



RP 12-7

ELECTRICAL SYSTEMS AND INSTALLATIONS - LOW VOLTAGE SWITCHGEAR

November 1994

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SCOPE AND PURPOSE This document supplements international standards and contains recommendations for the selection and use of Low Voltage Switchgear. Its purpose is to ensure the provision of fit for purpose equipment at minimum cost/complexity											
AMENDMENTS <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">Amd</th> <th style="width: 15%;">Date</th> <th style="width: 20%;">Page(s)</th> <th style="width: 50%;">Description</th> </tr> </thead> <tbody> <tr> <td colspan="4" style="height: 150px;"> </td> </tr> </tbody> </table>				Amd	Date	Page(s)	Description				
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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

This Recommended Practice provides guidance additional to that available in national and international documents and draws the designers attention to the peripheral issues affecting the design of a low voltage switchgear installation.

Application

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Recommended Practice, and may discuss alternative options.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Principal Changes from Previous Edition

Generally updated and re-formatted with references updated to include latest IEC standards.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

BP Group RP 12 series specify BP general requirements for electrical systems, equipment, materials and installations.

This document (BP Group RP 12-7) specifies requirements for the selection and application of low voltage switchgear.

2. DESIGN REQUIREMENTS

2.1 Switchgear Type and Specification

2.1.1 Low voltage switchgear and control gear shall comply with BP Group [GS 112-8](#).

This document gives detailed guidance for equipment for indoor installation. Much of the data is equally applicable to both outdoor and totally insulated designs, and hence this document may be used, making specific reference on the Data Sheets to additional requirements and to those clauses that are not applicable.

2.1.2 The equipment should be a factory built assembly (FBA) from a manufacturer capable of providing an acceptable technical and commercial back-up service.

Additionally, where the equipment is to be installed on an existing location the following factors are to be considered.

- (i) Compliance with BP Group [GS 112-8](#) as far as is practical.
- (ii) Installing equipment with which the site maintenance staff are familiar.

This should not be a justification for the continued use of outdated equipment. The use of new designs and innovative approaches should always be pursued.

- (iii) Minimise spares holding.

2.1.3 When BP Group [GS 112-8](#) is used by design contractors or any other party acting on behalf of BP, they may substitute their own Data Sheets.

2.1.4 The complete FBA shall be of an adequate fault rating to meet the requirements of BP Group [RP 12-3](#).

Note that the d.c. content of current waveform at any time following fault application is affected by the X/R ratio of the circuit to the point of fault.



Switchgear tested in accordance with [IEC 439](#) and [IEC 947](#) have a relationship between 'make' and 'break' current which assumes a system X/R ratio according to the short circuit loading of the gear. Where the system X/R ratio exceeds this value it may be necessary to undertake supplementary testing to prove equipment is adequate for the duty.

2.2 Enclosures

2.2.1 The height of equipment should be limited to 2.5 m unless there is a height restriction in the location in which it is to be installed.

2.2.2 The standard ingress protection (IP) is IP 42, this may need to be enhanced for other than indoor protected environments.

Outdoor locations would normally require IP 54 onshore and IP 55 offshore.

2.3 Motor Starters and Contactor Feeder Units

2.3.1 Swingout or fixed panel type units should be provided. The use of FBA's with a withdrawable type of unit shall be supported by evidence that the design integrity is sufficient.

Requirements to be satisfied include:-

- (i) *That the segregation requirements can be achieved.*
- (ii) *That the installation of external cables by the use of individual cable boxes for each unit can be achieved.*
- (iii) *That any spring loaded connection to the busbars are certified for the full short circuit current and time rating.*
- (iv) *That the connection to busbars will not suffer oxidation and subsequent local heating effects while operating continuously at full load in the specified environment over the maintenance period adopted at the site of installation.*
- (v) *That the number of withdrawable contactor units together with the possible weaknesses illustrated by (i) to (iv) above does not reduce switchgear reliability to an unacceptable degree.*

2.3.2 Short circuit protection can be provided by fuse or moulded case circuit breaker (MCCB). A MCCB can also provide the means of isolation for a feeder.

MCCB's should preferably be of the fixed or withdrawable type. Isolation can be achieved by a fixed type if it has specifically been designed to perform this function, or can be achieved by using a withdrawable type. Plug in versions should be avoided.

- 2.3.3 The minimum rating of a contactor feeder, below which a manually switched feeder would be utilised will be determined from the overall earth fault protection philosophy adopted.

Since circuits above 200A will normally have earth leakage protection, they shall be provided with a switching device (contactor) to ensure automatic operation. Therefore, manually switched feeders are not recommended above 200A rating.

Outgoing circuits rated above 200A will normally feed sub circuits having no earth fault protection (protection provided exclusively by fuse or moulded case circuit breaker). To ensure discrimination, earth fault protection shall be time and current graded with the sub-circuit.

Sensitive earth leakage protection will be required on some circuits of less than 200A. Typical applications include trace heating, where the provision of sensitive earth leakage protection may be necessary to comply with the installation recommendations for use in hazardous areas, and circuits supplying sockets, where there is a possibility of using portable equipment.

2.4 Circuit Breakers

- 2.4.1 Circuit breakers can be either 'open' type construction or MCCB type and shall be of a withdrawable pattern.

The requirements of 2.3.1 (i) to (iv) should be satisfied.

- 2.4.2 When assessing the peak making capability for circuit breakers fed via transformers up to 1250 kVA capacity, a short circuit breaking power factor of 0.15 should be assumed for calculation of the d.c. decrement. For larger capacities a detailed calculation check shall be carried out in accordance with BP Group [RP 12-3](#).

This approach ensures a simple procedure with an adequate safety margin for specifying circuit breakers in small installations.

- 2.4.3 When accommodating circuit breakers within an enclosure as part of an FBA, the design of the enclosure is critical to achieving the specified performance of the complete assembly. The performance of the circuit breaker for full short circuit duty in accordance with [IEC 947](#) Part 2 shall be supported either by tests of the circuit breakers installed in the FBA or by tests of the circuit breakers in enclosures with the same or more stringent air supply and exhaust provisions.

The test certificates should be inspected or testing arrangements agreed before order placement.

- 2.4.4 The short circuit breaking capacity of a circuit breaker should be based on the 'service short circuit breaking capacity' as it will normally be a requirement that the circuit breaker can be returned to service without maintenance following clearance of a through fault.

In assessing the short circuit breaking capability of a circuit breaker the difference between the 'service short circuit breaking capacity' (I_{CS}) and the 'ultimate short circuit breaking capacity' (I_{CU}) should be understood. The type test in [IEC 947 Part 2](#) for a circuit breaker at its 'service short circuit breaking capacity' includes checks to ensure the performance of the breaker has not deteriorated and the current carrying, breaking and making capacities of the breaker are still intact. The type test at the 'ultimate short circuit breaking capacity' ensures the breaker can safely break this current, but there is no requirement for the breaker to be capable of continued service without remedial work being performed.

In any event, and whichever rating is selected, the capability of the breaker must be in excess of the prospective fault level at the point of connection.

- 2.4.5 Direct current solenoid operated circuit breakers shall have the required d.c. voltage stated on the certificate of rating and it is vital that this is maintained for those breakers with an 'enhanced making' capability. Specific attention shall be given to the d.c. power supply specification.

A breaker with an enhanced making capacity has a modified closing mechanism which ensures a short closing time. It is therefore essential that this time is not extended by operation outside the design values.

- 2.4.6 A circuit breaker handling truck should be provided in each location containing low voltage FBA's.

2.5 Control

- 2.5.1 All circuit breakers and contactors shall have a manual trip facility local to the FBA.

- 2.5.2 Circuit breaker intertripping between low voltage and high voltage switchgear should be provided in accordance with the recommendations of BP Group [RP 12-4](#).

There are many methods of implementing an intertripping scheme. The most common schemes are based on 4 wire designs with intertripping from high-voltage to low-voltage, and low-voltage to high-voltage ends, each having electrically separate circuits utilising two wires each.

- 2.5.3 All remote controlled circuit breakers and contactors shall have the closing device local to the panel either omitted or made inoperable when the circuit breaker or contactor is in the normal operating position.

A local closing device may be useful for maintenance purposes when the circuit breaker or contactor is in the test position but its use would be undesirable in the operating position where this may contravene the operation philosophy.

- 2.5.4 Circuit breakers with power assisted closing, and withdrawable type contactors, should be provided with a means of operational testing when in the test, or part withdrawn isolated position. The tripping device local to the panel shall be operable in the test position as shall the closing device local to the panel if fitted. In the test position all other remote and automatic control circuits shall be inoperable.

This facility should allow for the testing of the circuit breaker or contactor without unnecessary or unexpected operation.

- 2.5.5 Circuit breakers shall normally be closed and tripped from the FBA.

- 2.5.6 A motor starter shall normally be opened and closed from a control station adjacent to the motor. For further guidance on motor control, reference should be made to BP Group [RP 12-4](#).

- 2.5.7 Any emergency 'stop' control for motor starters should form part of the primary stop control circuit and the use of interposing relays should be avoided. If interposing relays and/or the introduction of an auxiliary power supply is unavoidable then the latter shall be derived from a secure source.

The release of any emergency 'stop' control shall not cause re-energisation of the equipment concerned.

This requirement is primarily related to drives functioning on automatic control, the restart inhibit can be achieved either at the switchgear or with the drive control logic.

- 2.5.8 For motor contactor units directly controlled via control circuits over 600 m long, the following alternatives should be considered:-

- (i) The use of interposing relays.

Providing remote control circuits do not exceed 600m of 2.5 mm² cable the voltage drop in the remote control circuit (when a contactor closes) should not exceed 5%.

- (ii) 110 V d.c. control.

Very long lengths of control cable, typically in excess of 1500m, will have an appreciable capacitance which may cause relays to remain energised incorrectly. The use of 110 V d.c. will overcome this problem.

2.6 Protection

- 2.6.1 The precise location of the neutral/earth current transformer in a low voltage system will be dependant upon the type of protection applied to each circuit. The protection scheme used should be in accordance with

BP Group [RP 12-4](#). Where several different protection schemes are specified, it may be necessary to install current transformers in low voltage controlgear in locations applicable to each scheme.

Current transformer locations for:-

- (i) unrestricted earth fault
- (ii) restricted earth fault
- (iii) partial differential protection

are shown in Figure 1, Figure 2, and Figure 3 respectively, and are for a typical star connected transformer secondary.

2.7 Earthing

- 2.7.1 The earthing of single core cables with a metallic sheath and/or armour requires particular care.

Single core cables entering a gland plate should have provision to reduce the effects of eddy currents flowing in the gland plate.

Single core cables with a metallic sheath/armour may require to be de-rated if they are earthed at both ends due to circulating currents in the sheath/armour.

If the de-rating associated with earthing at both ends is unacceptable, the sheath/armour should be earthed at one end only, the other ends being insulated from earth and each other. The earthed end should always be at the 'field' end as the insulation integrity is better maintained in an 'indoor' environment and additionally, if the field end is in a hazardous area, the conditions for a safe installation are easily met if the sheath/armour is earthed.

More detailed guidance on this topic is given in BP Group [RP 12-16](#).

2.8 Motor Re-acceleration

- 2.8.1 For schemes involving the automatic re-acceleration of motors, proposals should be developed for the automatic reclosure of contactors and circuit breakers from studies as described in BP Group [RP 12-3](#).

Re-acceleration schemes will provide either a 'ride-through' capability where the circuit breaker or contactor remains closed for the duration of a power system disturbance or a 're-start' capability where dedicated logic will automatically restart a stopping or stopped drive (or number of drives) following a disturbance. The choice of scheme will depend on the criticality of the drive and the capability of the power system.

A number of factors need to be considered:-

The motor residual voltage which could cause damaging transient torques if the supply is reconnected out of phase with a large residual voltage.

The ability of the power system to support the starting current of a number of motors. If the power system cannot re-accelerate all the motors on the system simultaneously then motors should be arranged in groups, and time delays introduced so each group achieves full speed before the next group is started. An under voltage detection with an appropriate time delay will ensure that no attempt will be made to re-accelerate drives if the undervoltage persists for an unacceptably long time.

Care should be exercised as a number of drives will have a 'standby' which will attempt to start from for instance a process condition (low flow, low pressure etc.) due to the duty drive stopping. It should be ensured that a conflict in control strategy does not arise.

2.9 Interlocks

2.9.1 Mechanical interlocking should be provided on switchgear to achieve the following:-

- (i) Prevention of access to live parts. Safe and adequate provision should nevertheless be made to enable access for tests.

The ingress protection of the switchgear in its normal operating condition (typically IP 3X or better) will ensure a safe installation. However, the equipment could be operated in such a manner that the ingress protection is reduced (i.e. circuit breakers withdrawn, voltage transformers withdrawn) and free access is given to live parts. Devices should then be installed (typically shutters) such that the ingress protection is maintained under all conditions.

- (ii) Prevention of operation of isolators or earthing devices until necessary switchgear conditions are satisfied.

It shall be impossible to operate such devices under conditions other than those for which they are intended. For example an isolator should only be operated when the associated circuit breaker, switch or contactor is in the open position. Similarly it should be ensured that all possible incoming feeds to a point of earth application are isolated before an earth application is possible.

- (iii) Prevention of operation of the main circuit device until necessary switchgear conditions are satisfied.

The operation of a circuit breaker, switch or contactor shall be impossible unless it is in the service, disconnected, removed, test or earthing position.

2.9.2 Where circuits include electrical interlocks the design should be as far as possible 'fail safe'.

The failure of electrical components (such as relays and switches) in their recognised failure modes shall ensure that there is no reduction in the safe operation of the equipment. This would normally mean that a failure would result in the circuit becoming de-energised if it was originally energised, or that energisation would be prevented if it was not energised already, or that an earth could not be applied.

2.10 Alarms and Indications

- 2.10.1 Alarms and indicators shall be provided in accordance with the requirements of BP Group [RP 12-4](#).

2.11 Ancillary Equipment

- 2.11.1 All necessary equipment shall be included for the operation, maintenance and handling of the installed equipment, e.g. switch trucks, special tools, testing and earthing equipment.

3. SWITCHGEAR INSTALLATION

3.1 Access

Adequate clearance should be provided around the switchgear for maintenance, operation, access and anticipated extensions.

Local regulations will determine the minimum clearances allowed around a switchboard. In the absence of such regulations a 1 m minimum clearance in front of switchboards has been found to be practical. This may need to be increased when withdrawable equipment is fitted, and in this event a minimum clearance of 0.4 m should be allowed when the equipment is fully withdrawn. A minimum clearance of 0.6 m should be allowed at the rear of switchboards, and this dimension is appropriate for the ends, due consideration being given to any requirement for future extension of the switchboard at either end.

The equipment manufacturer should always be consulted for recommended clearances.



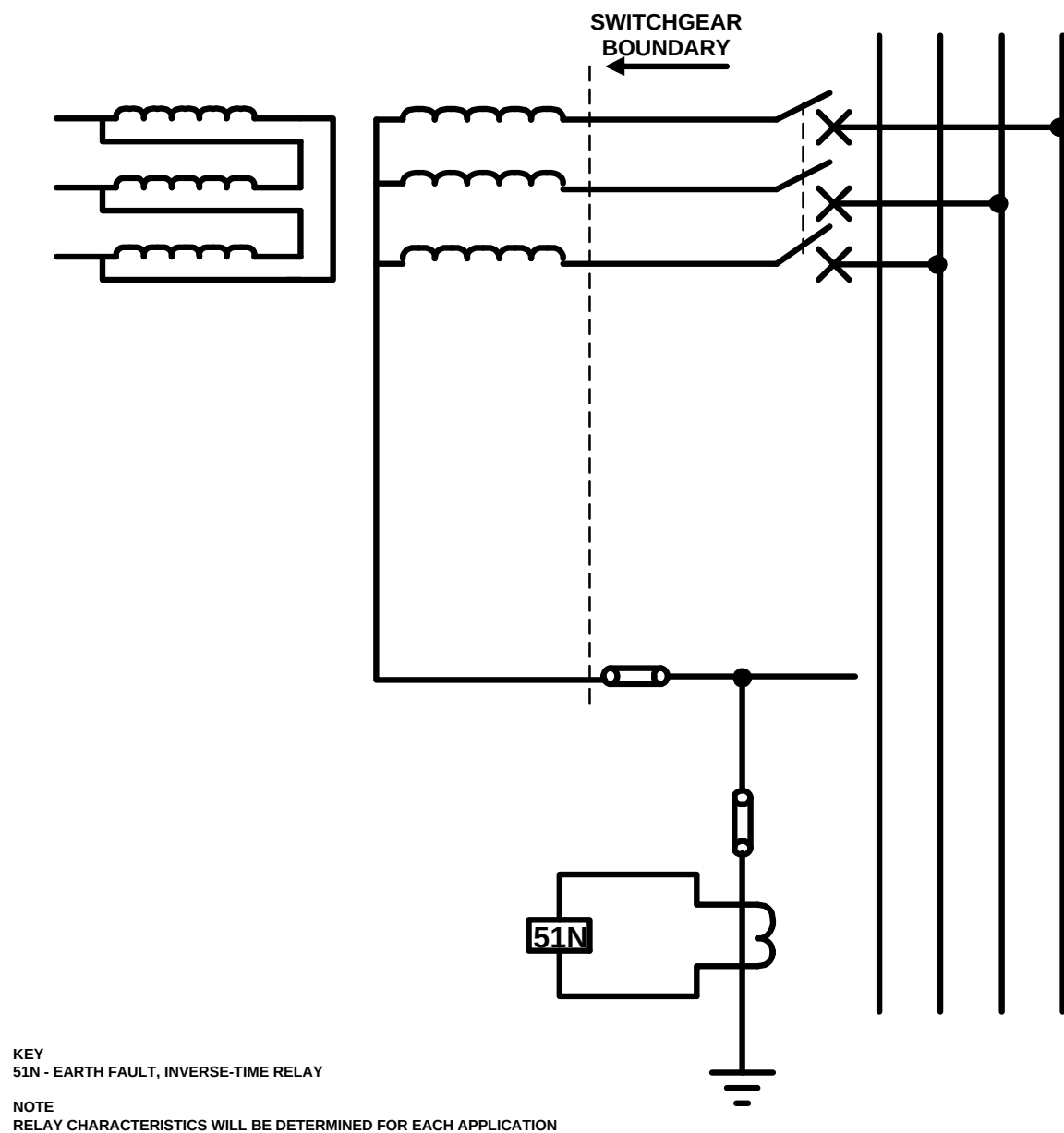


FIGURE 1

C.T. LOCATION FOR UNRESTRICTED EARTH FAULT PROTECTION

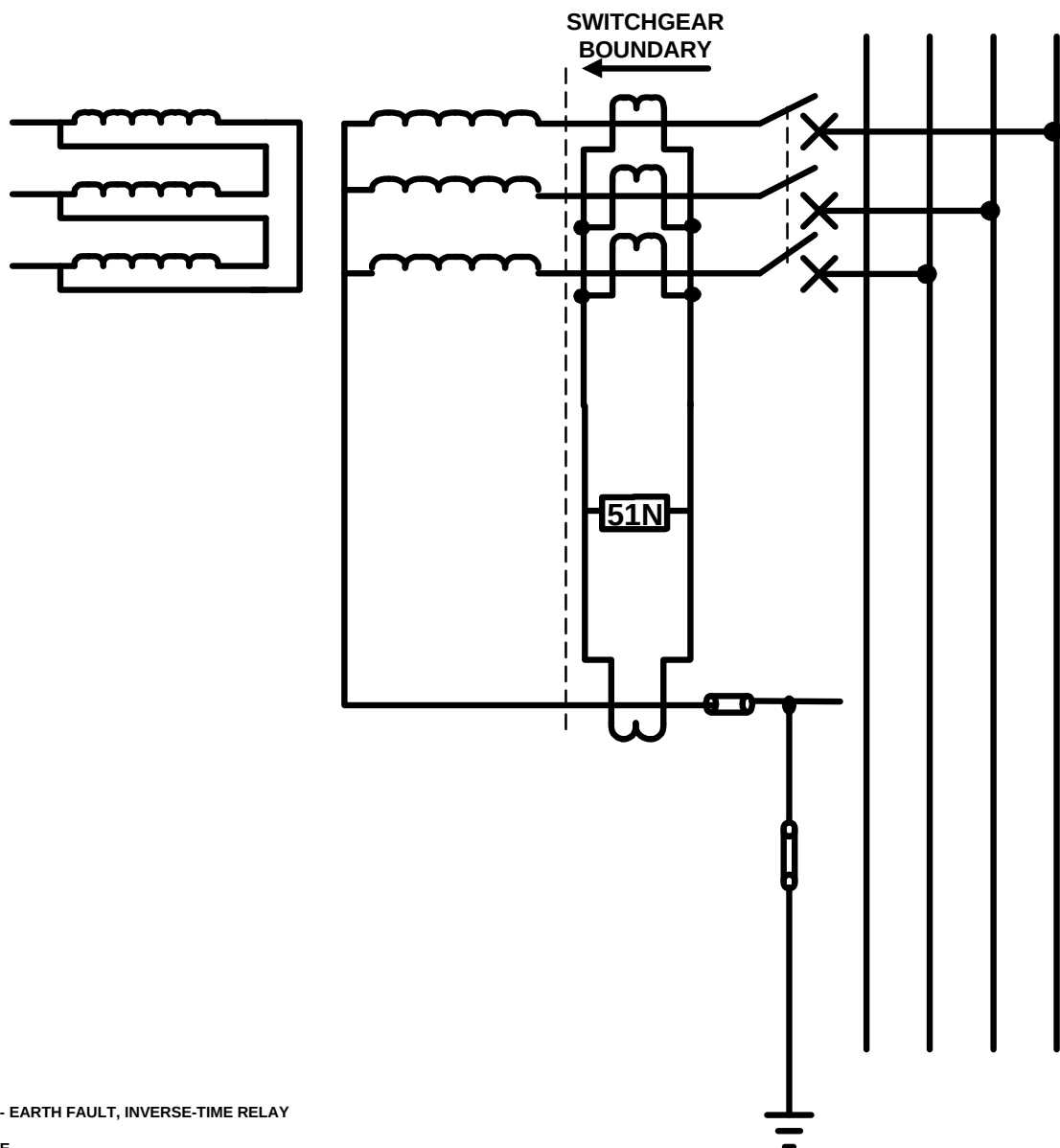
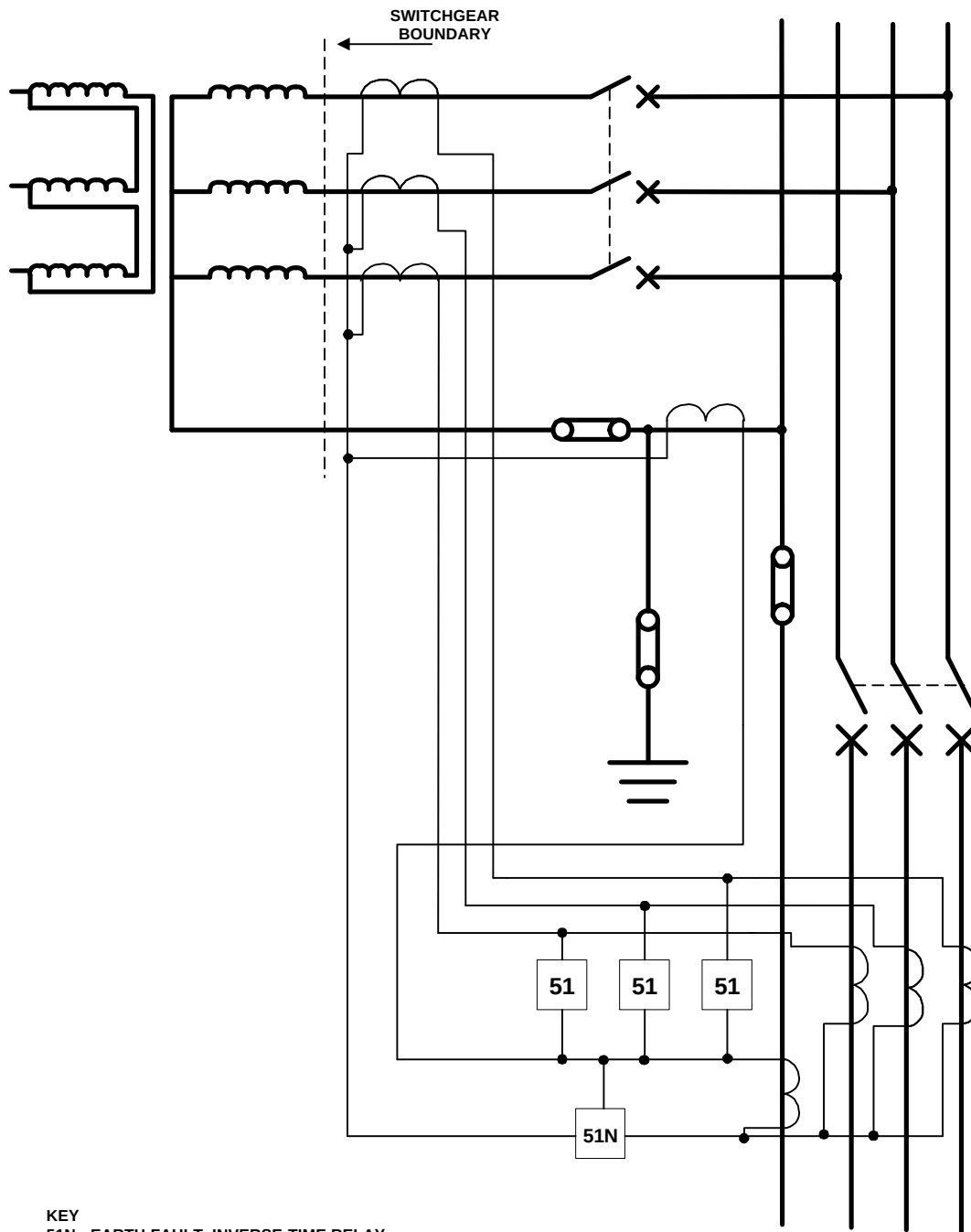


FIGURE 2

C.T. LOCATION FOR RESTRICTED EARTH FAULT PROTECTION



KEY
 51N - EARTH FAULT, INVERSE-TIME RELAY
 51 - OVERCURRENT, INVERSE TIME RELAY

NOTE
 RELAY CHARACTERISTICS WILL BE DETERMINED FOR EACH APPLICATION

FIGURE 3

C.T. LOCATION FOR PARTIAL DIFFERENTIAL PROTECTION

DEFINITIONS AND ABBREVIATIONS**Definitions**

Standardised definitions may be found in the BP Group RPSE's Introductory Volume.

low-voltage: a system whose voltage does not exceed 1000 V a.c. or 1500 V d.c. between conductors

Abbreviations

IEC	International Electrotechnical Commission
d.c.	direct current
a.c.	alternating current
X/R	Reactance/Resistance
FBA	Flactory Built Assembly
IP	Ingress Protection
MCCB	Moulded Case Circuit Breaker



LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

International Codes or Standards

<i>IEC 439</i>	<i>Low-voltage switchgear and controlgear assemblies</i>
<i>IEC 947-2</i>	Low -Voltage Switchgear and Controlgear Part 2: Circuit Breakers

BP Group Documents

BP Group <i>RP 12-3</i>	Power System Design (replaces BP CP 17 Part 3)
BP Group <i>RP 12-4</i>	Power System Protection and Control (replaces BP CP 17 Part 4)
BP Group <i>RP 12-16</i>	<i>Electrical Systems and Installations Earthing and Bonding</i> (replaces CP 17 Part 16)
BP Group <i>GS 112-8</i>	Low Voltage Switchgear and Controlgear (replaces Std 227)

