IEC specifications for LV assembly switchboards

Schneider Electric

Within the IEC 61439 series of standards for low-voltage switchgear and controlgear assemblies (**Assemblies**) a variety of data need to be specified by the user to enable the **Assembly** Manufacturer (shortly the Manufacturer) to meet his expectations.

In any case, the user is responsible for properly specifying his needs while the Manufacturer is not only responsible for meeting these needs, but also for providing data and instructions necessary for proper utilization, maintenance and evolution of the actual **Assembly.**

To help the user of any Assembly to the IEC 61439 standards to properly specify his needs, this Guide identifies the various data to be specified, including some of them not considered in IEC 61439-X, and explains the corresponding Manufacturer's commitments, especially through the information delivered with the **Assembly**.

Annex A provides a practical specification schedule to be used as the main piece of a contract or before purchasing a product Assembly.

This guide covers the characteristics common to all **Assemblies**.
For some specific characteristics, such as voltage drop for Busbar Trunking System, it will be necessary to interpret and complete it.

To give the priority to the user's point of view, contrary to IECTR 61439-0, and while remaining compatible with the IEC 61439 standards, this Guide is broken down according to 10 user's functions as identified in 1.1.

Note

The user is the party who specifies or selects the Assembly characteristics, i.e. the party who will use and operate the Assembly, or a party acting on his behalf.

Throughout this guide, an "Assembly standard" is a part of the IEC 61439 series other than Part 1; all other normative references can be found in Clause 2 of IEC 61439-1 and of the various Assembly standards.

Contents

General

User's functions

The basic function of an Assembly is to house the electrical equipment (switching devices, other power devices, phase, neutral, and protective conductors, auxiliary circuits...) intended to operate an electrical installation as specified through the overall system diagram and associated data.

Excluding the design of this overall system diagram according to the relevant standards, which is out of the scope of the IEC 61439 series of standards and of this guide, safety and power availability will depend on three kinds of user's functions:

- Operating, maintenance and modification capabilities:
  - Capability to operate the electrical installation
  - Maintenance and modification capabilities
  - Capability to be installed on site.
- Protection of persons and livestock against any hazards due to the Assembly itself:
  - Protection of persons and livestock against electric shock
  - Protection of persons against risk of fire or explosion.
- Control of various interactions which are not dealt with in the switching device and enclosure standards, especially when the Assembly is optimized for specific devices:
  - Voltage stresses withstand capability
  - Current carrying capability
  - Short-circuit withstand capability
  - Electro-Magnetic Compatibility (EMC)
  - Protection of the Assembly against environmental conditions.

User's needs and Manufacturer's commitments

The various needs to be specified by the user include the expected "operating facilities", the ratings of the electrical installation the Assembly is intended to be connected to *(see page 5),* the external influences (i.e. environmental conditions (codified AXi), utilisation (codified BXi) and construction of buildings (codified CXi), according to 512.2 of IEC 60364-5-51) *(see page 6)*, and possible local safety standards, regulations or practices it will be subject to.

As far as possible, these data will be defined so as to let the Manufacturer free to select any architecture, devices, materials and technological details, while properly using the various devices and materials.

The Manufacturer will state the electrical and environmental ratings of the actual Assembly as well as any instructions for use.

Ratings of the electrical installation

Voltages and frequencies

The main depending function is capability to operate the electrical installation.
See page 6.

Design currents

The main depending function is current carrying.
See page 9.

Prospective short circuit currents

The main depending function is short-circuit protection and short-circuit withstand.
See page 11.

Voltage stresses

The main depending function is insulation coordination (functional insulation and basic and fault insulation).
See page 7 to 8.

External influences

Ambient air temperature and relative humidity (indoor / outdoor) (1)

Unless otherwise specified, an indoor Assembly will be assumed to operate at ambient air temperatures between -5°C and +40°C (according to AA4), with an average over a period of 24 h not exceeding +35°C.

Unless otherwise specified, an outdoor Assembly will be assumed to operate at ambient air temperatures between -25°C and +40°C, with an average over a period of 24 h not exceeding +35°C.

Unless otherwise specified, an indoor Assembly will be assumed to operate at air relative humidity not exceeding 50 % at a maximum temperature of +40°C. Higher relative humidity may occur at lower temperatures, for example 90 % at +20°C. Moderate condensation should be borned in mind which may occasionally occur due to variations in temperature.

Unless otherwise specified, an outdoor Assembly will be assumed to operate at air relative humidity temporarily as high as 100 % at a maximum temperature of +25°C, with occasional moderate condensation due to variations in temperature.

Altitude (2)

Unless otherwise specified, the Assembly will be assumed to operate at a low altitude, i.e. not exceeding 2000 m, according to AC1.

Pollution (3)

The degree of pollution is intended to characterize the expected pollution according to the principles of insulation coordination within the installation.
See IEC 60664-1.

- Unless otherwise specified:

- An indoor Assembly for industrial or similar applications will be assumed to operate in a pollution degree 3 environment, where conductive pollution occurs, or dry, non-conductive pollution occurs which is expected to become conductive due to condensation;
- An indoor Assembly for commercial or similar applications will be assumed to operate in a pollution degree 2 environment, where only non-conductive pollution occurs, except that, occasionally, a temporary conductivity caused by condensation is to be expected.

The user will specify particularly onerous conditions according to environments AF2 to AF4 (exposure to sea spray, corrosive or polluting smokes, dust, particles or vapours…).

Mechanical constraints

See page 21.

Electromagnetic, electrostatic, or ionising influences

See clause 6 of IEC 61439-1&2.

Presence of water and of foreign solid bodies

See page 21.

Capability of persons

Such operations as operating man machine interfaces (MMI) (see page 6), or mechanical or electrical work on the installation operated by the Assembly (see page 7), or maintenance or modification on internal parts of the Assembly should not be allowed to ordinary persons (BA1), but only allowed to specifically empowered persons, usually skilled (BA5) or instructed persons (BA4), depending upon local safety standards and regulations. See definitions in IEC 61439-1.

The user is responsible for identifying and specifying the relating requirements.
The Manufacturer will precisely state the relating characteristics.

Miscellaneous

- The user should specify any onerous conditions such as:

- Solar radiation, likely to affect current carrying or resistance to UV radiation;
- Presence of fungus or small creatures…

Note

(1) Main depending characteristics: rated currents (see page 9) and resistance to corrosion (see page 21).

(2) Main depending characteristics: rated currents (see page 9), rated short-circuit currents (see page 12) and rated impulse withstand voltage (see page 8).

(3) The pollution degree inside the Assembly may be different from the ambient pollution degree.

Main depending characteristics: creepage distances (see page 14) and resistance to corrosion (see page 21).

Capability to operate the electrical installation

Function

Besides housing the electrical equipment according to the overall system diagram and data the user may require the Assembly to provide operating facilities such as:

- Safe, and possibly controlled, access to man-machine interfaces (MMI),
- Safe access to the circuits and equipment of the installation on the load-side of the Assembly in order to perform electrical or mechanical maintenance on the installation…

Installation diagram (1)

The user will provide an electrical single line diagram, and specify the distribution system (system of live conductors and system earthing), all ratings of the electrical installation, the required facilities and any other requirements for the Assembly.

For the protective circuit, *see page 19.*

Possible future upgrading or addition of outgoing circuits should be specified (number, type…), *see also page 16.*

Voltages and frequencies (2)

The user will specify the nominal voltage and frequency of the system and of each of the circuits designed for different voltages or frequencies, if any.

The rated voltage Un and the rated frequency fn, or range of rated frequencies, of an Assembly, are the voltage and frequency at which it is capable of performing its specified functions.

The rated voltage of an Assembly will be at least equal to the nominal voltage of the system.

The rated operational voltage Ue of a circuit of an Assembly, if different from the rated voltage of the Assembly, will be at least equal to the nominal voltage of this circuit.

Standard rated frequencies are d.c., 50 Hz, and 60 Hz. Unless otherwise stated by the Manufacturer, the Assembly will be suitable for frequencies within 98 % to 102 % of the rated frequency.

Note

(1) These elements and all provisions relating to protection against overloads, short-circuits, (including coordination of protective devices), overvoltages, electric shock... should be specified according to the principles and technical requirements for the design and erection of electrical installations specified by the IEC 60364 series, IEC 60092-302 (ships), IEC 61892 (off-shore units), IEC 60204-1 (machines), IEC 61992-6 (railway applications) or any other relevant standards.

The auxiliary circuits are expected to take account of the supply earthing system and ensure that an earth-fault or a fault between a live part and an exposed conductive part does not cause unintentional dangerous operation.

The wiring diagram should be in accordance with IEC 61082.

(2) Connecting a circuit of an Assembly to a supply outside its rated voltage or frequency can result in the Assembly not operating correctly or being damaged.

Access to man-machine interfaces (MMI)

Access to man-machine interfaces (MMI) may be specified so that it is possible to:

- Read visual signals of lights, displays, screens…,
- Operate handles, pushbuttons…,
- Verify switching devices, settings and indicators… by visual inspection,
- Adjust and reset relays, releases and electronic devices…

The user should specify that the degree of protection against access to hazardous live parts according to IEC 60529 is at least equal to IP XXB when accessing to MMI (1). *See page 14.*

The user may specify that operation of specified devices be restricted to authorized persons only. Unless otherwise specified, the relating means will be able to withstand 200 operating cycles. Specific requirements such as types of locking may be specified.

Unless otherwise specified, MMI of a floor-standing Assembly will be situated at such a height that they can easily be read or operated; their centreline will 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.

Unless otherwise specified by the user or stated by the Manufacturer, the operational positions of MMI will be identified according to IEC 60447, and the colours of indicator lights and push-buttons will be in accordance with IEC 60073.

Isolating the external load-side circuits

The user should assess his needs for continuity of supply during any mechanical or electrical works on the external load-side circuits and equipment, and determine whether one or more isolating device(s) should be installed in the incoming unit, or in specified outgoing circuits of the Assembly to isolate the corresponding external circuits, or whether it is possible to use the isolating device at the origin of the upstream circuit.

These devices, especially off-load ones, will prevent unintentional closure or opening (2).

Isolating devices, including the associated locking means, will be able to withstand 200 operating cycles. Specified test facilities of external control circuits may be required (3).

In the run of protective conductors, links removable by means of a tool and accessible to authorized persons only may be required for certain tests.

Note

(1) Operating MMI located inside the enclosure, or replacing lamps or fuse links, should be considered as maintenance.

(2) This may be achieved by padlocking, or locating the device in a lockable space or enclosure, or by interlocking the device with a load breaking one...

(3) Such test facilities can be provided by withdrawable parts according to 8.5.2.103 of IEC 61439-2.

Voltage stresses withstand capability

Function

An Assembly must be able to withstand long term voltages, and temporary and transient overvoltages.

Voltage stress during a long period of time

Capability of withstanding voltage stress during a long period of time is characterized by the rated insulation voltage Ui. The rated insulation voltage of a circuit of an Assembly Ui will be at least equal to its operational voltage Ue.

Temporary overvoltages

Capability of withstanding is characterized by the power frequency withstand voltage. Unless otherwise specified, the r.m.s. value of the power frequency withstand voltage will be at least equal to Ui + 1200 V for a maximum duration of 5 s (1).

Transient overvoltages

Capability of withstanding transient overvoltages is characterized by the rated impulse withstand voltage Uimp. Unless otherwise specified, Uimp will be at least equal to the relevant value from Table 1 depending on the nominal voltage of the supply system and on the place of installation of the Assembly.

Table 1 – Rated impulse withstand voltage Uimp (2)

Nominal voltage Un of the supply system	Rated impulse withstand voltage	
	Main Assembly (Overvoltage category IV)	**Distribution Assembly** (Overvoltage category III)
V	**kV**	**kV**
120 - 240 (single phased)	4	2.5
230 / 400	6	4
400 / 690	8	6
690 / 1000	12	8

Insulation

These voltage stresses and the relating rated characteristics will be used to design and verify insulation for basic and fault insulation *(see clause 7 of IEC 61439-1&2)*, as well as functional insulation, between active conductors, necessary for proper functioning of the Assembly.

Creepage distances will be designed and verified according to the rated insulation voltage Ui.
Solid insulation will be designed and verified according to the rated power frequency withstand voltage and to the rated impulse withstand voltage Uimp. Clearances will be designed and verified according to the rated impulse withstand voltage Uimp.

For the a.c. or d.c. auxiliary circuits which do not operate directly from the main circuit, or with means for reduction of overvoltage, Uimp will depend on the actual conditions for that circuit (3).

In case of exceptional overvoltage conditions, protection may be necessary e.g. by use of surge protective devices (SPD) *(see page 7 of IEC 61439-1)*.

Note

(1) This value is based on clause 442 of IEC 60364-4-44 dealing with temporary overvoltages caused by fault between the high-voltage system and earth, loss of the neutral in a low-voltage TN and TT system, accidental earthing of a low-voltage IT system, and short-circuit in the low-voltage installation.

(2) These values of the rated impulse withstand voltage are based on clause 443 of IEC 60364-4-44 dealing with transient overvoltages of atmospheric origin transmitted by the supply distribution system and switching overvoltages generated by the equipment within the installation.
Connecting a circuit of an Assembly to a supply outside its rated voltage stresses can result in altered protection against electric shock or in the Assembly being damaged.

(3) Besides voltage stresses, insulation properties are sensitive to ambient air temperature and relative humidity (see page 5), to pollution (see page 5), to altitude (see page 5), to external mechanical stress (see page 21), and to internal stresses, such as temperature rise (see page 9) and short-circuits (see page 11).

Current carrying

Function

An Assembly must be able to withstand mutual heating of devices and conductors, by conduction, convection or radiation, and to carry the specified currents so that it ensures:

- Protection of persons against burns from accessible enclosures, depending on whether they need or not be touched during normal operation, and hand-held means of operation,
- Protection of the Assembly against damage, especially to current-carrying parts and parts made of insulating materials.

An Assembly will be so constructed that, within specified ambient air temperature and specified current ratings, none of its various parts will exceed the temperatures limit compatible with the materials they are made of, with the incorporated equipment, and with protection of persons against burns (1).

Note

(1) Economical or environmentally friendly operation may also be required.

External influences

See page 5.

The user should specify such onerous conditions as installation likely to affect the cooling conditions (equipment intended for surface mounting but recessed into walls or built into machines), solar radiation higher than AN2…

Design currents (or assumed load currents)

In practice, it is extremely unlikely that all circuits, or groups of adjacent circuits 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.

Therefore, besides the electrical diagram which includes the design currents of the circuits, the user should provide information about the actual loads, such as load patterns or thermal equivalent true r.m.s currents; see Annex E of IEC 61439-1.

Rated currents and rated diversity factor

The rated current of an outgoing circuit Inc is the value of the current that can be carried by this circuit loaded alone, for ambient air temperatures according to page 5 (ambient air temperature and relative humidity), without the temperatures obtained to cause damage to current-carrying or adjacent parts, or excessive surface temperatures.

The rated current of the circuits will be equal to or higher than the design current (or assumed loading current) of the outgoing circuits. The Rated Diversity Factor recognizes that multiple functional units are in practice not fully loaded simultaneously or are intermittently loaded, so reducing the mutual thermal influences.

Different Rated Diversity Factor may be stated for:

- Groups of outgoing circuits,
- All the outgoing circuits of the Assembly.

Within each of these groups, including the complete Assembly, the sum of the rated currents multiplied by the Rated Diversity Factor shall be equal to or higher than the assumed loading currents.

The rated current of the Assembly InA is the total current that can be carried by the Assembly, for ambient air temperatures according to "Ambient air temperature and relative humidity" page 5, without the temperatures obtained to cause risk of burns or damage to current-carrying or adjacent parts (2).

In case of lack of information relating to the actual load currents, the Manufacturer will select and declare appropriate Rated Diversity Factor values, preferably from the following conventional values.

Note

(2) The rated current of the Assembly is generally limited by the incoming unit(s) or by the main busbar.

Rated currents and rated diversity factor (cont.)

Table 2 – Conventional rated diversity factors for PSC-Assemblies (IEC 61439-2)

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

Table 3 – Conventional rated diversity factors for Distribution Boards (IEC 61439-3) (1)

Number of outgoing circuits	Diversity factor (DF)
2 and 3	0.8
4 and 5	0.7
6 to 9 inclusive	0.6
10 and above	0.5

If special precautions are required at the place of installation to ensure proper cooling, the Manufacturer will furnish the necessary information, for instance indication of the need for spacing with respect to parts that are liable to impede the dissipation of heat or produce heat themselves (2).

Note

(1) The rated diversity factor of a Busbar Trunking System is equal to 1 because thermal influences between tap-off units are negligible; however a rated diversity factor should be specified for tap-off units with several outgoing circuit.

(2) In the case of high currents, the current carrying capability may be affected by connecting a circuit of an Assembly to a supply with a frequency outside its intended range. See 1.3.1 of IEC 61439-1&2.

Unbalanced currents and harmonic currents

Unless otherwise specified, it will be assumed that there are no unbalanced phase currents or 3rd, 9th, 12th… harmonic currents and that the phase currents are not modified and the neutral conductors are not loaded. In case of significant harmonic currents, especially third harmonic currents.

Short circuit withstand capability

Function

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 and resulting in lower air insulation,
- Overpressure due to arc breaking and resulting in high forces applied to the enclosure.

Assemblies will be so constructed that an internal short-circuit is not to be expected and that short-circuit currents not exceeding the rated values do not impair the condition of the equipment incorporated in the Assembly or any of its functions.

Prospective short-circuit currents

The prospective short-circuit current (Icp) at the point the Assembly is connected into the system is the current which flows when the supply conductors to the circuit are short-circuited by a conductor of negligible impedance located as near as practicable to the supply terminals of the Assembly. In an a.c. circuit, it comprises a peak current and a symmetrical current.

It may be specified 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 as limited by the operation of an upstream protective device.

Unless otherwise specified, the prospective peak short-circuit current will be assumed to be a function of the symmetrical short-circuit current according to Table 4.

Table 4 – Factor n (1)

r.m.s. value of short-circuit current	cos φ	n
kA		
I ≤ 5	0.7	1.5
5 < I ≤ 10	0.5	1.7
10 < I ≤ 20	0.3	2
20 < I ≤ 50	0.25	2.1
50 < I	0.2	2.2

Note

(1) In special locations, for example in the vicinity of transformers or generators, lower values of power factor may be found, whereby the maximum peak current may become the limiting value instead of the r.m.s. value of the symmetrical short-circuit current.

Rated short-circuit currents

The rated short-circuit currents of the Assembly will be at least equal to the relevant components of the prospective short-circuit current.

For an Assembly not protected by a current limiting device[1]:

- The rated peak withstand current Ipk will be equal to or higher than the peak value of the prospective short-circuit current,
- The rated short-time withstand current Icw will be equal to or higher than the r.m.s. value of the prospective short-circuit current, for a specified duration.

For an Assembly protected by a specified current limiting device, the rated conditional short-circuit current will be equal to or higher than the r.m.s. value of the prospective short-circuit current limited by this current limiting device for the operating time of that device.

For an Assembly having several incoming units which are unlikely to be in operation simultaneously, the short-circuit ratings will be indicated for each of the incoming units in accordance with the above.

For an Assembly having several incoming units which are likely to be in operation simultaneously, and for an Assembly having one incoming unit and one or more outgoing high-power units likely to contribute to the short-circuit current, it is necessary to determine the values of the prospective short-circuit current in each incoming unit, in each outgoing unit and in the busbars based on data provided by the user.

In three-phase circuits the fault current, in the neutral circuit is reduced, relative to the three-phase short-circuit current, by the impedance in the neutral circuit. Unless otherwise specified, the short-circuit current in the neutral circuit will be assumed not to exceed 60 % of the three-phase value.

Similarly, in three-phase circuits, the fault current in the protective circuit is reduced, relative to the three-phase short-circuit current, by the impedance in the protective circuit. Unless otherwise specified, the short-circuit current in the protective circuit will be assumed not to exceed 60 % of the three-phase value.

Note

(1) Unless otherwise specified the duration for Icw is 1 s.

For times up to a maximum of 3 s, the relationship between Icw and the associated time is given by the formula I2t = constant, provided that the peak value does not exceed Ipk.

Short-circuit protective devices

The user may specify that a short-circuit protective device (SCPD) be included in the Assembly, excluded from the Assembly, or accept the Manufacturer recommendation.

Where the short circuit withstand is characterized by a rated conditional short-circuit current Icc the Manufacturer will indicate the characteristics of the current limiting protective device, either incorporated in the Assembly or not.

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

Electro-Magnetic Compatibility (EMC)

Function

Assemblies must not:

- Be too sensitive to electromagnetic internal or external disturbances,
- Generate too high disturbances.

Electromagnetic environment

Two typical sets of electromagnetic influences are considered:

- **Environment A** [1] relates to low-voltage non-public or industrial networks / locations / installations including highly disturbing sources, such as arc welders.
- **Environment B** [2] relates to low-voltage public networks such as domestic commercial and light industrial locations / installations.

The user will specify either Environment A or B; conversely the Manufacturer will state the environment A and/or B the Assembly is suitable for.

Note

(1) Environment A
Corresponds to: Equipment Class A in CISPR 11 and to IEC 61000-6-4.

Industrial locations are characterized by one or more of the following conditions:

- industrial, scientific and medical apparatus, e.g. working machines are present;
- heavy inductive or capacitive loads are frequently switched;
- currents and associated magnetic fields are high.

(2) Environment B
Corresponds to: Equipment Class B in CISPR 11 and to IEC 61000-6-3.

The following list, although not comprehensive, gives an indication of locations included.

- residential properties, e.g. houses, apartments;
- retail outlets, e.g. shops, supermarkets;
- business premises, e.g. offices, banks;
- areas of public entertainment, e.g. cinemas, public bars, dance halls;
- outdoor locations, e.g. petrol stations, car parks, sport centres;
- light-industrial locations, e.g. workshops, laboratories, service centres.present;
- heavy inductive or capacitive loads are frequently switched;
- currents and associated magnetic fields are high.

Emission / Immunity

Under both environment A or B, Assemblies are deemed to satisfy the immunity and emission requirements provided:

- The incorporated devices and components, especially electronic ones, are in compliance with the requirements for EMC for the stated environment as required by the relevant product or generic EMC standard.
- The internal installation and wiring is carried out in accordance with the devices and components Manufacturers‘ instructions (arrangement with regard to mutual influences, cable, screening, earthing, etc.).

Exposure to a more sensitive or disturbing electromagnetic environment, or to conducted and radiated disturbances other than electromagnetic will be the subject of a special agreement.

The Manufacturer will provide the measures to be taken, if any, with regard to EMC associated with the installation, operation and maintenance of the Assembly.

Note

Such Assemblies are not sensitive to electromagnetic disturbances and can only generate disturbances during occasional switching operations, the duration of which is of the order of milliseconds. The frequency, the level and the consequences of these emissions are considered as part of the normal electromagnetic environment of low-voltage installations. Otherwise they will be verified to a standard set of immunity and emission tests.

Protection of persons and livestock against electric shock

Function

Persons and livestock nearing and operating the Assembly must be protected against electric shock, which means hazardous-live-parts must not be accessible, and accessible conductive parts must not be hazardous live, either under normal conditions (basic protection or protection against direct contact), or under single-fault conditions (fault protection or protection against indirect contact).

Basic protection is provided by the following measures:

- Protection against access to hazardous live parts,
- Basic insulation, made of appropriate dielectric properties of clearances, creepage distances and solid insulation between the accessible surfaces, either conductive or not, and hazardous live parts.

Fault protection is generally provided by one of the following measures:

- Automatic disconnection of supply [1];
  a Class I Assembly will be equipped with a protective equipotential bonding system providing an effective connection between the exposed conductive parts of the Assembly and the protective circuit.
- Total insulation providing both basic and fault protection.

Other protective measures may be used:

- Electrical separation of circuits, in which:
  - basic protection is provided by basic insulation between hazardous live parts and exposed conductive parts of a separated circuit,
  - fault protection is provided:
  - by simple separation of the separated circuit from other circuits and from earth;
  - by an earth-free protective equipotential bonding interconnecting exposed equipment parts of the separated circuit where more than one item of equipment is connected to the separated circuit.
- SELV or PELV,
- Combinations of different protective measures, each applying to different parts of the Assembly.

Additional protections apply to capability to operate the electrical installation according to clause 2, or to maintenance or modification capability according to clause 8 of IEC 61439-1&2.

Note

(1) In a TT-system installation protected by a single residual current protective device, the circuits on the supply side of the device must comply with the requirements for protection by the use of class II or equivalent equipment (according to IEC 60364-5-53).

Protection against access to hazardous live parts

Unless otherwise specified, the enclosure of the final Assembly installed in accordance with the Manufacturer's instructions will provide a degree of protection at least equal to IPxxB as codified by IEC 60529 (xxD for readily accessible horizontal top surfaces of enclosures having a height equal to or lower than 1,6 m above the standing area) [2].

It will be possible to open the enclosure only by the use of any mechanical aid such as a key or tool, or after isolation of the supply of the specified sections, restoration of the supply being possible only after replacement or reclosure of the enclosure. Any part of an enclosure that can be opened without using any mechanical aid will not be considered as an enclosure.

All devices intended for opening, closing, or locking any part of the enclosure, or for interlocking them with disconnectors, will be able of withstanding 200 operating cycles.

Note

(2) The degree of protection of parts of the Assembly, for example of the operating face, may differ from that of the main portion, provided it is specified / indicated separately. Examples:
IP00, operating face IPxxB; IPxxB, upper face IPxxD; IPxxC, mounted on a wall.

An open-type Assembly, or a dead front Assembly, the degree of protection from the front of which is at least IP XXB, with accessible hazardous-live-parts, may be specified, provided additional installation measures are taken by the user (e.g. installation of the Assembly in a location where access is only permitted for authorized personnel, or use of appropriate protective barriers or protective obstacles).

Protective equipotential bonding

All exposed conductive parts of the Assembly will be interconnected together and to the protective conductor of the installation in such a way that:

- The resistance of the circuits between any exposed conductive part to the terminal of the external protective conductor will not exceed 0.1 ohm,
- When a part of the Assembly is removed, for example for routine maintenance, the protective circuits for the remainder of the Assembly will not be interrupted,
- The continuity of the protective circuit of a withdrawable part will remain effective until the isolating distance is established, i.e. from the connected position to the isolated position or to the removed position inclusively.

Basic insulation

See page 8.

Class II or equivalent incoming circuits

Dielectric properties for supplementary insulation will be designed as for basic insulation. Dielectric properties for reinforced insulation will be designed as for double insulation (basic insulation plus supplementary insulation).

Total insulation (1)

The equipment will be completely enclosed in insulating material, which is equivalent of double or reinforced insulation.

The enclosure of the final Assembly installed in accordance with the Manufacturer's instructions will provide a degree of protection equal to IPxxC as codified by IEC 60529.

The enclosure will carry the graphical symbol no. 5172 of IEC 60417-2 ⧈ which will be visible from the outside.

Note

(1) According to 413.2.1.1 of IEC 60364-4-41, total insulation is equivalent to class II equipment.

Maintenance and modification capability

Function

Specific design provisions may improve the continuity of supply while ensuring safety for example when maintenance or modification operations need be performed with adjacent functional units or circuits being still under voltage.

Maintenance may include:

- Replacing components (lamps, fuse-links, switching devices or functional units…),
- Certain fault location operations, e.g. voltage and current measuring…,
- Thermo graphic measuring, visual inspection and tightening of conductor connections…,
- Verifying the proper functioning of the auxiliary circuits within the Assembly…

Modifications may include:

- Insertion and connection of additional functional units or groups,
- Extensions…

Maintenance and modification capability include:

- Capability for maintenance or modification on a dead Assembly,
- Capability for maintenance or modification on a live Assembly,
- Speed of exchange of functional units,
- Capability for extension of a live Assembly.

Implicit capability of the Assembly

For restoring protection against electric shock after the end of maintenance or modification operations, *see page 14.*

The Manufacturer will make it easy to understand the circuitry or provide suitable information, for example wiring diagrams or tables. Any designations used will be identical with those in IEC 61346-1.
Where appropriate, the identification according to IEC 60445 and IEC 60446 will be applied.

The Manufacturer will provide information for the operation and maintenance (recommended extent and frequency…) of the Assembly (1).

Capability for maintenance or modification on a dead Assembly

The user should assess his needs for continuity of supply during maintenance and/or modification of the Assembly and determine whether isolating device(s) should be installed in the incoming unit, or in specified sections of the Assembly to isolate the corresponding internal circuits.

In such a case the user should specify that the degree of protection against access to hazardous live parts belonging to the upstream circuits and connections or other sections is at least equal to IP XXB, as codified by IEC 60529 (2).

Unless otherwise specified, any isolating device will provide isolation according to either IEC 60947-3 or IEC 60364-4-53-536-2. These devices, especially off-load ones, will prevent unintentional closure or opening (3).

Isolating devices, including the associated locking means, will be able to withstand 200 operating cycles. The Manufacturer will include a warning plate if the Assembly contains items of equipment which may have steady-state touch current and charges after they have been switched off (capacitors, etc.) (4).

Note

(1) Parts likely to be removed should be fitted with retainable fastening means.

(2) Otherwise the user would have to rely on an isolating device situated at the origin of the upstream circuit.

(3) This may be achieved by padlocking, or locating the device in a lockable space or enclosure, or by interlocking the device with a load breaking one...

(4) Charges falling below a d.c. voltage of 60 V in less than 5 s after disconnection from the power supply and charges of small capacitors such as those used for arc extinction, for delaying the response of relays, etc., will not be considered dangerous.

Capability for maintenance or modification on a live Assembly

The user may specify supplementary requirements in order to perform maintenance and/or modification operations while the Assembly or specified parts of it are in service.

In such a case, the user should specify that:

- Access to specified internal areas is possible to authorized persons,
- The degree of protection against access to hazardous live parts from the specified areas is at least equal to IPxxB, as codified by IEC 60529, whether these live parts belong to this area, or to other compartments, or to the main busbar (1),
- The degree of protection against the passage of solid bodies from the specified areas to the other ones is at least equal to IP2X, as codified by IEC 60529 (2),
- Any internal parts, including internal partitions or obstacles, either conductive or not, which can be touched during the specified maintenance operations will be considered as exposed parts. See clause 7 of IEC 61439-1&2 (3).

The user may require provisions for safely removing specified functional units from the Assembly and replacing them even though the main circuit is live. Such provisions will prevent on-load removal and insertion (4).

Removable parts and their interlocking devices will be able to withstand 200 operating cycles. Unless otherwise specified by the user or stated by the Manufacturer, the degree of protection of an Assembly applies to the connected position of the removable (and/or withdrawable) parts (5).

Additionally, the user may require provisions for testing the internal auxiliary circuits relating to specified outgoing circuits while the main circuit is switched off (not necessarily disconnected) and the test situation is clearly discernible (6).

Speed of exchange of functional units

The user and the Manufacturer may make an agreement on a specified speed of exchange of specified functional units, either power off or on (7).

The Manufacturer should state the actual typical duration of such operation.

Capability for extension of a live Assembly

The user and the Manufacturer may make an agreement on versatility of spaces assigned to functional units so that any type of functional units may be inserted in any specified spaces.

Ability for extension of busbars while the Assembly is under voltage and/or for insertion and connection of additional outgoing cables when the existing cables are under voltage will be the subject of a special agreement

Note

(1) Openings larger than those defined by IPxxB can happen during the replacement of certain lamps or fuses.

(2) IP 2X covers IPxxB.

(3) IPxxB and IP 2X for any internal part brings the protection required by form of separation 4b according to see page 15 of IEC 61439-2. The user may also specify any other typical form of separation.

The user may also expressly specify only protection against unintentional access to hazardous internal parts according to a special agreement. In such a case, devices to be accessed will be easily accessible and sufficiently spaced out from the other devices and functional units.

(4) This may be achieved by padlocking, or locating the specified functional units in a lockable space or enclosure, or by interlocking it with a load breaking device...

Such facilities can be provided by removable parts according to page 15 of IEC 61439-1.

(5) Shutters according to page 7 of IEC 61439-1 may be specified to provide IPxxB and IP 2X when the functional unit is removed.

(6) Such test facilities can be provided by withdrawable parts according to 8.5.2.103 of IEC 61439-2.

(7) Such facilities can be provided by removable parts according to 8.5.2 of IEC 61439-1. For example the duration of exchange could be less than one hour where the connections of the main incoming circuit can be connected and disconnected without a tool, and less than one quarter of an hour where all the connections (main incoming circuit, main outgoing circuit and auxiliary circuits) can be connected and disconnected without a tool.

Capability to be installed on site

Function

Capability to be installed on site includes :

- Withstanding handling, transport, storage, (+ transport units),
- Capability to be erected,
- Capability to be connected.

Withstanding handling, transport, storage

The user will specify the conditions during transport, storage and installation, such as:

- Special measures to protect the transport units,
- Special measures to record excessive constraints during transport,
- Maximum size or weight of packed transport units,
- Temperature and humidity conditions, if they differ from the normal service conditions…

The Manufacturer will indicate the methods and measures of particular importance during transport, handling, and storage of the Assembly, such as weight details, the correct location, installation and thread size of lifting means…

Capability to be erected (1)

Unless otherwise specified, an Assembly is stationary. The user may specify a movable Assembly.

The user may specify a typical mode of erection of the Assembly, such as a wall mounted or a floor-standing cubicle-type Assembly, or a specific arrangement, such as a desk-type or a recessed type Assembly.

The user will specify any constraints such as maximum overall dimensions and weight. In any case the corresponding characteristics will be provided by the Manufacturer, as well as any conditions for the installation, including floor flatness conditions, if any.

Note

(1) The user may also specify aesthetical requirements, for example the colour of the enclosure.

Capability to be connected (2)

Unless otherwise specified, external conductors entries will meet the IP specified for the Assembly *(see page 14)*.

The user may specify connections to busbar trunking systems, or other systems, that conductors enter the Assembly from specified directions (top, bottom), and that the external connections are accessible from specified directions (rear, front).

Unless otherwise specified by the user or indicated by the Manufacturer, terminals for external conductors will be capable of accommodating only one copper cable of cross-sectional areas according to the rated current. *See Table 5*.

Note

(2) For external conductors connected directly to built-in apparatus, the relevant cross-sections are valid.

Table 5 – Terminal capacity

Rated current	Solid or stranded conductors		Flexible conductors	
	Cross-sections		Cross-sections	
	min.	max.	min.	max.
A	mm²		mm²	
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

Unless otherwise specified (see page 10), on three-phase circuits, terminals for the neutral conductor will allow the connection of conductors having a current-carrying capacity:

- equal to half the current-carrying capacity of the phase conductor, with a minimum of 10 mm², if the size of the phase conductor exceeds 10 mm²,
- equal to the full current-carrying capacity of the phase conductor, if the size of the latter is less than or equal to 10 mm².

The user may specify the type and characteristics of conductors termination.

Unless otherwise specified, the types of terminals (with screws, springs…) are free, provided they maintain the necessary contact pressure corresponding to the rated current and to the rated short-circuit current.

The terminals for external conductors will be so arranged as to be accessible for mounting, wiring, maintenance and replacement. In particular, it is recommended that the terminals be situated at least 0.2 m above the base of floor-mounted Assemblies and, moreover, be so placed that the cables can be easily connected to them. Unless otherwise specified, identification of terminals will comply with IEC 60445.

Specific requirements for the protective conductors

The terminals for external protective conductors (PE, PEN) and metal sheathing of connecting cables (steel conduit, lead sheath, etc.) will suitable for the connection of copper conductors. A separate terminal of adequate size will be provided for the protective conductor(s) in the vicinity of the associated phase conductors terminals of each circuit.

Unless otherwise specified by the user or indicated by the Manufacturer, terminals for external protective conductors will allow the connection of copper conductors having a cross-section depending on the cross-section of the corresponding phase conductors according to Table 6.

Table 6 – Minimum terminal capacity for copper protective conductors (PE, PEN)

Cross-sectional area of phase conductors S	Minimum cross-sectional area of the corresponding protective conductor (PE, PEN)
mm²	mm²
S ≤ 16	S
16 < S ≤ 35	16
35 < S ≤ 400	S / 2
400 < S ≤ 800	200
800 < S	S / 4

Unless otherwise specified, identification of terminals will comply with IEC 60445.

The available wiring space will permit proper connection of the external conductors of the specified material and size, and, in the case of multicore cables, spreading of the cores, without stresses likely to reduce their normal life expectancy.

Protection of persons against risk of fire or explosion

Function (1)

An Assembly must not present a fire hazard to adjacent material and contribute to, or propagate a fire. Unless otherwise specified protection against risk of fire or explosion includes resistance to internal faulty glowing elements.

Resistance to abnormal heat and fire due to internal electric effects

Parts of insulating material possibly exposed to excessive thermal stress due to internal electric effects (internal glowing wires in case of fault current, overloading of components, or bad connections) and the deterioration of which might impair the safety of the Assembly will not be unduly affected by internal glowing elements.

Unless otherwise specified, parts of insulating materials will be able to withstand the glow-wire test according to IEC 60695-2-11 with the following test temperature:

- 960°C for parts necessary to retain current carrying parts in position,
- 850°C for parts intended to be installed in hollow walls,
- 650°C for all other parts, including parts necessary to retain the protective conductor.

Specific risk should be specified, such as conditions of evacuation in an emergency BD2, BD3, BD4, nature of processed or stored materials BE2, BE3, combustible constructional materials CA2, fire propagating structures CB2

Miscellaneous

Protection of persons against arcing due to internal fault may be subject to a specific agreement according to IEC TR 61641. IEC TR 61641 also provides guidance to specify protection of the Assembly.

Busbar trunking systems according to IEC 60439-2 and to the new IEC 61439-6 provide resistance to flame propagation and fire resistance in building penetration.

Note

(1) Busbar trunking systems according to IEC 60439-2 and to the new IEC 61439-6 provide resistance to flame propagation and fire resistance in building penetration.

Protection of persons against arcing due to internal fault may be subject to a specific agreement according to IEC TR 61641. IEC TR 61641 also provides guidance to specify protection of the Assembly.

Protection of the Assembly against environmental conditions

Function(s)

Protection against environmental conditions includes [1]:

- Protection against ingress of solid foreign bodies and liquid,
- Protection against mechanical stresses,
- Resistance to corrosion, for Assemblies intended for outdoor use only,
- Resistance to ultra-violet (UV) radiation.

Note

(1) The micro-environment inside the Assembly may be different from the ambient environment.

For outdoor installation, supplementary protection, such as protective roofing, may be used.

(2) Some regulations or good practice documents provide guidance for specifying an appropriate IP code.

Protection against ingress of solid foreign bodies and liquid

Protection of the Assembly against ingress of solid foreign bodies and liquid will be specified by the IP code, as codified by IEC 60529, depending on the class of presence of water (ADi) and of foreign solid bodies (AEi) at the place of installation.

For Assemblies for outdoor use having no supplementary protection, protection against ingress of liquid should be at least IPX3 [2].

An agreement may be necessary about the measures to be taken to ensure adequate protection if the original degree of protection is not maintained after the removal of removable and/or withdrawable parts.

Protection against mechanical constraints

Protection of the Assembly against external mechanical impacts may be specified through the IK code, as codified by IEC 62262, so that no function, especially protection against electric shock, is impaired by the expected level of mechanical stress. Schneider Electric advises IK according to Table 7.

Table 7 – Degree of protection against mechanical impact

External influence	Class I Assembly
Minimum protection	IK 05
Medium conditions (e.g. corridors)	IK 07
Stringent conditions (e.g. workshops and construction sites)	IK 08
Outdoor equipment	Impact energy: 50 J

Exposure to heavy vibration (AH3), shocks (AG3), seismic effects (AP3) should be specified.

Resistance to corrosion

Unless otherwise specified, ferrous enclosures, and external as well as internal mechanisms will be verified to standard corrosion tests, according to the intended indoor or outdoor use of the Assembly *(See page 19 of IEC 61439-1).*

Resistance to ultra-violet (UV) radiation

Resistance to ultra-violet radiation is required for outdoor Assemblies. External parts made of synthetic materials or metals entirely coated by synthetic material parts will be verified to a standard UV test *(See page 19 of IEC 61439-1).*

Annex A - Specification schedule

Primary user's requirements			Manufacturer's declarations	
N°	Operating facilities, ratings of the electrical installation and external influences	Values or ref.	Values or ref.	Standard electrical and environmental ratings
1	**Main external influences**			
1.1	Ambient air temperature: indoor / outdoor			Max.: 40°C / 40°C (Max. daily average 35°C) Min.: -5°C / -25°C
1.2	Relative humidity: indoor / outdoor			50 % - 40°C / 100 % - 25°C
1.3	Pollution: commercial / industrial applications			Degree of pollution 2/ 3
1.4	Altitude			≤ 2 000 m
2	**Capability to operate the electrical Installation**			
2.1	Electrical installation diagram (including earthing system)			(IEC 60364-X)
2.2	System nominal voltages			Un, Ue (max 1 000 V a.c. or 1 500 V d.c.)
2.3	System nominal frequencies			fn (d.c. / 50 / 60 Hz)
2.4	List of MM Interfaces accessible to authorized persons only / freely, to ordinary persons			
2.5	Isolation of load installation equipment items (none, individual, groups, all)			
2.6	Number or size, and type of possible future extensions			
3	**Voltage stresses withstand capability**			
3.1	Long term voltages / Temporary over-voltages			Ui / Ui + 1 200 V
3.2	Transient over-voltage (nominal system voltage and location: origin / distribution)			Uimp
4	**Current carrying capability**			
4.1	Design currents of the circuits (assumed outgoing currents)			Inc
4.2	Design current of the supply(s)			InA
4.3	Type of loads, loads patterns			Rated diversity factor conventional / specific
4.4	Max voltage drop (Busbar Trunking System only)			
5	**Short circuit protection withstand capability**			
5.1	Prospective short circuit current Icp			Icw & Ipk = n x Icw or Icc
5.2	SCPD in the incoming functional unit requirement			
5.3	Coordination of SC protective devices including external SCPD details			
5.4	Data associated with loads likely to contribute to the SC current			
5.5	Max fault loop impedances (for Busbar Trunking System only)			
6	**Electro-Magnetic Compatibility (EMC)**			
6.1	Environment industrial / domestic			A (indus.) / B (domestic)
7	**Protection of persons against electric shock**			
7.1	Protection against access to hazardous live parts by authorized persons / ordinary persons		IPXXB / XXC	
7.2	Fault protection			Class I
8	**Maintenance and modification capabilities**			
8.1	Electrical condition of the Assembly or specified parts during specified maintenance operations (isolated / live)			Isolated
8.2	Electrical condition of the Assembly or specified parts during specified modification / extension operations (isolated / live)			Isolated
8.3	Speed of insertion / removal of specified functional units (typically no requirement / < 1 h / < 0.25 h)			
8.4	Versatility of specified spare spaces			
9	**Capability to be installed on site**			
9.1	Enclosure type (stationary / movable, floor standing / wall mounted…)			
9.2	Maximum overall dimensions and weight			
9.3	External conductor types (cable/ busbar trunking systems…)			
9.4	Direction(s) of external conductors (top / bottom) and direction of access to the external connections (front / rear…)			
9.5	External conductor material (copper / aluminium / both)			Copper
9.6	External phase conductor cross sections and terminations			
9.7	External PE, N, PEN conductor cross sections and terminations			
9.8	Maximum dimensions and weight of transport units			
9.9	Methods of handling and transport (e.g. forklift, crane)			
10	**Protection of persons against risk of fire or explosion**			
10.1	Resistance to internal glowing elements			Standard test
10.2	Protection against arcing due to internal fault (IEC TR 61641)			
10.3	Resistance to flame propagation (Busbar Trunking System only)			
10.5	Prevention of propagation of fire through building divisions (Busbar Trunking System only)			
11	**Protection of the Assembly against environmental conditions**			
11.1	Presence of solid foreign bodies (AE1 to AE4) / liquid (AD0 to AD6)			IP (1st letter) / (2nd letter)
11.2	External mechanical constraints			IK
11.3	Corrosion – Indoor / Outdoor			Standard tests
11.4	UV radiations (outdoor only)			Standard test

Possible secondary user's requirements	
Corresponding row N° in table primary requirements	
1.3	Exposure to sea spray, corrosive or polluting smokes, dust, smoke, particles or vapours…
2.1	● Independent stand-by circuits ● Special requirements for the auxiliary circuits ● Special tolerances on network frequency ● Additional on-site testing requirements
2.4	● Special requirements fo access to MMI (location, height, special legal requirements, IP, number of cycles for locking means, identification) ● Special requirements about the general architecture, the front face and functional units lay out ● Type of locking means ● Number of operating cycles of doors and locking means > 200
2.5	● Special legal requirements ● Individual external circuits test facilities ● Number of operating cycles > 200
3.1	● Special requirements for Ui ● Unusual temporary overvoltages
3.2	● Information on the situation of the Assembly within the installation ● Unusual transient overvoltages
4.1	● Special installation conditions affecting the cooling conditions ● Unbalanced currents ● Harmonic currents
5.1	● Prospective short circuit current in the neutral > 60 % of the phase value ● Prospective short circuit current in the protective circuit > 60 % of the phase value ● Specific cos φ ● Loads likely to contribute to the short-circuit current
6.1	● Environment more sensitive or disturbing than Environment A or B ● Maximum Electromagnetic field (for Busbar Trunking System only)
7.1	● Special requirements, including legal requirements (IP, kind of protection) ● Number of operating cycles of locking or interlocking devices > 200
7.2	● Special requirements (Class II insulation for the incoming circuit, total insulation, electrical separation, SELV / PELV…)
8.1 to 8.3	● Special legal requirements ● List of components to be changed by ordinary persons ● Test facilities ● Protection of persons against contact with hazardous live parts in the specific case of removable parts in removed position ● Protection against unintentional access to hazardous internal parts only (see EN 50274), if expressly specified ● Facilities for thermo-graphic measuring ● Ability for extension of busbars ● Number of operating cycles of functional units > 200
9.1	● Special environmental conditions ● Packing details
9.2	● Surface mounted / Recessed into walls ● Specific enclosure colours
9.3	● Special terminal identification requirements
10	● ATEX
10.1	● Special legal requirements
11.2	● External mechanical impacts, heavy vibrations (AH3), shocks (AG3), seismic effects (AP3)
11.3	● See 1.3

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