



Guide to Verification

Low Voltage Power Switchgear and Controlgear
Assemblies (PSC) in Accordance with BS EN 61439-2



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BEAMA is the long established and respected trade association for the electrotechnical sector. The association has a strong track record in the development and implementation of standards to promote safety and product performance for the benefit of manufacturers and their customers.

This guide is the result of a long running project to develop the 61439-2 standard and explains in clear and simple terms, exactly how manufacturers can comply with its requirements relating to assembly verification.

The guide has been produced by BEAMA's Engineered Systems Product Group (ESPG). The ESPG comprises companies specialising in the design and manufacture of switchboards and busbar trunking systems – for a wide range of commercial and industrial distribution and control requirements.

The expertise of the ESPG is built on substantial combined experience and dedication to achieving quality and continual improvement. Representatives from ESPG companies are key members of influential technical committees, fully participating in the work of many international, European and national standards committees. This close involvement ensures their ability rigorously to adhere to the requirements of these standards for design, development, manufacture, testing and verification for compliance – resulting in quality equipment of the highest standards of safety and performance.

ESPG is part of BEAMA's Installation sector; well known for its authoritative industry guides.

Details of other BEAMA Installation Sector guides can be found on the BEAMA website www.beama.org.uk.

BEAMA would like to thank IEC and BSI for allowing reference to their standards.

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List of current and prospective parts of the BS EN 61439 series

BS EN 61439 Series	TITLE	Applicable To:
	Low-voltage switchgear and controlgear assemblies	
IEC/TR 61439 part 0	User guide*	Users and specifiers
BS EN 61439 part 1	General rules	Reference document for low voltage assemblies
BS EN 61439 part 2	Power switchgear and controlgear assemblies	Switchboards, Panel boards and Motor Control Centres
BS EN 61439 part 3	Particular requirements for distribution boards	Consumer units and Distribution boards (standard catalogue items)
BS EN 61439 part 4	Assemblies for construction sites	Assemblies for temporary supplies
BS EN 61439 part 5	Assemblies for power distribution in public networks	Feeder pillars, fuse cabinets and fuse boards
BS EN 61439 part 6	Busbar trunking systems	Busbar trunking
* Informative IEC document that is not a standard.		

Preface

BS EN 60439-1 has been revised and restructured. The new standard to which low-voltage switchboards and motor control centres should be manufactured is BS EN 61439-2: Power switchgear and controlgear assemblies (PSC).

This standard uses as a reference BS EN 61439-1:
General rules.

1 Introduction

This guide is intended to provide information on the methods to confirm verification of a PSC Assembly and the information a specifier should provide to enable Switchboard Manufacturers to also verify that an assembly meets customer requirements in the most efficient and economical manner.

2 The New Standard

BS EN 61439-1 is the General rules for the 61439 series and applies only when required by the relevant assembly standards.

BS EN 61439 Part 2 Power switchgear and controlgear Assemblies (PSC-Assemblies)

This standard defines the specific requirements of power switchgear and controlgear Assemblies (PSC-Assemblies), the rated voltage of which does not exceed 1 000 V a.c. or 1 500 V d.c.

BS EN 61439 Parts 1 & 2 are harmonized with IEC 61439 Parts 1 & 2 and EN 61439 Parts 1 & 2 respectively.

3 Useful Definitions

An Assembly

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

Power switchgear and controlgear Assembly (PSC-Assembly)

Low-voltage switchgear and controlgear Assembly used to distribute and control energy for all types of loads, intended mainly for industrial and commercial applications where access and operation is normally limited to skilled or instructed persons.

Reference design

An Assembly that has satisfactorily completed verification, by test where applicable.

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 self-employed person.

4 Using the 61439 Series of Standards

The contents of BS EN 61439 – 1 are for reference by all parts of the 61439 series, clauses are individually cited if applicable by each of the individual product standards forming the series. Part 1 itself is not a product standard.

BS EN 61439 – 2 is referred to as the Standard in this document, other standards will be stated in full.

5 Benefits

5.1 Confidence

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

With a verified PSC Assembly concerns of this nature are eliminated. The design is proven through a comprehensive design verification process which includes tests or other equivalent means. Where methods other than test are used, margins are included to ensure the specified performance is achieved. This is an essential assurance for user confidence.

5.2 Low-voltage Directive

The Electrical Equipment (Safety) Regulations – implementing ‘The Low-voltage Directive’ (LVD) – require 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.

There are several routes to demonstrating compliance, but the most readily and widely used is through unquestionable conformance to appropriate harmonised Standards. In the case of a Power switchgear and controlgear assembly (PSC-Assembly), fully meeting BS EN 61439-2 ensures compliance with the LVD.

5.3 Electricity at Work Regulations

All manufacturers of PSC Assemblies and Duty Holders responsible for their use are obligated by these statutory safety Regulations. The provision and use of verified 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 essential to use a verified assembly.

5.4 EMC Directive

In the case of PSC Assemblies, fully meeting BS EN 61439-2 is the easiest route to presumption of compliance with the EMC Directive.

5.5 CE Marking

Low voltage Assemblies marketed within the EU have to comply with all relevant Directives and be CE marked. For the majority of Assemblies this requires compliance with the Low Voltage and the EMC Directives.

Fully meeting BS EN 61439-2 allows the PSC Assembly to be CE marked.

5.6 Commercial considerations

Verification of a PSC Assembly by exhaustive testing is an expensive and time consuming process. When an Assembly is produced in significant volumes, costs can be recovered over time through the efficient use of manufacturing processes and materials.

Where bespoke arrangements and adaptations of standard designs are being considered, some verification by means other than tests is likely to be commercially advantageous.

6 Verification Objectives

The verification process consists of two elements:

- I. Design Verification – performed once on a representative sample or samples of a PSC Assembly to confirm the design complies fully with the requirements of the standard.
- II. Routine Verification – undertaken on every PSC Assembly produced; is intended to detect faults in materials and workmanship and to ascertain proper functioning of the manufactured PSC Assembly.

7 Design Verification

It is the responsibility of the manufacturer undertaking the development of a reference design to demonstrate compliance with the standard. The manufacturer shall determine the appropriate verification option available from the standard.

In case of verification by test, the test(s) shall be performed on a PSC Assembly in a clean and new condition.

Bespoke elements of an assembly must be subjected to design verification. Such design verification may be undertaken at the same time as routine verification. It is essential that any design verification is carried out by a person(s) with relevant expertise and understanding of the original design parameters.

The extent and requirements of the verifications are detailed in the standard and comprise the following as detailed in Table I:

Table I – List of design verifications to be performed

No.	Characteristic to be verified	Clauses or subclauses	Verification options available		
			Verification by testing	Verification by calculation	Verification by design rules
7.1	Strength of material and parts:	10.2			
	Resistance to corrosion	10.2.2	YES	NO	NO
	Properties of insulating materials:	10.2.3			
	Thermal stability	10.2.3.1	YES	NO	NO
	Resistance of insulating materials to normal heat	10.2.3.2	YES	NO	NO
	Resistance to abnormal heat and fire due to internal electric effects	10.2.3.3	YES	NO	NO
	Resistance to ultra-violet (UV) radiation	10.2.4	YES	NO	NO
	Lifting	10.2.5	YES	NO	NO
	Mechanical impact	10.2.6	YES	NO	NO
	Marking	10.2.7	YES	NO	NO
7.2	Degree of protection of enclosures	10.3	YES	NO	YES
7.3	Clearances and creepage distances	10.4	YES	YES	YES
7.4	Protection against electric shock and integrity of protective circuits:	10.5			
	Effective continuity between the exposed conductive parts of the ASSEMBLY and the protective circuit	10.5.2	YES	NO	NO
	Effectiveness of the assembly for external faults	10.5.3	YES	YES	YES
7.5	Incorporation of switching devices and components	10.6	NO	NO	YES
7.6	Internal electrical circuits and connections	10.7	NO	NO	YES
7.7	Terminals for external conductors	10.8	NO	NO	YES
7.8	Dielectric properties:	10.9			
	Power-frequency withstand voltage	10.9.2	YES	NO	NO
	Impulse withstand voltage	10.9.3	YES	NO	YES
7.9	Temperature-rise limits	10.10	YES	YES	YES
7.10	Short-circuit withstand strength	10.11	YES	YES	YES
7.11	Electromagnetic compatibility (EMC)	10.12	YES	NO	YES
7.12	Mechanical operation	10.13	YES	NO	NO

The performance of a PSC Assembly may be affected by some verification tests (e.g. short-circuit test). Such tests should not be performed on a manufactured PSC Assembly which is intended to be placed in service.

7.1 Strength of materials and parts

7.1.1 Resistance to corrosion

Two levels of resistance to corrosion for metallic parts are required; one level for external surfaces of indoor equipment and certain internal parts of outdoor and indoor equipment and a second more onerous level for external surfaces of outdoor assemblies. Tests are carried out on representative samples of enclosures for each basic corrosion protection system used.

7.1.2 Properties of insulating materials

Insulating materials included in components manufactured to their own product standards e.g. circuit breakers, contactors, fuse switches, terminal blocks etc. and decorative surfaces, do not need further verification when they are incorporated in a PSC Assembly.

The manufacturer may perform his own tests or use data provided by the material supplier.

7.1.2.1 Thermal stability

For enclosures or parts of enclosures made of insulating materials a thermal stability test at 70 °C is required.

7.1.2.2 Resistance of insulating materials to normal heat

Resistance to heat under normal operating conditions is generally demonstrated by selecting a material with a suitable relative temperature index as declared by the material manufacturer.

7.1.2.3 Resistance to abnormal heat and fire due to internal electric effects

Resistance to abnormal heat is generally demonstrated by selecting a material with a suitable glow wire withstand capability as declared by the material manufacturer.

7.1.3 Resistance to ultra-violet (UV) radiation

Verification requirement applies to enclosures and external parts of PSC Assemblies made of, or coated with, synthetic material.

7.1.4 Lifting

The test verifies the capability of a PSC Assembly to be lifted smoothly, without jerking and in accordance with the manufacturer's instructions.

7.1.5 Mechanical impact

Not required for PSC Assemblies enclosures designed and verified in accordance with the standard.

7.1.6 Marking

The durability test is only applicable to printed markings.

7.2 Degree of protection of enclosures

The standard requires that the degree of protection provided by any PSC Assembly against contact with live parts, ingress of solid foreign bodies and liquid is indicated by the designation IP.. according to BS EN 60529.

Clause 8.2 'Degree of protection provided by a PSC-Assembly enclosure' (the IP value), is 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 BS EN 60529.

In specifying the degree of protection required, careful consideration should be given to the location and accessibility of the assembly. For the majority of indoor installations, in a switch room, IP31 will usually be a more than adequate degree of protection.

It is not recommended that assemblies are installed in locations with heavily dust laden atmospheres or where exposure to liquids is highly probable. Where this is unavoidable a greater degree of protection will be necessary. The implication of higher IP ratings is to significantly increase assembly size and cost.

The level of protection declared by the manufacturer for withdrawable parts whilst being withdrawn and in the withdrawn position shall be verified. In addition the Form of separation included within the PSC Assembly has to be verified with an IP test in accordance with BS EN 60529.

BEAMA has produced a 'Guide to the 'IP' Codes for Enclosures' which gives guidance on interpretation of the requirements for enclosure protection. Verification can be achieved by carrying out the tests set out in BS EN 60529 or by using a certified enclosure.

7.3 Clearances and creepage distances

Clearance and creepage distances are not simple arbitrary values. Minimum distances within an assembly are established from a knowledge of the intended operating environment and the insulating materials used.

Clearance and creepage distances for devices within an assembly are determined in accordance with their own product Standards.

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 PSC 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. The pollution has no influence.*
- Pollution degree 2:** *Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.*
- Pollution degree 3:** *Conductive pollution occurs, or dry, non-conductive pollution occurs which is expected to become conductive due to condensation.*
- Pollution degree 4:** *Continuous conductivity occurs due to conductive dust, rain or other wet conditions. Unless advised otherwise, a maximum of pollution degree 3 is assumed. In environments of pollution degree 4, a supplementary protection is required to provide a micro environment of pollution degree 3, or better, into which the assembly is installed.*

b) Impulse withstand

The highest peak value of an impulse voltage the PSC Assembly is designed to withstand is determined from the rated operational voltage of the PSC Assembly, and the over voltage category applicable. Table 2 gives details for a 400/230 V system.

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

Over voltage category	Position in Installation	Impulse level (kV)	Minimum clearances (mm) ¹
I	Specially protected level	1.5	1.5
II	Load (appliance, equipment) level	2.5	1.5
III	Distribution circuit level	4.0	3.0
IV	Origin of insulation (service entrance level)	6.0	5.5

¹ Based on inhomogeneous field conditions and pollution degree 3.

Table 2
Voltage categories and minimum impulse levels for PSC Assemblies to be installed on a 400/230 volt, earthed neutral system.

c) Material group

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

Material group	Comparative tracking index (CTI)	Minimum creepage distances (mm) ¹			
		Pollution Degree			
		1	2	3	4
I	600 ≤ CTI	1.5	2.0	5.0	Not recommended
II	400 ≤ CTI < 600	-	2.8	5.6	
IIIa	175 ≤ CTI < 400	-	4.0	6.3	
IIIb	100 ≤ CTI < 175	-	4.0	6.3	

¹ Ratings applicable to a rated insulation voltage (U) of 400 V, for other ratings refer to Table 2 of BS EN 61439-1

Table 3
Minimum creepage distances for 400/230 V equipment

The rated insulation voltage of a PSC Assembly or a circuit within an assembly determines the creepage distances. In all cases the rated insulation voltage (and the operational voltage) must be equal to or higher than the rated voltage of the assembly. Tables 2 and 3 assume the rated voltage of the assembly, insulation and operational voltages are equal.

7.3.1 Clearance confirmation

Once the rated operational 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 PSC Assembly suitable for connection to 400/230 Volt, earthed neutral system. On this basis, many assemblies, for example sub-distribution assemblies, can have clearances as low as 3 mm and still be acceptable, in accordance with the standard. Alternatively clearances can be verified by conducting an impulse test as detailed in 7.8.2.

7.3.2 Creepage confirmation

Creepage distances are a function of;

- i. the rated insulation voltage of the PSC Assembly,
- ii. the pollution degree applicable to the environment into which it is intended to be installed,
- iii. the Material Group in 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.

As Table 3 shows, for a typical PSC Assembly suitable for connection to a 400/230 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.

7.4 Protection against electric shock and integrity of protective circuits

The protective circuit within a PSC 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.

7.4.1 Effective continuity between the exposed conductive parts of the PSC Assembly and the protective circuit

All exposed conductive parts shall be effectively bonded to the protective circuit within an assembly, thereby providing personal protection.

Doors and other exposed conductive parts not supporting live electrical equipment may not need additional bonding over and above their normal fixing means. This is verified by testing to confirm that the maximum resistance between the conductive part and the main incoming earth terminal does not exceed 0.1 ohms.

Where ancillary electrical equipment is mounted on doors or covers, a separate bonding lead of appropriate cross-sectional area (as required by the standard) has to be provided.

7.4.2 Effectiveness of the PSC Assembly for external faults

Where the short circuit current is in excess of 10 kA rms or 17 kA peak the short circuit capability of the protective circuit has to be verified for each type of circuit in the PSC Assembly. This may be achieved by one of the following methods:

- Test or
- Comparison with a reference design or
- Interpolation from a verified design in accordance with IEC/TR 61117.

It should be noted that where the short circuit protective device for ancillary items has a cut-off current of less than 17 kA, no verifying test is required for the ancillary circuits.

7.5 Incorporation of switching devices and components

The standard defines three categories of parts that can be installed into a PSC Assembly: Fixed, Removable and Withdrawable.

The manufacturer must verify the following:

- i. Switching devices and other components installed in an assembly are compliant with relevant standards (e.g. BS EN 60947 Series).
- ii. Short circuit protective devices used in the assembly will not be subjected to short circuit stresses beyond their capability.
- iii. The installation and connection of switching devices and other components are carried out in accordance with manufacturer's instructions and in such a way that in normal service, their interaction with other installed devices does not impair their required performance in the assembly.

In addition the standard requires, unless otherwise agreed, that the physical positioning of certain external accessible switching elements, controls, indicators etc must be within defined height limits.

7.6 Internal electrical circuits and connections

The manufacturer shall verify that all internal connections comply with the requirements of the standard. In particular the manufacturer must ensure that the probability of a short circuit on connections considered as being in “fault free zones” is very remote and that such connections are compliant with the requirements defined in the standard.

7.7 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 on the arrangement drawings and wiring diagrams.

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

7.8 Dielectric properties

The dielectric properties of a PSC Assembly must be proven to be capable of withstanding temporary overvoltages, (power frequency) and transient overvoltages (impulse).

7.8.1 Power frequency withstand

This dielectric test confirms the voltage withstand of the main and auxiliary circuits. Current consuming apparatus, e.g. instruments are excluded. The method of proving for this requirement is to conduct a power frequency test to the values given in Tables 4 and 5 for a duration of 5 s (+2/-0) s.

7.8.2 Impulse withstand voltage

Verification is achieved by one of the following methods:

- By design rules (measurement) or
- One of three different methods of test:
 - i. Impulse test
 - ii. Power frequency test
 - iii. d.c. voltage test

If the design rules option is selected a safety margin is included by increasing the values stated in Table 2 by 50%.

NOTE 1 routine Power frequency tests on main circuits have a duration of 1 s.

NOTE 2 there is no requirement for routine Power frequency tests on auxiliary circuits.

Rated insulation voltage U_i (line to line a.c. or d.c.) V	Dielectric test voltage a.c. r.m.s. V	Dielectric test voltage ¹ d.c. V
$60 < U_i \leq 300$	1 500	2 120
$300 < U_i \leq 690$	1 890	2 670

¹Test voltages based on 4.1.2.3.1, third paragraph, of IEC 60664-1.

Table 4
Power-frequency withstand
voltage for main circuits

Table 5
Power-frequency withstand
voltage for auxiliary and
control circuits

Rated insulation voltage U_i (line to line) V	Dielectric test voltage a.c. r.m.s. V
$U_i \leq 12$	250
$12 < U_i \leq 60$	500
$60 < U_i$	$2 U_i + 1\ 000$ with a minimum of 1 500

7.9 Temperature-rise limits

It is the manufacturer's responsibility to select the appropriate method for temperature rise verification.

All the temperature rise limits given in the standard assume that the PSC Assembly will be located in an environment where the daily average and peak ambient temperatures do not exceed 35 °C and 40 °C, respectively.

The standard also assumes that all outgoing circuits within an assembly will not be loaded to their rated current at the same time. This recognition of the practical situation is defined by a 'rated diversity factor'. Subject to the loading of the incoming circuit not exceeding its rated current, diversity is the proportion of the individual rated currents that any combination of outgoing circuits can carry continuously and simultaneously, without the assembly overheating. Diversity factor (assumed loading) is usually defined for the assembly as a whole, but a manufacturer may choose to specify it for groups of circuits, for example the circuits in a section.

Unless otherwise specified it is assumed the diversity factor for the assembly is as shown in Table 6

Table 6
Values of
assumed loading

Number of main circuits	Assumed loading factor
2 and 3	0,9
4 and 5	0,8
6 to 9 inclusive	0,7
10 (and above)	0,6

Temperature rise verification confirms two criteria;

- i. That each type of circuit is capable of carrying its rated current when it is incorporated in the assembly. This takes into account the way in which the circuit is connected and enclosed within the assembly, but excludes any heating affects that may result from adjacent circuits carrying current.
- ii. The assembly as a whole will not overheat when the incoming circuit is loaded to its rated current and, subject to the maximum current of the incoming circuit, any combination of outgoing circuits can be simultaneously and continuously loaded to their rated current multiplied by the rated diversity factor for the assembly.

Temperature rise limits within the assembly are the manufacturers' responsibility, they are essentially determined on the basis of operating temperature not exceeding the long term capability of the materials used within the assembly. At interfaces between the assembly and the 'wider world', for example, cable terminals and operating handles, the standard defines temperature limits.

Within boundaries defined in the standard, temperature rise verification can be undertaken by test, calculation or design rules. It is permissible to use one or a combination of the verification methods set out in the standard to verify temperature rise performance of an assembly. This allows the

manufacturer to choose the most appropriate method for the assembly, or part of an assembly, taking into consideration volumes, the construction, design flexibility, current rating and size of the assembly. Indeed, in typical applications involving some adaptation of a standard design it is highly likely more than one method will be used to cover various elements of the assembly design.

7.9.1 Test

In order to avoid unnecessary testing the standard provides guidance on selecting groups of comparable functional units. It then details how to select the critical variant from the group for test. Design rules are then applied to assign ratings to other circuits that are 'thermally similar' to the critical variant tested.

Three options for test are offered in the standard.

a) Verification of the complete PSC Assembly

This is a quick and conservative approach to achieving a result for a particular arrangement of assembly. It proves the rating of the outgoing circuits and the assembly in the same test. The incoming circuit and busbars are loaded to their rated current; and as many outgoing circuits in a group as are necessary to distribute the incoming current are loaded to their individual rated currents when installed in the assembly. For most installations this is an unrealistic situation since outgoing circuits are not normally loaded to unity diversity (fully loaded). If the group of functional units tested does not include one of each of the different types of outgoing circuit incorporated in the assembly, then further tests are carried out considering different groups of outgoing circuits until one of each type has been tested.

Testing in this manner requires the minimum number of temperature rise tests, but the test arrangement is more onerous than necessary and the result is not applicable to a range of assemblies.

b) Verification considering individual functional units separately and the complete PSC Assembly

With this arrangement of testing each critical variant of outgoing circuit is tested separately to confirm its rating and then the assembly as a whole is tested with the incoming circuit loaded to its rated current and groups of outgoing circuits, as necessary to distribute the incoming current, loaded to their rated current multiplied by the diversity factor. The group tested should include one outgoing circuit of each critical variant to be incorporated in the assembly. Where this is not practical, further groups are tested until all critical variants of outgoing circuit have been considered.

This test regime takes into account the diversity in the loading of outgoing circuits that is applicable in the majority of applications. However, as in method a) above, the result is only applicable to the specific arrangement of assembly tested.

c) Verification considering separate elements and the complete PSC Assembly

This test method enables modular systems to be temperature rise verified without the need to test every conceivable combination of circuits. Temperature rise tests are carried out separately to prove the rating of:

- i. functional units,
- ii. main busbars,
- iii. distribution busbars,
- iv. complete assembly.

When verifying the performance of the assembly as a whole, these tests are then complimented by a test on a representative assembly in which the incoming circuit is loaded to its rated current and the outgoing circuits are loaded to their rated current multiplied by the diversity factor.

Whilst this approach requires more testing than methods a) and b) it has the advantage that the modular system rather than a specific arrangement of assembly is verified.

7.9.2 Calculation

Two methods of verifying temperature rise performance by calculation are included within the standard.

a) Single compartment PSC Assembly with a rated current not exceeding 630A.

A very simple method of temperature rise verification that requires confirmation that the total power loss of the components and conductors within the assembly do not exceed the known power dissipation capability of the enclosure. The scope of this approach is very limited and in order that there are no difficulties with hot spots, all components must be de-rated to 80% of their free air current rating.

b) Multiple compartment PSC Assembly with rated currents not exceeding 1600 A.

Temperature rise verification is by calculation in accordance with IEC 60890 with additional margins. The scope of this approach is limited to 1600 A, components are de-rated to 80% of their free air rating or less and any horizontal partitions must have, as a minimum, a 50% open area for connection.

7.9.3 Design Rules

The standard allows, in clearly defined circumstances, for the derivation of ratings from similar variants that have been verified by test. For example, if the current rating of a double lamination busbar has been established by test, it is acceptable to assign a rating equal to 50% of the tested arrangement to a busbar comprising a single lamination with the same width and thickness as the tested laminations, when all other considerations are the same.

In addition, the rating of all circuits within a group of comparable functional units (all devices must be of the same frame size and belong to the same series) can be derived from a single temperature rise test on the critical variant within the group. An example of this may be to test a nominal 250 A outgoing mccb and establish a rating for it in the assembly. Then, assuming the same frame size breaker is being considered and other specified conditions are met, verify by calculation the rating of a nominal 160 A mccb within the same enclosure.

Lastly, in respect of temperature rise, there are very strict design rules that permit the substitution of a device with a similar device from another series or even another make, without retesting. In this case, in addition to the physical arrangement being essentially the same, the power loss and terminal temperature rise of the substitute device, when it is tested in accordance with its own product standard, must not be higher than those of the original device.

Note: When considering device substitution all other performance criteria, in particular that dealing with short circuit capability, must be considered and satisfied, in accordance with the standard, before an assembly is deemed to be verified.

7.10 Short-circuit withstand strength

BS EN 61439-2 allows verification of short circuit withstand strength by the application of design rules (defined within the standard), by calculation or by test. The alternative routes to verification will reduce the requirement for repetitive testing.

The exemptions to test, where a test to prove short circuit withstand strength are not required, are:

- The assembly is to be used in a system where it is known the short circuit fault current cannot exceed 10 kA rms;

- The assembly is protected by a current limiting device which will limit the cut-off current to below 17 kA;
- Auxiliary circuits intended to be connected to transformers whose rated power does not exceed 10 kVA for a rated secondary voltage of not less than 110 V, or 1,6 kVA for a rated secondary voltage less than 110 V, and whose short-circuit impedance is not less than 4%.

It is accepted practice that auxiliary circuits connected to main circuits do not require short circuit testing when protected by a short circuit protective device which limits the cut-off current to 17 kA or less.

Verification by the application of design rules:

The manufacturer undertakes a comparison of a PSC Assembly to be verified with an already tested design in accordance with a checklist provided (See Table 1). If any of the criteria in the table are not met, then either further calculation or a test is required for verification.

Verification by comparison with a reference design (by interpolation)

Using the calculation method to verify the short circuit withstand strength of a PSC Assembly and its circuits is undertaken by comparing the assembly to be assessed with a PSC Assembly already verified by test, in accordance with IEC/TR 61117. In addition each of the circuits of the assembly to be assessed must meet basic requirements from the same table used for design rule comparison (above). Again, if any of the compared elements do not fulfil the requirements of the standard, then a test is necessary.

Substitution of an alternative short circuit protective device from the same manufacturer (e.g. replacing an ACB range with a new range of devices) is possible without the need for repeating testing provided the device manufacturer declares the performance characteristics to be the same or better in all relevant respects to the series used for verification, e.g. breaking capacity and limitation characteristics (I^2t , Ipk), and critical distances.

Verification by test

Short circuit withstand test is required to verify the capability of the complete PSC 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 by through-fault tests on the outgoing circuits.

Where the Neutral conductor is:

- the same shape and cross-section as the phase conductors;
- supported in an identical manner as the phase conductors and with support centres along the length of the conductor not greater than that of the phases;
- spaced at a distance from the nearest phase(s) not less than that between phases;
- spaced at a distance from earthed metalwork not less than the phase conductors; then the test on the neutral need not be performed if the required rating is 60% of the phase current.

7.11 Electromagnetic compatibility (EMC)

PSC Assemblies are in most cases manufactured or assembled on a one-off basis, incorporating a selection or combination of devices and components to meet customer specific requirements.

No EMC immunity or emission tests are required on final assemblies if the following conditions are fulfilled;

- a) The incorporated devices and components are in compliance with the requirements for EMC for the stated environment as required by the relevant product or generic EMC standard.

- b) The internal installation and wiring is carried out in accordance with the devices and components manufacturers' instructions (arrangement with regard to mutual influences, cable, screening, earthing etc.)

In all other cases the EMC requirements are to be verified by tests in accordance with annex J of the Standard.

7.12 Mechanical operation

Where products incorporated in the PSC 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 e.g. a racking mechanism of a withdrawable starter, a test of 200 mechanical operations should be conducted by the manufacturer. At the end of the test, the mechanical efficiency shall be maintained.

8 Routine Verification

Routine verification is carried out on each PSC Assembly produced by the manufacturer completing the assembly. The verification is normally undertaken at the manufacturer's premises and is:

- To ensure full compliance with the specific and any generic manufacturing instructions;
- Part of the quality control activity. It is 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 on the installer to ensure the assembly's correct installation and obligations to test under BS 7671. Before tests under BS 7671 or other testing is undertaken, the effects of the tests on voltage sensitive components should be established.

As applicable for the particular assembly being considered, routine verification will include checks and/or tests to confirm the following are in accordance with the design specification:

- a) degree of protection of enclosures;
- b) clearances and creepage distances;
- c) protection against electric shock and continuity of protective circuits;
- d) incorporation of built-in components;
- e) internal electrical circuits and connections;
- f) terminals for external conductors;
- g) mechanical operation;
- h) dielectric properties;
- i) wiring, operational performance and function.

9 Specifier Responsibilities

The specifier should advise the environment and system design requirements within which the PSC Assembly is required to operate by providing the information detailed in Table 7.

The standard arrangement shown in Table 7 will be used for details not supplied by the specifier. Where there are no standard arrangement details or information supplied by the specifier, the manufacturer will supply their normal arrangement.

Table 7 – Items subject to agreement between the PSC Assembly Manufacturer and the User

User defined functions and characteristics	Reference clause (for Parts I & 2)	Standard arrangement	User requirement ¹
Electrical system			
Earthing system	5.5, 8.4.3.2.3, 8.6.2, 10.5, 11.4	***	Terminal for External Earth
Rated voltage U_n (Volts)	3.8.8.1, 5.2.1, 8.5.3	***	400 V
Overtoltage category	5.2.4, 8.5.3, 9.1, Annex G	***	IV (if at the origin of the installation)
Unusual voltage transients, voltage stresses, temporary overvoltages	9.1	No	No
Rated frequency f_n (Hz)	3.8.11, 5.4, 8.5.3, 10.10.2.3, 10.11.5.4	***	50Hz
Additional on site testing requirements: wiring, operational performance and function	11.10	***	On site function check
Short circuit withstand capability			
Prospective short-circuit current at supply terminals I_{cp} (kA)	3.8.6	***	Conditioned by 800amp fuse
Prospective short circuit current in the neutral	10.11.5.3.5	60% of phase values	Standard
Prospective short circuit current in the protective circuit	10.11.5.6	60% of phase values	Standard
SCPD in the incoming functional unit	9.3.2	***	See schematic No. xx
Co-ordination of short-circuit protective devices including external short-circuit protective device details	9.3.4	***	See schematic No. xx
Data associated with loads likely to contribute to the short-circuit current	9.3.2	***	See schematic No. xx
Protection of persons against electric shock in accordance with IEC 60364-4-41			
Type of protection against electric shock – Basic protection (protection against direct contact) <i>NOTE This types of protection is intended to protect against electric shock due to direct contact within the ASSEMBLY during normal service conditions.</i>	8.4.2	Basic protection	Basic protection
Type of protection against electric shock – Fault protection (protection against indirect contact) <i>NOTE These types of protection are intended to protect against the consequences of a fault within the ASSEMBLY.</i>	8.4.3	***	Fault protection See schematic No. xx for device type

User defined functions and characteristics	Reference clause (for Parts I & 2)	Standard arrangement	User requirement ¹
Installation Environment			
Location type	3.5, 8.1.4, 8.2	***	Indoor
Protection against ingress of solid foreign bodies and ingress of liquid	8.2.2, 8.2.3	***	IP 3X indoor
External mechanical impact (IK) <i>NOTE IEC 61439-1 does not nominate specific IK codes.</i>	8.2.1, 10.2.6	***	Not required, not positioned in a vulnerable location
Resistance to UV radiation (applies for outdoor assemblies only unless specified otherwise)	10.2.4	Standard	Not required
Resistance to corrosion	10.2.2	Standard	Standard
Ambient air temperature – lower limit	7.1.1	Indoor: -5 °C Outdoor: -25 °C	Indoor Standard
Ambient air temperature – upper limit	7.1.1	40 °C	Standard
Ambient air temperature – daily average maximum	7.1.1	35 °C	Standard
Maximum relative humidity	7.1.2	Indoor: 50% @ 40 °C Outdoor: 100% @ 25 °C	Indoor Standard
Pollution degree	7.1.3	Industrial: 3	3
Altitude	7.1.4	≤ 2000 m	Standard
EMC environment	9.4, 10.12, Annex J	***	B
Special service conditions (e.g. vibration, exceptional condensation, heavy pollution, corrosive environment, strong electric or magnetic fields, fungus, small creatures, explosion hazards, heavy vibration and shocks, earthquakes)	7.2, 8.5.4, 9.3.3, Table 7	***	None. Indoor switchroom commercial environment
Installation method			
Type	3.3, 5.5	***	Indoor Cubicle
Portability	3.5	***	Floor fixed
Maximum overall dimensions and weight	6.2.1	***	Manufacturer's standard
External conductor type(s)	8.8	***	SWA
Direction(s) of external conductors	8.8	***	In bottom out top front access
External conductor material	8.8	***	Cu
External phase conductor, cross sections, and terminations	8.8	Standard	See schematic No. xx
External PE, N, PEN conductors cross sections, and terminations	8.8	Standard	See schematic No. xx
Special terminal identification requirements	8.8	***	L1, L2, L3, N
Storage and handling			
Maximum dimensions and weight of transport units	6.2.2, 10.2.5	***	Manufacturer's transport
Methods of transport (e.g. forklift, crane)	6.2.2, 8.1.7	***	Crane (2 ton)
Environmental conditions different from the service conditions	7.3	***	Same
Packing details	6.2.2	***	Manufacturer's standard

User defined functions and characteristics	Reference clause or subclause	Standard arrangement	User requirement ¹⁾
Operating Arrangements			
Access to manually operated devices	8.4, 8.5.5	***	Front
Isolation of load installation equipment items	8.4.2, 8.4.3.3, 8.4.5.2	***	Manufacturer's standard
Maintenance and upgrade capabilities			
Requirements related to accessibility in service by ordinary persons; requirement to operate devices or change components while the ASSEMBLY is energised	8.4.5.1	No	Only when isolated
Requirements related to accessibility for inspection and similar operations	8.4.5.2.2	No	Only when isolated
Requirements related to accessibility for maintenance in service by authorized persons	8.4.5.2.3	No	Connection of cables only
Requirements related to accessibility for extension in service by authorized persons	8.4.5.2.4	No	Only when isolated
Method of functional units connection <i>NOTE This refers to the capability of removal and re-insertion of functional units.</i>	8.5.1, 8.5.2	***	Only when isolated
Protection against direct contact with hazardous live internal parts during maintenance or upgrade (e.g. functional units, main busbars, distribution busbars)	8.4	No	Only when isolated
Method of functional units connection <i>NOTE This refers to the capability of removal and re-insertion of functional units.</i>	8.5.101	***	F (fixed)
Form of separation	8.101	***	Form 4
Capability to test individual operation of the auxiliary circuits relating to specified circuits while the functional unit is isolated	3.1.102, 3.2.102, 3.2.103, 8.5.101, Table 103	***	See control drawing No. xx
Current carrying capability			
Rated current of the ASSEMBLY I_{nA} (amps)	3.8.9.1, 5.3, 8.4.3.2.3, 8.5.3, 8.8, 10.10.2, 10.10.3, 10.11.5, Annex E	***	See schematic No. xx
Rated current of circuits I_{nc} (amps)	5.3.2	***	
Rated diversity factor	5.3.3, 10.10.2.3, Annex E	According to product standards	See schematic No. xx
Ratio of cross section of the neutral conductor to phase conductors: phase conductors up to and including 16 mm ² <i>NOTE Current in the neutral may be influenced where there are significant harmonics, unbalanced phase currents, or other conditions in the load that will necessitate a larger conductor.</i>	8.6.1	100%	As product standard 100%
Ratio of cross section of the neutral conductor to phase conductors: phase conductors above 16 mm ² <i>NOTE For the standard value, the neutral current is assumed not to exceed 50% of the phase currents. Current in the neutral may be influenced where there are significant harmonics, unbalanced phase currents, or other conditions in the load that will necessitate a larger conductor.</i>	8.6.1	50% (min. 16 mm ²)	Manufacturer's standard

¹⁾ This column is user information with an example of the information to be provided.

For particular applications, the user may need to specify more stringent requirements to the examples in this table.

*** Indicates that there is no default arrangement within the standard, specifiers must state their requirement.



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