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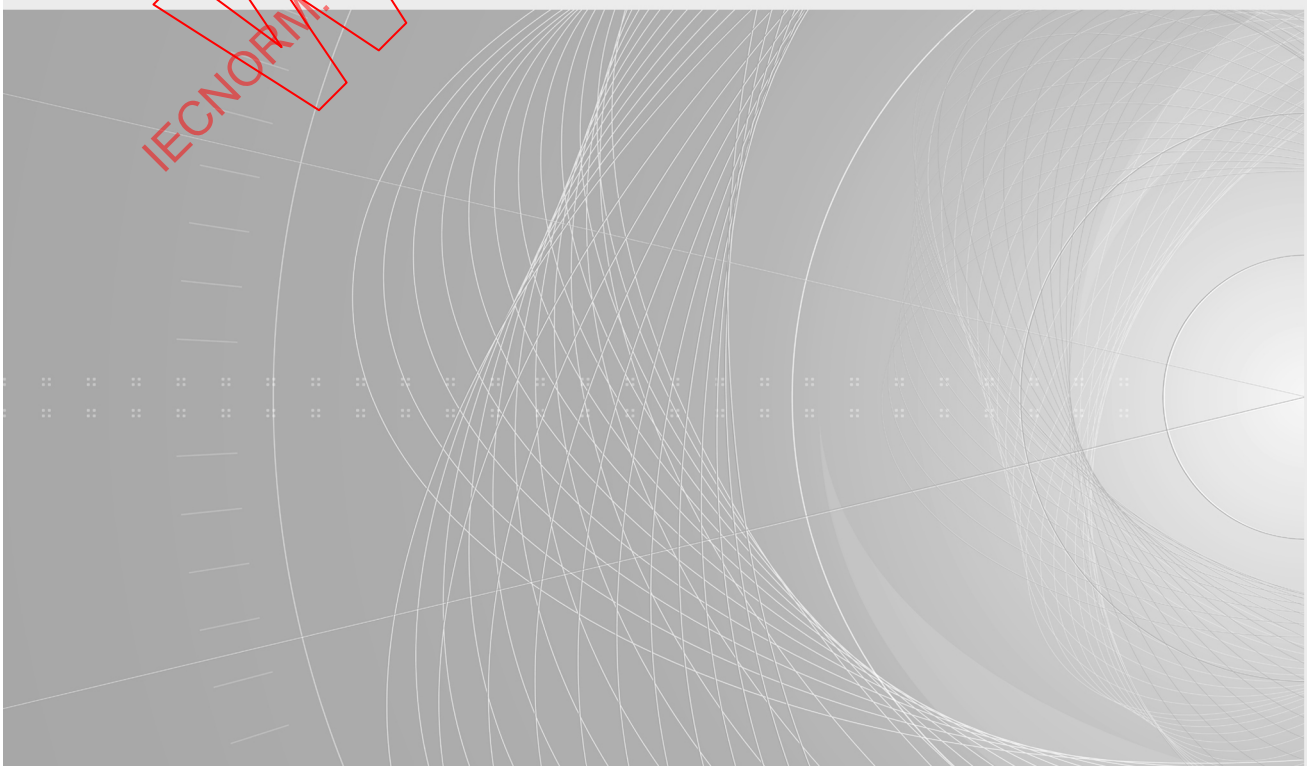
TECHNICAL REPORT

Low-voltage switchgear and controlgear assemblies – Part 0: Guidance to specifying assemblies



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES –

Part 0: Guidance to specifying assemblies

FOREWORD

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The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC/TR 61439-0, which is a technical report, has been prepared by subcommittee 17D: Low-voltage switchgear and controlgear assemblies, of IEC technical committee 17: Switchgear and controlgear.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
17D/402/DTR	17D/421/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61439 series, under the general title *Low-voltage switchgear and controlgear assemblies*, can be found on the IEC web site.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

For the purposes of this technical report, the user is the party who specifies or selects the ASSEMBLY characteristics. The user may be the same party as the one who will use and operate the ASSEMBLY, or someone acting on their behalf. The aim of this technical report is to provide the user with guidance on the specification that should be provided in order to achieve the desired design of an assembly. Throughout this technical report, the term ASSEMBLY is used for a low-voltage switchgear and controlgear assembly. The term "manufacturer" refers to the ASSEMBLY manufacturer unless specifically noted otherwise.

The purpose of the IEC 61439 series of standards is to harmonize as far as practicable, all the general rules and requirements that apply to ASSEMBLIES. The series further seeks, in order to obtain uniformity of requirements for ASSEMBLIES, consistency in the verification of ASSEMBLIES and to avoid the need for verification to other standards.

All those requirements for the various ASSEMBLIES that can be considered as general, together with specific subjects of wide interest and application, e.g. temperature rise, dielectric properties, have therefore been gathered in Part 1 of IEC 61439 as general rules. For each type of ASSEMBLY only two main standards are necessary to determine all requirements and the corresponding methods of verification:

1) the standard giving the general rules and designated "Part 1", and
2) the specific ASSEMBLY standard, hereinafter referred to as the relevant ASSEMBLY standard.

The IEC 61439 series of standards encompasses ASSEMBLIES for a wide variety of uses, some of which have specific needs as dictated by their particular application. In order to define clearly these specific needs, relevant ASSEMBLY standards focussed on a particular type of application have been (or are being) developed. These are identified as IEC 61439-2 to IEC 61439-6, inclusive (see list below). Each relevant ASSEMBLY standard with reference to IEC 61439-1, the general rules, as appropriate, specifies the characteristics and performance required by an ASSEMBLY within its defined scope of application. Each relevant ASSEMBLY standard includes, as an annex, a template for "items subject to agreement between the ASSEMBLY manufacturer and the user" to facilitate the specifying of an ASSEMBLY. These are reproduced and explained in this technical report.

Within this technical report, reference to IEC 61439 means the series of ASSEMBLY standards, including:

- IEC 61439-1(2009), *Low-voltage switchgear and controlgear assemblies – Part 1:General rules*
- IEC 61439-2(2009), *Low-voltage switchgear and controlgear assemblies – Part 2:Power switchgear and controlgear assemblies*
- IEC 61439-3 (in preparation), *Low-voltage switchgear and controlgear assemblies – Part 3: Distribution boards intended to be operated by ordinary persons (DBO)* (to supersede IEC 60439-3)
- IEC 61439-4 (in consideration), *Low-voltage switchgear and controlgear assemblies – Part 4: Assemblies for construction sites* (to supersede IEC 60439-4)
- IEC 61439-5 (to be published), *Low-voltage switchgear and controlgear assemblies – Part 5:Assemblies for power distribution in public networks* (to supersede IEC 60439-5)
- IEC 61439-6 (in preparation), *Low-voltage switchgear and controlgear assemblies – Part 6:Busbar trunking systems (busways)* (to supersede IEC 60439-2)

A reference to "general rules" means a reference to IEC 61439-1(2009).

A reference to “ASSEMBLY standard” means the relevant part of the IEC 61439 series (e.g. Part 2, 3, etc.).

A reference to “product standard” means the relevant part or parts of the IEC standard for the components used in the ASSEMBLY (e.g. IEC 60947-2 for circuit breakers).

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES –

Part 0: Guidance to specifying assemblies

1 Scope

Within the IEC 61439 series of standards for low-voltage switchgear and controlgear assemblies (ASSEMBLIES), there are system and application details that need to be specified by the user to enable the manufacturer to produce an ASSEMBLY that meets the needs and expectations of the user. This technical report identifies, from the user's perspective, those functions and characteristics that should be defined when specifying ASSEMBLIES. It provides:

– an explanation of the ASSEMBLY characteristics and options within the IEC 61439 series;

– a guidance on how to select the appropriate option and to define characteristics so as to meet specific application needs, using a functional approach; and

– an assistance in the specification of ASSEMBLIES.

References within this technical report to the interface characteristics of an ASSEMBLY and the requirements with which they will comply assume that the ASSEMBLY is designed, manufactured, and verified in accordance with the relevant IEC 61439 standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-6, *Low-voltage electrical installations – Part 6: Verification*

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61439-1:2009, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the relevant ASSEMBLY standard apply (e.g. IEC 61439-2).

4 Application of ASSEMBLIES within the IEC 61439 series

4.1 General

ASSEMBLIES manufactured in accordance with the relevant ASSEMBLY standard of the IEC 61439 series of standards are suitable for installation in the majority of operating environments. Many of the characteristics of ASSEMBLIES are fully defined within the standard and do not require further consideration by the user. In some instances there may be a default condition specified within the standard and a range of other identified alternative options, from which the user may choose to suit the application. For other characteristics, the user may be required to choose from a list of options within the standard.

Where special and exceptionally onerous conditions exist, the user should identify these in their specification. Examples of these onerous conditions include: high UV radiation applications, conditions of high particulates/pollutants, more stringent short circuit conditions, special fault protection, special protection due to risk of fire, explosions, burns, etc.

In some instances, the user may wish to seek the advice of experts in order to identify their requirements correctly, e.g. with regard to system harmonics.

The annexes from Annex C onward provide specification templates that the user should complete when defining the interface characteristics and application requirements for an ASSEMBLY in accordance with the relevant ASSEMBLY standard. An explanation of each interface characteristic is given in the subsequent clauses.

4.2 ASSEMBLY design and verification

An ASSEMBLY is intended to be used within an electrical installation of defined characteristics. The ASSEMBLY may be designed and verified with a specific set of application criteria, to suit a particular use, or more usually, it may be designed and verified to meet typical application criteria that make it usable in a range of common applications.

The configuration for a particular user application of an ASSEMBLY usually requires four main steps:

a) definition or selection of service conditions and interface characteristics. The user should specify these characteristics;

b) design of the ASSEMBLY by the manufacturer to meet the arrangements, characteristics, and functions particular to the application. The design will generally be based on previously developed standard ASSEMBLY arrangements, characteristics, and functions;

c) for ASSEMBLIES or parts of ASSEMBLIES where the design is not previously proven, design verification carried out by the manufacturer;

d) routine verification, carried out on each ASSEMBLY by the manufacturer.

For further information on the design and routine verification carried out by the manufacturer, see Clause 14.

4.3 Service conditions and interface characteristics

The characteristics of the ASSEMBLY should be compatible with the ratings of the circuits to which it is connected and the installation conditions.

Where no user specification is provided, information given in the manufacturer's documentation may take the place of an agreement between the manufacturer and the user.

It is assumed that the user will provide an electrical single line diagram, or equivalent, to define the incoming and outgoing circuit arrangements, loads, external conductors, and selected interface characteristics that are required for the application of a specific ASSEMBLY.

4.4 Design

Once the user has specified any arrangements, characteristics, or functions particular to the application, the manufacturer is responsible for the design of the ASSEMBLY and ensuring it complies with the relevant ASSEMBLY standard in the IEC 61439 series. From the information provided by the user, the manufacturer will derive additional ASSEMBLY characteristics in order to provide an ASSEMBLY that fulfils the user's stated application requirements.

5 Electrical system

5.1 General

The electrical system includes all of the elements of the electrical network within which the ASSEMBLY is intended to operate. The electrical system determines the characteristics (capabilities) an ASSEMBLY should possess in order to perform its required duty safely. The characteristics of the ASSEMBLY should at all times be at least equal to the needs of the application and, where essential, they may exceed those offered in the standard options detailed in the IEC 61439 series.

The user should provide an electrical single line diagram and/or any other information necessary to define their requirements for the ASSEMBLY, as detailed in 5.2 to 5.6 below.

5.2 Earthing system

The means of earthing a low-voltage network, when, how and where, differs from application to application. For a particular network, the earthing system used may be dictated by local regulation, the supply authority, legacy requirements, or the benefits of one system relative to others.

The standard configurations of earthing system are TT, TN-C, TN-C-S, IT, TN-S. Specific systems require and/or permit different solutions. For example, during the isolation of a supply for maintenance:

- in TN-C systems, the PEN conductor is not permitted to be isolated or switched, but,
- in TN-S systems and TN-C-S systems the neutral conductors may or may not be isolated or switched (see IEC 60364-5-53, 536.1.2).

The design of the auxiliary circuits should take into account the supply earthing system to ensure that an earth-fault does not cause unintentional operation.

It is therefore essential that users specify the earthing system.

5.3 Nominal voltage

The nominal voltage of the electrical system determines a number of the ASSEMBLY characteristics.

The user should specify the nominal voltage of the system.

When provided with the nominal voltage, the manufacturer will determine the appropriate values for other voltages including:

- the rated operational voltage U_e (of a circuit of an ASSEMBLY)

This is the voltage at which all the devices in a circuit, or a group of circuits, are capable of performing a specified function, for example switching a particular load a given number of times. In all cases, the rated operational voltage will be at least equal to the rated voltage of the ASSEMBLY.

- the rated insulation voltage U_i

  Like U_e, the rated insulation voltage also applies to a circuit or group of circuits of the ASSEMBLY. It is the long-term voltage withstand capability of the insulation and is never less than the rated operational voltage. Generally an insulation voltage equal to the operational voltage is sufficient, but where particularly arduous conditions apply, a higher insulation voltage may be appropriate.

5.4 Overvoltage category (OVC)

All networks experience occasional transient overvoltages caused by switching, lightning, etc. Generally, within a low-voltage network, the magnitude of the overvoltages is reduced as the distance from the source of supply is increased. It is therefore possible to have ASSEMBLIES suitable for different levels of overvoltage as determined by their location in the electrical network.

Various levels of overvoltage category are defined using a series of roman numbers.

The overvoltage category (OVC) options are:

- Category I: Specially protected level (internal to equipment, not normally applicable to an ASSEMBLY)
- Category II: Load level (appliance, equipment, not normally applicable to an ASSEMBLY)
- Category III: Distribution circuit level (typical industrial applications)
  Examples: Equipment which is part of the fixed electrical installation and other equipment where a high degree of availability is expected, e.g. distribution boards, motor control centres.
- Category IV: Origin of installation level (service entrance)
  Examples: Equipment to be used at or in the proximity of the origin of the electrical installation upstream of the main distribution board, e.g. electricity meter, primary overcurrent protective device.

The manufacturer will determine the likely overvoltage category from the electrical system, single line diagram. Where exceptional overvoltage conditions apply, the user should specify the required overvoltage category option for his application.

From the overvoltage category, the nominal voltage and the type of electrical supply system the manufacturer will determine the appropriate values for the rated impulse withstand voltage (U_{imp}). This relationship is illustrated for information in Figure 1.

The rated impulse withstand voltage U_{imp} is a measure of the ASSEMBLY's tolerance to transient overvoltages. In normal networks, it will be equal to or higher than the transient overvoltages occurring in the system(s) to which the circuit is designed to be connected.

5.5 Unusual voltage transients, temporary overvoltages

The ASSEMBLY will be capable of withstanding:

- transient overvoltage – short duration overvoltage of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped, and
- temporary overvoltage – overvoltage at power frequency of relatively long duration (several seconds).

The rated impulse withstand voltage (U_{imp}) defines the transient overvoltage to be withstood, ranging from 0,33 kV to 12 kV.

The rated insulation voltage (U_i) defines the level of temporary overvoltage to be withstood.

If unusual voltage transients or temporary overvoltages are anticipated, the user should specify the conditions to be met. Where such unusual conditions apply, it is important that they are identified in order that the appropriate ASSEMBLY can be provided. (Guidance is provided e.g. in IEC 61643-12 for transient overvoltages.)

5.6 Rated frequency f_n (Hz)

ASSEMBLIES are designed to operate at a particular (rated) frequency or over a range of frequencies. Connecting a circuit of an ASSEMBLY to a supply with a frequency outside its intended range can result in devices not operating correctly, altered interrupting capacity and in the case of higher current, the current carrying ability may be affected. Standard frequencies are 50 Hz, and 60 Hz.

Unless otherwise stated, the manufacturer of the ASSEMBLY will assume it is suitable for a frequency within the limits of 98 % to 102 % of the rated frequency.

The user should specify the nominal frequency of the system as the required rated frequency of the ASSEMBLY. If any of the circuits within the ASSEMBLY are required to operate at different frequencies, this should be identified accordingly by the user in the specification.

5.7 Additional on-site testing requirements: wiring, operational performance and function

The routine verification is intended to detect faults in materials and workmanship, to confirm an ASSEMBLY has been manufactured in accordance with the design specification and to ascertain proper functioning of the complete ASSEMBLY. It is made on each ASSEMBLY normally at the manufacturer's premises.

ASSEMBLIES do not require any on-site testing to re-confirm the integrity of the ASSEMBLY. In cases where the ASSEMBLIES are delivered in sections, the manufacturer may recommend tests to confirm the ASSEMBLY has been correctly coupled on site.

IEC 60364-6 defines on-site verification to check the correct integration of the ASSEMBLY into the electrical system. Where additional on-site testing by the manufacturer is required, the user should specify these tests.

6 Short-circuit withstand capability

6.1 General

Short-circuits within correctly designed and managed networks are a very rare occurrence, but when they occur, they place abnormal demands on ASSEMBLIES. Short-circuit currents and short-circuit current breaking may cause different kinds of stresses:

- extremely high forces between conductors,
- very high temperature rise in a very short time,
- air ionisation due to arc breaking, resulting in lower air insulation,
- overpressure due to arc breaking, resulting in high forces applied to the enclosure.

ASSEMBLIES should be capable of withstanding the thermal and dynamic stresses resulting from short-circuit currents emanating from the supplies to which they are connected.

Unless otherwise specified in the manufacturer's operating and maintenance instructions, ASSEMBLIES that have been subjected to a short-circuit should be subject to inspection and/or maintenance by skilled personnel to determine the suitability of the ASSEMBLY for further service.

6.2 Prospective short-circuit current at supply terminals I_{cp} (kA)

The prospective short-circuit current is the current that would flow if the supply conductors to the ASSEMBLY were short-circuited with negligible impedance at the supply terminals of the ASSEMBLY. In most cases, faults occurring in practise have an impedance that results in a lower fault current compared to the prospective short-circuit current. Therefore, the selection of an ASSEMBLY which is designed and verified for the prospective fault current usually includes some safety margin.

The prospective short-circuit current is usually expressed as an r.m.s. short time current for a specified duration, e.g. 0,2 s, 1 s or 3 s, or a conditional short-circuit current, which is a reduced let through current limited by the operation of the upstream protective device.

From this current, an ASSEMBLY is assigned a short-circuit rating by the ASSEMBLY manufacturer, defined in terms of the maximum prospective short-circuit current applicable at the point of connection to the system. When the assigned short-circuit rating is based on a conditional short-circuit current, the ASSEMBLY manufacturer will provide details of the required upstream protective device.

The terminology to define the short-circuit rating of an ASSEMBLY is summarised as follows:

- the rated peak withstand current (I_{pk});
- the rated short-time withstand current (I_{cw});
- the rated conditional short-circuit current of an ASSEMBLY (I_{cc}).

ASSEMBLIES are protected against short-circuit currents by means of, for example, circuit breakers, fuses, or combinations of both upstream of the ASSEMBLY. Frequently the incoming functional unit of an ASSEMBLY is a short-circuit protective device (SCPD), which may further reduce the short-circuit requirements of the ASSEMBLY. Where a user has a preference for a particular form of device as the incoming functional unit, this should be specified (see 6.5).

The user should specify the prospective short-circuit current (I_{cp}) applicable at the incoming terminals of the ASSEMBLY.

6.3 Prospective short-circuit current in the neutral

In three-phase circuits, the neutral fault current is reduced, relative to the three-phase short-circuit current, by the impedance in the neutral circuit. In a typical network the neutral short-circuit current does not exceed 60 % of the three-phase value.

Where a neutral conductor exists within the circuit and the neutral prospective short-circuit current exceeds 60 % of the three-phase short-circuit current, the user should specify the value of the neutral short-circuit current capability required.

6.4 Prospective short-circuit current in the protective circuit

As in the case of the neutral circuit, the prospective short-circuit current in the protective circuit is reduced, relative to the three-phase value, by the impedance in the protective circuit. Hence, the protective circuit requires the same consideration as the neutral circuit (see 6.3).

6.5 Short-circuit protective device (SCPD)

The user may nominate that the short-circuit protective device (SCPD) is to be included in the ASSEMBLY, or that it is to be external to the ASSEMBLY. Alternatively the manufacturer's recommendation may be accepted.

For ASSEMBLIES with a short-circuit protective device incorporated in the incoming unit, the user should provide the prospective short-circuit current value that can occur at the incoming terminals of the ASSEMBLY.

In turn, the manufacturer will provide documentation or labelling (marking) of the incoming unit indicating the ASSEMBLY's short-circuit capability as protected by the incoming functional unit.

If a circuit breaker with time-delay release is used as the short-circuit protective device, the manufacturer will state the maximum time-delay and the current setting corresponding to the indicated prospective short-circuit current.

For ASSEMBLIES where the short-circuit protective device is not incorporated in the incoming unit, the manufacturer will indicate the short-circuit withstand capability in one or more of the following ways:

a) rated short-time withstand current (I_{cw}) together with the associated duration, and

b) rated peak withstand current (I_{pk}), or

c) rated conditional short-circuit current (I_{cc}).

For an ASSEMBLY having several incoming units which are unlikely to be in operation simultaneously, the short-circuit withstand strength can be indicated for each of the incoming units in accordance with the above.

Refer to 6.7 for information concerning an ASSEMBLY with several incoming units which are likely to be in operation simultaneously, or having one incoming unit and one or more outgoing high-power units likely to contribute to the short-circuit current.

The user should specify any additional protective functions required of the incoming short-circuit protective device, such as overload or arcing fault limitation.

6.6 Co-ordination of short-circuit protective devices including external short-circuit protective device details

Switching devices and components incorporated in ASSEMBLIES will comply with the relevant IEC standards.

The manufacturer will select the switching devices and components to be suitable for the particular application with respect to the external design of the ASSEMBLY (e.g. open type or enclosed), their rated voltages, rated currents, rated frequency, service life, making and breaking capacities, short-circuit withstand strength, etc.

Any switching devices and components having a short-circuit withstand strength and/or a breaking capacity rating lower than that likely to occur at the place of installation, will be adequately protected by means of current-limiting protective devices, for example fuses or circuit-breakers.

Co-ordination of switching devices and components, for example co-ordination of motor starters with short-circuit protective devices, will comply with the relevant IEC standards.

If the operating conditions require maximum continuity of supply, the settings or selection of the short-circuit protective devices within the ASSEMBLY will, where possible, be so graded that a short-circuit occurring in any outgoing branch circuit is cleared by the switching device installed in the faulted branch circuit without affecting the other outgoing branch circuits, thus providing selectivity of the protective system. For more information, see IEC/TR 61912-2.

The co-ordination of protective devices should be the subject of an agreement between the manufacturer and the user. Information given in the manufacturer's documentation may take the place of such an agreement.

6.7 Data associated with loads likely to contribute to the short-circuit current

An ASSEMBLY may have several incoming units which are likely to be in operation simultaneously and one or more outgoing high-power units likely to contribute to the short-circuit current. In such cases, the user should provide appropriate data for the circuits concerned. The manufacturer will then determine the values of the prospective short-circuit current available to each incoming unit, each outgoing unit and the busbars, and provide the ASSEMBLY accordingly.

7 Protection of persons against electric shock

7.1 General

Many of the requirements described in this technical report contribute to the capability of the ASSEMBLY to provide protection of persons against electric shock in accordance with IEC 60364-4-41. These include relevant characteristics of the installation environment, operating arrangements, maintenance and upgrade capabilities, current carrying capability, and short-circuit withstand capability.

In addition, the methods used for protection against contact with live parts are integral to the protection of persons against electric shock; these are described in terms of:

- basic protection (protection against direct contact);
- fault protection (protection against indirect contact).

If the ASSEMBLY contains items of equipment that may have steady-state touch current and charges after they have been switched off (capacitors, etc.), a warning label is provided.

The means of providing protection against electric shock including the integration of the ASSEMBLY into the installation are given in IEC 60364-4-41. In addition, fault protection will be provided by the ASSEMBLY. In some instances, the means of fault protection may be selected from standard options. Where this is the case, the user should specify any preference he may have for one of these standard options detailed below.

7.2 Basic protection (protection against direct contact)

7.2.1 General

Basic protection is intended to prevent direct contact with hazardous live parts. It can be achieved either by appropriate constructional measures within the ASSEMBLY itself, or by additional measures taken during installation, for example installation in a location where access is only permitted for authorized personnel.

For basic protection by constructional measures, one or more of the two protective measures detailed below may be used.

7.2.2 Basic insulation provided by insulating material

Hazardous live parts will be completely covered with insulation that can only be removed by destruction. The insulation is required to be made of suitable materials capable of withstanding the mechanical, electrical and thermal stresses to which the insulation may be subjected in normal service.

7.2.3 Barriers or enclosures

Air insulated live parts will be inside enclosures or behind barriers providing at least a degree of protection of IP XXB. Horizontal top surfaces of accessible enclosures having a height equal to or lower than 1,6 m above the standing area, will provide a degree of protection of at least IP XXD.

The manufacturer may construct the ASSEMBLY so as to enable it to be opened or barriers be removed for maintenance (refer to maintenance and upgrade capabilities in Clause 12 of this technical report). With such an arrangement, at least one of the following conditions will apply:

a) a key or tool is required to open the door, remove the cover or override an interlock;

b) isolation of the supply to live parts that are protected by the barriers or enclosures is required before the enclosure can be opened or the barriers removed. In addition, it should not be possible to restore the supply until the enclosure has been closed and/or the barriers replaced;

c) an intermediate barrier providing a degree of protection at least IP XXB prevents contact with live parts, the removal of the barrier requiring the use of a key or tool.

7.3 Fault protection (protection against indirect contact)

7.3.1 General

Fault protection is intended to protect against the consequences of a fault within the ASSEMBLY and those of a fault within an external circuit supplied through the ASSEMBLY. The ASSEMBLY will normally include protective measures and be suitable for installation in a network designed to be in accordance with IEC 60364-4-41. Protective measures suitable for other types of installation should be subject to agreement between the manufacturer and the user.

For fault protection, at least one of the three protective measures detailed below should be used.

7.3.2 Protection by automatic disconnection of the supply

7.3.2.1 Faults within the ASSEMBLY

Each ASSEMBLY will include a protective means such that, in the event of a fault within the ASSEMBLY, it automatically initiates disconnection of the supply to a faulted circuit and/or the complete ASSEMBLY.

For an adequate protective circuit all exposed conductive parts of the ASSEMBLY will be interconnected together, noting the following:

a) when a part of the ASSEMBLY is removed, the protective circuits (earth continuity) for the remainder of the ASSEMBLY should not be interrupted;

b) for lids, doors, cover plates and the like, the usual metal screwed connections and metal hinges are considered sufficient to ensure continuity provided that no electrical equipment exceeding the limits of extra low voltage is attached to them.

If apparatus with a voltage exceeding the limits of extra-low voltage are attached to lids, doors, or cover plates, additional measures will be taken to ensure earth continuity. A protective conductor (PE) or an equivalent electrical connection especially designed and verified for this purpose will be used.

Exposed conductive parts of a device that cannot be connected to the protective circuit by the fixing means of the device will be connected to the protective circuit of the ASSEMBLY by a conductor of adequate cross-sectional area.

Certain minor exposed conductive parts (not exceeding 50 mm x 50 mm) of an ASSEMBLY that do not constitute a danger need not be connected to a protective conductor. This applies to screws, rivets, nameplates, parts of small devices, and similar.

The connection of an exposed conductive part to the incoming protective circuit is considered sufficient if the resistance of this connection is less than 0,1 Ω.

7.3.2.2 Faults in external circuits supplied through the ASSEMBLY

The protective circuit within an ASSEMBLY will in the majority of installations form an integral part of the protective circuit for a circuit downstream of an ASSEMBLY. Any current in the protective circuit downstream of the ASSEMBLY will pass through the protective circuit until interrupted by the short-circuit protective device, within the ASSEMBLY, thereby protecting the faulted circuit.

Hence, the manufacturer will provide a protective circuit within the ASSEMBLY that is capable of withstanding the highest thermal and dynamic stresses that may occur at the place of installation of the ASSEMBLY, for faults in external circuits supplied through the ASSEMBLY. The protective circuit provided may be the ASSEMBLY'S enclosure or frame and/or a separate conductor.

With the exception of the instances mentioned below, the protective conductors within an ASSEMBLY will not include a disconnecting device (switch, disconnector, etc.):

– removable links are permitted in the protective conductor, but they should only be removable by means of a tool, and only accessible by authorised personnel;

– plug-and-socket devices may only interrupt the protective circuit after the live conductors have been interrupted, and continuity of the protective circuit should be established before the live conductors are reconnected.

7.3.3 Electrical separation

Protection by electrical separation means that there is no path, with a single fault, for a current to flow in the event of failure of basic insulation within the ASSEMBLY or a circuit downstream of the ASSEMBLY. Contact with exposed conductive parts, which may be energized as a result of a fault, will not result in an electric shock.

Usually, the separated circuit is supplied via an isolating transformer, the secondary winding of which is not connected to earth. Users considering this form of protection should be fully aware of its benefits and limitations, and specify their requirements accordingly.

7.3.4 Protection by total insulation

Protection by total insulation is a means of providing adequate protection against electric shock without the need for an accessible protective circuit. With this alternative form of construction the equipment is totally insulated and has no exposed conductive parts. Hence, contact with such an ASSEMBLY cannot result in an electric shock.

The construction of ASSEMBLIES that are protected by total insulation requires specific features so that adequate protection against electric shock is provided under all anticipated operating conditions. These features, which will be provided by the manufacturer, include:

a) Completely enclosing all apparatus in insulating material that is equivalent of double or reinforced insulation and marked accordingly.

b) No conducting parts pierce the enclosure and no point should be pierced by conducting parts in such a manner that there is the possibility of a fault voltage being brought out of the enclosure. This requirement includes metal parts such as actuator shafts.

c) Arrangements such that when the ASSEMBLY is ready for operation and connected to the supply, all live parts, exposed conductive parts and parts belonging to a protective circuit will be enclosed (to at least IP 2XC) so that they cannot be touched.

d) Exposed conductive parts within the ASSEMBLY will not be connected to the protective circuit.

e) For arrangements where any doors or covers of the enclosure can be opened without the use of a key or tool, a secondary barrier will be provided behind the door or cover. This barrier will be manufactured from insulating material. It will provide protection

against unintentional contact with the accessible live parts and with the exposed conductive parts that would otherwise become accessible, after the door or cover has been opened.

Users considering this form of protection against indirect contact should understand its benefits and limitations and specify it when appropriate.

8 Installation environment

8.1 General

The installation environment of an ASSEMBLY defines the ambient conditions at the place of installation, detailing operating conditions such as the presence of liquids, foreign bodies, mechanical impact, UV radiation, corrosive substances, temperature, humidity, pollution, altitude, and EMC.

ASSEMBLIES conforming to IEC 61439 are intended for use under the normal service conditions detailed in each clause of this technical report. For each condition considered, a typical value is nominated, or options defined. Where options are listed the user should specify the option that fulfils his needs. Where more onerous or any special service conditions exist, the user should inform the manufacturer of such exceptional service conditions.

8.2 Location type

An ASSEMBLY may be specified as being suitable for either indoor locations or outdoor locations.

The selection of an indoor or outdoor location varies the standard conditions for protection against ingress of solid foreign bodies or water (see 8.3), exposure to UV radiation (see 8.5), ambient temperature (see 8.7), and relative humidity (see 8.8). It may also vary the requirements for external mechanical impact (see 8.4), corrosion (see 8.6), pollution degree (see 8.9), or any of the special service conditions (see 8.12).

The user should specify which type of location is applicable.

8.3 Protection against ingress of solid foreign bodies and ingress of water

The degree of protection provided by any ASSEMBLY against contact with live parts, ingress of solid foreign bodies and water is indicated by the IP code according to IEC 60529.

Users may specify an IP code for the assembly suitable for their application; the following are standard options:

- for ASSEMBLIES for indoor use where there is no requirement for protection against ingress of water, the following are IP code options :

IP 00, IP 2X, IP 3X, IP 4X, IP 5X;

- the degree of protection of an enclosed ASSEMBLY will be at least IP 2X, after installation in accordance with the manufacturer's instructions. The degree of protection provided from the front of a dead front ASSEMBLY will be at least IP XXB;
- for fixed ASSEMBLIES not subject to tilting in normal service IP X2 is not applicable. For ASSEMBLIES for outdoor use having no supplementary protection, the second characteristic numeral will be at least 3.

NOTE 1 For outdoor installation, supplementary protection may be protective roofing or the like.

Unless otherwise specified, the degree of protection indicated by the manufacturer applies to the complete ASSEMBLY when installed in accordance with the manufacturer's instructions.

Where the ASSEMBLY does not have the same IP rating throughout, the manufacturer will declare the IP rating for the separate parts.

For ASSEMBLIES incorporating withdrawable parts the degree of protection indicated for the ASSEMBLY normally applies to the connected position of the withdrawable parts. The ASSEMBLY manufacturer shall indicate the degree of protection obtained in the other positions and during the transfer between positions.

ASSEMBLIES with withdrawable parts may be so designed that the degree of protection applying to the connected position is also maintained in the test and isolated positions and during transfer from one position to another.

If, after the removal of a withdrawable part, it is not possible to maintain the original degree of protection e.g. by closing a door, the user may specify what measures are to be taken to ensure adequate protection. Information provided by the ASSEMBLY manufacturer may take the place of such an agreement.

NOTE 2 In the United States of America (USA) and in Mexico enclosure "Type" designations are used to specify "the degree of protection" provided to the ASSEMBLY. For applications in the USA, the appropriate enclosure Type designation is used as specified in NEMA 250.

8.4 External mechanical impact

The user may specify a required mechanical impact (IK) code for the assembly in accordance with IEC 62262. As standard, there is no minimum requirement defined for an ASSEMBLY.

8.5 Resistance to UV radiation

The enclosures of ASSEMBLIES which are constructed of synthetic material or manufactured from metal that is coated with synthetic material are resistant to UV radiation. The level of resistance is sufficient for satisfactory performance in temperate climates. When an ASSEMBLY is subject to intense sun light, the user should specify their requirements and agree the means of providing any higher levels of resistance to UV radiation with the manufacturer.

8.6 Resistance to corrosion

All ASSEMBLIES are designed to be resistant to corrosion. Two levels are included for metallic parts:

- severity A – indoor equipment and the internal parts of outdoor equipment, and
- severity B – external parts of outdoor equipment located in normal environments.

For outdoor equipment, where exceptionally long service without maintenance is required, or where particularly onerous conditions prevail (for example, exposure to sea spray), additional protection and/or measures may be necessary. The user should specify such exceptional requirements and agree the means of providing adequate corrosion protection with the manufacturer.

8.7 Ambient air temperature

ASSEMBLIES are designed to be operated over a range of ambient temperatures:

- For indoor enclosures:

  Lower limit -5 °C

  Upper limit 40 °C

  Daily average maximum 35 °C

- For outdoor enclosures:

  Lower limit -25 °C

Upper limit 40 °C

Daily average maximum 35 °C

If alternative temperatures apply, the user should specify them.

8.8 Maximum relative humidity

ASSEMBLIES are designed to be suitable for operation in conditions where the humidity is as follows:

- For indoor enclosures:

  Upper limit 50 % at 40 °C for clean air

  NOTE Higher relative humidity may be permitted at lower temperatures, for example 90 % at +20 °C. Moderate condensation which may occasionally occur due to variations in temperature is taken into account.

- For outdoor enclosures:

  Upper limit 100 % at 40 °C for clean air

If alternative conditions apply, the user should specify these.

8.9 Pollution degree

ASSEMBLIES are designed to tolerate moderate levels of atmospheric pollution in service. The level of tolerance is defined by the pollution degree and it refers to the level and type of pollution permissible in the environment where the ASSEMBLY is intended to be installed.

From the pollution degree of the installation environment of the ASSEMBLY and on the design of the enclosure, the manufacturer derives the pollution degree in the micro-environment inside the ASSEMBLY, which is the basis for evaluating the clearances and creepage distances and the selection of suitable devices and components. The following four degrees of pollution are established to describe the severity :

– 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.

Pollution degree 4 is not applicable for a micro-environment inside the ASSEMBLY.

Unless otherwise specified by the user, the manufacturer will provide, for industrial applications, ASSEMBLIES for use in a pollution degree 3 environment. For general (non-industrial) applications, a pollution degree of 1, 2, or 3 is valid and an ASSEMBLY may be provided with any one of these three pollution degrees.

Users should specify where their application requires a particular pollution degree that differs from the standard option.

8.10 Altitude

ASSEMBLIES are designed to operate at altitudes less than or equal to 2 000 m.

Operation above this altitude may have a negative affect on the performance of the equipment. The user should specify where a higher installation altitude applies.

8.11 EMC environment

ASSEMBLIES need to be tolerant of all electromagnetic disturbances present at the location where they are installed. Equally, they should not emit disturbances that cause interference to anything else that may be located nearby. For the majority of ASSEMBLY applications two sets of environmental conditions are considered:

a) Environment A: relates to a power network supplied from a high or medium voltage transformer dedicated to the supply of an installation feeding manufacturing or similar plant, and intended to operate in or in proximity to industrial locations, as described below. This standard applies also to apparatus which is battery operated and intended to be used in industrial locations.

   The environments encompassed are industrial, both indoor and outdoor.

   Industrial locations are in addition characterized by the existence of one or more of the following examples:

   – industrial, scientific and medical (ISM) apparatus (as defined in CISPR 11);
   – heavy inductive or capacitive loads are frequently switched;
   – currents and associated magnetic fields are high.

NOTE 1 Environment A is covered by the generic EMC standards IEC 61000-6-2 and IEC 61000-6-4.

b) **Environment B:** relates to low-voltage public mains networks or apparatus connected to a dedicated DC source which is intended to interface between the apparatus and the low-voltage public mains network. It applies also to apparatus which is battery operated or is powered by a non-public, but non-industrial, low voltage power distribution system if this apparatus is intended to be used in the locations described below.

   The environments encompassed are residential, commercial and light-industrial locations, both indoor and outdoor. The following list, although not comprehensive, gives an indication of locations which are included:

– residential properties, for example houses, apartments;
– retail outlets, for example shops, supermarkets;
– business premises, for example offices, banks;
– areas of public entertainment, for example cinemas, public bars, dance halls; outdoor locations, for example petrol stations, car parks, amusement and sports centres;
– light-industrial locations, for example workshops, laboratories, service centres.

  Locations which are characterized by being supplied directly at low voltage from the public mains network are considered to be residential, commercial or light-industrial.

NOTE 2 Environment B is covered by the generic EMC standards IEC 61000-6-1 and IEC 61000-6-3.

The user should specify a requirement for either Environment A or B.

If an ASSEMBLY specifically intended for Environment A is to be used in Environment B, the manufacturer will include the following (or the equivalent) warning in the operating instructions:

CAUTION
This product has been designed for Environment A. Use of this product in Environment B may cause unwanted electromagnetic disturbances in which case the user may be required to take adequate mitigation measures.

The measures to be taken, if any, with regard to EMC associated with the installation, operation and maintenance of the ASSEMBLY will be specified in the manufacturer's instructions.

8.12 Special service conditions

8.12.1 General

Consideration should be given for providing an environment commensurate with the requirements for a standard ASSEMBLY.

Special service conditions are those where either:

- the standard conditions are varied, but the assumptions concerning the environment's influence on the ASSEMBLY remain consistent with those of the standard conditions, or
- the standard conditions are varied and the assumptions concerning the environment's influence on the ASSEMBLY are not consistent with those of the standard conditions.

Variances of type (a) are dealt with in 8.3 to 8.11.

This subclause considers variances of type (b). Specific examples are included in 8.12.2 to 8.12.7. Generally, the user should specify any special service conditions that will be present at the place of installation and which may affect the performance of the ASSEMBLY; for example, the current carrying capacity of equipment may be affected if it is built into machines or recessed into walls.

8.12.2 Climatic conditions

The user should specify where there are any special climatic conditions that may apply.

Examples can be:

- variations in temperature and/or air pressure take place at such a speed that exceptional condensation is liable to occur inside the ASSEMBLY;
- exposure to extreme climatic conditions is expected.

8.12.3 Protection against ingress of solid foreign bodies and ingress of water

The user should specify where any special requirements for protection against ingress of solid foreign bodies or water apply.

Examples can be:

- heavy pollution of the air by dust, smoke, corrosive or radioactive particles, vapours or salt;
- attack by fungus or small creatures.

8.12.4 Shock, vibration, and external mechanical impact (IK)

The user should specify where any special requirements for resistance to shock, vibration, or mechanical impact apply.

Examples can be:

- exposure to heavy vibration or shock, and the associated frequency, such as might be associated with transport, industrial, or mining applications;
- exposure to high energy impacts.

8.12.5 Fire and explosion hazards

The user should specify where there is any special risk of fire or explosion.

Examples can be:

- the presence of explosive atmospheres;
- possibility of exposure to fire.

8.12.6 Exceptional overvoltages

The user should specify any exceptional overvoltages that may be present in their network and to which the ASSEMBLY may be exposed, other than those described in 5.4 and 5.5.

8.12.7 EMC environment

The user should specify where any special EMC environment applies.

Examples can be:

- exposure to strong electric or magnetic fields;
- exposure to conducted and radiated disturbances other than electromagnetic and electromagnetic disturbances in environments other than those described by Environment A or B (see 8.11).

It may be necessary in certain installations (for example, those involving high-speed data networks, radiology apparatus, workstation monitors, etc.) to know the strength of the power frequency magnetic field in the vicinity of a busbar trunking or high-current conductors. A method for measurement and calculation of the modulus of the magnetic field around a busbar trunking will be given in future IEC 61439-6.

9 Installation method

9.1 General

The installation method of an ASSEMBLY, how it will be positioned, mounted, and connected at the place of installation has a significant impact upon the design and overall arrangement of the ASSEMBLY. Whilst an ASSEMBLY may be designed with some flexibility for common installation methods, specific applications differ in their requirements. The manufacturer needs to be informed of any special requirements of the user. The user should specify connection details, location, physical size of the place of installation, external conductors, and other similar aspects.

9.2 Assembly type

Various arrangements and configurations of ASSEMBLY are available; several basic standard external designs are identified below:

- open-type ASSEMBLY;
- dead-front ASSEMBLY;
- enclosed ASSEMBLY;
- cubicle-type ASSEMBLY;
- multi-cubicle-type ASSEMBLY;

- desk-type ASSEMBLY;
- box-type ASSEMBLY;
- multi-box-type ASSEMBLY;
- wall-mounted surface type ASSEMBLY;
- wall-mounted recessed type ASSEMBLY.

Typical mounting arrangements are floor standing (the assembly is mounted on the floor), or wall mounted.

Where the installation method requires a specific ASSEMBLY arrangement, users should specify their requirements.

9.3 Portability

An ASSEMBLY may be stationary (fixed at its place of installation), or movable (designed so that it can readily be moved from one place of use to another).

The user should specify which is required.

Where a movable assembly is specified, the user may also need to specify the range of installation environment characteristics to which the assembly will be subjected (refer to Clause 8).

9.4 Maximum overall dimensions and weight

As part of the documents provided by the manufacturer, the conditions for the installation of the ASSEMBLY including the overall size and weight are provided.

The user should specify any particular requirements related to the application. For example:

- where the space available for the ASSEMBLY is limited, the user should specify the maximum dimensions permitted for the application;
- where the mounting structure on which the ASSEMBLY is to be installed has limited capacity, the user should specify the maximum weight allowed.

9.5 External conductor type(s)

The user should specify his requirements for conductor type for each circuit of the ASSEMBLY, namely whether:

- cable;
- busbar trunking system; or
- other system.

In the absence of any user specification, the manufacturer will select terminals capable of accommodating cables relative to the circuit current.

9.6 Direction(s) of external conductors

The manufacturer is required to arrange openings for cable entries, cover plates, etc., so that when the cables are properly installed, the stated degree of protection is obtained. Where the user requires that external conductors enter the ASSEMBLY from one or more specific directions (for example from the top, bottom, rear, front, or sides of the ASSEMBLY), the user should specify these requirements including which requirements apply to which circuits.

9.7 External conductor material

The manufacturer will indicate in the product documentation whether the terminals are suitable for connection of copper or aluminium conductors, or both. The terminals will be such that the external conductors may be connected by a means (screws, connectors, etc.) which applies and maintains the necessary contact pressure corresponding to the current rating and short-circuit strength of the circuit.

The user should specify his requirements for conductor type for each circuit of the ASSEMBLY, namely whether it is:

- copper;
- aluminium; or
- another material.

In the absence of any user specification and unless otherwise indicated by the manufacturer, terminals will only be capable of accommodating copper conductors.

Where aluminium conductors are to be terminated, the type, size and termination method of the conductors should be specified by the user, or agreed between the manufacturer and the user.

9.8 External phase conductor, cross-sections, and terminations

The manufacturer is required to design the ASSEMBLY so that the available wiring space permits proper connection of the external conductors of the specified material and size, and in the case of multicore cables, spreading of the cores. The user should specify the cross section and any special termination requirements for the phase conductors of each external circuit.

In the absence of any user specification, terminals will be capable of accommodating conductors from the smallest to the largest cross-sectional areas corresponding to the appropriate rated current (see Annex A).

9.9 External PE, N, PEN conductors cross-sections, and terminations

The terminals for external protective conductors (PE, PEN) and metal sheathing of connecting cables (steel conduit, lead sheath, etc.) will, where required, be bare and, unless otherwise specified, suitable for the connection of copper conductors. A separate terminal of adequate size will be provided for the external protective conductor(s) of each circuit.

The user should specify the cross-section and any special termination requirements for the PE, N, and PEN conductors of each external circuit. The user specification should detail any applications in which the current in the neutral conductor may reach high values (for example large fluorescent lighting installations, power electronic equipment such as drives, etc). In such cases a neutral conductor having the same or greater current-carrying capacity than the phase conductors may be necessary.

In the absence of any user specification:

- terminals for protective conductors will allow the connection of copper conductors having a cross-section depending on the cross-section of the corresponding phase conductors;
- on three-phase and neutral circuits, terminals for the neutral conductor will allow the connection of copper conductors having a current-carrying capacity:
  - 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.

9.10 Special terminal identification requirements

Unless otherwise advised by the manufacturer or otherwise agreed with the user, identification of terminals will be in accordance with IEC 60445.

The terminals for external protective conductors will be marked according to IEC 60445. This may, for example, be achieved by using graphical symbol ⏚ No. 5019 of IEC 60417. Alternatively, where the external protective conductor is intended to be connected to an internal protective conductor, the latter may be clearly identified with the colours green and yellow.

The user may specify additional terminal identification requirements to suit his application.

10 Storage and handling

10.1 General

An ASSEMBLY intended for a specific application needs to be configured to suit the intended method of transport from the place of manufacture to the place of installation, storage (if any), and handling.

10.2 Maximum dimensions and weight of transport units

As part of the documentation provided by the manufacturer, the conditions for the handling of the ASSEMBLY including the size and weight of transport units is provided.

The user should specify any particular constraints relating to the application.

10.3 Methods of transport (e.g. forklift, crane)

The location and installation of lifting means and the thread size of lifting attachments, if applicable, are given in the manufacturer's documentation or the instructions on how the ASSEMBLY has to be handled.

The user should specify any particular requirements related to the application where these differ from the manufacturer's normal practices.

10.4 Environmental conditions different from the service conditions

If the conditions during transport, storage and installation, for example temperature and/or humidity, differ from those defined for the operating environment, the user should specify them.

10.5 Packing details

The user should specify any particular requirements related to the application for the packing of the ASSEMBLY for storage, and/or transport to the place of installation. Specific application requirements may include:

- special measures required from the packing to protect the ASSEMBLY during transport or storage;
- the use of any specific packing materials;
- markings or indicators to record any excessive shock or vibration that the ASSEMBLY is exposed to during transport;
- the maximum size or weight of packed transport units that can be handled during transport to the place of installation (which may differ from the transport units themselves).

11 Operating arrangements

11.1 General

Most, if not all ASSEMBLIES, have a need for some form of visual interface or manual operation. This may include:

- reading visual signals from lights, displays, and screens;
- visual inspection of switching devices, settings and indicators;
- adjusting and resetting relays, releases and electronic devices;
- the use of operating handles, pushbuttons, toggle switches and similar devices.

For the purposes of this technical report, manual operation means operation by hand, with or without a tool.

11.2 Access to manually operated devices

The manufacturer is required to ensure that, subject to the appropriate protection against electric shock, all manually operated components are accessible.

Different requirements apply for protection against electric shock as determined by the intended level of skill of the operator. Four types of operators are defined as follows:

- skilled person – a person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create;
- instructed person – a person adequately advised or supervised by skilled persons to enable him or her to perceive risks and to avoid hazards electricity can create;
- ordinary person – a person who is neither a skilled person nor an instructed person;
- authorized person – a skilled or instructed person, who is empowered to execute defined work.

Unless the user specifies otherwise, the following accessibility requirements associated with floor-mounted ASSEMBLIES apply:

– the terminals, excluding terminals for protective conductors, will be situated at least 0,2 m above the base of the ASSEMBLIES and, moreover, be so placed that the cables can be easily connected to them;

– indicating instruments that need to be read by the operator will be located within a zone between 0,2 m and 2,2 m above the base of the ASSEMBLY;

– operating devices such as handles, pushbuttons, or similar will be located at such a height that they can easily be operated; this means that their centreline should be located within a zone between 0,2 m and 2 m above the base of the ASSEMBLY;

– actuators for emergency switching devices (see 536.4.2 of IEC 60364-5-53) will be accessible within a zone between 0,8 m and 1,6 m above the base of the ASSEMBLY.

The user should advise if different requirements and, in particular, if operation other than by a skilled or instructed person is required.

11.3 Isolation of functional units for maintenance or service

In some applications, the ASSEMBLY is required to facilitate the isolation of a functional unit or a group of functional units for maintenance while adjacent groups of circuits remain energized and in service. Such facilities can be provided by the use of measures such as:

– sufficient space between the actual functional unit or group and adjacent functional units or groups;

- use of barriers or obstacles designed and arranged to protect against direct contact with equipment in adjacent functional units or groups;
- use of terminal shields;
- use of a compartment for each functional unit or group;
- insertion of additional protective means provided or specified by the manufacturer.

Should it be necessary to remove barriers, open enclosures or to remove parts of enclosures, as part of the maintenance, this will only be possible if one of the conditions a) to c) in 7.2.3 of this technical report is fulfilled.

Where facilities for isolation of a functional unit or a group of functional units for maintenance is required, the user should specify this, and any measures necessary to achieve it should be agreed with the manufacturer.

12 Maintenance and upgrade capabilities

12.1 General

During the lifetime of an ASSEMBLY, most will require maintenance and some may require an upgrade of equipment, and/or an extension. Most ASSEMBLIES are maintained, upgraded and extended when fully isolated from the supply. However, this is not always feasible. The following provides some guidance on how particular operations may be carried out with suitable precautions, and with a limited and defined part of the ASSEMBLY isolated.

12.2 Requirements related to accessibility for inspection and similar operations

The user should specify where inspection or similar operations are to be performed when the ASSEMBLY is in service and under voltage.

Such operations may consist of:

- visual inspection of:
  - switching devices and other apparatus;
  - settings and indicators of relays and releases;
  - conductor connections and marking;
- adjusting and resetting of relays, releases and electronic devices;
- replacement of fuse-links;
- replacement of indicating lamps;
- certain fault location operations, for example voltage and current measuring with suitably designed and insulated devices.

The user may specify requirements for the types of electrical connections of the auxiliary circuits of fixed, disconnectable, or withdrawable functional units or parts. The third letter of the three-letter code described in 12.5 is used.

The user may specify that auxiliary circuits are either capable or not capable of being tested while the associated functional unit is in the test position.

12.3 Requirements related to accessibility in service by authorized persons

If the user requires an ASSEMBLY to be capable of maintenance by authorized persons while energized, it should be specified which of the following are required:

- use of interlocks or devices permitting authorized persons to obtain access to live parts while the equipment is live;

- service operations to be performed while the ASSEMBLY is in service and under voltage, such as visual inspection, adjustment of relays and devices, replacement of fuse-links and indicating lamps, and fault finding;
- maintenance on an isolated functional unit or isolated group of functional units, with adjacent functional units or groups of functional units still under voltage, by the use of measures such as:
  - sufficient space between the actual functional unit or group and adjacent functional units or groups;
  - use of barriers or obstacles designed and arranged to protect against direct contact with equipment in adjacent functional units or groups;
  - use of terminal shields;
  - use of compartments for each functional unit or group;
  - insertion of additional protective means provided or specified by the manufacturer.

12.4 Requirements related to extension under voltage

There is no requirement in the ASSEMBLY standards for an ASSEMBLY to be capable of extension under voltage or otherwise. If the user requires an ASSEMBLY to be capable of extension, the user should specify the additional features required. These may include:

- sections equipped with busbars and enclosures made ready for extension to additional sections;
- circuit arrangements that permit some sections to be isolated whilst others are energized;
- particular constructional arrangements using some or all of barriers, compartments, obstacles, partitions, removable covers, doors, cover plates and covers.

There are no requirements for an ASSEMBLY to incorporate unequipped spaces, partially equipped spaces, or fully equipped spare functional units. These are defined as follows:

- *unequipped space* – a space within an ASSEMBLY suitable for the future installation of a functional unit. Normally, the space is equipped with mountings for the intended functional unit, but it would not include distribution busbar connections, auxiliary wiring, switchgear and controlgear associated with the functional unit, mechanisms for withdrawal or removal of the functional unit, or the functional unit itself.
- *partially equipped space* – a space within an ASSEMBLY that is equipped with one or more of distribution busbar connections, auxiliary wiring, switchgear and controlgear associated with the functional unit, mechanisms for withdrawal or removal of the functional unit (but not the functional unit itself).
- *fully equipped spare functional unit* – a complete functional unit within the ASSEMBLY, which has no dedicated application at the initial installation but may be required for service at some time in the future.

If the user requires an ASSEMBLY to be provided with any of these facilities, they should be specified.

12.5 Protection against direct contact with hazardous live internal parts during maintenance or upgrade

Users should detail in their specification any maintenance and upgrade functions to be carried out while all or part of the ASSEMBLY is energized. See also 12.3 and 12.4 above.

12.6 Removable functional units – methods of connection

The user has the opportunity to specify the means of connecting removable functional units within the ASSEMBLY. The options are denoted by a three-letter code:

– the first letter denotes the type of electrical connection of the main incoming supply to the functional unit;
– the second letter denotes the type of electrical connection of the main outgoing supply from the functional unit;
– the third letter denotes the type of electrical connection of the auxiliary circuits.

Each of the three letters in the code is selected from the following and is determined by the type of connection required:

– F for fixed connections;
– D for disconnectable connections;
– W for withdrawable connections.

As an example, a removable functional unit having withdrawable supply connections, fixed outgoing connections and disconnectable auxiliary circuits would be allocated the code WFD.

12.7 Operating and maintenance gangways within an ASSEMBLY

Operating and maintenance gangways within an ASSEMBLY should comply with the requirements for basic protection (see 7.2). The requirement for such gangways should be specified by the user and, where required, the design and construction agreed with the manufacturer.

Recesses within an ASSEMBLY of limited depth, in the order of 1 m, are not considered to be gangways.

12.8 Internal separation

Typical arrangements of internal separation by barriers or partitions are described in Table B.1 and are classified as forms, for diagrammatical representations see Annex B.

Internal separation may be used to attain one or more of the following conditions between functional units, separate compartments or enclosed protected spaces:

– protection against contact with hazardous parts. The degree of protection shall be at least IP XXB;
– protection against the passage of solid foreign bodies. The degree of protection shall be at least IP 2X.

NOTE The degree of protection IP 2X covers the degree of protection IP XXB.

Separation may be achieved by means of partitions or barriers (metallic or non-metallic), insulation of live parts or the integral housing of a device, e.g. a moulded case circuit breaker.

The form of separation, and higher degrees of protection where required, should be specified by the user.

13 Current carrying capability

13.1 General

The current carrying capability of an ASSEMBLY is defined as the maximum current that can be continuously carried without damage or increased risk of failure through overheating or other mechanisms.

Current carrying capabilities are verified to a standard set of ambient and temperature rise limits. Users may specify lower or higher ambient temperatures, or lower temperature rise limits, if their application requires.

13.2 Rated current I_{nA} (A) (maximum current allowable)

The rated current of the ASSEMBLY (I_{nA}), is the maximum load current the ASSEMBLY is designed to manage and distribute. It is the smaller of the sum of the rated currents of the incoming circuits within the ASSEMBLY that are operated in parallel, and the total current which the main busbar is capable of distributing in the particular ASSEMBLY arrangement.

The user should specify the rated current of the ASSEMBLY **(I_{nA})** as relevant to his or her application.

13.3 Rated current of circuits I_{nc} (A)

For this particular application, the user should specify the rated current of all the incoming and outgoing circuits that are required within the ASSEMBLY. The manufacturer will then select the appropriate components to achieve these circuit ratings, by taking into consideration the ratings of the devices within the circuit, their disposition and application within the ASSEMBLY.

In the absence of any user specification for the rated current of circuits, the manufacturer will state the rated currents of circuits of the ASSEMBLY within the documentation.

13.4 Rated diversity factor (RDF)

All circuits within an ASSEMBLY are individually capable of carrying continuously the rated current assigned to them, but the current carrying capacity of any circuit may be influenced by adjacent circuits. This thermal interaction is such that, if a group of adjacent circuits within an ASSEMBLY are to operate at rated current at the same time, significant de-rating of components is necessary to ensure there is no overheating.

In practice, it is extremely unlikely that all circuits, or a group of adjacent circuits, within an ASSEMBLY will be required to carry their rated current continuously and simultaneously. Within a typical application the type and nature of loads differ appreciably. Some circuits will be rated on the basis of inrush currents and intermittent or short duration loads. A number of circuits may be heavily loaded while others are lightly loaded or switched off.

Diversity is a pragmatic approach to this practical situation. It recognises that all outgoing circuits will not normally be fully loaded at the same time and thereby avoids the need to provide over-designed equipment for the actual application. The rated diversity factor specifies the average loading conditions for which the ASSEMBLY, or a group of circuits within an ASSEMBLY, is designed. For example, in the case of an ASSEMBLY with a diversity factor 0,8, any combination of outgoing circuits within an ASSEMBLY can be loaded to 80 % of their rated current, provided the total load on the outgoing circuits does not exceed the rated current of the ASSEMBLY.

Rated diversity factor(s) can be specified by the user to suit the application, or stated by the manufacturer, for:

– groups of circuits;
– the whole ASSEMBLY.

13.5 Ratio of cross-section of the neutral conductor to phase conductors

13.5.1 General

In the majority of three-phase networks, the load on the three phases is reasonably balanced. This generally results in a current in the neutral that is much less than the corresponding

phases. However, some loads, particularly those with significant harmonics, can lead to increased neutral currents. The neutral conductor cross-sectional area will be as follows:

13.5.2 Phase conductors up to and including 16 mm^2

For circuits with a phase conductor, cross-sectional area up to and including 16 mm^2, 100 % of that of the corresponding phases.

The user may specify an alternative ratio if deemed necessary for the application.

13.5.3 Phase conductors above 16 mm^2

For circuits with a phase conductor cross-sectional area above 16 mm^2, 50 % of that of the corresponding phases with a minimum of 16 mm^2 .

The user may specify an alternative ratio if deemed necessary for the application.

14 ASSEMBLY design and routine verification processes

14.1 Design verification

14.1.1 Object

Design verification is intended to verify compliance of the design of an ASSEMBLY with the requirements of the relevant ASSEMBLY standard in the IEC 61439 series. Usually design verification is carried out on typical arrangements within a standard product range, and at the time the product is developed. An ASSEMBLY is not normally verified for a specific application, unless it includes significant deviations from the previously verified arrangement. The manufacturer is responsible for design verification.

Repetition of verifications in the product standards of switching devices or components incorporated in the ASSEMBLY is not required.

An ASSEMBLY which is verified in accordance with IEC 61439 by an original manufacturer and then manufactured or assembled by another does not require the original design verifications to be repeated if the requirements and instructions specified and provided by the original manufacturer are fulfilled.

14.1.2 Methods

The design of all ASSEMBLIES should be verified in accordance with the relevant ASSEMBLY standard. At the manufacturer's discretion, design verification may be achieved by means of testing, calculation and/or adherence to strict design rules. The various options for verification, when and where each can be used, are clearly defined and restricted as appropriate, within the IEC 61439 series of standards. All the permitted means of design verification are equivalent in terms of the performance achieved. In some instances, the performance of the ASSEMBLY may be affected by the verification tests (e.g., short-circuit test). Accordingly, these tests are not performed on a manufactured ASSEMBLY that is intended to be placed into service.

14.1.3 Records

The manufacturer will maintain a record of all design verifications, including data used, calculations and comparisons made and the result of tests carried out. These design verification test records form part of the manufacturer's intellectual property. Such proprietary information will not normally be made available to any third party including the user, except at the manufacturer's sole discretion.

14.2 Routine verification

14.2.1 General

Routine verification is carried out on every ASSEMBLY that is manufactured, normally prior to it being dispatched from the manufacturer's works. It is intended to detect faults in materials and workmanship and to confirm correct and proper functioning of the manufactured ASSEMBLY. The manufacturer determines if routine verification is carried out during and/or after manufacture.

Routine verification is not required to be carried out on devices and self-contained components incorporated in the ASSEMBLY.

Routine verification of the ASSEMBLY is carried out employing test, inspection or comparison with manufacturer's instructions as detailed in the relevant ASSEMBLY standard.

Generally, three methods are used for routine verification of the construction and performance of the ASSEMBLY:

- Verification by testing is used for:
  - clearances and creepage distances,
  - protection against electric shock and integrity of protective circuits (for bolted connections),
  - terminals for external conductors (connections),
  - mechanical operation, and
  - dielectric properties.
- Verification by visual inspection is used for:
  - degree of protection of enclosures,
  - clearances and creepage distances (for limited conditions),
  - protection against electric shock and integrity of protective circuits (for effective continuity between the exposed conductive parts of the ASSEMBLY and the protective conductor, and effectiveness of the ASSEMBLY for external faults).
- Verification to the component manufacturer's and original manufacturer's instructions, where appropriate, are used for:
  - incorporation of switching devices and components,
  - internal electrical circuits and connections, and
  - terminals for external conductors (connections).

14.2.2 Records

Where the user requires details of the ASSEMBLY'S routine verification, it should be requested in the user's specification.

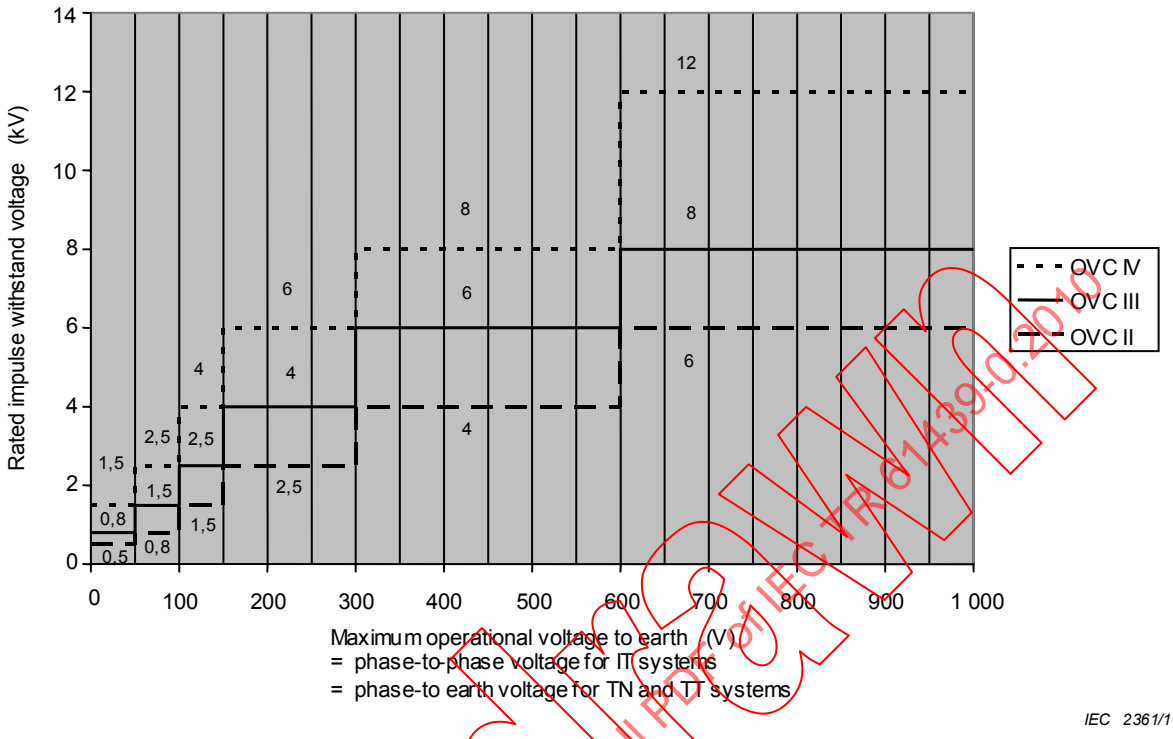


Figure 1 – Required rated impulse withstand voltage

Annex A
(informative)

Cross-section of copper conductors suitable for connection to terminals for external conductors

Table A.1 applies for the connection of one copper cable per terminal.

Table A.1 – Cross-section of copper conductors suitable for connection to terminals for external conductors

Rated current	Solid or stranded conductors		Flexible conductors	
	Cross-sections		Cross-sections	
	min.	max.	min.	max.
A	mm^2		mm^2	
6	0,75	1,5	0,5	1,5
8	1	2,5	0,75	2,5
10	1	2,5	0,75	2,5
13	1	2,5	0,75	2,5
16	1,5	4	1	4
20	1,5	6	1	4
25	2,5	6	1,5	4
32	2,5	10	1,5	6
40	4	16	2,5	10
63	6	25	6	16
80	10	35	10	25
100	16	50	16	35
125	25	70	25	50
160	35	95	35	70
200	50	120	50	95
250	70	150	70	120
315	95	240	95	185

If the external conductors are connected directly to built-in apparatus, the cross-sections indicated in the relevant specifications are valid.

In cases where it is necessary to provide for conductors other than those specified in the table, special agreement should be reached between the manufacturer and the user.

Annex B
(informative)

Forms of internal separation (see 12.8)

This annex provides a description of the various forms of separation (see Table B.1) and related representation by diagrams (see Figures B.1, B.2 and B.3.).

Table B.1 – Forms of internal separation

Main criteria	Subcriteria	Form
No internal separation		Form 1
Separation of busbars from the functional units	Terminals for external conductors not separated from busbars	Form 2a
	Terminals for external conductors separated from busbars	Form 2b
Separation of busbars from the functional units and separation of all functional units from one another. Separation of terminals for external conductors and the external conductors from the functional units, but not from those of other functional units	Terminals for external conductors not separated from busbars	Form 3a
	Terminals for external conductors and external conductors separated from busbars	Form 3b
Separation of busbars from all functional units and separation of all functional units from one another. Separation of terminals for external conductors associated with a functional unit from those of any other functional unit and the busbars. Separation of the external conductors from the busbars but not necessarily from each other	Terminals for external conductors in the same compartment as the associated functional unit	Form 4a
	Terminals for external conductors not in the same compartment as the associated functional unit, but in individual, separate, enclosed protected spaces or compartments	Form 4b

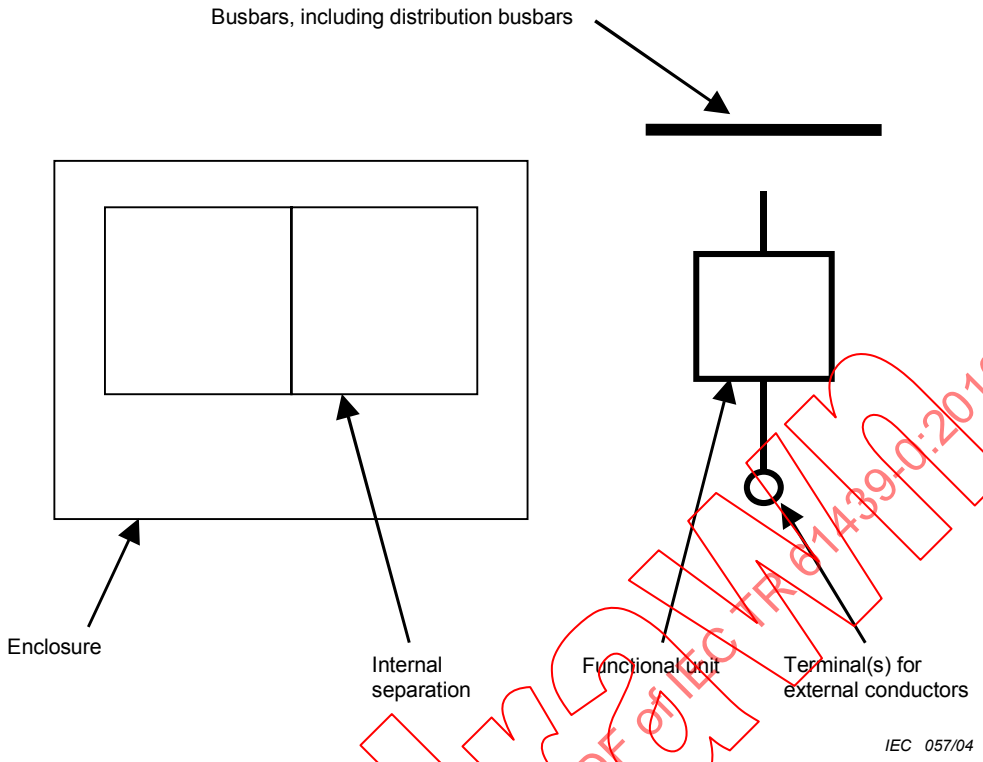
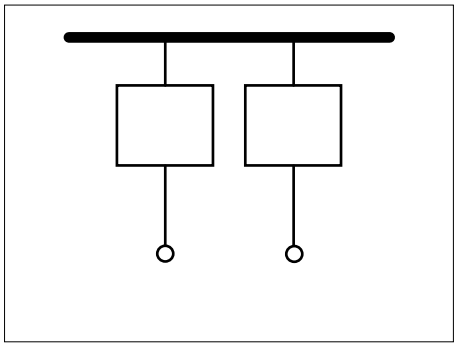


Figure B.1 – Symbols used in Figures B.2 and B.3

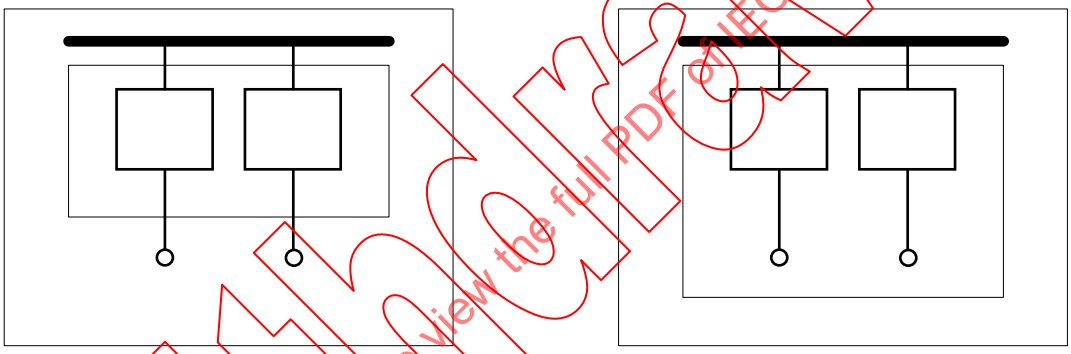
Form 1

No internal separation



Form 2

Separation of busbars from the functional units



Form 2a:
Terminals not separated from busbars

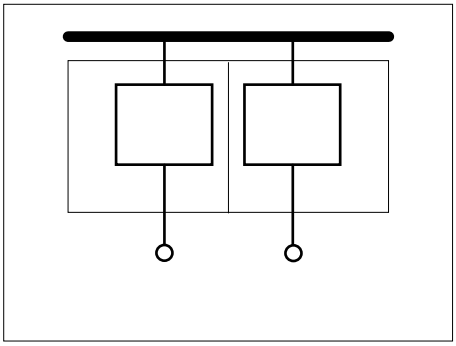
Form 2b:
Terminals separated from busbars

IEC 1121/99

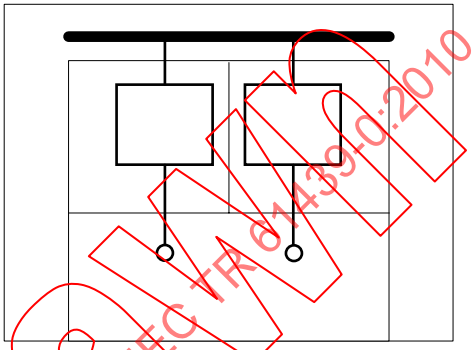
Figure B.2 – Forms 1 and 2

Form 3

Separation of busbars from all functional units
+
Separation of all functional units from one another
+
Separation of terminals for external conductors and external conductors from the functional units, but not from those of other functional units



Form 3a:
Terminals not separated
from busbars

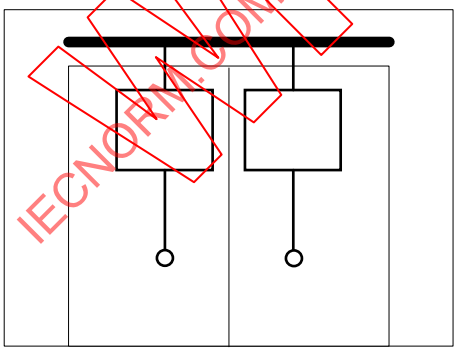


Form 3b:
Terminals and external
conductors separated from busbars

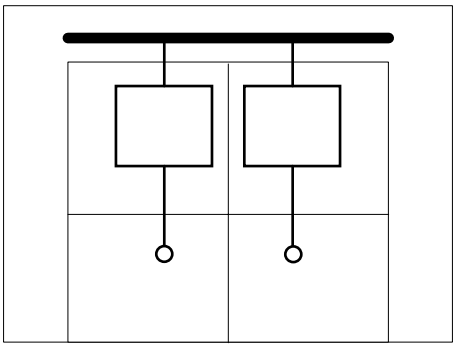
IEC 2362/10

Form 4

Separation of busbars from all functional units
+
Separation of all functional units from one another
+
Separation of terminals for external conductors associated with a functional unit from those of any other functional unit and the busbars. External conductors separated from the busbars but not necessarily from each other



Form 4a:
Terminals in same compartment
as associated functional unit



Form 4b:
Terminals not in same compartment
as associated functional unit

IEC 1123/99

Figure B.3 – Forms 3 and 4

Annex C
(informative)

Items subject to agreement between the ASSEMBLY manufacturer and the user for IEC 61439-2 ASSEMBLIES

C.1 Standard options

Table C.1 compiles information that the standard identifies as subject to an agreement between the ASSEMBLY manufacturer and the user. Unless specified otherwise, the default arrangement will apply. In some cases, information declared by the ASSEMBLY manufacturer may take the place of an agreement.

Table C.1 – Items subject to agreement between the ASSEMBLY manufacturer and the user

User defined characteristics	Reference clause or subclause	Default arrangement b)	Options listed in standard	User requirement a)
Electrical system	**5**			
Earthing system	5.2	Manufacturer's standard, selected to suit local requirements	TT / TN-C / TN-C-S / IT, TN-S	
Nominal voltage of the power supply (V)	5.3	Local, according to installation conditions	Max. 1 000 V a.c. or 1 500 V d.c.	
Transient overvoltages	5.4, 5.5	Determined by the electrical system	Overvoltage category I / II / III / IV	
Temporary overvoltages	5.5	Nominal system voltage + 1 200 V	None	
Rated frequency f_n (Hz)	5.6	According to local installation conditions	d.c. / 50 Hz / 60 Hz	
Additional on site testing requirements: wiring, operational performance and function	5.7	Manufacturer's standard, according to application	None	
Short-circuit withstand capability	**6**			
Prospective short-circuit current at supply terminals I_{cp} (kA)	6.2	Determined by the electrical system	None	
Prospective short-circuit current in the neutral	6.3	Max. 60 % of phase values	None	
Prospective short-circuit current in the protective circuit	6.4	Max. 60 % of phase values	None	
SCPD in the incoming functional unit	6.5	According to local installation conditions	Yes / No	
Co-ordination of short-circuit protective devices including external short-circuit protective device details.	6.6	According to local installation conditions	None	
Data associated with loads likely to contribute to the short-circuit current	6.7	No loads likely to make a significant contribution allowed for	None	

User defined characteristics	Reference clause or subclause	Default arrangement b)	Options listed in standard	User requirement a)
Protection of persons against electric shock in accordance with IEC 60364-4-41	**7**			
Type of protection against electric shock – Basic protection (protection against direct contact)	7.2	Basic protection	According to local installation regulations	
Type of protection against electric shock – Fault protection (protection against indirect contact)	7.3	According to local installation conditions	Automatic disconnection of supply / Electrical separation / Total insulation	
Installation environment	**8**			
Location type	8.2	Manufacturer's standard, according to application	Indoor / outdoor	
Protection against ingress of solid foreign bodies and ingress of water	8.3	Indoor (enclosed): IP 2X Outdoor (min.): IP 23	IP 00, 2X, 3X, 4X, 5X, 6X	
Protection after removal of withdrawable part	8.3	Manufacturer's standard	As for connected position / reduced protection to manufacturer's standard	
External mechanical impact (IK)	8.4	None	None	
Resistance to UV radiation (applies for outdoor assemblies only unless specified otherwise)	8.5	Indoor: not applicable. Outdoor: temperate climate		
Resistance to corrosion	8.6	Normal Indoor/Outdoor arrangements		
Ambient air temperature – Lower limit	8.7	Indoor: –5 °C Outdoor: –25 °C	None	
Ambient air temperature – Upper limit	8.7	40 °C	None	
Ambient air temperature – Daily average maximum	8.7	35 °C	None	
Maximum relative humidity	8.8	Indoor: 50 % at 40 °C Outdoor: 100 % at 25 °C	None	
Pollution degree	8.9	Industrial: 3	1/2/3	
Altitude	8.10	≤ 2 000 m		
EMC environment (A or B)	8.11	A or B according to the application	A/B	
Special service conditions (e.g. vibration, exceptional condensation, heavy pollution, corrosive environment, strong electric or magnetic fields, fungus, small creatures, explosion hazards, heavy vibration and shocks, earthquakes)	8.12	No special service conditions		