



Image courtesy of Schneider Electric

Electrical Panels by Mark Coles

Introduction

At many events in which the IET participate, such as the ELEX and InterBuild shows, questions are asked about standards to which hand-wired electrical control panels are to comply. This article looks at types and forms of electrical panels, uses, competency and the standards to which they are to comply.

Electrical panels come in many shapes and sizes (of course) and have many applications. Consider a simple empty box which is then firmly fixed to the ground or building structure, adapted to enclose electrical equipment and terminations to perform a particular function - the empty box becomes an electrical panel and issues relating to electrical safety are to be considered.

Factory built panels and Forms of Electrical Separation

BS EN 60439-1:1999 gives guidance on the forms of separation applicable to

factory-built switchgear and controlgear assemblies (switchboards, motor control centres, distribution boards, busbar trunking systems, etc.), known as type-tested and partially type-tested assemblies. These forms of separation provide protection against contact with live parts (known as basic protection) belonging to adjacent devices and protection from the probability of initiating arcing faults and the passage of foreign bodies between units of the assembly. The Standard also gives guidance on other requirements for protection against electric shock.

Four forms of separation are indicated in the main text of BS EN 60439-1:1999 but there is no specific detail given on how these forms are to be achieved. It is stated in the Standard that the form of separation should be agreed between manufacturer and designer/user. It shall be remembered that higher forms of separation specified will

increase costs but will give better operational flexibility regarding safe working when connecting in additional circuits or carrying out maintenance. This 'trade-off' must be carefully assessed.

The four forms given have basic definitions and applications but Forms 2 to 4 can be further subdivided into more specific 'Types' (applications) by discussion and agreement with manufacturers.

Form 1

This form provides for an enclosure to provide protection against direct contact with live parts but does not provide any internal separation of switching, isolation or control items or terminations. These overall assemblies are often known as 'wardrobe' type with large front opening doors, usually with an integral door-interlocked isolator. Operating the isolator interrupts all functions but allows the door to be opened to gain access to the assembly for installation or

maintenance. Such assemblies normally have lower fault withstand and it may be inconvenient to shut down a whole plant or system for a simple maintenance or repair operation.

Form 2

The overall assembly enclosure provides protection against direct contact with live parts; separation is provided between the busbar assembly and switching, isolation, control items and terminations. There is very little advantage of this over Form 1 and the style is similar. Form 2 can be subdivided into:

- Type 1 - in which the busbars are separated by insulation of the bars.
- Type 2 - in which the busbars are separated by metallic or non-metallic rigid barriers.

Form 3

The enclosure provides protection against direct

contact with live parts and also separation is provided between the busbars and switching, isolation or control items and between all these items. Outgoing terminals are not separated from each other, or perhaps from the busbars. Form 3 can be subdivided into:

- Form 3a - in which outgoing terminals are not separated from the busbars.

- Form 3b - in which outgoing terminals are separated from the busbars.

Form 3b can be further subdivided into:

- Type 1 - in which the busbars are insulated for separation.

- Type 2 - in which busbar separation is by metallic or non-metallic rigid barriers or partitions.

Form 4

The enclosure provides protection against direct contact with live parts and internal separation of the busbars from all switching, isolation and control items and outgoing terminations and separation of all items and outgoing terminations from each other. This allows for access to any single item, such as a switch-fuse or starter and its outgoing terminations, to enable work to be carried out whilst the assembly remains operational. Protection is also provided against an arcing fault in one device affecting other items. This is the usual form specified for commercial and industrial switchgear and controlgear assemblies but the designer has to consider whether, due to the extra cost, such requirements are necessary or justified. Form 4 can be subdivided into seven types:

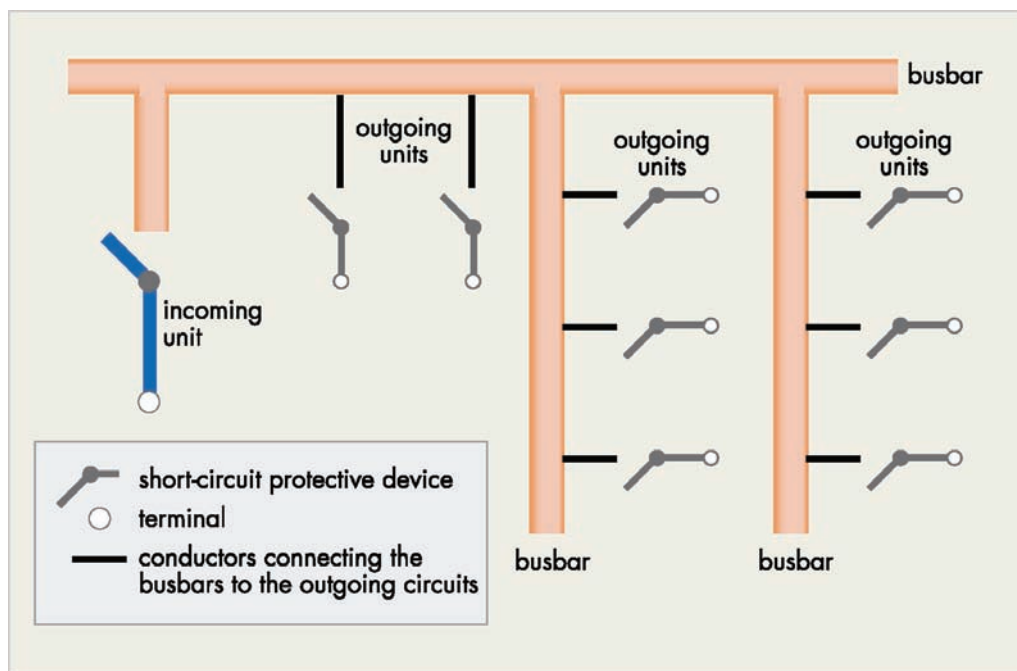


Figure 1: Form 1 construction

Type 1 - in which the busbars are separated by insulation or coverings. Terminals for external conductors are in the same compartment as the associated item of switchgear, etc., but cables may be glanded elsewhere.

Type 2 - in which the busbars are separated by metallic or non-metallic rigid barriers or partitions. Terminals or external conductors are in the same compartment as the associated item of switchgear, etc., but cables may be glanded elsewhere.

Type 3 - in which separation requirements are by metallic or non-metallic rigid barriers or partitions. Terminals or external conductors are in the same compartment as the associated item of switchgear, etc. and each item has its own integral cable glanding facility.

Type 4 - in which the busbars are separated by insulated coverings. Terminals for external conductors are not in the same compartment as the

associated item of switchgear, etc., but in separate enclosed spaces. However, cables may be glanded elsewhere.

Type 5 - in which busbars are separated by metallic or non-metallic rigid barriers or partitions. Terminals for external conductors are not in the same compartment as the associated item of switchgear, etc., but in separate enclosed spaces and terminals may be separated by insulated coverings. Cables may be glanded in common cabling chambers.

Type 6 - in which all separation requirements are by metallic or non-metallic rigid barriers or partitions. Terminals for external conductors are not in the same compartment as the associated item of switchgear, etc., but in separate enclosed spaces and cables are glanded in common cabling chambers.

Type 7 - in which all separation requirements are by metallic or non-metallic rigid barriers or partitions. Terminals for

external conductors are not in the same compartment as the associated item of switchgear, etc., but in separate enclosed spaces and the termination for each item has its own integral glanding facility (see Figure 2). Switchboard manufacturers therefore cannot give all-embracing assurances for safe working, according to the form of separation with parts of the assembly energized. Specifying a particular form of separation will not guarantee this for any given form number.

General

Assemblies are to be designed and constructed so as to be able to withstand the thermal and dynamic stresses resulting from fault currents up to their rated values.

The installation designer must specify the prospective fault current conditions at the point of installation. Busbar systems for switchgear and controlgear should be adequately rated for the normal duty and maximum fault current level expected

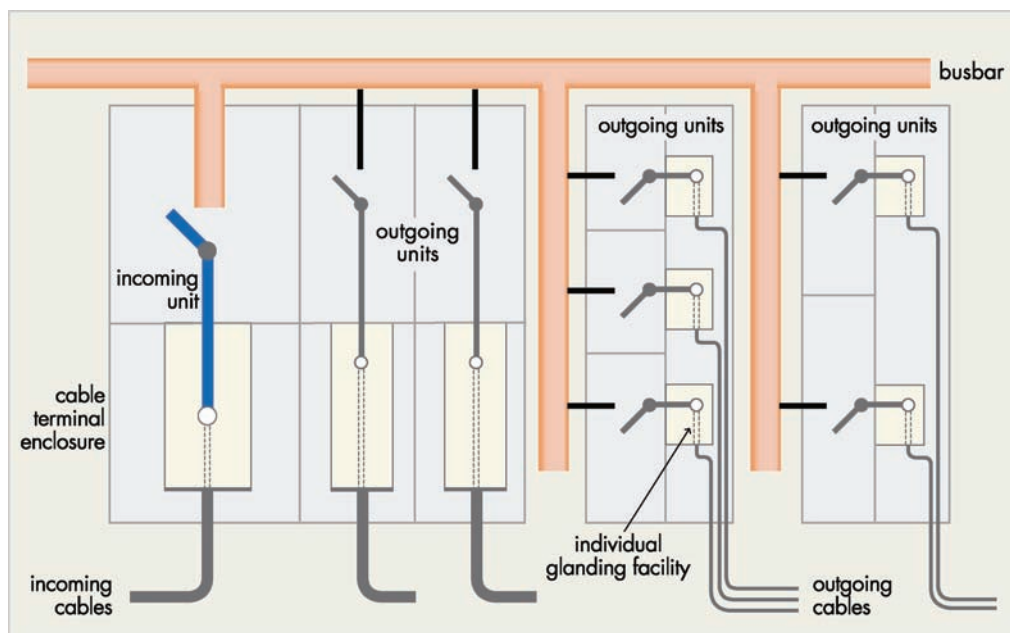


Figure 2: Form 4 construction

and should be well supported and braced, as the electromechanical stresses under fault conditions can be severe.

Bespoke panels

Many electrical panels are made for bespoke applications which require much more consideration than selecting factory built units from a catalogue. The environmental and local conditions will have the greatest influence on the choice of panel. The following issues will need to be considered when choosing the correct panel for the application:

■ **weather** - if the panel is to be located outdoors, a feeder-pillar or telecommunications cabinet for example, the weather will be a factor in deciding the overall IP rating of the cabinet; see BS EN 50529

■ **material** - the material of manufacture is an important issue - metallic or a type of plastic, for example. Plastic materials are usually much lighter than metallic; metallic units are often made from

aluminium, sometimes stainless steel

■ **mechanical impact** - if there is a mechanical impact issue, such as the risk of being struck by moving objects, BS EN 62262 provides information on the IK rating of enclosures

■ **vandalism** - if the panel is susceptible to unauthorised entry or vandalism a locking mechanism will need to be considered in addition to vandal-proof fixings

■ **hazardous locations** - panels installed in hazardous locations will need to meet the requirements of BS EN 60079 suite of standards, e.g. Group I: electrical apparatus for mines susceptible to firedamp; Group II: electrical apparatus for places with an explosive gas atmosphere other than mines susceptible to firedamp with sub-division IIA, IIB or IIC

■ **temperature** - ambient temperature expected and the amount of heat emitted by internal components; external low temperatures may mean

that internal heating would be required; high external temperatures (solar gain) may call for internal cooling

■ **electromagnetic** compatibility and interference issues may need to be addressed

A concise list of external influences can be found in Appendix 5 of BS 7671:2008.

Electrical safety

When constructing a bespoke electrical panel, the requirements of BS 7671 are to be considered. The method of protection against electric shock will be established based on the environment in which the panel is located and the particular application. Regulation 410.3.3 requires that in each part of an installation, one or more protective measures are to be applied, taking account of the conditions of external influence. BS 7671 generally recognises the following four methods of protection against electric shock:

(i) Automatic disconnection of

- supply (Section 411)
- (ii) Double or reinforced insulation (Section 412)
- (iii) Electrical separation for the supply to one item of current-using equipment (Section 413)
- (iv) Extra-low voltage (SELV and PELV) (Section 414).

In electrical installations the most commonly used protective measure is automatic disconnection of supply. Automatic disconnection of supply is a protective measure in which:

- (i) basic protection is provided by basic insulation of live parts or by barriers or enclosures, and
- (ii) fault protection is provided by protective earthing, protective equipotential bonding and automatic disconnection in case of a fault.

Regulation 412.2.4.1 states that the requirements for basic and fault protection can be met if the rated voltage of the cable(s) is not less than the nominal voltage of the system and at least 300/500 V and that adequate mechanical protection of the basic insulation is provided.

Adequate implies the non-metallic sheath of the cable or non-metallic trunking or ducting complying with the BS EN 50085 series, or non-metallic conduit complying with the BS EN 61386 series.

Note that where a lid or door in an insulating enclosure can be opened without the use of a tool or key, all conductive parts which are accessible when the lid or door is open must be behind an insulating barrier (providing a degree of protection not less than IPXXB or IP2X) preventing persons from coming unintentionally into contact with those conductive parts. This insulating barrier shall be removable only by the use of a

tool or key; Regulation 412.2.2.3 refers.

Slotted trunking, Figure 3, will not meet the IPXXB or IP2X requirement of Regulation 412.2.2.3, therefore, if the panel remains fully energised upon opening, only insulated and sheathed cables or wiring from SELV or PELV sources should be installed within the trunking. If non-sheathed cables operating at voltages in excess of the SELV and PELV requirements of Regulation 414.1.1 are installed in slotted trunking, a further barrier must be installed preventing access.

It should also be realised that Regulation 8 of the Electricity at Work Regulations places an absolute requirement (one that shall be met regardless of cost or any other consideration) on protective conductor connections to earth:

... a conductor shall be regarded as earthed when it is connected to the general mass of earth by conductors of sufficient strength and current-carrying capability to discharge electrical energy to earth.

It may be questioned whether the termination of steel or aluminium wire armour (where used as a protective conductor) with glands into metal gland plates, which themselves may only be bolted to the switchgear or controlgear frame, is an adequate connection. Cable gland 'earth tags' and supplementary connections to the equipment earth terminals may be necessary. In any case it should be ensured that any paint or other surface finish on the switchgear does not prevent effective electrical continuity between the adjacent parts. During site installation and commissioning, tests as

required by BS 7671 Part 6 should be carried out on the complete assembly, plus any other specific tests advised by the manufacturer or required by the client, user or engineer. It is not usual to carry out a repeat of specialist tests, e.g. a flash test at site; however, in the event of such a requirement or request, the manufacturer's advice should be sought.

Competency

As with all installations, work must only be undertaken by competent persons. BS 7671 is not a statutory document and it is not a legal requirement to follow the practices referred to within. Primarily, the main piece of legislation to consider is the Electricity at Work regulations 1989 (EWR). The EWR states that all systems are to be safe so as to prevent danger and prevent the risk of injury.

The designer and installer must be aware of the statutory requirements under the Electricity at Work Regulations and the Construction (Design & Management) Regulations 2007 (CDM 2007), etc., for the safe design, construction, operation and provision for maintenance of electrical equipment assemblies.

Adequate access,

working space and lighting need to be provided where work is to be carried out on or near equipment, in order that persons may work safely.

The Memorandum to the Electricity at Work Regulations 1989, HS(R)25, records that the IEE Wiring Regulations is widely recognised and accepted in the UK and compliance with them is likely to achieve compliance with relevant aspects of the 1989 Regulations in point 7 of the introduction. ■

References and further information

- BS 7671:2008 Requirements for Electrical Installations, IEE Wiring Regulations, Seventeenth Edition
- Electricity at Work regulations 1989 - www.opsi.gov.uk/si/si1989/Uksi_19890635_en_1.htm
- Memorandum of guidance on the Electricity at Work Regulations 1989 (HSR25) - free download - www.hse.gov.uk/pubns/books/hsr25.htm
- The Construction (Design & Management) Regulations 2007 - www.hse.gov.uk/construction/cdm.htm

■ Guidance Note 1 - Selection and Erection

■ BS EN 50529:1992 *Degrees of protection provided by enclosures (IP code)*

■ BS EN 62262:2002 *Degrees of protection provided by enclosures for electrical equipment against mechanical impacts (IK code)*

■ BS EN 60079 *Electrical apparatus for explosive gas atmospheres* suite of standards

■ BS EN 60439-1:1999 *Low-voltage switchgear and controlgear assemblies. Type-tested and partially type-tested assemblies*

■ BS EN 50085-1:2005 *Cable trunking systems and cable ducting systems for electrical installations. General requirements*

■ BS EN 61386-1:2008 *Conduit systems for cable management. General requirements*

■ BEAMA Guide to verification of low voltage power switchgear and control gear - www.beama.org.uk/UserFiles/file/publications/installation/BAVG.pdf

Figure 3:
Slotted trunking

