

GUIDE TO TYPE TESTED AND PARTIALLY TYPE TESTED ASSEMBLIES



**Low Voltage Switchgear and
Controlgear Assemblies:**

BS EN 60439-1:2000
(IEC 60439)

BEAMA*Installation* Ltd



ABOUT BEAMAInstallation

BEAMAInstallation is an independent, incorporated association of manufacturers of electrical installation equipment and cable management products, representing 95% of the industry.

Its roots go back to the early days of the electrotechnical industry.

During 1972 EIEMA was formed from the Electrical Installation Equipment Department of BEAMA – The British Electrotechnical and Allied Manufacturers' Association. April 2003 saw the creation of BEAMAInstallation Limited through the merger between EIEMA (the Electrical Installation Equipment Manufacturers' Association) and BESA (the British Electrical Systems Association).

BEAMAInstallation has many members - from UK divisions of large multi-nationals to small owner-managed niche market companies. The association is organised into these product groups:

- **Single Phase Product Group (SPPG)**
Wiring accessories, MCBs, RCDs, consumer units.
- **Industrial Products Group (IPG)**
Fuses, distribution boards (standard), switch & fusegear, MCCBs (as well as MCBs and RCDs), ACBs, industrial plugs and sockets.
- **Engineered Systems Product Group (ESPG)**
Low voltage switchboards, busbar trunking systems (busduct) products.
- **Cable Management Product Group (CMPG)**
Cable trunking, cable tray and Powertrack systems.
- **Cutout & Feeder Pillar Group (COFP)**
Cut-outs, feeder pillars.

Benefits of membership fall into two broad categories - representation and access to association services. The main areas in which the association represents its members are in legislative and standardisation matters. The former is by established relationships with appropriate government/EU departments in London and Brussels, through BEAMA and various European manufacturers' groups including ORGALIME, the European Federation for Engineering.

Active participation in the work of numerous national, international and European standards committees has ensured the safety and performance of the design, development and manufacture of BEAMAInstallation members' products.

The result is quality equipment of the highest standard throughout each association group.

Other services include legal, statistics and export support. The association is also a channel for liaison with customer associations such as the Electrical Distributors' Association (EDA) and the Electrical Contractors' Association (ECA).

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This publication is available at £15 plus postage and packing

CONTENTS



About BEAMA Installation

	Preface	2
1	Definitions	3
	An Assembly	
	Type Tested Assembly	
	Partially Type Tested Assembly	
2	Benefits	4
	Confidence	
	Low-voltage Directive	
	Electricity at Work Regulations	
	Commercial considerations	
3	Test Objectives	5
4	Type Tests	5
	Temperature rise	
	Dielectric properties	
	Short-circuit withstand strength	
	Effectiveness of the protective circuit	
	Clearance and creepage distances	
	Mechanical operation	
	Degree of protection	
5	Marking of terminals for external conductors	12
6	Routine Tests	12
	BEAMA Installation switchboard manufacturers	



PREFACE

The Standard to which low voltage switchboards and motor control centres should be manufactured is BS EN 60439-1. This, as is the case for most Standards, details performance criteria and tests to prove that requirements have been met. In general the Standard is non prescriptive and creates an opportunity for the manufacturer to be innovative whilst fully meeting the Standard and providing the user with the equipment required. The Standard also details two categories of assembly, Type Tested Assembly (TTA) and Partially Type Tested Assembly (PTTA), both have advantages for particular applications.

To choose the appropriate Assembly for a particular application, specifiers need a clear understanding of the objectives and criteria detailed in the Standard and the differences in the two categories (TTA & PTTA). Additionally it is essential to understand how BS EN 60439-1 assists in complying with statutory obligations related to low voltage switchgear.

This BEAMA *Installation* guide seeks to assist in providing knowledge of the 'Type Test' aspects of low voltage Assemblies and ensure specifiers can readily make the most appropriate choice for every application.

AN ASSEMBLY

'A combination of one or more low-voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, etc., completely assembled under the responsibility of the manufacturer with all the internal electrical and mechanical interconnections and structural parts.'

The most commonly used meaning of an Assembly is for main Switchboards and other electrical power Control centres. These Assemblies are likely to be produced for specific customers or users who specify in great detail their own requirements. Hence the phrase *'by agreement between manufacturer and user'* is used throughout the Standard.

However within the scope of the Standard the term does include MCCB or Fuse-switch Panelboards, mcb or Fuse distribution boards, and household Consumer units. These products may be obtained via Wholesalers or Distributors and are much more standardized. Here the customer or user makes his own choice of what is freely available in the market place.

TYPE TESTED ASSEMBLY (TTA)

BS EN 60439-1, defines a TTA as:

'A low-voltage switchgear and controlgear assembly conforming to an established type or system without deviations likely to significantly influence the performance, from the typical ASSEMBLY verified to be in accordance with this standard.'

This means:

- The generic design of the Assembly including all the various elements used in its construction have completed the Type Tests detailed in the Standard.
- Deviations from the tested configuration are permitted, but they will be very minor and not *'likely to significantly influence the performance'* e.g. a functional unit may have been short circuit tested in the top of the Assembly and in service be located lower down.
- Design verification must be via stringent testing, and does not rely on subjective assessments, calculations, safety margins and engineering judgements.
- The Assembly will consist of a series of standardized elements including interconnections, all of which have previously been proven by tests in the Type Tested Assembly(s), but may be configured differently to suit the application.
- Assemblies may be built by licensed assemblers under strict controls.

PARTIALLY TYPE TESTED ASSEMBLY (PTTA)

BS EN 60439-1, defines a PTTA as:

'A low-voltage switchgear and controlgear assembly, containing both type-tested and non-type-tested arrangements provided the latter are derived (e.g. by calculation) from type-tested arrangements which have complied with the relevant tests'

This means:

- The assembly will be derived from a Type Tested Assembly.
- Deviations from the tested configuration are only permitted provided they can be verified by calculation or equivalent methods. Such methods have their limitations which must be fully understood and, where appropriate, allowed for through safety factors in the analysis.
- As a means of demonstrating design compliance with the Standard, manufacturers must have available Type Test documentation for the original design and any calculations relating to modified elements.
- The Assembly will consist, as far as practical, of a series of standard elements configured to suit a particular application. Customisation should be restricted to situations where it cannot be avoided, e.g. facilities for terminating over size cables, use of an alternative tested component, etc.
- All components and devices will be fully Type Tested to their respective product standards. Documentation will be available for examination.
- Combinations of Type Tested components and devices installed in an otherwise untested Assembly *are not* covered by this definition and the Standard.



2 BENEFITS

Using a TTA offers many advantages relative to the alternatives. Some relate to longer term requirements while others assist in meeting statutory obligations.

CONFIDENCE

Low-voltage Assemblies, by the nature of their application, may be installed for many years before they are called on to operate close to their intended capability, for example, under planned expansion or fault conditions. As a result, any marginal performance in the design may not be immediately evident.

With a TTA concerns of this nature are eliminated. The design is proven through comprehensive Type Testing and there are no subjective elements in the design verification process. This is an invaluable attribute in user confidence.

LOW-VOLTAGE DIRECTIVE

The Electrical Equipment (Safety) Regulations, better known as 'The Low-voltage Directive' requires all electrical equipment to be safe in its intended use. As Low-voltage switchgear has a basic safety function it must not only be safe to use, but must also be capable of performing its safety related duties in respect of problems elsewhere, in effect a double responsibility. If challenged by the enforcing authorities, all manufacturers and *Duty Holders must be able to demonstrate they have met their obligations in respect of this onerous and statutory duty.

***Duty Holder:** The term used within the Electricity At work Regulations to refer to the person appointed to be responsible for the electrical equipment, systems and conductors and any work or activities being carried out on or near electrical equipment. The Duty Holder must be competent and may be the employer, an employee, or a self-employed person.

There are several routes to demonstrating compliance, but the most readily and widely used is through unquestionable conformance to appropriate Mandated Standards. In the case of Low-voltage Assemblies, this is BS EN 60439-1, with TTA being the less subjective option. This removes any doubts relating to design performance and provides the assurances this Act requires.

ELECTRICITY AT WORK REGULATIONS

All manufacturers of low-voltage Assemblies and Duty Holders responsible for their use are obligated by these statutory safety Regulations. The provision and use of TTAs through tested designs assists in demonstrating compliance with the following two Regulations:

Regulation 4(1):

*'All **systems** shall at all times be of such construction as to prevent, so far as is reasonably practical, **danger**.'*

Regulation 5:

*'No **electrical equipment** shall be put into use where its strength and capability may be exceeded in such a way as may give rise to **danger**.'*

It is therefore advantageous and prudent to use a TTA whenever practical.

COMMERCIAL CONSIDERATIONS

TTAs are of a proven design. Their design costs are high, but are recouped over time through efficient use of manufacturing processes and materials. The closer a PTTA is to a TTA, then design for the particular Assembly is minimised.

Marketing information shows that TTAs are the same price as an equivalent PTTA for the majority of applications. Overall the TTA is therefore a more attractive option.



3 TEST OBJECTIVES

Tests defined within BS EN 60439-1 are in two clear and precise categories, each of which has specific objectives. These categories are: Type Tests and Routine Tests.



4 TYPE TESTS

The Standard states:

'Type tests are intended to verify compliance with the requirements laid down in this standard for a given type of ASSEMBLY.'

Type tests are carried out on a sample of such an ASSEMBLY or on such parts of ASSEMBLIES manufactured to the same or similar design.

They shall be carried out on the initiative of the manufacturer.'

The Standard also requires switching devices and other components to comply with their own relevant standards.

Type tests for Assemblies are carried out for, *Temperature rise, Dielectric properties, Short-circuit withstand strength, Effectiveness of the protective circuit, Clearance and creepage distances, Mechanical operation, and Degree of protection.*

They are intended to:

- prove the design capability. They are part of the design validation process and are undertaken initially when the equipment is developed or when changes are made which require further verification.
- be conducted on representative samples for the design of Assembly, but are not intended to be undertaken on an Assembly which is subsequently put into service.
- be undertaken at the instigation of the manufacturer, and whilst all standard circuits can be tested, it is recognised that it is impractical to test every conceivable configuration of circuit within an Assembly. It is the manufacturer's responsibility to identify the representative (most onerous configurations) samples to be tested.
- be tested either in the manufacturer's own laboratory or at an independent facility. In accordance with the Standard, the choice between self or third party certification is the manufacturer's decision.
- have results recorded in reports or certificates that are available for purchaser's and specifier's examination.

TEMPERATURE RISE

Temperature rise (K) testing is the method to provide assurance on the Assembly of its operating current rating. This is an involved subject since, Assemblies can be a complex combination of equipment and components, operating at different temperatures, but generally interacting with each other. Actual temperature rise testing is therefore essential, as methods of verification by calculation alone are considered to be inadequate.

Considerations which affect the design and test results are Ventilation, Position of equipment within the Assembly, Heat transfer and proximity effects. Any or all of these could significantly affect the current rating.

For individual circuits the Standard requires as previously stated, that each device complies with its own Standard which will include temperature rise testing at its maximum rating. e.g. Switches to BS EN 60947-3, Circuit breakers to BS EN 60947-2. Where the device mounting arrangements differ from those in proving tests to the product Standard, additional testing to prove the declared rating of individual circuits shall be undertaken in the Assembly to BS EN 60439-1.

As an Assembly BS EN 60439-1 recognises that not all circuits are fully loaded at the same time, and therefore, depending on the number of circuits within the

Terminals for external cables	70K
Manual operating means:	
• of metal	15K
• of insulating material	25K
Accessible external enclosures & covers:	
• metal surfaces	30K
• insulated surfaces	40K

Assembly, a diversity factor should be applied. If no other information regarding the actual installation is provided, the Standard states factors to be used ranging from 0.9 (for two or three main circuits), to 0.6 (for ten or more circuits).

Within the Standard there are a few specific temperature rise limits. They are imposed where they relate to the outside world, namely cable terminals and areas which may need to be touched by an operator.

In cases where there is no need for touching during normal operation, a further 10K is acceptable.

All other temperatures are effectively limited to temperatures which do not result in unacceptable deterioration. Establishing these values is the manufacturer's responsibility.

As the standard is not specific in defining 'accessible', in this context it is taken to mean the operating face and any other surfaces that are reachable from floor level by an operator. This would normally exclude surfaces such as top plates or other surfaces above 2.0m from floor level.

Working temperatures may be quite high. The actual working temperature is the temperature rise above, plus the ambient temperature, which as recognised in the Standard may be as high as 40°C. For environments with an ambient higher than 40°C, other considerations need to be made.

DIELECTRIC PROPERTIES

Table I

The dielectric type test confirms the voltage withstand of the main and auxiliary circuits. Current consuming apparatus, e.g. instruments are excluded.

Rated insulation voltage U_i V	Dielectric test voltage a.c r.m.s. V
$U_i \leq 60$	1000
$60 < U_i \leq 300$	2000
$300 < U_i \leq 690$	2500
$690 < U_i \leq 800$	3000
$800 < U_i \leq 1000$	3500
$1000 < U_i \leq 1500^*$	3500
* For d.c. only	

- The Standard allows two options:
- impulse testing
 - power frequency dielectric testing.

The rated impulse voltage of the Assembly shall be equal or greater than the values of transient overvoltage occurring in the system. Impulse testing is mainly used in device product standards.

For Assemblies the normal method of proving for this requirement is to conduct a power frequency test to the values given in table I.

SHORT-CIRCUIT WITHSTAND STRENGTH

Short-circuit testing is required to be conducted on all elements of an Assembly unless:

- the Assembly is to be used in a system where it is known the short-circuit fault current can not exceed 10kA.
- the Assembly is protected by a current limiting device (fuse, MCCB etc.) which will limit the cut off current below 15kA.

- all parts of Assemblies (busbars, busbar supports, connections, switching devices, etc.) have already been proved to type tests valid for the same conditions.
- auxiliary circuits intended to be connected to transformers whose rated power does not exceed 10kVA for a rated secondary voltage of not less than 110V or 1.6kVA for a rated secondary voltage less than 110V, and whose short-circuit impedance is not less than 4%.

For all other cases a short circuit withstand test is required to verify the capability of the complete Assembly, including busbars, all interconnections, and where appropriate mounting arrangements. This is covered by short-circuit tests on the incoming circuit(s) and busbar system, and through fault tests on the outgoing circuits.

Main switchboards are frequently installed adjacent or close to the main incoming supply point and therefore potentially extremely high fault currents will occur in the event of a failure. Such applications may call for, e.g. 50kA for 3 seconds or 80kA for 1 second. The dynamic and thermal stresses which such faults subject to an Assembly can only really be verified through adequate testing.

The magnetic effects on busbars, support systems and enclosures during such high fault will impose oscillating forces measured in tonnes. The thermal effects on the copper busbars themselves may reach a level which would anneal the copper, thereby rendering them unfit for further service.

In the case of insulated busbars, thermal characteristics must be taken into account.

- As a typical example consider a simple copper busbar required to carry a full load current of 1000A in normal service. In a still air environment, a cross section of 60mm x 6mm would be reasonable. However if this same section is subjected to a high fault current of say 50kA for 3 seconds, then the temperature of the busbar will rise to just over 300°C. If the fault current were to be 80kA, the temperature would increase to 260°C in just 1 second.

EFFECTIVENESS OF THE PROTECTIVE CIRCUIT

The protective circuit with an Assembly serves two distinct functions:

- to ensure all exposed conductive parts are effectively bonded to the main earth terminal, thereby providing personal protection, and
- provide a safe earth return for earth faults down stream of the Assembly.

To ensure these requirements are met the following are carried out:

- 1 Doors and other exposed conductive parts not supporting live electrical equipment do not need additional bonding over and above their normal fixing means. This is verified by inspection.*

* *Note: Future work within standard writing bodies is considering a maximum resistance between any exposed conductive parts and the main earth bar of 0.1 ohms.*

- 2 Where ancillary electrical equipment is mounted on doors or covers a separate bonding lead should be provided. Where the short circuit protective device for

these ancillary items has a cut-off current of less than 15kA, then according to the Standard no verifying test is required.

- 3 A short circuit test is conducted on the main earth bar to ensure it has a short circuit capability compatible with the incoming circuit and main busbars.
- 4 For faults down stream of the Assembly, a short circuit test is carried out to simulate worst case conditions on each outgoing unit to prove the adequacy of the earth return path. In this test the fault is only applied for such time as it takes the short circuit protective device in the circuit to operate.

CLEARANCE AND CREEPAGE DISTANCES

Clearance and creepage distances for devices within an Assembly are determined in accordance with their own product Standards. Minimum distances for other parts within the Assembly are established from a knowledge of the Assembly's intended operating environment and the insulating materials used. Clearance and creepage distances are no longer simple arbitrary values.

The criteria to be considered when determining clearance and creepage distances are:

a) Pollution degree

The level of pollution in the environment in which the Assembly is intended to be installed. Four categories are defined in the Standard as follows:

- Pollution degree 1:** *No pollution or only dry, non-conductive pollution occurs.*
- Pollution degree 2:** *Normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation may be expected.*
- Pollution degree 3:** *Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation.*
- Pollution degree 4:** *The pollution generates persistent conductivity caused, for instance, by conductive dust or by rain or snow.*

Unless advised otherwise, the Standard and the manufacturer will assume pollution degree 3 is applicable for industrial applications.

b) Impulse withstand

The highest peak value of an impulse voltage the Assembly is designed to withstand is determined from the rated operational voltage of the Assembly, and the over voltage category applicable.

This latter criteria is assigned on the basis of the Assembly's intended location within the distribution system, e.g. appliance level, origin of installation, etc.

Table 2 gives over voltage categories and minimum impulse levels for Assemblies to be installed on a 415/240 volt, earthed neutral system.

OVER VOLTAGE CATEGORY	POSITION IN INSTALLATION	IMPULSE LEVEL (KV)	CLEARANCE (MM) - INHOMOGENEOUS FIELD			
			POLLUTION DEGREE			
			1	2	3	4
I	Specifically protected level	1.5	0.5	0.5	0.8	1.6
II	Load (<i>appliance, equipment</i>) level	2.5	1.5	1.5	1.5	1.6
III	Distribution circuit level	4.0	3.0	3.0	3.0	3.0
IV	Origin of installation (service entrance level)	6.0	5.5	5.5	5.5	5.5

Table 2

c) Material group

Insulating materials used within an Assembly are classified into four groups, depending on their resistance to tracking - comparative tracking index (CTI). Table 3 identifies the four groups and their respective tracking indices.

d) Nature of the electric field

If the electric field within an Assembly can be considered to be homogeneous (uniform) clearance distances can be much reduced. As however, minimum clearances generally occur at bolted joints in conductors, or similar, this condition is unlikely to be satisfied. For all practical purposes, clearance distances should be determined on the basis of an inhomogeneous field. Should a manufacturer consider the electric field within his Assembly is homogeneous, and determine clearances on this basis, he must carry out an impulse test to confirm they are adequate.

CLEARANCE CONFIRMATION

Once the rated insulation voltage and the over voltage category have been established, the minimum distances can be readily determined from the Standard. Thereafter, confirmation is a simple measurement task. Minimum values to the Standard may, however, be much less than often anticipated. Table 2 gives the minimum distances for a typical Assembly suitable for connection to 415/240 volt, earth neutral system. On this basis, many Assemblies, for example panelboards, can have clearances as low as 3mm and still be acceptable, in accordance with the Standard.

CREEPAGE DISTANCES

Table 3:
Minimum creepage distances,
415/240 volt equipment

Creepage distances are a function of; (i) the rated insulation voltage of the Assembly, (ii) the pollution degree applicable to the environment it is intended to be installed in, and (iii) the Material Group into which the insulating materials belong. Having established these parameters, minimum creepage distances can readily be determined from the Standard and confirmed by measurement. Annex F of the Standard gives guidance on how to accommodate ribs, grooves, etc. in this exercise.

MATERIAL GROUP	COMPARATIVE TRACKING INDEX	MINIMUM CREEPAGE DISTANCES (MM)			
		POLLUTION DEGREE			
		1	2	3	4
I	600+	1.0	2.0	5.0	8.0
II	400 to 599	1.0	2.8	5.6	10.0
IIIa	175 to 399	1.0	4.0	6.3	12.5
IIIb	100 to 174	1.0	4.0	6.3	<i>Not recommended</i>

As Table 3 shows, for a typical Assembly suitable for connection to a 415/240 volt system, minimum values to the Standard are often much less than envisaged. If different insulating materials are used, different minimum distances may also apply to different parts of the Assembly. Minimum creepage distances must however, never be less than minimum clearances.

MECHANICAL OPERATION

Where products incorporated in the Assembly are proven to comply with their own respective Standard, no further testing to this requirement is necessary. For other devices specifically designed for the assembly, a test of 50 mechanical operations should be conducted by the Assembly manufacturer. At the end of the test, the mechanical efficiency shall be maintained.

DEGREE OF PROTECTION

BS EN 60439-1 states: *'The degree of protection provided by any ASSEMBLY against contact with live parts, ingress of solid foreign bodies and liquid is indicated by the designation IP... according to IEC 60529.'*

Annex E of BS EN 60439-1 lists 'Degrees of Protection' (the IP value), as subject to agreement between manufacturer and user. This is necessary as the protection can vary from IP00 (no protection) to IP65 (totally protected against ingress of dust and protected against hosing from all directions). Even higher degrees of protection (e.g. protected against immersion) are listed in IEC 60529.

BEAMA *Installation* has produced a 'Guide to the 'IP' Codes for Enclosures' with the object of providing an easily understood document aiding the interpretation of the requirements for enclosure protection related to BEAMA *Installation* products. This document gives many illustrations of the application of the relevant IP codes and is a valuable aid to understanding the requirements of IEC 60529 (BS EN 60529:1992).

The general interpretation of the IP number is in terms of the external protection of an assembly. Any dust or moisture that is permitted to enter the enclosure of the assembly shall have no harmful effect and, in normal service, personnel shall not be able to touch any dangerously live parts. These requirements can only be proven by carrying out the relevant tests according to IEC 60529.

In addition to determining the external protection, the IP code is also used to define the internal degree of protection under conditions necessitating the accessibility to internal parts by authorised personnel or for assemblies with movable or withdrawable parts. This IP number may differ from that of the main enclosure.

In determining the degree of protection demanded, careful consideration should be given to the siting, accessibility and application of the completed assembly. For the majority of indoor installations, in a switchroom, IP31 will usually be a more than adequate degree of protection. Only in locations with heavily dust laden atmospheres or where exposure to liquids is highly probable is it likely that a greater degree of protection will be necessary.

Verification of the IP number requires Type Testing in accordance with IEC 60529.

For a PTTA no IP codes can be given unless the appropriate verification is made according to IEC 60529 or tested standard enclosures are used. Thus, to ensure a proper degree of protection, without incurring additional testing costs, it is always preferable to use a TTA.

5 MARKING OF TERMINALS FOR EXTERNAL CONDUCTORS

It is the manufacturer's responsibility to provide clear indication of conductor arrangements at the point of connection of external circuits. These markings must be consistent with those shown on the wiring diagrams and drawings.

It is recommended that phase and neutral connections be marked L1, L2 L3 & N. Clear indication should be provided to identify the source phase of a single-phase supply. Earth symbols shall be marked according to IEC 60445. As an example, see graphical symbol No 5019 of IEC 60417. This symbol is not required where the external protective conductor is clearly identified with the colours Green/Yellow.

6 ROUTINE TESTS

These tests have a totally different function to Type Tests, BS EN 60439-1, states: *'Routine tests are intended to detect faults in materials and workmanship. They are carried out on every ASSEMBLY after its assembly or on each transport unit. Another routine test at the place of installation is not required.'*

Hence, Routine Tests on Assemblies are normally undertaken at the manufacturer's premises, and are:

- part of the quality control activity. They are intended to ensure materials and workmanship included in every assembly produced meet the standards required by the design.
- carried out on every assembly or transportable unit to be put into service. It is recognised that it is unnecessary, with modern modular designs, to fully couple assemblies for routine test, if they are subsequently to be shipped in several sections.
- of a non-destructive nature having minimal effect on the service life of the equipment.
- not intended to duplicate routine tests, previously carried out on components as part of their manufacturing process.
- not intended to be repeated on site. This does not remove the onus of the installer to ensure the assembly's correct installation and obligation to test under BS 7671. Before tests under BS 7671, or other testing is undertaken, the effects of these tests on voltage sensitive components should be established.



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*Other publications from BEAMA*Installation*:*

Guide to the 'IP' Codes for Enclosures

Guide to Switch & Fusegear Devices

Guide to Fuse Link Applications

Guide to Forms of Separation

Guide to Circuit Breaker Standards

Guide to Low Voltage Busbar Trunking Systems

RCD Handbook