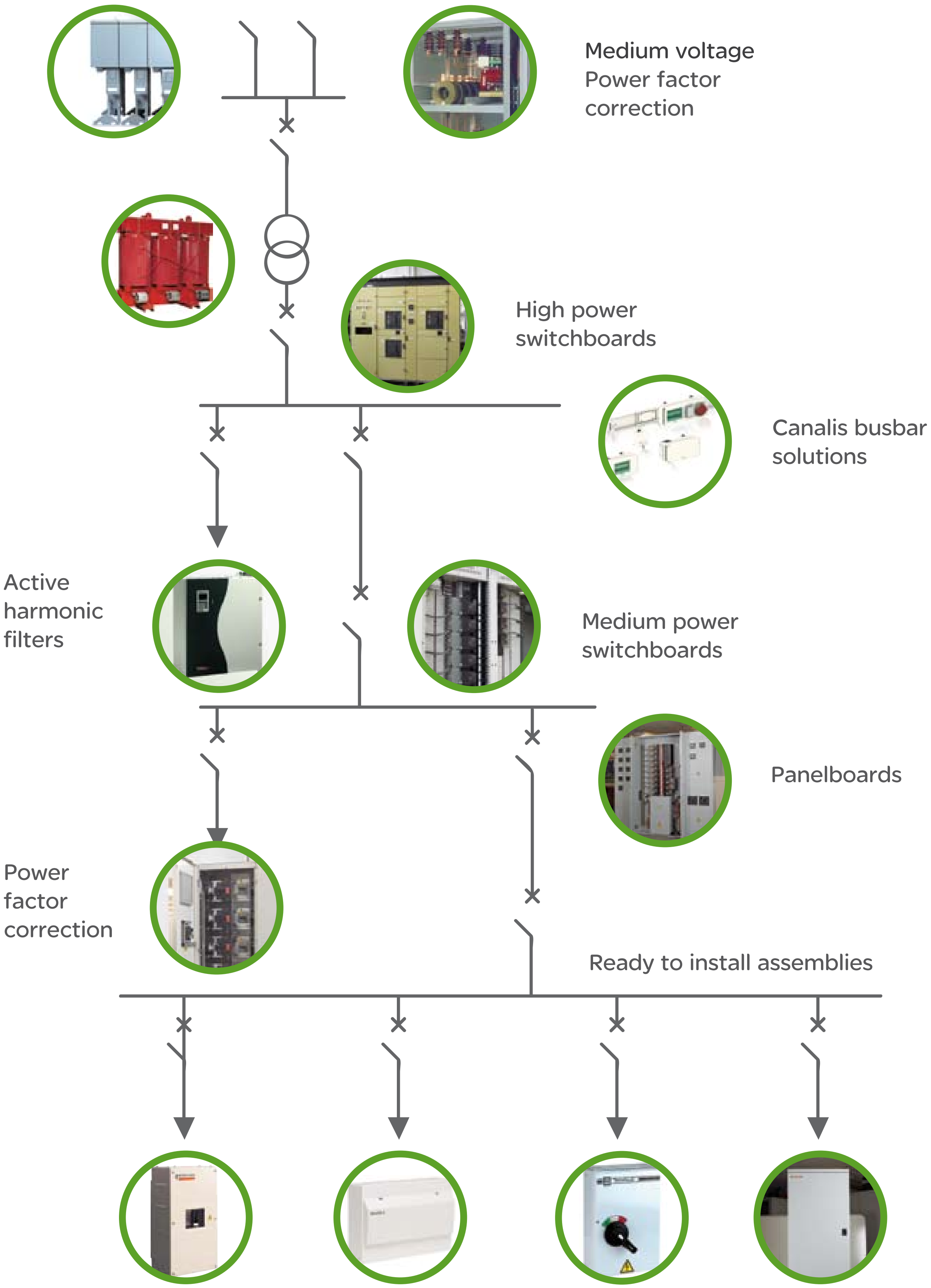
Improving safety and performance in electrical assemblies

A guide to IEC 61439-2

Schneider Electric

Contents

Typical schematic diagram



Introduction

Since it was first published over 35 years ago, IEC 60439 has provided the basis for specification and testing of low-voltage electrical assemblies. As was the case for many early IEC standards, it was a compromise between different national approaches, some of which were very stringent, even prescriptive, and others that were more subjective.

Where consensus could not be achieved, the subject was ignored, or some vague clause was added that could be interpreted to suit the reader's point of view.

These weak foundations have made it difficult to evolve the standard in line with market needs and pressures. Every assembly manufactured should meet minimum performance and safety criteria, in spite of ever increasing demands to optimise manufacture and reduce costs.

Application needs, however, make it impractical to type test every variant that is provided. Some frequently used design concepts, such as modular systems, are not adequately covered. Furthermore, many assemblies produced do not fit neatly into the Type Tested Assembly (TTA) or Partially Type Tested Assembly (PTTA) categories.

Some smaller assemblies may not be covered by either TTA or PTTA and are therefore effectively outside the scope of IEC 60439. In the case of a PTTA, the standards' requirements for proving a design are very subjective and entirely dependent on the knowledge and integrity of the particular manufacturer.

Schneider Electric, along with other leading UK assembly manufacturers, long recognised the limitations of IEC 60349. Some 10 years ago the company proposed, via the Manufacturers' Associations and British Standards, that the IEC carry out a radical review of the IEC 60349 series of standards.

It also suggested, if practical, that the IEC restructure and improve the series of standards to reflect the present and future applications and requirements for assemblies.

A fundamental review has questioned every aspect of IEC 60439 and has been a long and tortuous task. Despite there having been an International standard for many years and, although major manufacturers have attempted to promote international designs of assemblies, views differ markedly around the world about basic performance and requirements.

Achieving consensus has once again been very difficult. However, the first parts of the new series of standards have been published. The approach to specifying an assembly, proving its capability, and the format of the standard itself, have all fundamentally changed.

In due coarse, the two parts of the series that have been published by IEC will be issued as EN Standards and then subsequently automatically as British Standards. The EN Standards will be identical to the IEC Standards. The only difference in the British Standard is that it is expected to contain additional detail on forms of separation. These are given in annex NA of BS EN 60439-1 and will be transferred to the new series, again as an informative annex.

Users, purchasers, builders and specifiers of assemblies will need to familiarise themselves with the new approach. This guide provides an easy transition from the old to the new standards, identifying the fundamental changes and the parameters that need to be defined in an assembly specification.

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New series

The new series of low-voltage assembly standards will be numbered IEC 61439, a single digit change that belies fundamental changes in the structure and format of the standards.

Historically IEC 60439-1 has been a complete standard that defined the requirements of assemblies not otherwise covered by product-specific assembly standards. In addition, IEC 60439-1 was a reference for the product-specific assembly standards, IEC 60439 Part 2 to 5 inclusive, with all the requirements of IEC 60439-1 applying to the product-specific parts, unless specifically excluded.

This approach to the structure of a series of standards leads to difficulties when standards are revised. A change to IEC 60439-1 can inadvertently impose changes on specific products unless their part of the series of standards is revised at the same time.

The IEC 61439 series of standards will use the same structure as other series within IEC. Part 1 is General Rules, detailing requirements that are common to two or more generic types of assembly. Each generic type of assembly then has a product-specific Part within the series of standards.

This then references applicable clauses within the General Rules and details any specific requirements pertaining to the particular generic type of assembly. Any clause in the General Rules that is not called up in the product-specific Part does not apply. Part 2 of IEC 6149 is the only Part that has a dual role, it covers power switchgear and control gear assemblies and any assembly not covered by any other product specific Part.

This structure will make revision easier, as changes to General Rules will tend to lag their introduction in product-specific Parts. It also means that assemblies cannot be specified or manufactured to IEC 61439-1, one of the product-specific Parts must be referenced in any assembly specification.

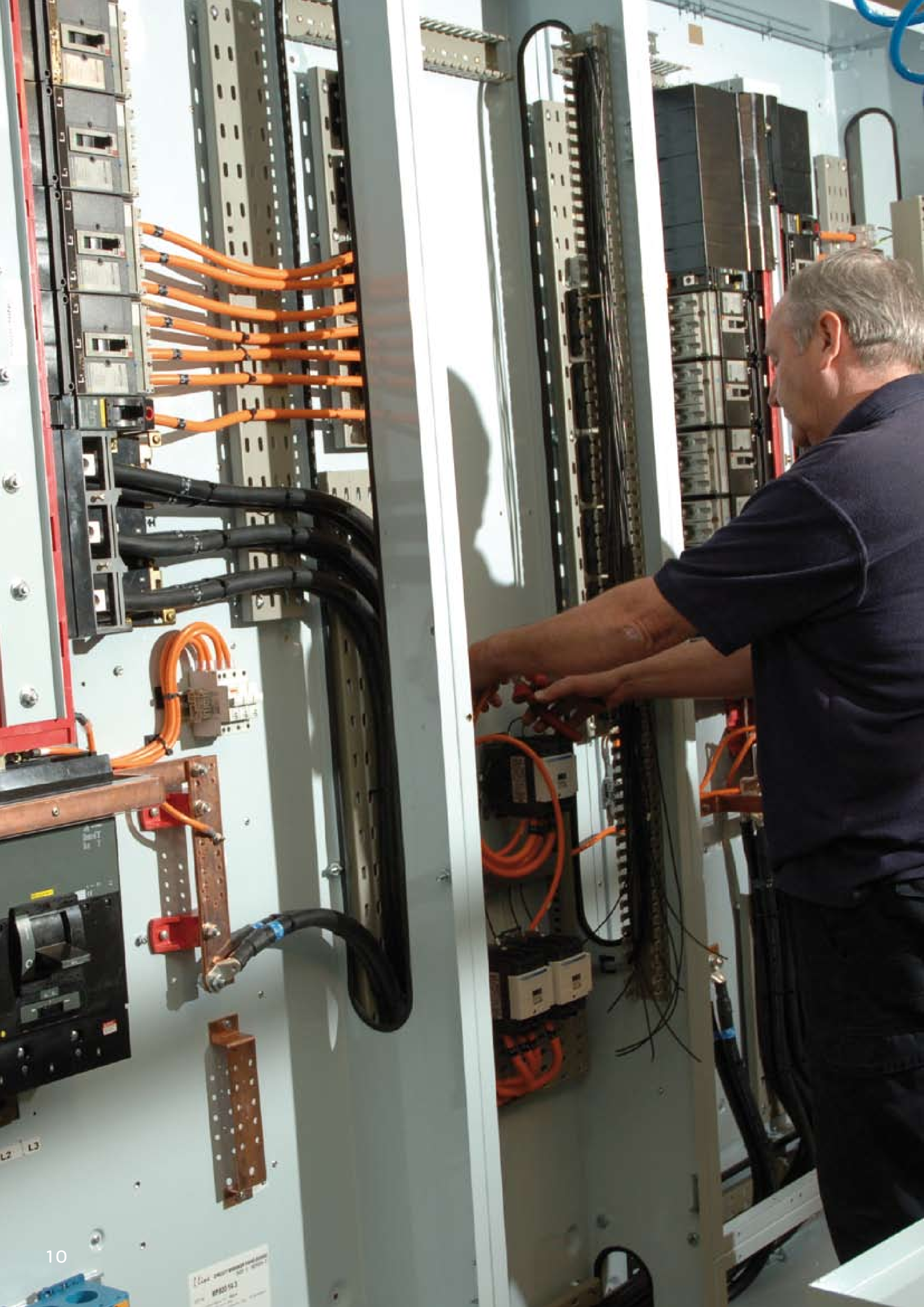
In order to demonstrate how the new series will work and to prove the approach, Parts 1 and 2 of the IEC 61439 series were the first to be developed. Now that they have been published, all other Parts to replace product-specific Parts in the IEC 60439 series, as shown in Table 1, are being prepared by IEC. These four additional Parts will not necessarily be the full extent of the new series.

The series has been set up to enable further parts to be added to cover new and specific product needs, as and when they are identified.

New Standard	Title	Previous Standard
IEC 61439-1	General rules	IEC 60439-1
IEC 61439-2	Power switchgear and controlgear assemblies	IEC 60439-1
IEC 61439-3*	Distribution boards	IEC 60439-3
IEC 61439-4*	Assemblies for construction sites	IEC 60439-4
IEC 61439-5*	Assemblies for power distribution in public networks	IEC 60439-5
IEC 61439-6*	Busbar trunking systems	IEC 60439-2

Table 1:

Anticipated standards for Low-voltage switchgear and control gear assemblies
(* title may change when standard is published)



Recognition

Assemblies are very multifaceted. They consist of a number of components closely connected together in an almost infinite number of possible combinations.

Interactions between the various elements of an assembly, thermal, magnetic, etc., all affect the performance of individual circuits and the assembly as a whole. This is a very different scenario from that presented by an individual component, such as a circuit breaker. The performance of a component is usually well defined in its product standard, but it assumes operation alone and under specific operating conditions, thus making it feasible to readily prove the components capability by type test.

With assemblies, the permutations and configurations are effectively limitless. Fully type testing every manufactured variant within a modular system and each bespoke assembly or part of an assembly is simply not practical. Costs and time preclude this.

While IEC has recognised this fundamental issue, it is equally clear that there must be a way of ensuring all assemblies meet defined performance and safety criteria. Accepting that the design of some assemblies is only 'partially' proven, or perhaps only routine tested, is no longer an option.

New approach

Market trends and requirements for assemblies may evolve, but they will not suddenly change. Assemblies will continue to be manufactured in a wide range of volumes from one-off bespoke arrangements, through adapted standards, to mass-produced units with defined options.

The pressure on operators of electrical distribution networks to improve the utilisation of their assets will continue. Manufacturers are also continuously optimising their designs. Taking all of this into account, together with the need to ensure increasingly demanding safety requirements are met, it is clear that the approach to specifying and demonstrating the capability of assemblies is out-dated and must change radically.

After much debate and deliberation, IEC has taken a practical and pragmatic approach to proving the capability of assemblies. The capability of each assembly will be verified, effectively in two stages: (i) design verification, to prove the design performance of the assembly is in accordance with IEC 61439; and, (ii) routine verification, to confirm the materials and workmanship are in accordance with the design specification. The latter verification is more defined, but otherwise, the requirements are generally as the routine test requirements in the previous standard.

Design verification, however, uses a radical new approach. Where volumes justify it, type testing will remain the preferred option for design verification, since it can, and does, lead to material and labour optimization. When adaptations or bespoke arrangements are required, the standard offers other equivalent routes to design verification.

These include comparison to a verified reference design, calculation, and interpolation from a verified design, measurement, etc. The 'multiple option' route to verification is strictly controlled. When, where and how each is used is defined. While it is possible to build a small assembly, of the order of 200A, with the only type tests being an earth continuity measurement and a dielectric test, the standard effectively limits the design verification of assemblies of the higher ratings to type test.

When design verification, other than by type test is used, the standard insists on margins being added to the design, for example; (i) 50% added to clearance if an impulse test is not carried out, (ii) components are de-rated by 20% when the assembly is not temperature tested.

These design margins ensure the alternatives to type testing provide a minimum level of performance in accordance with the standard. Inevitably adding margins has an adverse effect on the physical size of the assembly, the quantity of materials used and if it is an application where a standard design could have been used, commercial implications.

Fundamental changes

In order to meet its objectives, the review of the IEC 60439 series of standards had to make changes and indeed, it has made radical changes. A number of the foundations of the old standard have been discarded in order to have a standard that better meets the low-voltage assembly market's needs and the way it operates.

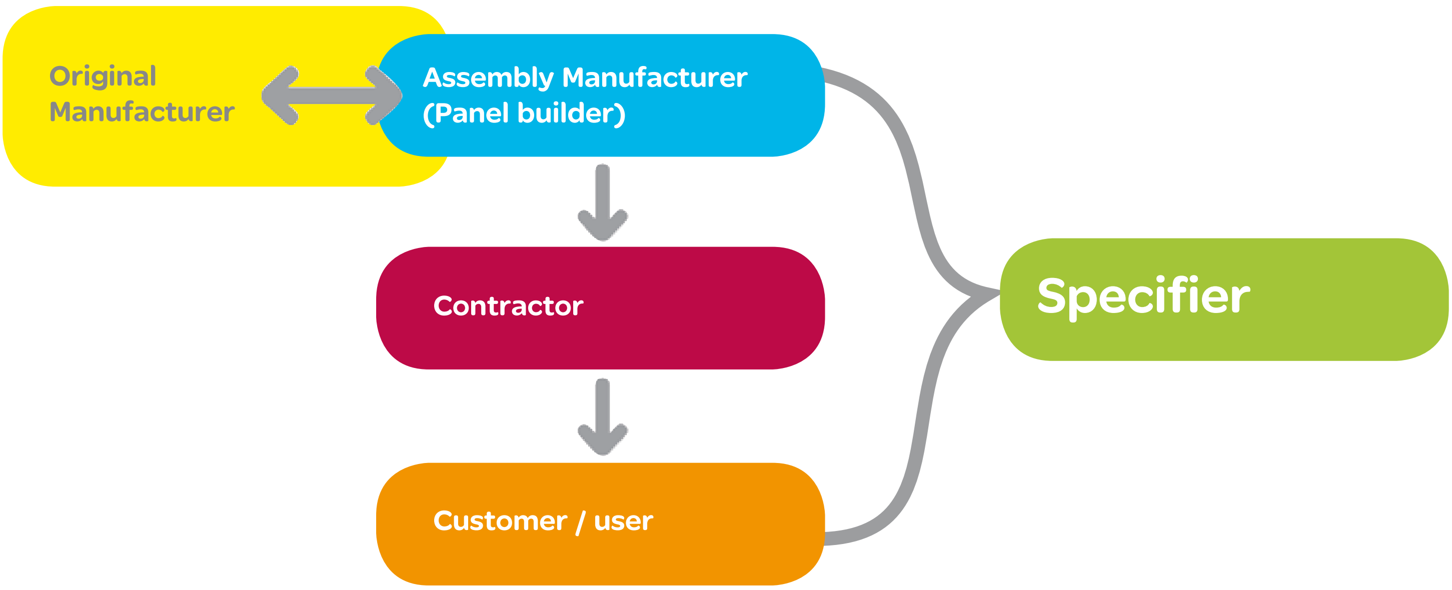
In some instances, the changes are so fundamental that it may take users some time to adjust to the new order and the benefits it brings. The categories of TTA and PTTA have been discarded in favour of a design 'verified assembly'. This is a classless designation where demonstration of design capability can be achieved by type test and/or by other equivalent means that include appropriate margins.

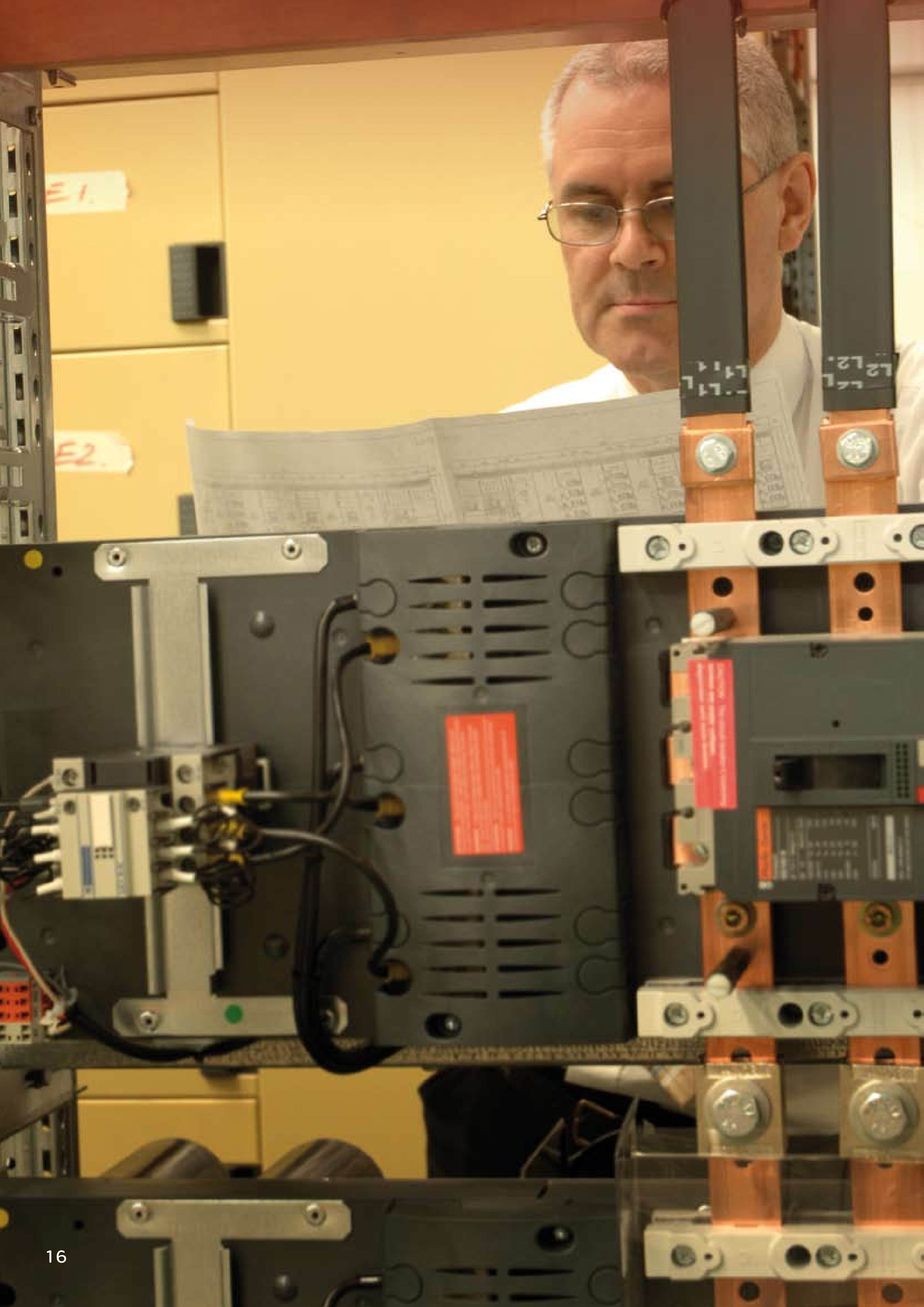
As business becomes more global there is a need for portable designs. This is fully recognised within the new series of assembly standards. The standard confirms that, contrary to the previous views of some parties, designs and design verification are portable. For example, subject to a suitable quality assurance regime being in place, a type test certificate obtained in France, for a design carried out in the UK, is valid for an assembly manufactured in Australia.

For the first time the standard recognises that more than one party may be involved between concept and delivery of an assembly. The standard identifies the original manufacturer as the one responsible for the basic design and its verification and possibly, the supply of a kit of parts. It then designates the manufacturer who completes the assembly and conducts the routine tests as the assembly manufacturer.

The original and assembly manufacturer can be the same, or, a transition may take place somewhere between concept and delivery, for some or all of the assembly. In any event, all parts of the assemblies must be design and routine verified by a manufacturer. See figure 1 for a typical assembly supply chain.

Figure 1: Typical supply chain for a low-voltage assembly





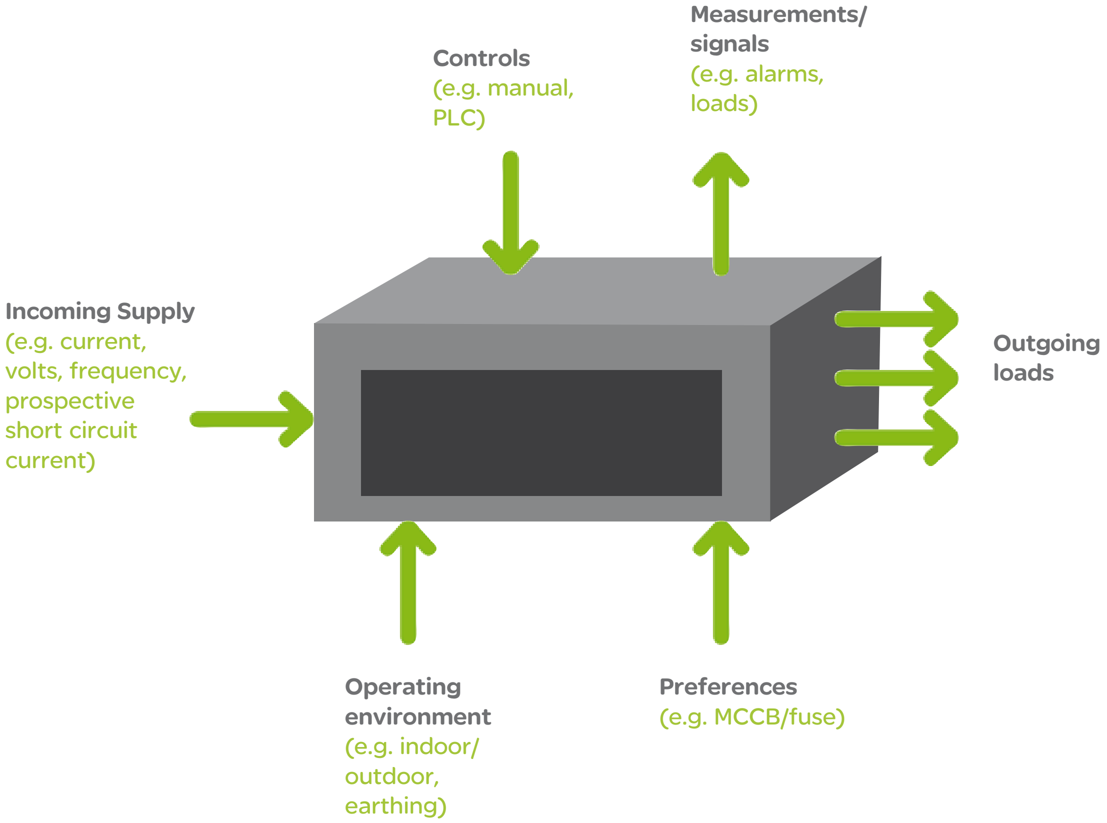
Responsibilities

The new standard, so far as any standard is able to do so, attempts to focus all parties involved in the provision of a low-voltage assembly on their respective responsibilities. Purchasers and specifiers are encouraged to view an assembly as a 'black box'.

Their prime function is to specify the inputs and outputs to the assembly and to define the interfaces between the assembly and the outside world. See figure 2.

How the assembly is configured internally and the performance of the assembly, relative to the external parameters as defined by the purchaser or specifier, is clearly the responsibility of the manufacturer(s). They are responsible for the correct incorporation of the individual components and must ensure the design meets the specification, is fully verified and it is fit for purpose. The manufacturer, or combination of manufacturers (original manufacturer and assembly manufacturer), is/are regarded as the expert and they must have sufficient knowledge of assemblies to satisfy this role.

Figure 2: Responsibilities



Design verification

Design verification is a prerequisite for all assemblies provided. It is fundamental to ensuring every assembly meets its defined design requirements. There is flexibility in the way in which this is achieved within the new standard, and some new concepts have been introduced, but the options are defined and where necessary their use is restricted and a design margin applied.

Examples of the limitations and margins applied to verification without type test include;

- All assemblies connected to a supply with a prospective short circuit current in excess of 10kA rms or having a cut-off current of 17kA peak must be of a type-tested design or the verification must be an interpolation from a reference design. Under no circumstances can the assigned short circuit current rating be higher than that of the reference design.
- So as to take account of the air temperature within the enclosure, thermal interactions and possible hot spots; components within a circuit that has not been temperature rise tested, must be de-rated to 80% of their free air current rating.
- Comparison of the power loss of the components within an assembly with the known heat dissipation capability of an enclosure, is restricted to assemblies having a rating of 630A.
- Confirmation of temperature rise performance by calculation is limited to assemblies with a rating not exceeding 1600A. Test or interpolation from a tested design must be used to verify higher ratings.

A modular assembly can be temperature rise verified, without the need to test every permutation.

New concepts in verification

In addition to the fundamental change from type testing (or perhaps turning a blind eye in the case of PTTAs) to design verification, a number of new approaches to proving design capability of assemblies have been recognised and included in the standard. In summary these are:

- **Modular systems** – a means of ensuring all anticipated arrangements within a modular assembly can be temperature rise verified, without the need to test every possible permutation.

- **Critical variants** – the testing of the most onerous arrangement, as determined by criteria given in the standard, and then assigning ratings to lower rated arrangements within defined rules. As an example, if the section of a temperature rise tested busbar halved, then the current rating of the busbar is also halved, assuming all other conditions remain the same.

- **Comparison to a reference design** – using a prescribed checklist to ensure that design is at least equivalent in all respects to a previously verified design.

- **Simplified verification** – options within the standard enable low rating assemblies; where the prospective short circuit current of the incoming supply is less than 10kA rms/17kA cut off, and a type tested enclosure is used, allow the assembly to be design verified without a type test, other than the carrying out of a power frequency dielectric test and an earth continuity measurement.

Additional verification

IEC 60439-1 was deficient in a number of respects.

A number of these issues have been addressed and in line with good standards' practise, for each new performance measure, a new verification has been introduced.

These include:

- Two levels of verification of corrosion resistance; one for internal/indoor parts and a second, more onerous requirement for outdoor parts.

- Verification of resistance to UV radiation for outdoor plastic enclosures.

- Confirmation that the assembly, via its lifting points, is capable of being lifted without danger or damage.

- Mandatory declaration and confirmation of an impulse rating.

- The use of an insulation resistance measurement as the only means of confirming dielectric performance is no longer permitted. All assemblies must be design verified by means of a power frequency dielectric test.

- Labels that are not engraved or similar must be subject to a test to confirm their legibility and durability.


NEUTRAL
DANGER

Ambiguities clarified

As part of the review of the IEC 60439 series of standards a number of hitherto imprecise requirements have been clarified. Previously a manufacturer had to assign a current rating to each circuit, but they were never required by the standard to prove its rating.

This has been rectified and manufacturers, in accordance with the new standard, have to verify the rating of each type of circuit. All the previous concerns about the rating of a device once it has been installed in an assembly are overcome.

In the old standard, diversity was ill defined. The definition allowed, subject to the maximum rating of the incoming circuit: a maximum number of circuits to be loaded to their rated current multiplied by the diversity factor; or, a smaller number of adjacent circuits to be loaded to their rated current; or any loading arrangement between the two extremes. Clearly these extremes led to very different temperatures and performance and so this lack of clarity has been addressed.

Each type of circuit will have its rating verified within the assembly and the capability of the assembly as a whole will be proven by loading adjacent outgoing circuits to their rated current, multiplied by the diversity factor.

Historically it has been assumed that if nothing was said, the neutral could have a current rating equal to 50% of that of its associated phase. However, because this has not been stipulated in any low-voltage standards for many years, any query could only be answered by it's custom and practise'. IEC 61439 includes a default current rating in accordance with custom and practise for circuits with conductors above 16mm^2, but a specifier can ask for a higher rating to suit the needs of his application.

In addition the ongoing question in respect of forms of separation has been answered. A device's integral enclosure, for example the case of a moulded case circuit breaker, is defined as a means of providing separation from an adjacent circuit.

Specific issue addressed

The substitution of a device within a type tested assembly without re-testing has always been a contentious issue. Apart from the physical issues, all the design criteria within the standard must be considered if, after substitution, safety is to be assured. In particular, there are serious difficulties and concerns in respect of temperature rise and short circuit performance.

It is not sufficient to assume that, because the two devices comply with the same standard, they can be exchanged in respect of temperature rise. The device used in the assembly verification may operate well below the temperature limits in its product standard, while the alternative may approach the limit. Replacing the cool running device with the alternative one may potentially lead to problems in the assembly.

To overcome this dilemma, IEC 61439 has determined in respect of temperature rise, that devices can only be substituted without repeating the design verification if the alternative device has: (i) a power loss equal to or less than the original device; and (ii) the temperature rise of the alternative device's terminals is less than or equal to that of the original device, when both are tested in accordance with the same product standard.

When considering short circuit performance the difficulties are even more acute. The interrupting characteristic and performance of switching devices differ markedly between types and makes. Even if the energy let through and the cut off current of two devices is the same, the extent and direction of the emissions may vary. Some devices emit gases at the top only, some emit top and bottom, some restrict the emissions with mechanical filters, while others don't.

Clearly when considering short circuit performance it is not a simple matter of comparing values from catalogues. Much more detailed knowledge of both the original and alternative device is required.

For the time being, IEC has concluded that in respect of short circuit performance, substitution can only be carried out without new verification if: (i) the original and alternative devices are from the same manufacturer; and (ii) that the device manufacturer is prepared to certify that in all relevant respects the alternative device is equal to or better than the original device.
This enables Schneider Electric, for example, to confirm that its NSX circuit breaker can be substituted for its NS model without an assembly builder having to repeat their design verifications. However, exchanging between different makes of device is precluded.

Specifying an assembly

Assemblies are complicated and so is the standard that defines their performance. As the standard defines all the needs and performance requirements of an assembly as a whole, and without any consideration of any particular stakeholder's perspective, it is difficult for a reader to identify the parts that are interest to them. To assist specifiers of assemblies, an annex has been included in IEC 61439-2. This identifies the parameters that should be specified; the default values that will be assumed in the absence of any other information; and information that must be given in order to obtain the correct assembly for the particular application.

Much of the specifiers' guide in the annex is self explanatory.

However the guidance notes in Table 2 may avoid the need to delve into the standard too deeply.

Summary and conclusion

With the ever-increasing pressures of demand for higher network utilisation, assembly design optimisation and more stringent safety, the changes included in the assembly standard IEC 61439-2 are important and overdue. All assemblies that do not have a specific product standard are covered and there is no opportunity to avoid compliance.

In the new standard, the methods of confirming design performance are practical and pragmatic, reflecting the different market needs and ways in which assemblies are produced. Several alternative and equivalent means of verifying a particular characteristic of an assembly are included. These are defined and their use restricted. Where alternatives to type tests are used, a compensatory approach is taken and margins are added to ensure equivalence. Overall, the standard is performance based, but in some instances where design rules are used, it has to be proscriptive.

In due course IEC 61439-2 will become a European and therefore a British Standard. In the process of this the European Standards should be listed in the Official Journal of the European Union. Meeting this standard in full will then be the simplest route to a 'presumption of compliance' with the EMC Directive and the Low-voltage Directive, compliance with both is, for the majority of applications, essential in order to apply the CE mark to a low-voltage assembly.

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Technical specification

Guidance on producing an assembly specification

User defined functions & characteristics	Standard arrangement	Guidance notes
Electrical system		
Earthing system should be identified, e.g.	**	The type of earthing system used in the electrical distribution network should be identified, e.g. TT, TN, TN-C, IT, TNS. If there is a requirement to earth the neutral within the assembly, this should be stated within the assembly specification.
Rated voltage Un (Volts)	**	State the nominal voltage of the electrical distribution system, e.g. 400V.
Over voltage category	**	Electrical systems are subject to over voltages from time to time. Generally these are reduced at the lower levels of distribution. The standard defines categories I, II, III and IV, as determined by the position within the network. Assuming a system diagram is provided with the enquiry, the manufacturer will determine the likely over voltage category. Should the specifier anticipate exceptionally high over voltage they should provide details accordingly in their specification.
Unusual voltage transients, voltage stresses, temporary over volt ages	No	All electrical networks suffer from modest transient over voltages due to switching etc. If a specifier believes their network is subject to exceptionally high transients they should define the performance required in their specification.
Rated frequency fn (Hz)	**	State the nominal frequency of electrical distribution system.
Additional on site testing requirements: Wiring, operational performance and function.	**	IEC 61439-2 indicates that routine verifications do not need to be be repeated on site. If the particular application requires that they are repeated this should be detailed in the user's specification.
Short circuit withstand capability		
Prospective short circuit current at supply terminals Icp (kA)	**	The prospective short circuit current at the incoming terminals of the assembly should be specified. This will normally be defined in terms of an rms prospective short circuit current and duration, or, where there is current limiting protection upstream, cutoff current as limited by the upstream device.
Prospective short circuit current in the neutral	60% of phase values	IEC 61439-2 assumes that, for most installations, the impedance in the neutral circuit will limit the short circuit fault current in the neutral to 60% of the three-phase fault current. If the assembly is very closely coupled to the supply transformer this may not be the case. Where the prospective short circuit current in the neutral is higher than normal, specifier's should detail their requirements in the assembly specification.
Prospective short circuit current in the protective circuit	60% of phase values	As for prospective short circuit current in the neutral.
SCPD in the incoming functional unit	**	A manufacturer may provide a current limiting device as the incoming circuit to the assembly. This often reduces the short circuit requirement for the remainder of the assembly. If this is not acceptable to a user they should advise accordingly in their specification.

User defined functions & characteristics	Standard arrangement	Guidance notes
Co-ordination of short-circuit protective devices including external short-circuit protective device details.	**	Any specific co-ordination requirements within the assembly and with up or down stream devices should be detailed in the assembly specification.
Data associated with loads likely to contribute to the short-circuit current.	**	The specifier should include in their specification details of any large loads, e.g. motors, which may, in the event of a fault, add to the short circuit current from the supply. The manufacturer will then take this into account in the design of the assembly.
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).	Basic protection	Basic protection is protection against electric shock due to direct contact with live parts (within the assembly). Assuming enclosed switchgear is being considered, the minimum requirement for basic protection of IP XXB is usually provided by the enclosure, when the assembly is in normal service (all covers in place and doors closed). Where a specifier wishes further protection, for example, access to internal parts of the assembly whilst other parts remain in service, they should detail their particular requirements in the assembly specification.
Type of protection against electric shock - Fault protection (protection against indirect contact)	**	Fault protection is protection against the consequences of a fault within an assembly, or a fault in a circuit that is supplied from the assembly. Generally this is achieved by means of suitable earth conductors and bonding. However, if a specifier wishes to use alternative means, e.g. protection by total insulation they should detail their preferences in their specification.
Installation environment		
Location type	**	Specify whether the assembly is to be suitable for installation in an indoor or outdoor location.
Protection against ingress of solid foreign bodies and ingress of liquid	Outdoor: IP X3 Indoor **	For enclosed assemblies the IEC standard assumes a minimum level of protection of IP2X – no protection against dripping water. For outdoor applications without supplementary protection the minimum requirement is IPX3. In the absence of any other details the manufacturer will provide the minimum level of protection necessary to protect the equipment within the assembly, noting that this will not be less than that specified in the standard.
External mechanical impact (IK)	**	Resistance to mechanical impact is not normally specified within the UK. Where it is a requirement it should be defined by an IK code in accordance with IEC 62262.
Resistance to UV radiation (applies for outdoor assemblies only unless specified otherwise)	Standard	The resistance to UV radiation for plastic enclosure, as defined in IEC 61439-2, is generally adequate for temperate climates. Where more onerous conditions are anticipated, the means of protection should be agreed between the user and manufacturer.
Resistance to corrosion	Standard	The standard details corrosion resistance that provides an adequate level of protection for assemblies in a normal environment. Where exception conditions are expected, for example, outdoor shoreline, the corrosion protection measure should be agreed between the user and manufacturer.

User defined functions & characteristics	Standard arrangement	Guidance notes
Ambient air temperature – lower limit	Indoor: -5 °C Outdoor: -25 °C	Self-explanatory, where the conditions detailed are exceeded, the installation conditions should be included in the project specification.
Ambient air temperature – upper limit	40 °C	
Ambient air temperature – daily average maximum	35 °C	
Maximum relative humidity	Indoor: 50% @ 40 °C Outdoor: 100% @ 25 °C	
Pollution degree	Industrial: 3	IEC 61439-2 details four degrees of pollution 1. No pollution or only dry, non-conductive pollution occurs. The pollution has no influence. 2. Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected. 3. Conductive pollution occurs or dry, non-conductive pollution occurs which is expected to become conductive due to condensation. 4. Continuous conductivity occurs due to conductive dust, rain or other wet conditions. For industrial applications Polluting degree 3 is the default condition. Where a different level of pollution is anticipated, appropriate details should be given in the assembly specification.
Altitude	≤ 2000 m	The specifier should advise when the assembly is to be located above 2000m.
EMC environment	**	Assemblies can emit and the must be immune to external electromagnetic disturbances. IEC defines two categories a) Environment A - relates to low-voltage non-public or industrial networks / locations / installations including highly disturbing sources. b) Environment B - relates to low-voltage public networks such as domestic commercial and light industrial locations / installations. This environment does not cover highly disturbing sources such as arc welders. The specifier should detail a requirement for either Environment A or B. In exceptional applications, for example, some rail applications, it is necessary to specify a higher level of immunity.
Special service conditions	**	The standard details examples of special service conditions as; vibration, exceptional condensation, heavy pollution, corrosive environment, strong electric or magnetic fields, fungus, small creatures, explosion hazards, heavy vibration and shocks, earthquakes. Any such exceptional service conditions should be identified and detailed in the assemby specification.

User defined functions & characteristics	Standard arrangement	Guidance notes
Installation method		
Type	**	The standard identifies several generic types of assembly including; open-type, dead-front, enclosed, cubicle-type, multi-cubicle-type, desk-type, box-type, multi-box-type, wall-mounted surface type, wall-mounted recessed type. Specifiers should detail any particular preference they have for the general construction of the assembly in accordance with these recognised arrangements.
Portability	**	The majority of assemblies are stationary, however, the user should ake clear whether the assembly is to be stationary or in some way portable.
Maximum overall dimensions and and weight	**	If there are space or weight restrictions for the assembly these should be detailed in the specification.
External conductor type(s)	**	The specifier should detail conductor types, e.g. cable or busbar.
Direction(s) of external conductors	**	In order to ensure the external conductors can be accommodated the specifier should detail the direction they approach the assembly; bottom, top, left hand side, right hand side, etc.
External conductor material	**	Unless advised otherwise the manufacturer will assume copper conductor cables are to be terminated in the incoming and outgoing circuits.
External phase conductor, cross sections, and terminations	Standard	To avoid difficulties on site specifiers should detail the cable construction , e.g. 4 core, XLPE insulated, steel wire armoured, the size of the cable and any preference for terminating the cores – crimp lugs, mechanical connectors, etc
External PE, N, PEN conductors cross sections, and terminations	Standard	Specifiers should detail the size of each neutral, earth and combined neutral earth cable to be terminated. Without this the manufacturer will assume these conductor are: – equal to half the current-carrying capacity of the phase conductor, with a minimum of 16 mm^2, if the size of the phase conductor exceeds 16 mm^2; – equal to the full current-carrying capacity of the phase conductor, if the size of the latter is less than or equal to 16 mm^2.
Special terminal identification requirements	**	The manufacturer will use his standard terminal marking unless particular requirements for marking are identified in the assemby specification.
Storage and handling		
Maximum dimensions and weight of transport units	**	Specifiers should include in their specification any restrictions/ limitations for transport units.
Methods of transport (e.g. forklift, crane)	**	Any particular requirements in respect of transport and lifting should be included in the assemby specification.

User defined functions & characteristics	Standard arrangement	Guidance notes
Environmental conditions different from the service conditions	**	The specifier should provide details of storage conditions if these are different from the normal service conditions, e.g. advise if indoor equipment may be stored outdoors for a short while.
Packing details	**	Any specific packing requirements should be identified in the specification.
Operating arrangements		
Access to manually operated devices	**	Unless advised otherwise the manufacturer will assume the assembly is to be used by skilled or instructed persons.
Isolation of load installation equipment items	**	Specific requirements to isolate groups of circuits should be included in the assembly specification.
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	No	The standard assumes ordinary persons will not operate devices or change components. If ordinary persons are required to carry out any such duties the requirements should be detailed in the assembly specification.
Requirements related to accessibility for inspection and similar operations	No	The basic standard assumes that all maintenance and extensions of an assembly will be carried out with the assembly de-energised. Where, for a particular application, there is a need to undertake these operations with part or all of the assembly under voltage, the requirements must be detailed in the assembly specification.
Requirements related to, accessibility for maintenance in service by authorized persons	No	
Requirements related to accessibility for extension in service by authorized persons	No	
Method of functional units connection	**	The standard uses a three letter to describe the different method of connecting a functional unit within an assembly: • F - for fixed connections; • D - for disconnectable connections; • W - for withdrawable connections. These letters are then used in a three letter code to describe connections to functional units as follows: • first letter denotes the type of electrical connection of the main incoming supply to the functional unit; • second letter denotes the type of electrical connection of the main outgoing supply from the functional unit; • third letter denotes the type of electrical connection of the auxiliary circuits. For example: a functional unit with a plug on to busbar connection, bolted outgoing connections and disconnectable auxiliary circuits would be described as WFD. Any preference for the means of connection of functional units should be identified in the assembly specification.

User defined functions & characteristics	Standard arrangement	Guidance notes
Protection against direct contact with hazardous live internal parts during maintenance or upgrade (e.g. functional units, main busbars, distribution busbars)	No	See requirements for extension under voltage above.
Form of separation	**	Specifiers should detail their required Form of Separation.
Capability to test individual operation of the auxiliary circuits relating to specified circuits while the functional unit is isolated	**	Requirements to test auxiliary circuits with the main circuits isolated should be identified in the assembly specification.
Current carrying capability		
Rated current of the ASSEMBLY InA (Amps)	**	The standard defines the rated current of the assembly as the lessor of the sum of the rated currents of the incoming circuits within the ASSEMBLY that are operated in parallel, and the total current rating of the main busbar. Specifier's should detail the rating of the assembly they require in their specification.
Rated current of circuits Inc (Amps)	**	Specifiers should provide details of the current rating of all the incoming and outgoing circuits they require in their assembly.
Rated diversity factor	According to product standards Number of main outgoing circuits — Diversity factor 2 and 3 — 0.9 4 and 5 — 0.8 6 to 9 inclusive — 0.7 10 and more — 0.6	In reality all circuits within an assembly will not be called upon to carry their rated current simultaneously and continuously. Diversity is the proportion of their rated current each circuit within a group of outgoing circuits or all outgoing circuits within the assembly can carry, continuously and simultaneously, without the assembly overheating. In the absence of any other information in the assembly specification the manufacturer will assume the standard diversity factors for the whole assembly.
Ratio of cross section of the neutral conductor to phase conductors: Phase conductors up to and including 16 mm^2	100%	The current in the neutral circuit may be influenced by significant harmonics. When, for circuits using conductors up to 16mm^2 this is not sufficient, specifier's should define their requirements in their specification.
Ratio of cross section of the neutral conductor to phase conductors: phase conductors above 16mm^2	50% (min. 16 mm^2)	In the majority of applications the neutral current is much less than the associated phase current. Accordingly, the standards assumes that for circuits within an assembly incorporating conductors with a cross section exceeding 16mm^2 the neutral conductor may have a section equal to 50% of the phases with a minimum of 16mm^2. In circuits where significant harmonics are present or there are sever imbalances in phase current this may not be adequate and specifier's should define their requirements in their specification.

** The standard does not define a default condition

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