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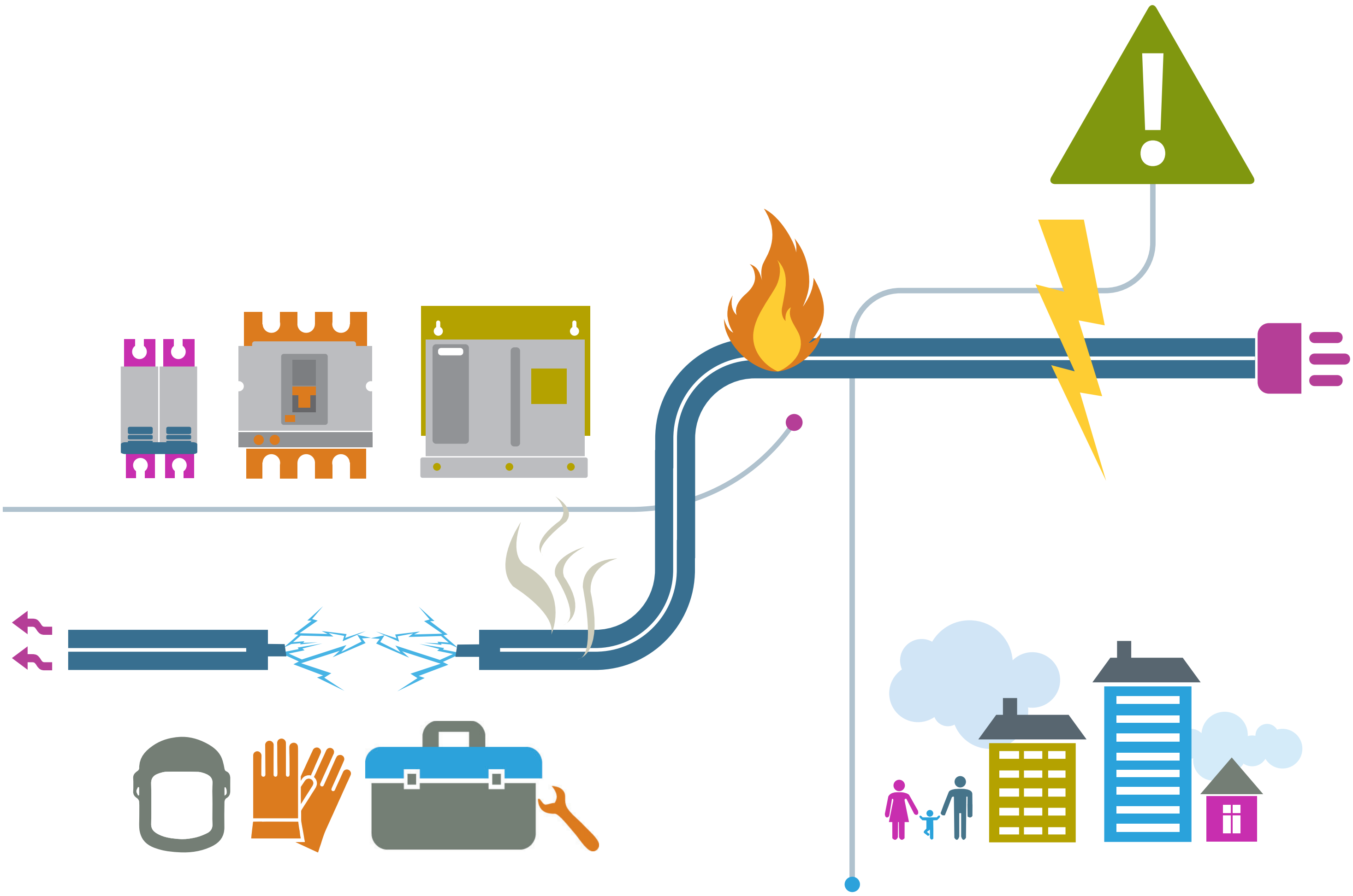
BEAMA GUIDE TO VERIFICATION

Low-voltage Power Switchgear and Controlgear Assemblies (PSC) in Accordance with BS EN IEC 61439-2:2021



July 2023

ABOUT BEAMA

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 publication provides guidance on BS EN IEC 61439-2:2021 and intends to explain in clear and simple terms, exactly how manufacturers can comply with its requirements relating to assembly verification.

This publication has been produced by BEAMA's Building Electrical Systems Sector operating under the guidance and authority of BEAMA, supported by specialist central services for guidance on UK Internal Market, European Single Market, Quality Assurance, Legal and Health & Safety matters. BEAMA's Building Electrical Systems Sector comprises of major UK manufacturing companies.

Details of other BEAMA Guides can be found on the BEAMA website www.beama.org.uk

ACKNOWLEDGEMENTS

BEAMA would like to thank BSI, CENELEC and IEC for allowing references to their standards.

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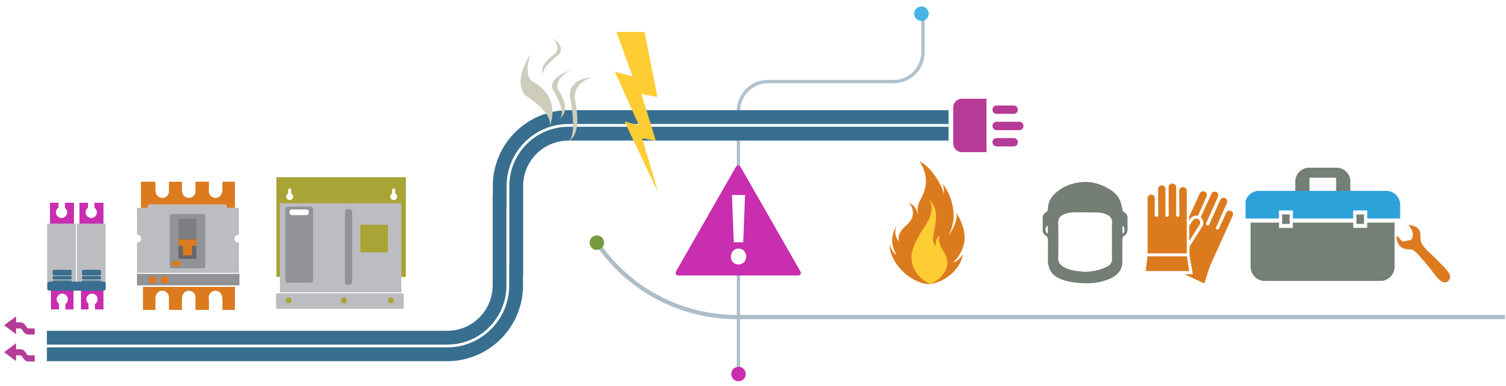
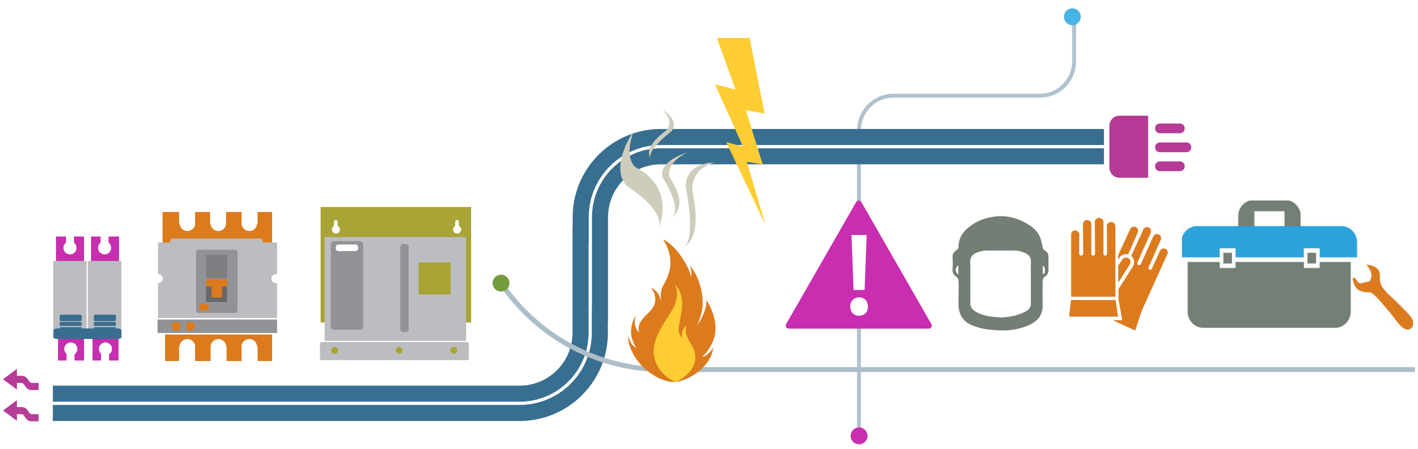


1. INTRODUCTION

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 the customer's requirements in the most efficient and economical manner.

This guide relates to the 2021 edition of BS EN IEC 61439-1 and BS EN IEC 61439-2.

NOTE: BS EN IEC 61439-2:2021 is referred to as "the Standard" in this guide.



2. DEFINITIONS

2.1 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.

2.2 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, commercial and similar applications where operation by ordinary persons is not intended.

2.3 Reference design

Design of an assembly or parts of an assembly that has been verified by test.

2.4 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.

3. THE STANDARD

3.1 BS EN IEC 61439-1 is the General rules for the BS EN IEC 61439 series and applies only when required by the relevant assembly standards. BS EN IEC 61439-1 itself is not a product standard. The contents of BS EN IEC 61439-1 are for reference by all parts of the BS EN IEC 61439 series. Clauses are individually cited if applicable by each of the individual product standards forming the series.

3.2 BS EN IEC 61439-2 defines the **specific requirements** for Power Switchgear and Controlgear Assemblies (PSC- Assemblies), the rated voltage of which does not exceed 1 000 V AC or 1 500 V DC. This is the Standard to which low-voltage switchboards, panelboards and motor control centres should conform to. BS EN IEC 61439-2 uses BS EN IEC 61439-1 General rules, as a reference document.

NOTE: BS EN IEC 61439-1 & 2 are identical with IEC 61439-1 & 2 and EN 61439-1 & 2

3.3 Previous edition – BS EN 61439-2:2011* has been superseded by BS EN IEC 61439-2:2021. Both editions remain valid until BS EN 61439-2:2011 is withdrawn in May 2024.

*The second edition of the BEAMA Guide to verification dated 2014 relates to BS EN 61439-2:2011.

4. BENEFITS

4.1 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.

4.2 The Electrical Equipment (Safety) Regulations (EESR)

The Electrical Equipment (Safety) Regulations 2016 (as amended) 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 conformance, but the most readily and widely used is through conformance to appropriate Designated Standards. In the case of a power switchgear and controlgear assembly (PSC-Assembly), fully meeting the Standard ensures conformance with the EESR when the Standard is designated.

NOTE: At the time of publication of this guide, BS EN IEC 61439-2:2021 had not been designated and therefore presumption of conformity continues to be afforded by conforming to BS EN 61439-2:2011.

4.3 Electricity at Work Regulations

All manufacturers of PSC Assemblies and Duty Holders responsible for their use are obligated by the statutory Electricity at Work 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 practicable, 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.

4.4 Electromagnetic Compatibility Regulations (EMC)

Conformance with the Electromagnetic Compatibility Regulations 2016 (as amended) is afforded by conforming to the appropriated Designated Standard. In the case of PSC Assemblies, fully meeting the Standard is the easiest route to presumption of conformity with the EMC Regulations.

NOTE: At the time of publication of this guide, BS EN IEC 61439-2:2021 had not been designated and therefore presumption of conformity continues to be afforded by conforming to BS EN 61439-2:2011.

4.5 UKCA Marking

Low voltage Assemblies marketed within the Great Britain (GB) have to conform with all relevant legislation and be UKCA marked. For the majority of assemblies this requires conformance with the Electrical Equipment (Safety) Regulations 2016 (as amended) and the Electromagnetic Compatibility Regulations 2016 (as amended).

Fully meeting the Standard allows the PSC Assembly to be UKCA marked when the Standard is designated.

NOTE 1: At the time of publication of this guide, CE marking can continue to be used for the GB market until the end of 2024.

NOTE 2: At the time of publication of this guide, BS EN IEC 61439-2:2021 had not been designated and therefore presumption of conformity continues to be afforded by conforming to BS EN 61439-2:2011.

4.6 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.

5. VERIFICATION OBJECTIVES

The verification process consists of two parts:

a) **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, and

b) **Routine Verification** – undertaken on every PSC Assembly produced. It is intended to detect faults in materials and workmanship and to ascertain proper functioning of the manufactured PSC Assembly.

6. DESIGN VERIFICATION

It is the responsibility of the manufacturer undertaking the development of a reference design to demonstrate conformity 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 not covered by previous verifications must be subjected to design verification. Such design verification may be undertaken at any stage during the manufacturing process including during 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 1 below.

Table 1: List of design verifications to be performed (As given in Table D.1 of BS EN IEC 61439-1)

No.	Characteristic to be verified	Subclauses	Verification options available		
			Testing[a]	Comparison with a reference design	Assessment
6.1	Strength of material and parts:	10.2			
	Resistance to corrosion	10.2.2	YES	YES	NO
	Properties of insulating materials:	10.2.3			
	Thermal stability	10.2.3.1	YES	YES	NO
	Resistance to abnormal heat and fire due to internal electric effects	10.2.3.2	YES	YES	YES
	Resistance to ultra-violet (UV) radiation	10.2.4	YES	YES	YES
	Lifting	10.2.5	YES	YES	NO
	Mechanical impact (IK)	10.2.6	YES	YES	NO
	Marking	10.2.7	YES	YES	NO
	Mechanical operation	10.2.8	YES	YES	NO
6.2	Degree of protection of enclosures (IP)	10.3	YES	NO	YES
6.3	Clearances	10.4	YES	NO	NO
6.4	Creepage distances	10.4	YES	NO	NO
6.5	Protection against electric shock and integrity of protective circuits:	10.5			
	Effective continuity between the exposed-conductive-parts of a class I assembly and the protective circuit	10.5.2	YES	NO	NO
	Short-circuit withstand strength of the protective circuit	10.5.3	YES	YES	NO

No.	Characteristic to be verified	Subclauses	Verification options available		
			Testing[a]	Comparison with a reference design	Assessment
6.6	Incorporation of switching devices and components	10.6	NO	NO	YES
6.7	Internal electrical circuits and connections	10.7	NO	NO	YES
6.8	Terminals for external conductors	10.8	NO	NO	YES
6.9	Dielectric properties:	10.9			
	Power-frequency withstand voltage	10.9.2	YES	NO	NO
	Impulse withstand voltage	10.9.3	YES	NO	YES
	Enclosures made of insulating material	10.9.4	YES	NO	NO
	External operation handles of insulating material	10.9.5	YES	NO	NO
	Conductors covered by insulating material to provide protection against electric shock	10.9.6	YES	NO	NO
6.10	Temperature-rise limits	10.10	YES	YES	YES
6.11	Short-circuit withstand strength	10.11	YES	YES	NO
6.12	Electromagnetic compatibility (EMC)	10.12	YES	NO	YES

[a] Testing may be on representative sample if permitted in the appropriate test clause.

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.

6.1 Strength of materials and parts

6.1.1 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 an enclosure or representative samples of enclosures for each basic corrosion protection system used.

6.1.2 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 their own tests or use data provided by the material supplier.

6.1.2.1 Thermal stability

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

6.1.2.2 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.

6.1.2.3 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.

6.1.3 Resistance to ultra-violet (UV) radiation

For assemblies intended to be installed outdoors this verification requirement applies to enclosures and external parts of PSC Assemblies made of, or coated with, synthetic material.

6.1.4 Lifting

Where lifting provision is provided this test verifies the capability of a PSC Assembly to be lifted smoothly, without jerking and in accordance with the manufacturer's instructions. Lifting can be by means of overhead crane or forklift truck.

6.1.5 Mechanical impact

An impact test is not required by the Standard; however, where required by the user, a mechanical impact test shall be performed according to BS EN 62262. Resistance to mechanical impact will inevitably increase the cost of an assembly (see Table 7).

6.1.6 Marking

Markings made by moulding, pressing, engraving or similar, including labels with a laminated plastic covering, are exempt from the durability test

6.1.7 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. This means that withdrawable circuit-breakers and similar, that have been fully verified in accordance with their own product standard and have been installed according to the manufacturer's instructions, do not require a mechanical operation verification. 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.

6.2 Degree of protection provided by a PSC – Assembly enclosure

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

The 'Degree of protection provided by a PSC-Assembly enclosure' (the IP code), 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.

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.

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, IP3X will usually be a more than adequate degree of protection for the PSC-Assembly; for a transformer housing IP2X is normally adequate.

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.

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.

6.3 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. The environment outside the assembly and in which the assembly is installed is the macro-environment, with the environment inside the assembly being designated the micro-environment. 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.

The specification for an assembly defines the macro-environment. Suitable enclosures can provide a lower level of pollution within an assembly; a feature that is often necessary as many components are only suitable to the lower order pollution degree environments.

Pollution degree 4 is not applicable inside an assembly.

(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.

The clearances shall be as specified in Table 2 unless a design verification test and routine impulse withstand voltage test is carried out in accordance with the Standard.

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.

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

Over voltage category	Position in Installation	Impulse level (kV)	Measured 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 the insulation (service entrance level)	6.0	5.5

[1] Based on inhomogeneous field conditions and pollution degree 3.

(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.

Table 3: Minimum creepage distances for 400/230 V equipment (Derived from Table 2 of BS EN IEC 61439-1)

Material group	Comparative tracking index (CTI)	Minimum creepage distances inside the assembly (mm)[1]		
		Pollution Degree		
		1	2	3
I	600 ≤ CTI	1.5	2.0	5.0
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_i) of 400 V, for other ratings refer to Table 2 of BS EN IEC 61439-1

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.

6.3.1 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 stated in the Standard may, however, be much less than is often expected. Table 2 gives the minimum distances for a typical PSC Assembly suitable for connection to 400/230 V, earthed neutral system. On this basis, many assemblies, for example sub-distribution assemblies, can have measured 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 6.8.2.

6.3.2 Creepage confirmation

Creepage distances are a function of:

a) The rated insulation voltage of the PSC Assembly

b) The pollution degree applicable to the environment in which the insulation and conductors are installed (usually the micro-environment inside an enclosed assembly)

c) The Material Group in which the insulating materials belong

Having established these parameters, minimum creepage distances can readily be determined from BS EN IEC 61439-1 and confirmed by measurement. Annex F of BS EN IEC 61439-1 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 V 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 the minimum clearance distances.

6.4 Protection against electric shock and integrity of protective circuits

The protective circuit within a PSC Assembly serves two distinct functions:

a) To ensure all exposed conductive parts are effectively bonded to the main earth terminal, thereby providing personal protection, and

b) Provide a safe earth return for earth faults down-stream of the assembly.

6.4.1 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 do not require an additional protective conductor (PE) over and above their normal fixing means, provided that the maximum resistance between the conductive part and the main incoming earth terminal does not exceed 0.1 Ω with a test current of 10 A.

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

6.4.2 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 the following methods:

a) Test, or

b) Comparison with a reference design, or

c) Interpolation from a verified design in accordance with Annex M of BS EN IEC 61439-1.

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.

Even if the short-circuit-current is not in excess of 10 kA RMS or 17 kA peak, the switching devices and components must still comply with the short-circuit withstand strength design verification requirements. See 6.5 of this publication.

6.5 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:

a) Switching devices and other components installed in an assembly are compliant with relevant standards (e.g. BS EN IEC 60947 Series)

b) Short-circuit protective devices used in the assembly will not be subjected to short-circuit stresses beyond their capability

c) 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 and 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.

The switching devices and components having a short-circuit withstand strength and/or a breaking capacity which is insufficient to withstand the stresses likely to occur at the place of installation, shall be protected by means of current-limiting protective devices, for example fuses or circuit-breakers.

When selecting current-limiting protective devices for built-in switching devices/components, account shall be taken of the maximum permissible short-circuit values specified by the device/component manufacturer, having due regard to co-ordination.

NOTE: Guidance is given in IEC/TR 61912-1: Low-voltage switchgear and controlgear. Overcurrent protective devices - Application of short-circuit ratings.

6.6 Internal electrical circuits and connections

The manufacturer shall verify that all internal connections conform 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.

6.7 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 IEC 60445. As an example, see graphical symbol number 5019 of BS EN 60417 for a protective earth/protective ground. This symbol is not required where the external protective conductor is clearly identified with the colours Green/Yellow.

6.8 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).

6.8.1 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 60 s (+2/-0) s for verification by test.

6.8.2 Impulse withstand voltage

Verification is achieved by one of the following methods:

a) By design rules (measurement) or

b) One of three different methods of test:

i.) Impulse test

ii.) Power frequency test

iii.) DC voltage test

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

Table 4: Power frequency withstand voltage for main circuits
(As given in Table 8 of BS EN IEC 61439-1)

Rated insulation voltage U_i (line to line AC or DC) V	Dielectric test voltage AC RMS V	Dielectric test voltage DC V
$60 < U_i < 300$	1 500	2 120
$300 < U_i < 690$	1 890	2 670

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.

Table 5: Power frequency withstand voltages for auxiliary and control circuits
(As given in Table 9 of BS EN IEC 61439-1)

Rated insulation voltage U_i (line to line) V	Dielectric test voltage AC RMS V
$U_i < 12$	250
$12 < U_i < 60$	500
$60 < U_i$	In accordance with Table 4 above

6.9 Temperature rise

6.9.1 Group rated current of a circuit of an assembly

BS EN IEC 61439-1 introduces a new characteristic, group rated current of a main circuit (I_{ng}). This is defined in clause 3.8.10.6 of the standard as:

Rated current which a main circuit can carry considering the mutual thermal influences of the other circuits that are simultaneously loaded in the same section of the assembly

It is further amplified in clause 5.3.3 of the BS EN IEC 61439-1 as;

The group rated current of a main circuit is the current that can be carried by this circuit when it is loaded continuously and simultaneously together with at least one other circuit in the same assembly or section of the assembly, in a specific arrangement as defined by the original manufacturer.

This clarification in 5.3.3 clearly indicates that a group rated current can apply to individual circuits including the incoming circuit. Furthermore, for the group rated current to be applicable to the specific circuit being considered, it is the manufacturer's responsibility to determine and define the loading of adjacent circuits.

NOTE: Group rated current is equal to the product of the free air rated current of the device(s) (I_n) within the circuit and the assumed loading factor. For a detailed explanation of the different rated currents within an assembly, how they apply and can be used, see BEAMA Guide on coordination between design current of an installation and rated currents of panelboards, switchboards and motor control centers (BS EN IEC 61439-2).

This is not the same characteristic as diversity factor in respect of an assembly. Group loading factor and diversity factor are applied to the free air rated current of the device(s) within the circuit and the rated current of the circuit of the assembly (I_{nc}), respectively.

The characteristic, group rated current of a main circuit of an assembly, offers much greater flexibility in loading of assemblies than previous issues of the standard. Consequently, additional attention is required to ensure the appropriate temperature rise verification of an assembly is carried out, and that the assembly's capability is correctly defined in the manufacturer's documentation.

6.9.2 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 an 'assumed loading factor.'

An assumed loading factor is applicable to incoming and outgoing circuits. It can be applied to an individual circuit, all the circuits in a group or section or all the circuits in a complete assembly.

The loading factor is the proportion of the rated currents (I_n) of the device(s) in free air within the specific combination of incoming and outgoing circuits being considered, can carry continuously and simultaneously, without the assembly overheating.

Unless otherwise specified, the manufacturer may use the assumed loading factors given in Table 6. However, a manufacturer can determine their own loading factors. Assembly designs can be optimized by applying different loading factors or group rated current to each circuit. Further optimization is possible if the rated current of each circuit (I_{nc}) within the assembly is determined. See BEAMA Guide on coordination between design current of an installation and rated currents of panelboards, switchboards, and motor control centers (BS EN IEC 61439-2) for further details.

Table 6: Values of assumed loading
(As given in Table 101 of BS EN IEC 61439-2)

Type of load	Assumed loading factor
Distribution – 2 and 3 circuits	0.9
Distribution – 4 and 5 circuits	0.8
Distribution – 6 to 9 circuits	0.7
Distribution – 10 or more circuits	0.6
Electric actuator	0.2
Motors < 100 kW	0.8
Motors >100 kW	1.0

Temperature rise verification confirms:

a) The assembly as a whole will not overheat when all circuits (incoming and outgoing) are loaded to the rated current of the device(s) (I_n) within the circuit, multiplied by the applicable loading factor.

b) At the manufacturer's discretion, 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.

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, by comparison with a reference design, or by assessment (calculation). 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.

6.9.3 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 methods are then applied to assign ratings to other circuits that are 'thermally similar' to the critical variant tested. This allows derivation of the rating of similar variants without testing, assuming the ratings of 'critical variants' have been established by test. For example, if the rating of a 125 A Moulded Case Circuit-Breaker (MCCB) circuit is verified by test, subject to rules defined in 10.10.2.2.3 of BS EN IEC 61439-1, the rating of a circuit / functional unit comprising say 25, 40, 63, 80 and 100 A of the same comparable group / series can be assigned without testing.

Three options for test are offered in the Standard as detailed in 6.9.3.1, 6.9.3.2 and 6.9.3.3.

6.9.3.1 Verification of the complete PSC Assembly

This is a quick and conservative approach to achieving a result for a specific arrangement of assembly. During the test the incoming circuit and any loaded outgoing circuits are loaded to the rated current of the device(s) included in the circuit (I_n) multiplied by their assumed loading factor. As many adjacent outgoing circuits in a group as are necessary to distribute the incoming current are loaded to their group rated currents. Several groups of outgoing circuits may have to be tested in order ensure the highest possible temperature rise is obtained and all the different variants of functional unit are included in at least one test.

Testing in this manner requires the minimum number of temperature rise tests, but the test arrangement does not enable the rated current of each circuit within the assembly to be determined.

6.9.3.2 Verification considering individual functional units separately and the complete PSC Assembly

With this arrangement of testing and at manufacturers discretion each critical variant of outgoing circuit is tested separately to confirm its rating (I_{nc}). Then the assembly as a whole is tested with the incoming circuit loaded to its group rated current and groups of outgoing circuits, as necessary to distribute the incoming current, loaded to the rated current of the device(s) (I_n) within each circuit multiplied by the assumed loading 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 assumed loading factor in the loading of outgoing circuits. However, as in method 6.9.3.1 above, the result is only applicable to the specific arrangement of assembly tested.

6.9.3.3 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:

a) Main busbars

b) Distribution busbars

c) Functional units (if the manufacturer declares the rated current of each circuit of the assembly)

d) Complete assembly

When verifying the performance of the assembly as a whole, these tests are carried out on a representative assembly in which the incoming circuit is loaded to its group rated current and the outgoing circuits are loaded to the rated current of the device(s) (I_n) within the circuit multiplied by the assumed loading factor applicable to the circuit.

Whilst this approach requires more testing than methods 6.9.3.1 and 6.9.3.2 it has the advantage that the modular system rather than a specific arrangement of assembly is verified.

6.9.4 Assessment (Calculation)

Several methods of verifying temperature rise performance by calculation are included within the Standard. All determine the approximate air temperature rise inside the enclosure, which is caused by the power losses of all circuits, and compares this temperature with the limits for the installed equipment. The methods differ only in the way the relationship between the delivered power loss and the air temperature rise inside the enclosure is ascertained.

6.9.4.1 Verification of temperature rise

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

The power loss method of temperature rise verification set out in sub clause 10.10.4.2.1 of BS EN IEC 61439-1 is a quick and conservative approach. Essentially, the total power loss from the components and conductors within the enclosure is compared with the enclosures ability to dissipate power without the air temperature exceeding the maximum operating temperature of any device. The scope of this approach is very limited and in order that there are no difficulties with hot spots, all components are assumed to have a group rated current (I_{ng}) of 80 % of the rated current of the device(s) (I_n) in the circuit.

To use this approach the following information is required:

1. Group rated current of each circuit (I_{ng}) within the assembly
2. Rated current of each device (power and control) (I_n) in free air
3. Power dissipation of each device when operating at the group rated current of the circuit in which it is to be installed. If the power loss of the device at the rated circuit is unknown, then it can be calculated using the following equation given that the power loss is directly proportional to the square of the current (I^2)

$$P(I_{nc}) = PI_n).\left(\frac{I_{nc}}{I_n}\right)^2$$

Where

$P(I_{nc})$ = Power loss at the rated current of the circuit

$P(I_n)$ = Power loss of the device at its rated current

I_{nc} = Rated current of the circuit in the assembly

I_n = Rated current of the device in free air

NOTE: The above equation does not take account of the power loss associated with fixed current consuming devices for example the coils of contactors, lamps etc. The power loss of fixed current devices needs to be added to the above calculation to obtain the total Watts loss.

4. Maximum permissible surrounding air temperatures for each device at various operating currents.
5. Enclosure parameters.
   Power dissipation capability of the enclosure for a known internal air temperature rise or a range of air temperature rises at the top of the enclosure. The enclosure manufacture may provide ranges of air temperature rise corresponding to different power dissipations. Alternatively, if the power dissipation for the enclosure is not known it can be established by test in accordance with sub clause 10.10.4.2.2 of BS EN IEC 61439-1.
6. Confirm the external ambient temperature shall not exceed a peak of +40 °C and its average over a period of 24 h shall not exceed +35 °C.

6.9.4.1.1 a) Simple assessment

The most simplistic temperature rise verification can be performed if:

i.) all devices are suitable for use in a surrounding air temperature of 55 °C, and

ii.) the power dissipation capability of the enclosure for an air temperature rise, not exceeding 20 K, at the top of the enclosure is known

When this is the case, the temperature rise performance is verified by the following analysis:

1. Confirm that the internal conductors have a minimum cross section for 125 % of the group rated current of the associated circuit, in accordance with Annexes H and K of BS EN IEC 61439-1 for an assumed internal air temperature at the top of the assembly of 55 °C. For cables the appropriate rating for a conductor with a temperature of 70 °C can be read directly from Table H.1. Likewise, for copper bars the rating can be taken directly from Table K.1 for an assumed conductor operating temperature of 70 °C. The higher temperature option of a conductor operating at 90 °C should not be considered as the device ratings assume the lower temperature of 70 °C.
2. Confirm that all insulating materials including busbar supports are capable of operating at their anticipated maximum temperatures.
3. Calculate the power dissipation of all the main circuit conductors within the enclosure (including incoming and outgoing cables) when operating at the group rated current of the applicable circuit within the assembly. For each circuit this is achieved by adjusting the power loss per meter of conductor given in Annex H or K of BS EN IEC 61439-1, as applicable, to suit the group rated current of the circuit in which the conductor is used and then multiplying the result by the length of conductor in meters to give the power loss of the conductor within the assembly.

4. Determine the power loss capability of the enclosure, P_{enc}, for an air temperature rise at the top of the enclosure not exceeding 20 K.
5. Sum the power loss from all devices and conductors in the incoming circuit plus as many outgoing circuits as are necessary to distribute all the incoming current, all operating at their group rated current, plus the dissipation of any normally energized control circuit devices to give the total power to be dissipated within the enclosure – P_{max}.

The assembly is verified if the total power dissipation, P_{max} is less than or equal to P_{enc}.

6.9.4.1.1 b) Detailed assessment

If the criteria defined in 6.9.4.1.1 a) are not all fulfilled, or the analysis does not lead to an acceptable result, a more in-depth analysis as follows may be beneficial.

1. For the devices being considered, determine, from the manufacturers data, the lowest of the maximum permissible surrounding air temperature (T_{LM}).
2. Establish the maximum permitted air temperature rise (K_M) at the top of the enclosure. This is the lesser of
   - i.) K_{M1}, where $K_{M1} = T_{LM}$ minus 35 °C (35 °C = daily average ambient), and,
   - ii.) The highest air temperature rise within the enclosure below K_{M1} for which the power dissipation of the enclosure is known.

Confirm that the internal conductors have a minimum cross section for 125 % of the group rated current of the associated circuit, in accordance with Annexes H and K of BS EN IEC 61439-1 for an assumed internal air temperature at the top of the assembly of (35 + K_M) °C. For this, it is necessary to take the current rating for a permissible conductor temperature of 70 °C from Table H.1 and adjust it by the factor in Table H.2.

Likewise, for copper bars the rating can be taken directly from Table K.1 and adjusted by the factor k_4 given in Table N.2. On this occasion, Tables K.1 and K.2 both use the same reference temperature of 55 °C. Hence the values given in Table K.1 are simply multiplied by the factor given in Table K.2 to determine ratings for the different conditions.

The higher temperature option of a conductor operating at 90 °C should not be considered as the device ratings assume the lower temperature of 70 °C.

3. Confirm that all insulating materials including busbar supports are capable of operating at their anticipated maximum temperatures.
4. Calculate the power dissipation of all the main circuit conductors within the enclosure (including incoming and outgoing cables) when operating at the group rated current of the applicable circuit within the assembly. For each circuit this is achieved by adjusting the power loss per meter of conductor given in Annex H or K of BS EN IEC 61439-1, as applicable, to suit the rated current of the circuit in which the conductor is used and then multiplying the result by the length of conductor in meters to give the power loss of the conductor within the assembly.
5. Determine the power loss capability of the enclosure, P_{enc}, for an air temperature rise at the top of the enclosure not exceeding K_M.

6. Sum the power loss from all devices and conductors in the incoming circuit plus as many outgoing circuits as are necessary to distribute all the incoming current, all operating at their group rated current, plus the dissipation of any normally energized control circuit devices to give the total power to be dissipated within the enclosure – P_{max}.

The assembly is verified if the total power dissipation, P_{max} **is less than or equal to** P_{enc}**.**

Should the foregoing methods conclude the assembly's temperature rise performance is not verified then the more detailed approach given in sub-clause 10.10.4.3 of BS EN IEC 61439-1 should be considered, see 6.9.4.1.2. This takes into account the position of components within the enclosure and the air temperatures at different heights within the enclosure, thereby providing a more accurate representation of temperature rise performance within the assembly.

6.9.4.1.2 PSC Assembly with Single or Multiple compartments and a rated current not exceeding 1600 A.

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

Initially, internal conductor cross sections have to be determined on the basis of an assumed internal air temperature within the assembly and the Tables set out in Annexes H and K of the Standard. The internal conductors shall have a minimum cross section for 125 % of the group rated current. Once the approximate air temperatures within the assembly have been established, components may have to be changed and/or internal conductor cross sections adjusted to suit the actual air temperatures, and further iterations of the calculation carried out until all components and conductors are operating within their intended parameters.

6.9.4.1.3 PSC Assembly with natural cooling and rated current exceeding 1600 A

Verification of temperature rise for assemblies with a rated current in excess of 1600 A is permissible by a combination of test, comparison to a reference design and calculation providing the following constraints are adhered to.

a) The assembly to be verified is of the same generic design and construction and by the same manufacturer, as the reference design.

b) The assembly to be verified is of the same or lower current rating (I_{nA}) and the same or lower group rated current of the circuit (I_{ng}) as the reference design.

c) All circuits with a group rated current more than 1600 A have been verified by test or comparison to a reference design, considering their position and configuration in the assembly.

d) The power loss of all circuits rated more than 1600 A, including main and distribution busbars, within the reference design have been measured during temperature rise verification tests on the reference design.

e) The circuits in the design to be verified are of the same general type as those in the reference design, for example, the circuits being considered in the design to be verified and the reference design are both air circuit-breakers.

Assuming the foregoing requirements are met, the air temperature rise within each section of the reference design and the design to be verified can be calculated using the method given in IEC TR 60890. This calculation must include:

i.) The measured power loss values for circuits with a rated current more than 1600 A

ii.) Power loss of main and distribution busbars using the value measured during test on the reference design adjusted for the rated current in the design to be verified

iii.) The device manufacturer's declared values of power loss for other devices with a rating not less than 1600 A

iv.) The conductor and cable loss as determined in accordance with Annexes H and K of BS EN IEC 61439-1, as applicable, for circuits with a rating not exceeding 1600 A.

The assembly being considered is verified if the calculated air temperature at the mounting height of any device does not exceed that of the:

- **calculated air temperature at the corresponding height of the reference design, and**
- **the permissible ambient air temperature as declared by the device manufacturer.**

6.9.4.1.4 PSC Assembly with active cooling and rated current not exceeding 1600 A

In accordance with the Standard, the temperature rise performance of PSC Assemblies with active cooling, fans, internal air conditioning, heat exchanger, etc., can be verified by calculation. For this, all the conditions applicable for verification of an assembly with natural cooling and a rated current not exceeding 1600 A, by calculation, must be fulfilled together with the following:

1. There are no horizontal partitions in the assembly that will restrict air flow, and
2. The instructions of the cooling equipment manufacture have been fully observed in the installation of the cooling equipment within the assembly.

By calculation in accordance with the Standard the following are determined:

a) Maximum permissible air temperature rise within the enclosure.

b) Power the enclosure can dissipate without active cooling with the maximum permitted air temperature rise within the enclosure.

c) Power loss generated within the enclosure.

d) Power to be dissipated by the cooling equipment.

The assembly is verified if the cooling equipment, as declared by the cooling equipment manufacturer, can at least dissipate the necessary power to ensure the air temperature inside the assembly does not exceed the maximum permitted value.

6.9.5 Comparison with a reference design

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.

The Standard also allows for by calculation:

i.) A temperature rise determined by test for a daily average ambient temperature of 35 °C to be adjusted to determine rating for daily average ambient temperature between 20 °C and 50 °C, and

ii.) A current rating to be increased (not exceeding the *I*n of the device) or decreased for changes in temperature rise not exceeding 5 K.

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 including one from 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.

It is critical that all other verification requirements must be considered when substituting devices, including short-circuit performance as highlighted in the note in 10.10.3.5 of BS EN IEC 61439-1. Table 13 of BS EN IEC 61439-1 relates to short-circuit performance and it does not permit substitution between different makes unless the short-circuit performance is exempt from verification in accordance with 10.11.2 of BS EN IEC 61439-1.

6.10 Short-circuit withstand strength

BS EN IEC 61439-2 allows verification of short-circuit withstand strength by comparison with a reference design (using a check list or by calculation) or by test. The alternative routes to verification will reduce the requirement for repetitive testing.

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

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

b) The assembly or circuits within the assembly protected by a current limiting device which will limit the cut-off current to below 17 kA, (it may be within or upstream of the assembly)

c) 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 %,

d) Circuits protected by frequency convertors where the outputs are provided with electronic short-circuit protection that limits the cut-off current to not more than 17 kA, as declared by the manufacturer.

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.

When the exemptions from the verification of the short-circuit withstand strength are applicable, the switching devices and components must still comply with the short-circuit withstand strength design verification requirements, see 6.5 of this Guide.

6.10.1 Verification by comparison with a reference design – using a check list:

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 13 of BS EN IEC 61439-1). If any of the criteria in the table are not met, then either further calculation or a test is required for verification.

6.10.2 Verification by comparison with a reference design – using calculation

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 Annex M of BS EN IEC 61439-1. In addition, each of the circuits of the assembly to be assessed must meet basic requirements of the check list (Table 13 of BS EN IEC 61439-1). 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, I_{pk}), and critical distances.

6.10.3 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:

a) The same shape and cross-section as the phase conductors,

b) 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,

c) Spaced at a distance from the nearest phase(s) not less than that between phases,

d) 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.

6.11 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 conformity 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.)

c) In all other cases the EMC requirements are to be verified by tests in accordance with Annex J of BS EN IEC 61439-1.

NOTE: At the time of publication of this guide, BS EN IEC 61439-1 was not designated. Conformity with the EMC Regulation is afforded by conformity with the designated BS EN 61439-1.

6.12 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. This means that withdrawable circuit-breakers and similar, that have been fully verified in accordance with their own product standard and have been installed according to the manufacturer's instructions, do not require a mechanical operation verification. 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.

7. 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:

a) To ensure full conformity with the specific and any generic manufacturing instructions

b) 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

c) Carried out on every assembly or transportable unit to be put into service. It is recognized 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

d) Of a non-destructive nature having minimal effect on the service life of the equipment

e) Not intended to duplicate routine tests previously carried out on components as part of their manufacturing process

f) Not intended to be repeated on site. This does not remove the obligation 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

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

For further guidance, refer to PD IEC TR 61439-0 Low-voltage switchgear and controlgear assemblies. Guidance to specifying assemblies.

Table 7: Items subject to agreement between the PSC Assembly Manufacturer and the User (As given in Annex AA of the Standard)

Characteristics	Reference clause or subclause	Default arrangement[a]	Options listed in document[b]	User requirement[c]
ELECTRICAL SYSTEM				
Earthing system	5.6, 8.4.3.1, 8.4.3.2.3, 8.6.2, 10.5, 11.4	Manufacturer's standard, selected to suit local requirements	TT / TN-C / TN C-S / IT / TN-S	
Nominal AC voltage (V) and/or maximum DC voltage (V)	3.8.9.1, 5.2.1, 8.5.3	Local, according to installation conditions	Max 1000 V AC or 1500 V DC	
Transient overvoltages	5.2.4, 8.5.3, 9.1, Annex G	Overvoltage category II	III and IV	
Temporary overvoltages	9.1	Nominal system voltage + 1 200 V	None	
Rated frequency f_n (Hz)	3.8.12, 5.5, 8.5.3, 10.10.2.3, 10.11.5.4	According to local installation conditions	DC/50 Hz/60 Hz	
Additional on-site testing requirements: wiring, operational performance and function	11.10	Manufacturer's standard, according to application	None	

Characteristics	Reference clause or subclause	Default arrangement[a]	Options listed in document[b]	User requirement[c]
SHORT-CIRCUIT WITHSTAND CAPABILITY				
Prospective short-circuit current at supply terminals I_{cp} (kA)	3.8.7	Determined by the electrical system	None	
Prospective short-circuit current in the neutral (three phase AC circuits)	10.11.5.3.5	Max. 60 % of phase values	None	
Prospective short-circuit current in the protective circuit	10.11.5.6	Max. 60 % of phase values	None	
SCPD in the incoming functional unit requirement	9.3.2	According to local installation conditions	Yes / No	
Coordination of short-circuit protective devices including external short-circuit protective device details	9.3.4	According to local installation conditions	None	
Data associated with loads likely to contribute to the short-circuit current	9.3.2	No loads likely to make a significant contribution allowed for	None	
PROTECTION OF PERSONS AGAINST ELECTRIC SHOCK IN ACCORDANCE WITH IEC 60364-4-41				
Type of protection against electric shock – Basic protection (previously protection against direct contact)	8.4.2	Basic protection	According to local installation conditions	
Type of protection against electric shock – Fault protection (previously protection against indirect contact)	8.4.3	According to local installation conditions	Automatic disconnection of supply/electrical separation/ double or reinforced insulation	
INSTALLATION ENVIRONMENT				
Location type	3.5, 8.14, 8.2	Manufacturer's standard, according to application	Indoor / outdoor without solar radiation / outdoor with solar radiation	
Protection against ingress of solid foreign bodies and ingress of water	8.2.2	**Indoor (enclosed):** minimum IP2X, when accessible to ordinary persons minimum IP2XC **Outdoor – minimum:** IP23.	None	

Characteristics	Reference clause or subclause	Default arrangement[a]	Options listed in document[b]	User requirement[c]
INSTALLATION ENVIRONMENT				
External mechanical impact (IK code)	8.2.1, 10.2.6	Restricted access: IK07, non-restricted access: IK09	None	
Resistance to UV radiation (applies for outdoor assemblies only unless specified otherwise)	10.2.4	**Indoor:** not applicable. **Outdoor:** temperate climate	None	
Resistance to corrosion	10.2.2	Normal Indoor/ Outdoor arrangements	None	
Ambient air temperature – Lower limit	7.1.1	**Indoor:** –5 °C **Outdoor:** Normal climate –25 °C / Arctic climate –50 °C	None	
Ambient air temperature – Upper limit	7.1.1	40 °C	None	
Ambient air temperature – Daily average maximum	7.1.1, 9.2	35 °C	None	
Maximum relative humidity	7.1.1	**Indoor:** 95 % at –5°C to +30 °C 70 % at +35 °C 57 % at +40 °C **Outdoor:** 100 % at –25 °C to +27 °C 60 % at 35 °C 46 % at 40 °C	None	
Pollution degree of the macro-environment (of the installation environment)	7.1.2	**Indoor:** domestic: 2 **Indoor:** other than domestic: 3 **Outdoor:** 4	None	
Altitude	7.1.1	≤ 2000 m	None	
EMC environment (A or B)	9.4, 10.12, Annex J	A/B	A/B	

Characteristics	Reference clause or subclause	Default arrangement[a]	Options listed in document[b]	User requirement[c]
INSTALLATION ENVIRONMENT				
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	No special service conditions	Arctic climate	
INSTALLATION METHOD				
Type	3.3, 5.6	Manufacturer's standard	Various e.g. floor standing / wall mounted	
Stationary/Movable	3.5	Stationary	Stationary / movable	
Maximum overall dimensions and weight	5.6, 6.2.1	Manufacturer's standard, according to application	None	
External conductor type(s)	8.8	Cable	Cable / Busbar Trunking System	
Direction(s) of external conductors	8.8	Manufacturer's standard	None	
External conductor material	8.8	Copper	Copper / aluminium	
External line conductor, cross-sections, and terminations	8.8	As defined within the document	None	
External protective, neutral, mid-point, PEL, PEM, PEN conductors-cross-sections, and terminations	8.8	As defined within the document	None	
Special terminal identification requirements	8.8	Manufacturer's standard	None	
STORAGE AND HANDLING				
Maximum dimensions and weight of transport units	6.2.2, 10.2.5	Manufacturer's standard	None	
Methods of transport (e.g. forklift, crane)	6.2.2, 8.1.6	Manufacturer's standard	None	
Environmental conditions different from those given in 7.3	7.3	−25 °C to + 55 °C and for periods not exceeding 24 h, up to +70 °C	None	
Packing details	6.2.2	Manufacturer's standard	None	

Characteristics	Reference clause or subclause	Default arrangement[a]	Options listed in document[b]	User requirement[c]
OPERATING ARRANGEMENTS				
Access to manually operated devices	8.4	Authorised persons	None	
Location of manually operated devices	8.5.5	Easily accessible	None	
Isolation of load installation equipment items	8.4.2, 8.4.3.3, 8.4.6.2	Manufacturer's standard	Individual / groups / all	
MAINTENANCE AND UPGRADE CAPABILITIES				
Requirements related to accessibility in service by authorized persons; requirement to operate devices or change components while the assembly is energized	8.4.6.2	Basic protection	None	
Requirements related to accessibility for inspection and similar operations	8.4.6.2.2	Manufacturer's recommendations	None	
Requirements related to accessibility for maintenance in service by authorized persons	8.4.6.2.3	Manufacturer's recommendations	None	
Requirements related to accessibility for extension in service by authorized persons	8.4.6.2.4	Manufacturer's recommendations	None	
Protection against direct contact with hazardous live internal parts during maintenance or upgrade (e.g. functional units, main busbars, distribution busbars)	8.4	Manufacturer's recommendations	None	
Gangways	8.4.6.2.101	Basic protection	None	
Method of functional unit's connection *NOTE This coding system relates to the capability to remove and re- insert functional units.*	8.5.1, 8.5.2, 8.5.101		**F** fixed connections **D** disconnectable connection **W** withdrawable connections	
Form of separation	8.101	No requirement	Form 1, 2a, 2b, 3a, 3b, 4a, 4b	
IP rating of separation (protection against contact with hazardous live parts and ingress of solid foreign bodies)	8.101	IPXXB	IP2X or as agreed between the user and manufacturer	
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		None	

Characteristics	Reference clause or subclause	Default arrangement[a]	Options listed in document[b]	User requirement[c]
CURRENT CARRYING CAPACITY				
Maximum total load current supplied by the assembly (from which the rated current of the assembly I_{nA} (A) will be determined)	3.8.10.1, 5.3, 8.5.3, 8.8, 101.10.2, 10.10.3, 10.11.5, Annex E	Manufacturer's standard, according to application	None	
Design current IB and nature of load for each circuit, alternatively, In of the devices and nature of the load (in such cases, the assumed loading factors as given in Table 101 can be used.	3.8.10.8	As given in Table 6 of this guide	None	
Ratio of cross-section of the neutral conductor to line conductors: line conductors up to and including 16 mm^2 (Three phase AC circuits only)	8.6.1	100 %	None	
Ratio of cross-section of the neutral conductor to line conductors: line conductors above 16 mm^2	8.6.1	50 % (min. 16 mm^2)	None	

[a] In some cases information declared by the assembly manufacturer may take the place of an agreement.
[b] 'None' in this column means that there are no options in the Standard other than the default condition or value.
[c] For exceptionally demanding applications, the user may need to specify more stringent requirements to those **in the document.**

ANNEX A

List of current parts of the BS EN 61439 series

BS EN 61439 Series	Low-voltage switchgear and controlgear assemblies	Applicable To:
PD IEC TR 61439-0: 2022	Guidance to specifying assemblies	Users and specifiers
BS EN IEC 61439-1: 2021	General rules	Reference document for low voltage assemblies
BS EN IEC 61439-2: 2021	Power switchgear and controlgear assemblies	Switchboards, Panel boards and Motor Control Centres
BS EN 61439-3: 2012	Distribution boards intended to be operated by ordinary persons (DBO)	Consumer units and Distribution boards.
BS EN 61439-4: 2013	Particular requirements for assemblies for construction sites (ACS)	Assemblies for temporary supplies
BS EN 61439-5: 2015	Assemblies for power distribution in public networks	Feeder pillars, fuse cabinets and fuse boards
BS EN 61439-6: 2012	Busbar trunking systems (busways)	Busbar trunking
BS EN IEC 61439-7:2020	Assemblies for specific locations at public sites such as marinas, camping sites, market squares and similar and for charging station for Electrical Vehicles	Assemblies in public locations

* Informative IEC publication that is not a standard.

ANNEX B

Photovoltaic Assemblies (PVAs)

BS EN IEC 61439-2 includes an informative Annex DD giving guidance on the requirements for Assemblies for photovoltaic applications. The design verification for these is the same as PSC assemblies, plus additional verifications to reflect the needs of this particular application.

The additional design verifications include:

1) For outdoor assemblies subject to direct sunlight should be temperature rise tested with simulated solar irradiance

2) Indoor and outdoor PVAs should be subject to a thermal cycling test

3) Indoor and outdoor PVAs should be subject to a climatic test

The procedures for conducting these additional verifications and the acceptance criteria are given in the Standard.

ANNEX C

Simplified design verification without a reference design and with minimal testing

Small relatively low power assemblies can be design verified without expensive type tests when the following criteria are fulfilled.

No.	Characteristic to be verified			Clauses or subclauses	Verification method
1	Strength of material and parts:	Resistance to corrosion		10.2.2	Use an enclosure in accordance with IEC 62208
		Properties of insulating materials:	Thermal stability	10.2.3.1	Only applicable to enclosures made of insulating material Use an enclosure in accordance with IEC 62208
			Resistance to abnormal heat and fire due to internal electric effects	10.2.3.2	Use insulating materials with an appropriate glow wire rating as determined by the material manufacturer
		Resistance to ultra-violet (UV) radiation		10.2.4	Only applicable to outdoor assembly enclosures Use an enclosure in accordance with IEC 62208
		Lifting		10.2.5	No verification required for assemblies intended to be lifted by manual means.
		Marking		10.2.7	Use engraved labels
		Mechanical operation		10.2.8	Incorporate only devices that have been tested in accordance with their own product standard
2	Degree of protection of enclosures			10.3	Use an enclosure in accordance with IEC 62208 plus visual inspection
3	Clearances			10.4	Measurement
4	Creepage distances			10.4	Measurement

No.	Characteristic to be verified		Clauses or subclauses	Verification method
5	Protection against electric shock and integrity of protective circuits:	Effective continuity between the exposed conductive parts of the assembly and the protective circuit	10.5.2	Resistance measurement
		Short-circuit withstand strength of the protective circuit	10.5.3	Test not required for assemblies connected to a supply with a prospective short-circuit current not exceeding 10 kA RMS or 17 kA cut-off.
6	Incorporation of switching devices and components		10.6	Device manufacturer's instructions plus inspection
7	Internal electrical circuits and connections		10.7	Inspection
8	Terminals for external conductors		10.8	Inspection
9	Dielectric properties:	Power-frequency withstand voltage	10.9.2	Dielectric test
		Impulse withstand voltage	10.9.3	Measurement
10	Temperature-rise limits		10.10	Calculation for assemblies with a rating not exceeding 1600 A
11	Short-circuit withstand strength		10.11	Test not required for assemblies connected to a supply with a prospective short-circuit current not exceeding 10 kA RMS or 17 kA cut-off
12	Electromagnetic compatibility (EMC)		10.12	Use EMC certified components, component manufacturer instruction and good practice

Holding records of the above design verifications in a technical file is essential for conformity with the Standard and to support UKCA/CE marking.

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