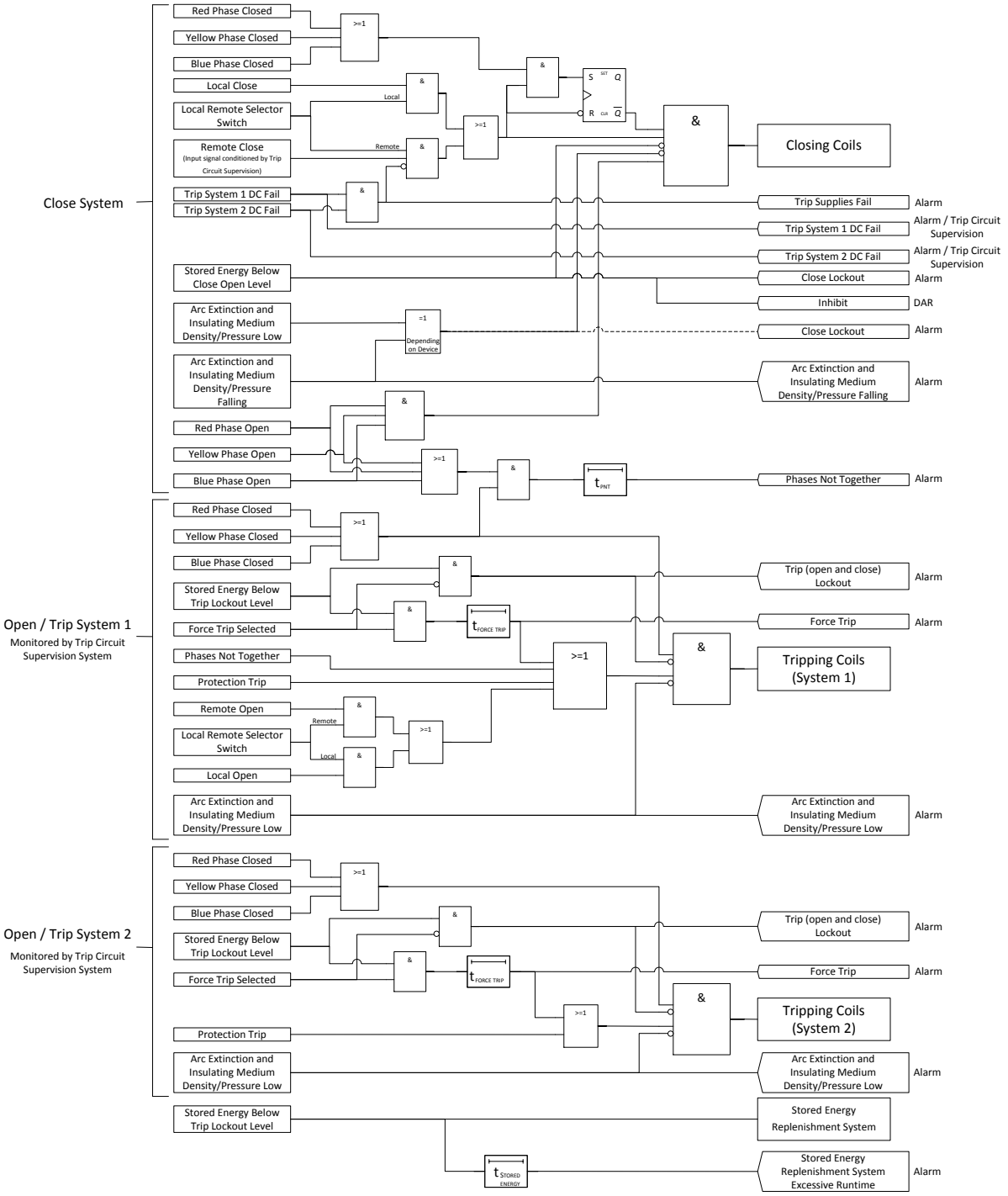
The attached logic diagrams detail the circuit segregation requirements applicable for the double opening release and series closing control schemes for circuit-breakers and switches.

Attachment 1 - Segregated phases with forced open facility

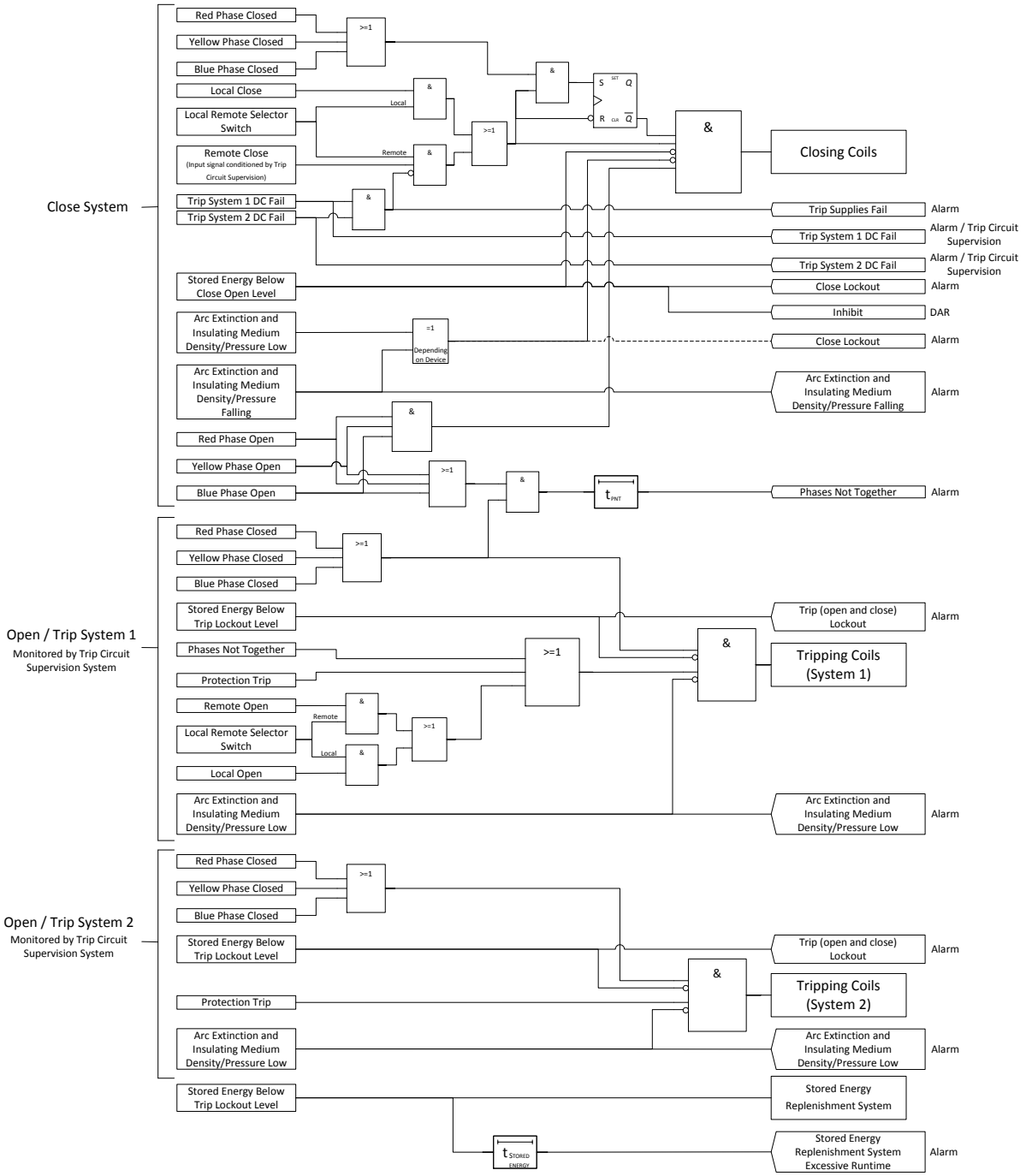
Attachment 2 - Segregated phases with open lockout

Attachment 3 - Three phase mechanism with forced open facility

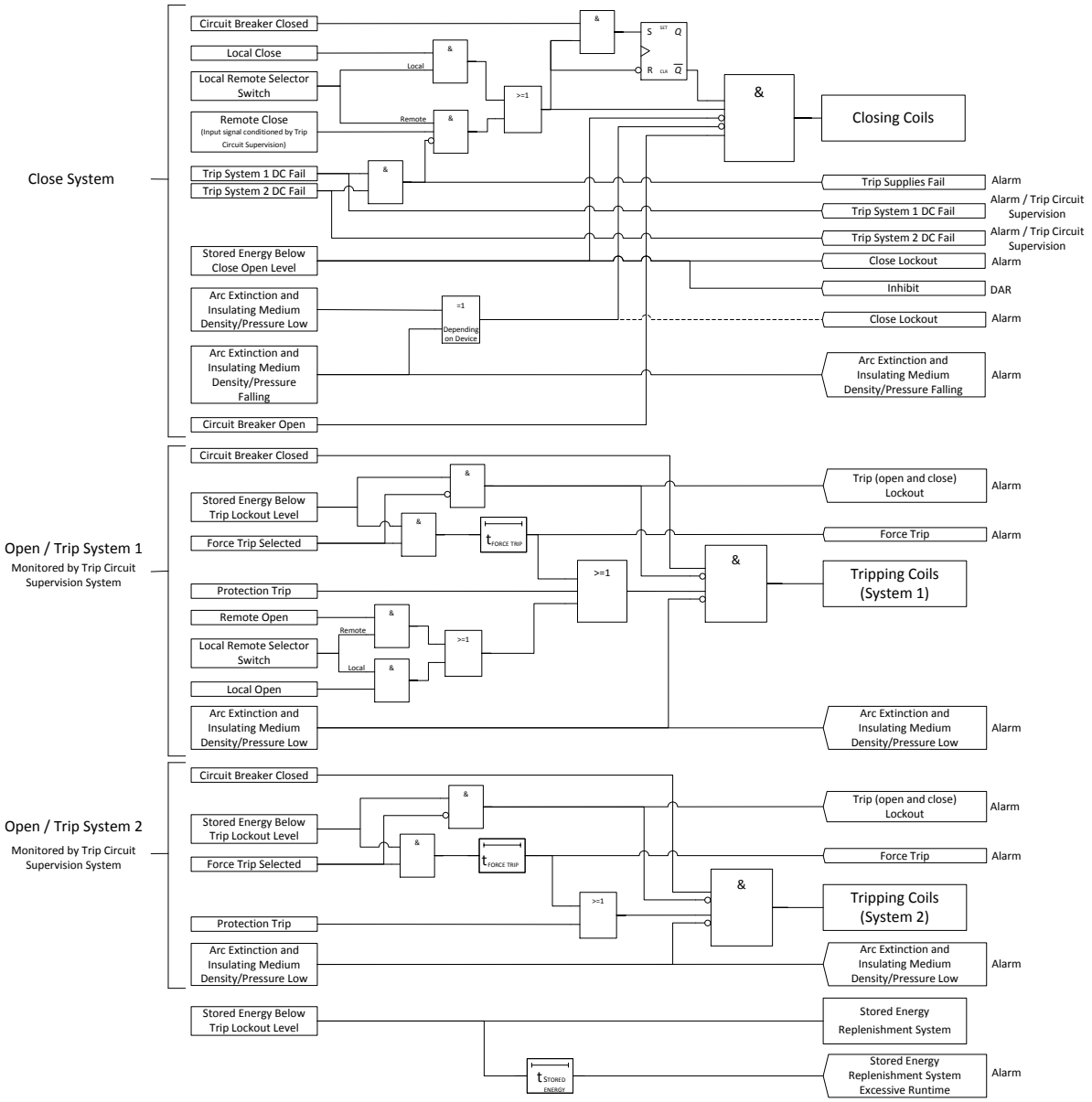
Attachment 4 - Three phase mechanism with open lockout



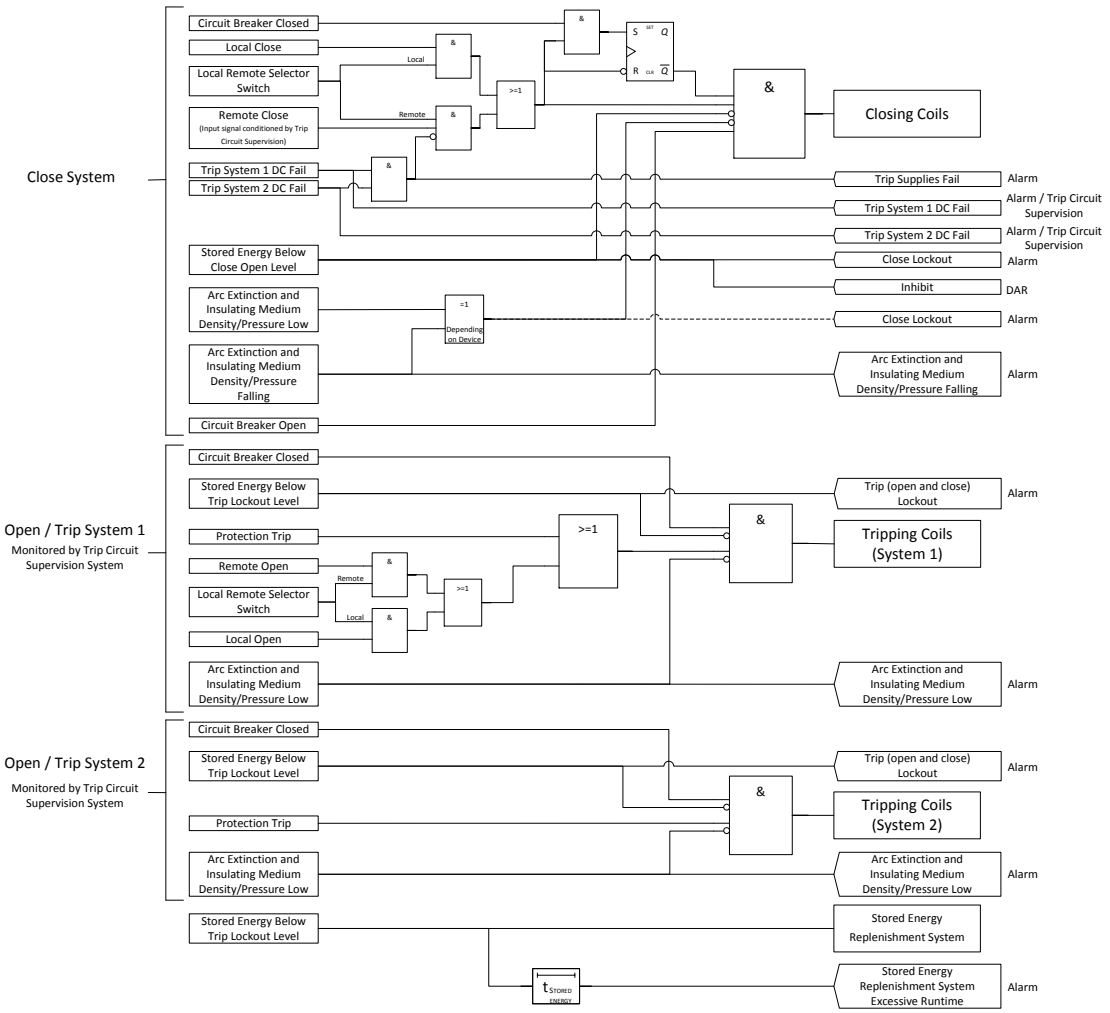
Attachment 1 – Segregated Phases with Force Open Facility



Attachment 2 – Segregated Phases with Open Lockout



Attachment 3 – Three Phase Mechanism with Force Open Facility



Attachment 4 – Thee Phase Mechanism with Open Lockout