How to assemble an electrical switchboard Technical guide

Schneider Electric

Dear customer,

Here is the new edition of the Switchboard Assembly and Installation Guide.

This guide presents and illustrates all the best practices to apply when building low-voltage switchboards, in compliance with IEC standards 61439-1 & -2.
The application of these rules means strict compliance, not only with applicable regulations and standards, but also with manufacturers' recommendations.

This guide has been updated to take into account recent changes to standards and the latest technological advances in switchboard assembly and installation. It draws on experience acquired by Schneider Electric and its customers over many years. It is intended for use by panelbuilders in the factory and on-site and also by design engineers to integrate design rules.

It is structured according to the logical procedure for switchboard building from the receipt of components in the workshop to the transport and installation of the complete switchboard on site.

This new edition has additional appendices in the form of removable job sheets for operators in workshops and additional chapters that provide responses to a request for more technical information.

Contents

How to assemble an electrical switchboard

Contents

How to use the guide

How to use the guide

> This guide is structured into 11 successive stages based on the chronological order of assembly of a switchboard.

Each of the workshop assembly phases up to transportation to the site and installation is described **according to a 3-column** page layout principle:

1- the left column states the **standard concerned**,

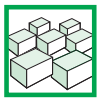
2- the middle column states trade **practices on theoretical or practical aspects,**

3- the right column illustrates these rules with **examples** from the various Schneider Electric switchboard ranges.

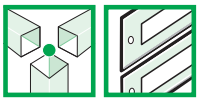
> Symbols used in the guide

Navigation pictograms

To help you to use the guide



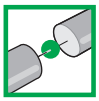
1 - Acceptance / Storage



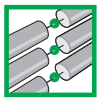
2 - Assembling and covering enclosures

3 - Main busbars and forms

4 - Installing the devices



5 - Power connectors



6 - Auxiliary and low-power circuits

7 - Labelling / Marking

8 - Final factory inspection

9 - Packaging

10 - Handling / Transportation

11 - On-site installation/ Commissioning

Information pictograms

To emphasise important information

Handy hints

Compliant

Non-compliant

Pictograms of the various types of switchboard

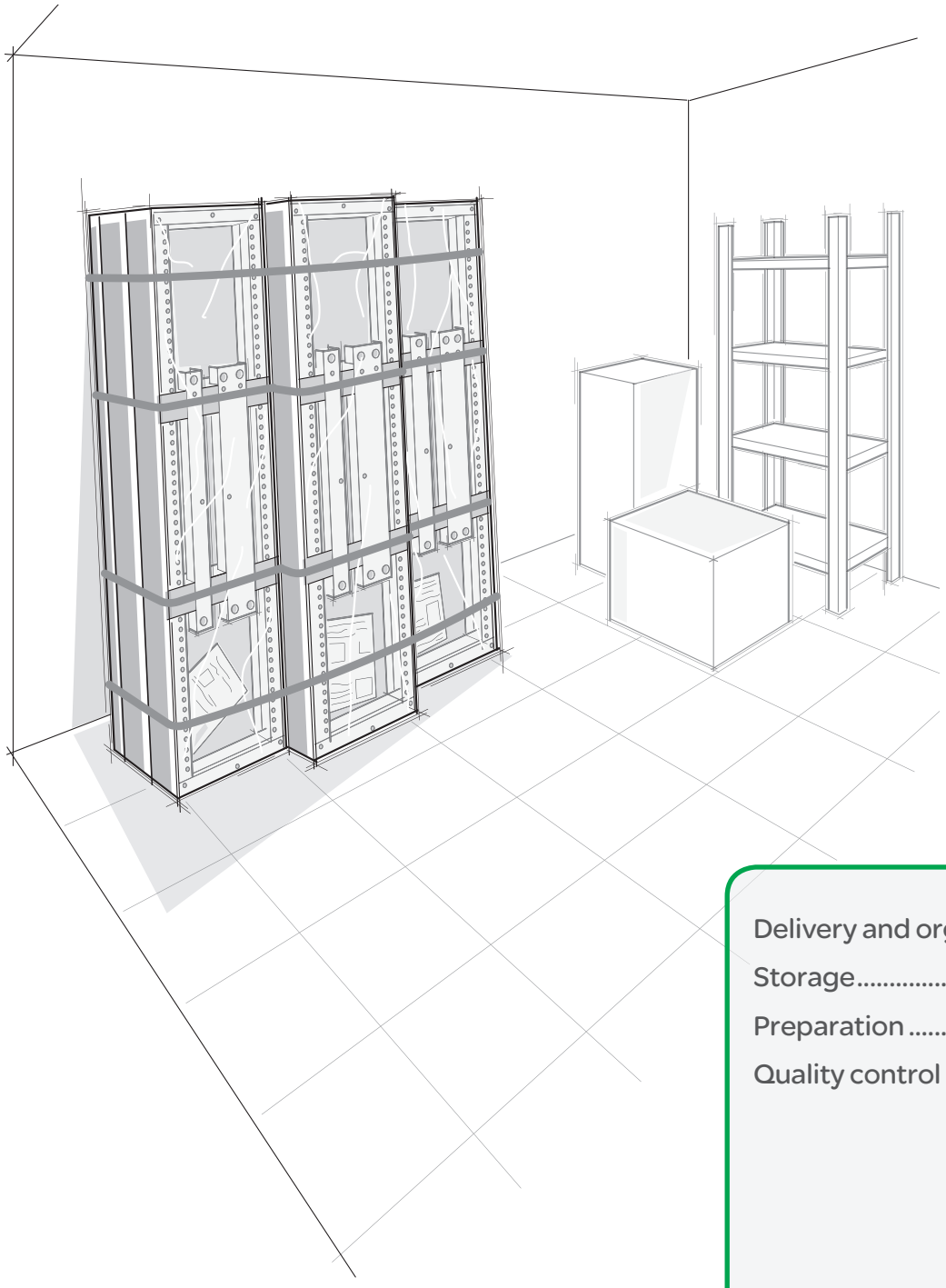
These pictograms are used to illustrate the "*Example*" paragraphs

Pre-assembled and universal switchboards

Switchboards to be assembled, in kit form

Drawout switchboards for critical applications

Delivery, storage and preparation of components



Delivery and organisation

Delivery of components

Good practice

1. Check the number of packages received against the delivery slip.
   Make sure that the packaging has not been damaged in a way that may have harmed the equipment inside.
   If necessary, send your complaints by registered mail to the carrier.
   If you detect any material damage on any of the products, they must be recorded by a representative of the carrier.

Astuce

Put your job ID on the packaging to optimise tracking.

Example

Most packages use plastic film to allow visual inspection of the equipment and the assembly manual.

The Prisma Plus kit system saves space for storage.

Workshop organisation

Good practice

1. To ensure efficient and high quality work, try to keep the workshop clean and tidy.

Example

Workshop organisation (contd.)

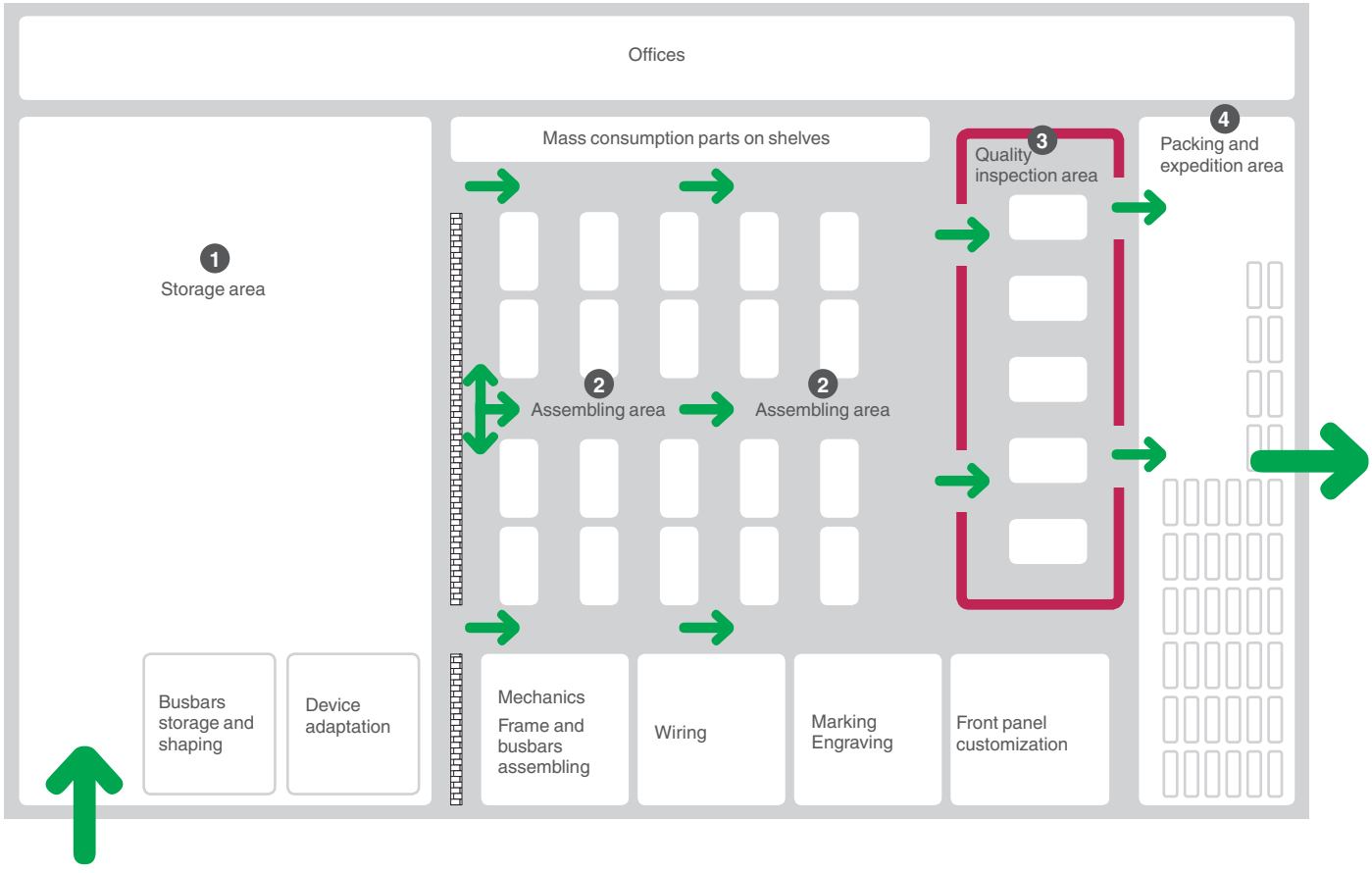
Good practice

2 For optimum organisation of the workshop, you must have three separate areas:

- 1 storage area (1),
- 1 assembling area (2),
- 1 quality inspection area (3),
- 1 packing and expedition area (4).

Example

Example of installation:



Storage

Storage of components

Good practice

1. The components must be stored in a dry and ventilated place, protected from rain, bad weather, run-off, dust, chemical agents and pollution.

Example

Prisma

Storage temperature: -25°C to +55°C (up to +70°C for periods not exceeding 24 hours).

Relative humidity: 55 % to 95 %.

2. Components must preferably remain unpacked until it is time to install them. This will protect them from all risks commonly encountered in the factory or on site (splashes, impacts, dust, etc.).

   If they should be unpacked to control delivery, the protective cover should be replaced until the switchboard is finally installed.

Example

3. Store the panels in such a way as to avoid all risks of distortion or deterioration of the paintwork.

Example

4. Do not stack the components to avoid all risk of deformation or deterioration.

Example

5. It is not advisable to store certain components (copper busbars, sensitive electronic components).

Example

Prisma

Copper busbars or busbars with a copper track (Power Busbars Linergy LGY and LGYE) run a risk of rusting according to environmental conditions.

Preparation before assembly

Good practice

1. The packaging may be made from different materials that are easy to separate plastic films, cardboard, etc.), thus allowing recycling.

   Make provision for containers dedicated to each type of waste (cardboard, metal, plastic, etc.).

Astuce

Some of them may sometimes be reused for on-site transportation after assembly.

Example

Containers for recovering copper

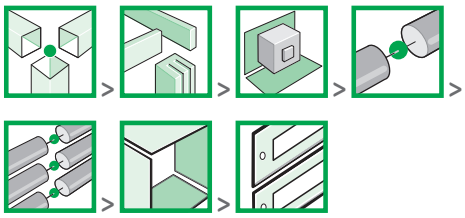
2. According to the schedule of manufacturing, make the equipment closest to the mounting areas.

   Ensure the good identification and allocation of the components (project, customer etc.).

3. Unpack the packages one after the other:
   - depending on the organisation of the workshop,
   - according to the assembly process.

Example

Follow the assembly order defined in the assembly guide or in the related guides:



4. For devices, follow the specific recommendations given in instructions sheets.

Quality control check list

Note: the list of control points presented is not exhaustive.
It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

Minimum checks required	Control points	Control resources	Self-control
☑	> Conformity of equipment received	> Purchase order	☐
☑	> Quantity of components received	> Delivery note	☐
☑	> General state of equipment	> Visual inspection	☐
☑	> Presents of certificates of conformity	> Visual inspection	☐
☑	> NC recording**	> NC procedure document	☐
☑	> Sheet metal acceptance procedure	> Sample selection or SQM***	☐

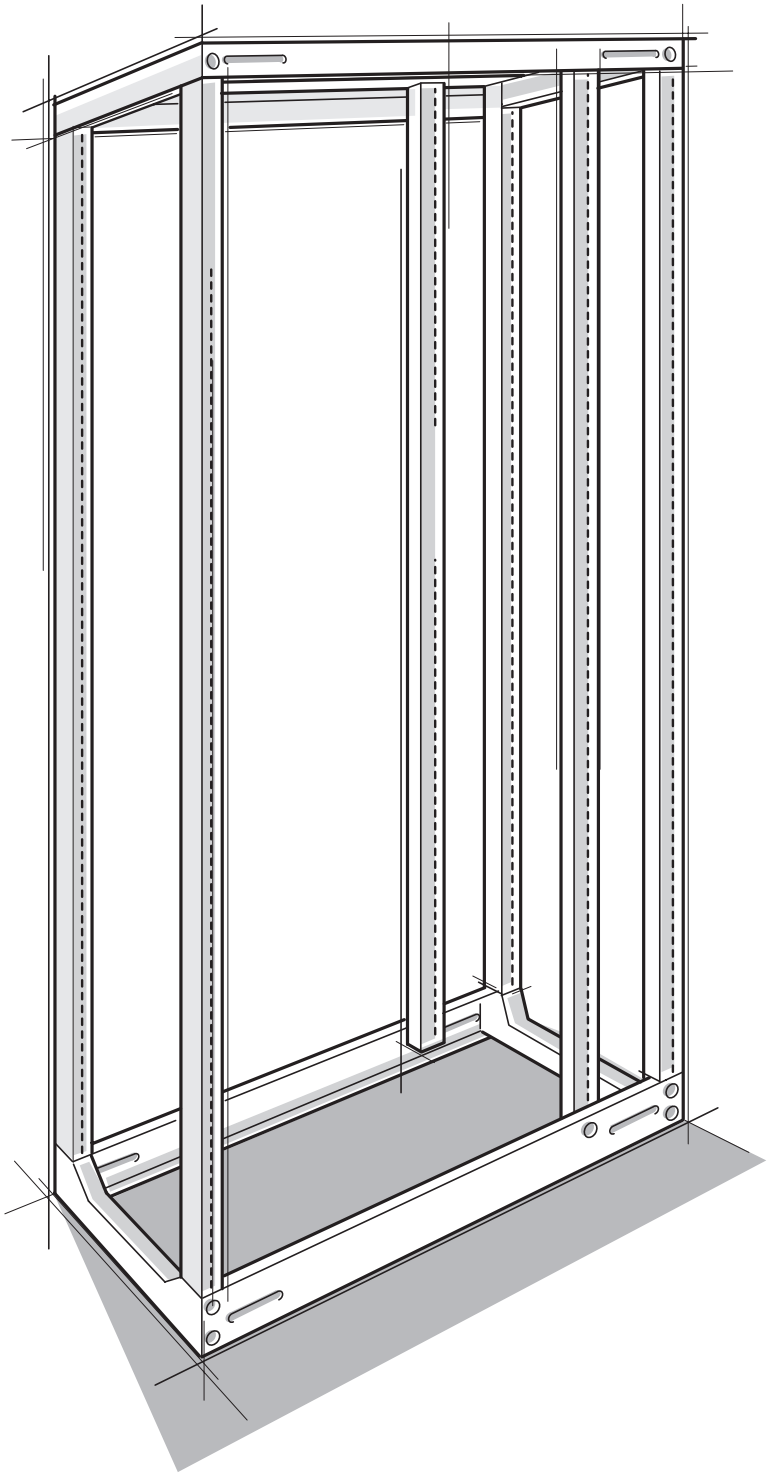
(*) copper, paint, etc.
(**) non-conformity procedure
(***) Supplier Quality Management

Objectives

- Avoid wasting time and unpleasant surprises during assembly
- Identify any manufacturing defects
- Where applicable, launch the necessary corrective actions

Please photocopy the check list before completing it

Assembly of enclosures



IP and IK degrees of protection

Foreword

Standards Theory

IEC 60529

and IEC 62262

1 Enclosures must protect equipment against environmental risks and persons against accidental contact with a powered equipment part.

2 The characteristics of the room in which the switchboard will be installed make it possible to:

- define an IK degree of protection,
- define an IP degree of protection,
- choose an appropriate switchboard type (kit, switchboard for critical applications, universal enclosure, etc.).

> *Refer to the technical data of each type of table.*

Example

The minimum IK degree of protection for Schneider Electric universal enclosures is IK10.

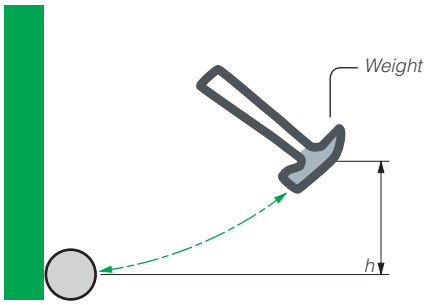
IK degree of protection

Standards Theory

IEC 62262

1 International standard IEC 62262 defines an IK protection code as the ability of enclosures to resist external mechanical impacts on their entire surface.

Each code represents a value of the impact energy for a weight dropped from a height **h**.



IK Code	Impact energy	Correspondance	
	In joules	In grams	Dropped from a height of:
01	0.15	200	2.5 cm
02	0.23	200	10 cm
03	0.35	200	17.5 cm
04	0.5	200	25 cm
05	0.7	200	35 cm
06	1	300	20 cm
07	2	500	40 cm
08	5	1700	29.5 cm
09	10	5000	20 cm
10	20	5000	40 cm

IK degree of protection (contd.)

Standards

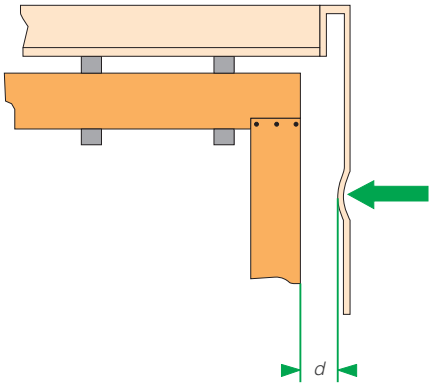
Good practice

IEC 62262

1 The mechanical resistance of the enclosure undergoes a standard mechanical resistance performance test that is conducted in compliance with the guidelines of the standard. It verifies and validates the IK performance given by the manufacturer.

2 Any deformations resulting from an IK test must in no way affect the safety of a switchboard:

- the IP protection index of the enclosure must be maintained,
- clearances between a live bare part and the enclosure components must be kept.



d = clearance distance

Example

A 20 mm clearance was chosen for the IK type tests during the study of the types of Schneider Electric switchboards.

If this distance is not possible, place an insulating barrier between the live parts and the enclosure walls (panels, doors, etc.).

IP and IK degrees of protection

IP degree of protection

Standards Theory

IEC 60529

1 IEC 60529 standard defines a code that characterizes the IP degree of protection provided by an enclosure of electrical equipment against:

- access to hazardous parts,
- the penetration of solid foreign bodies,
- the penetration of water.

The IP code is made up of two characteristic digits:

- the first digit characterizes the protection of persons and equipment against the ingress of foreign solid bodies,
- the second digit characterizes protection against the ingress of water with harmful effects.

Example

Protected against access with a wire and against dust

IP55

Protected against water sprayed from all directions by a nozzle

1st digit			2st digit		
Protection of persons		**Protection against the penetration of solid particles**	**Protection against liquid bodies**		
0	No protection	0	No protection	0	No protection
1	Protected against access with the back of the hand	1	Protected against solid bodies larger than 50 mm	1	Protected against drops of water falling vertically (condensation)
2	Protected against access with a finger	2	Protected against solid bodies larger than 12.5 mm	2	Protected against drops of water falling at an angle up to 15° from the vertical position
3	Protected against access with a tool	3	Protected against solid bodies larger than 2.5 mm	3	Protected against rainwater falling at an angle up to 60° from the vertical position
4	Protected against access with a wire	4	Protected against solid bodies larger than 1 mm	4	Protected against water projections from all directions
5	Protected against access with a wire	5	Protected against dust (no harmful deposit)	5	Protected against water projected from all directions by a nozzle
6	Protected against access with a wire	6	Fully protected against dust	6	Protected against water projections comparable to heavy sea
				7	Protected against the effects of temporary immersion
				8	Protected against the effects of continuous immersion

IP degree of protection (contd.)

Standards Theory

IEC 60529

2 The IP code must always be read and understood digit by digit and not as a whole.

Example

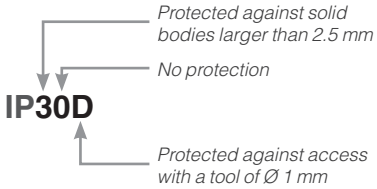
An IP31-rated enclosure can be used in an environment that requires a minimum protection rating of IP21. However, an IP30 enclosure will not be appropriate.

3 To improve the effective protection of persons against access to hazardous parts, the IP code may be completed by an additional letter.

This letter defines a higher protection than the one specified by the first digit of the IP code:

Additional letter	Corresponding protection
A	Protected against access with the back of the hand
B	Protected against access with a finger of Ø 12 mm
C	Protected against access with a tool of Ø 2.5 mm
D	Protected against access with a wire of Ø 1 mm

Example



Over and above existing rules, standards and recommendations, Schneider Electric recommends the use of IP/IK switchboards based on the French guide UTE C15-103 depending on applications (see the product catalogue).

4 When only personnel protection is worth mentioning, the two characteristic digits of the IP code are replaced by the letter X (example, IPXXB).

IP and IK degrees of protection

Assignment of an IP degree of protection

Standards Good practice

IEC 60529

1 The IP degree of protection of a switchboard accessible to unqualified persons must always be at least IP2X.

Example

Prisma

For enclosures in kit form, the IP degree of protection is at least IP30: control handles of devices may be operated in all safety.

2 The IP degree of protection assigned to a switchboard is subject to an agreement between the manufacturer and the end user:

- the end user must determine the desired degree of protection depending on the environment in which the switchboard will be installed,
- the manufacturer must install appropriate components (enclosures, switchgear and controlgear, accessories) and mount them in accordance with the supplier's instructions to reach the required degree of protection.

3 The floor and walls may not be used as enclosure components for the attribution of IP the degree of protection.

4 The degree of protection IP of a switchboard must be validated by a series of standard tests that ensure that the declared protection level has been effectively reached.

According to IEC 61439-1, this IP degree of protection may be assigned only if the enclosure has undergone this series of tests or if prefabricated and tested assemblies are used.

Example

The degree of protection defined by Schneider Electric for each switchboard type is valid only under the test conditions specified by Schneider Electric.

Moreover, the original IP degree of protection will be maintained only if the switchgear and controlgear is assembled and installed according to professional good practice.

Implementation of the IP degree of protection

Standards

Good practice

IEC 60529

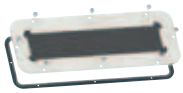
1 Install components that will make it possible to fulfill the conditions of the IP degree of protection used. These components must be meticulously installed. Always make sure that:

- you have all the accessories necessary for maintaining the original degree of protection of the enclosure: protective cover, cable gland plate, cable glands, etc.
- all the joints are present and carefully secured,
- you have the equipment required for maintaining the IP degree of protection if you are installing switchgear and controlgear on a door.

Example

Universal

Schneider Electric proposes cable gland plates that make it possible not to deteriorate the IP degree of protection of the assembly.



Okken Blokset

Protective cover mounted on a circuit-breaker to ensure an IP54 degree of protection rating.

2 **Installation of a switchboard on site**

Take the measures needed to maintain the IP degree of protection defined in the beginning for the assembly, in particular:

- by installing the appropriate accessories (cable glands, cable gland plates, grommets, end pieces, additional joints, etc.),
- by carefully repositioning all the elements that are liable to lower the IP rating (panels, top cover, cable gland plates, etc.).

At the end of the installation, visually check that the original IP degree of protection has been effectively maintained.

Example

For cable insertion, orifices that are not used must be blocked carefully because they can change the enclosure's IP rating.

Universal

Depending on the IP protection degree desired, you must use the appropriate accessories such as cable glands, grommets and end pieces.

Cable gland

Cable gland plate

3 The degree of protection IP of a switchboard has an impact on its heatdissipating capacity. The higher the IP degree of protection, the less the switchboard is able to evacuate heat.

You must therefore factor in a derating of performance when selecting busbars and switchgear and controlgear. The derating factor depends on the IP degree of protection and the ambient temperature around the table.

> *This topic is developed in chapter 5 - "Installing switchgear and controlgear".*

Example

Prisma

For each case, Schneider Electric provides derating tables (see catalog):

Permissible current for switchboard		Bar cross-section
IP ≤ 31	IP > 31	
1200	1080	1 bar, 50 x 10
1400	1250	1 bar, 60 x 10
1800	1600	1 bar, 80 x 10

Note: The permissible current values for the busbar are given for an ambient temperature 35°C around the switchboard.

***Example:** for a switchboard with an IP degree of protection lower than or equal to 31, the permissible current in a 50 x 10 mm flat copper bar is 1200 A. The permissible current in the same bar installed in a switchboard with an IP degree of protection of over 31 will be only 1080 A.*

Tip

The derating coefficient is the value that is used to calculate the actual performance of switchgear and controlgear (busbar, device, etc.) in a given environment.

Mechanical assembly

Enclosure structure

Standards **Good practice**

1 All switchboards must be mounted according to the manufacturer's instructions using approved equipment, regardless of their type (kit to be mounted, pre-assembled or dedicated to large industrial sites).

Example

The assembly of enclosures delivered as kits is reliable and particularly fast. It may be done in the factory or on site. It simplifies storage and transportation.

Assembly using 12 highly accessible screws

IEC 62208 (Empty enclosure standard)

2 Components of the enclosure structure, components contributing to the distribution of energy, as well as switchgear and controlgear must be provided and tested to withstand stresses due to:

- the weight of the switchgear and controlgear,
- electromechanical stress arising from a short-circuit,
- transport,
- vibrations,
- the switchboard environment (ambient temperature, humidity),
- seismic risk,
- electrical risk (internal arc).

These structural details also concern the various systems used to ensure the closing of doors, drawers, etc.

It must also ensure the protection of:

- the operator,
- the switchgear and controlgear against external influences.

Mechanical assembly

Assembling enclosures in kit form

Standards

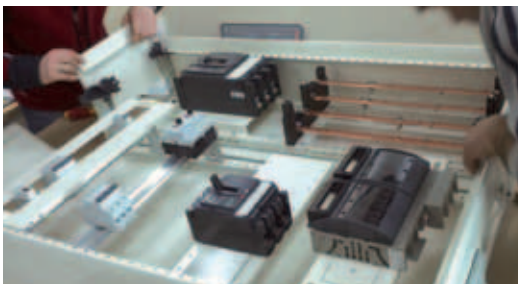
Good practice

1. Assemble the structure on a work surface that is:
   - clean and organized,
   - suited to the morphology of operators,
   - suited to the mounted process (mounting, assembly table, slant board, etc.),
   - equipped with the tools and consumables required for assembly.

   Follow the order of assembly described in the technical manuals.

Example

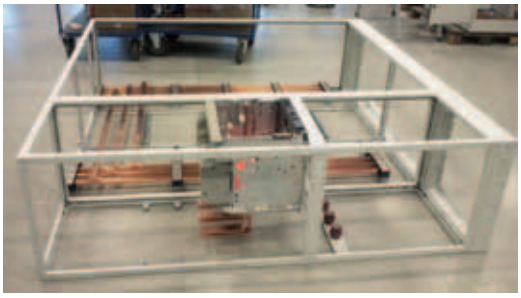
Some enclosures (kit enclosures) are designed to be assembled and wired horizontally on a work station.



2. Depending on the organization of the work area, it is often possible to mount other components such as:
   - busbar components,
   - switchgear and controlgear support plates.

Example

Provide for appropriate lifting equipment.



3. Be careful not to damage the coating of metal parts during assembly.

4. Always use the screws and bolts recommended by the enclosure manufacturer.

   You will obtain mechanical connections of excellent quality if you follow the guidelines provided by the manufacturers of the enclosure and the screws and bolts, especially concerning the tightening torques to apply. Incorrect tightening may result in deterioration of the fastening system or the part to be fastened.

   > *This point is covered in detail in the Appendix "Assembly Techniques".*

Example

All the screws and bolts provided by Schneider Electric have the property class 8-8. This ensures excellent mechanical fastening that will not come loose with time.

The appropriate tightening torques for the various screw and bolt diameters were determined by testing, with an accuracy of ±10 %.

Assembling enclosures in kit form (contd.)

Standards

Good practice

Tip

Self-tapping screws have the special characteristic of not producing any filings when used.

5 Various techniques may be used to assemble frames depending on the products:

- bolts, screws,
- self-tapping screws,
- breakstem rivets.

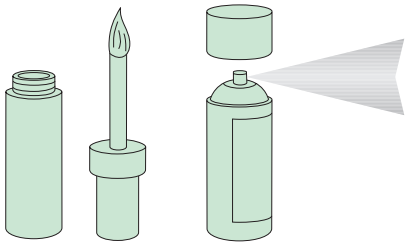
Read the instructions provided with the products (drawings, assembly manual, etc.) to use these fasteners.

6 When making cut-outs on an enclosure component (door, panel, top cover, etc.), take the necessary precautions to avoid scratching the coating or chipping the paintwork:

- use correctly maintained and sharpened tools,
- position the component on a flat base, that is clean and non-abrasive,
- remove any burrs,
- make the appropriate touch-ups of paint or varnish on the parts stripped by the cutting to avoid subsequent corrosion.

Example

Schneider Electric sells touch-up kits for touch-ups on its enclosures (see catalog).



Mechanical assembly

Universal Enclosures (UE)

Standards

Good practice

IEC 62208

1. Universal enclosures are delivered already assembled. You must remove the panels to carry out wiring inside this type of enclosure. Take the necessary precautions in order not to damage the paintwork or screws and bolts when mounting and dismantling the panels.

2. Store the panels in such a way as to avoid all risks of deformation or deterioration of the paintwork.

Example

3. Follow the manufacturer's instructions concerning the handling and transport of enclosures.

Example

Universal

A set of corner stays is provided for lifting and transporting assembled cubicles. It is fastened on the cubicle frame, in the axis of the uprights.

Combination of enclosures

Standards

Good practice

1. It is necessary to connect the enclosures mechanically (number and type of fastening) as per the enclosure manufacturer's recommendations.

Example

Prisma

Enclosure combination batches are available. They are used to mechanically connect enclosures to each other.

2. Depending on the IP degree of protection required for the switchboard, you may have to install a seal between enclosures to ensure that the original IP degree of protection is strictly maintained after the unit has been assembled.

Earthing continuity

Theory

Standards > Theory

IEC 60364

IEC 61439-1 and -2

1 The standard requires effective continuity of the exposed conductive parts of the switchboard:

- between each other,
- between them and the main protective conductor PE (equipotential bonding).

All exposed conductive parts of the switchboard must be connected to the earthing circuit, except for those that do not present a potential hazard for users (small fasteners such as screws or rivets).

You must measure the earthing continuity electrically in case of doubt.

> *This topic is developed in chapter 3 - "Power busbar".*

Example

Enclosure combination batches are available. They are used to mechanically connect enclosures to each other. In most cases, earthing continuity is obtained by the screws, nuts and bolts or by the assembly design.

To do this, you must:

- *use only components, screws, nuts and bolts and accessories recommended by the manufacturer,*
- *comply with the assembly instructions given in the technical manuals,*
- *tighten the screws to the recommended torque.*

Electrical continuity for fixed parts

Standards > Good practice

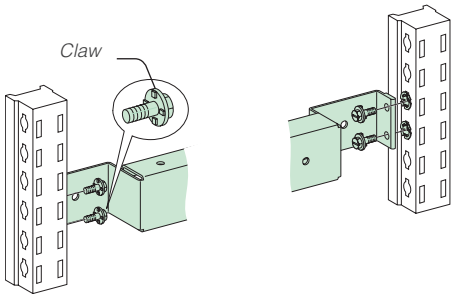
Tip

Assembly of screws and washers is detailled in the chapter "Beyond basics - Assembly Techniques".

1 If there is no specific system used, paint or any other insulating coating such as varnish will affect the electrical continuity between two assembled parts.

You must use screws fitted with washers (spikes or star washers). This system will scratch the paint up to the metal and thus ensure excellent electrical continuity.

Example

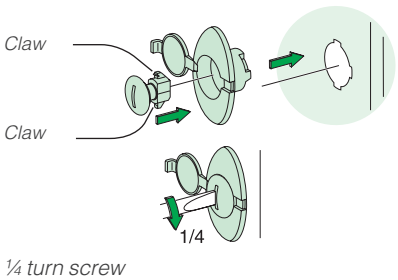


Screws + contact washers

2 There are other systems for ensuring earthing continuity without using specific washers or adding earth braids:

- 1/4 turn screws,
- clips,
- self-tapping screws (serrated under the head).

Example



¼ turn screw

Earthing continuity

Electrical continuity of moving parts

Standards

Good practice

IEC 60364
IEC 61439

Tip

Never earth a class 2 device.

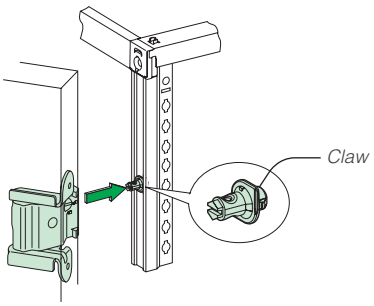
1

An earthing conductor must be fitted on all metal moving parts (door, panels, hinged front plates) that support electrical components with operating voltages of over 50 V.

Standard IEC 60364-5-54 defines the minimum cross-section of the connection based on the live conductors of the switchgear and controlgear installed on the moving part.

Example

The design of kit enclosures ensures electrical continuity of moving parts through hinges.



2

The earth conductor may be either an earthing wire or earthing braid:

- the switchboard does not have "sensitive" equipment in terms of electromagnetic compatibility: use a simple earthing wire,

- the switchboard has "sensitive" equipment in terms of electromagnetic compatibility: use an earthing braid that provides higher EMC protection and equipotential protection.

Example

An earthing wire is supplied as a standard feature for doors accommodating HSI (Human Switchboard Interface) electrical components.

Earthing wire

Earthing braid

Earthing continuity

Electrical continuity of moving parts (contd.)

Standards

Good practice

IEC 60364
IEC 61439

3 There are three techniques for fastening an earthing wire or braid on a painted part:

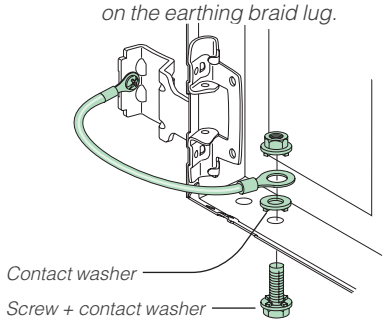
- screw + contact washer,
- insert,
- welded stud.

Always place a contact washer between the earthing wire lug and the painted part.

Example

Prisma

Assemblies are made:
- using screws with contact washers on the painted metal sheet,
- with nuts and contact washers on the earthing braid lug.



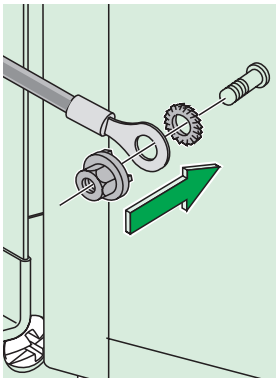
4 **Special case: wire connection or earthing braid on a welded stud**

Protect the stud with a sleeve during the painting operation.

Example

Prisma

The connection is made using a nut with a contact washer on each side.



For the weatherproof wall-mount or floor-standing enclosure offer (IP55), the connection is made on a self-cleaning stud by a fan type washer and a nut + contact washer.

Continuity of drawers

Standards

Good practice

1 Earthing continuity is obtained through the mutual contact between the parts installed on the moving part of the drawer (shoes, wheels or rails) and those installed on the fixed part of the drawer, regardless of the drawer's position.

Notes

Quality control check list

Note: the list of control points presented is not exhaustive.
It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

Minimum checks required	Control points	Control resources	Self-control
	> Identification of the project	> Assembly drawings	☐
	> Identification of columns and quantity	> Assembly drawings	☐
	> Conformity with front panel drawings	> Assembly drawings	☐
	> Dimensions	> Assembly drawings	☐
☑	> Quality of paints*	> Visual inspection	☐
☑	> Protection degree**	> Visual inspection and technical documentation	☐
☑	> Bonding continuity***	> Visual inspection and installation guide	☐

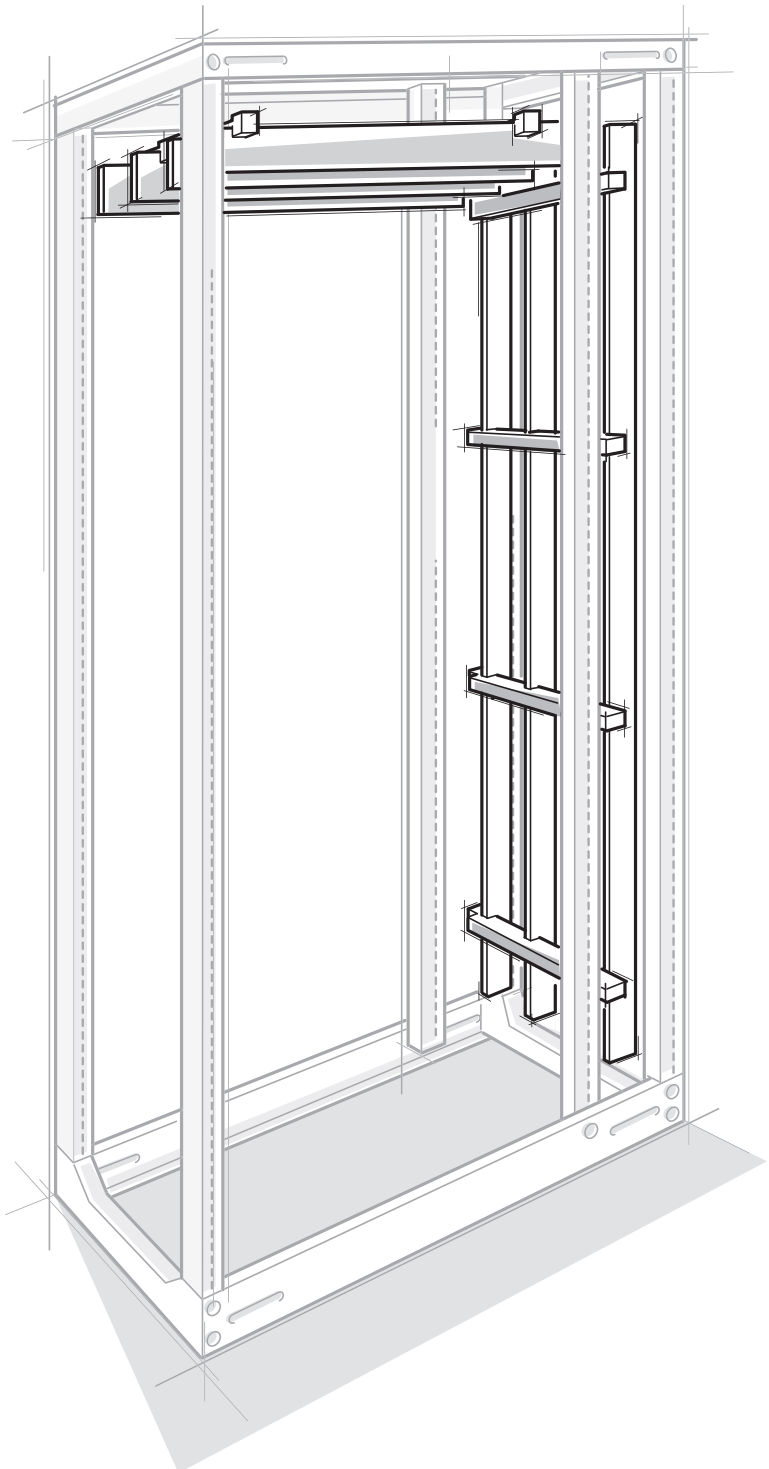
(*) homogeneity, no scratches, deformations, etc.
(**) quality of washers
(***) screws, contact washers, etc.

Objectives

- View ongoing projects
- Save time (avoid having to redo anything, do not forget anything from the beginning of the process, etc.)
- Check conformity with civil engineering drawings
- Check conformity with assembly standards

Please photocopy the check list before completing it

Power busbar



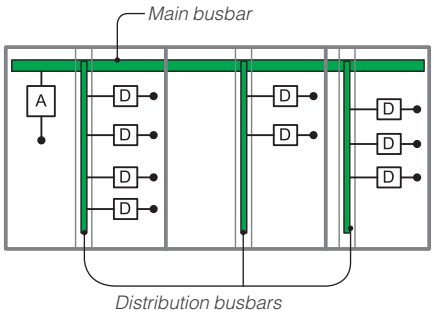
Foreword

Foreword

Standards Theory

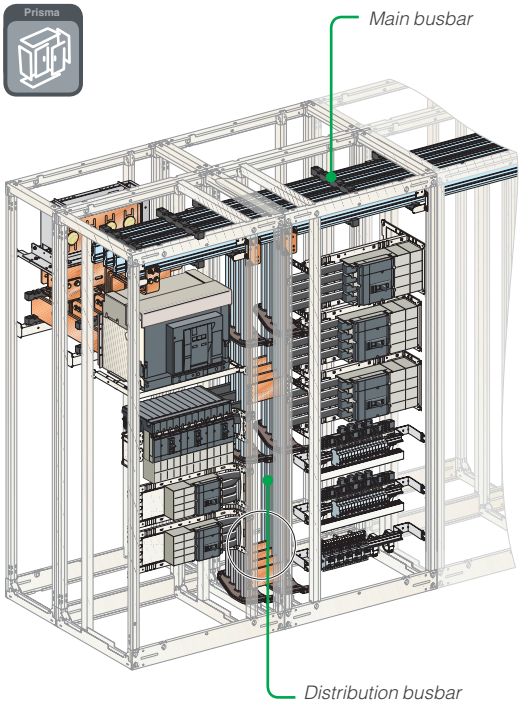
1 Power is distributed in switchboards through the following means:

- a **main busbar** that distributes power horizontally between the various switchboard columns. It may be installed on the top, middle or bottom of the switchboard depending on the type of switchboard, customer specifications and/or local practices,
- **distribution busbars** connected to the main busbar. They provide power to outgoing devices.



A: *Incoming device*
D: *Outgoing device*

Example



IEC 61439-1

2 The following must be taken into account when choosing a power busbar:

- environmental characteristics of the switchboard (ambient temperature, IP degree of protection, pollution),
- type of switchboard installed regarding to validation test,
- characteristics of the client's power supply: on the top, middle or bottom,
- the rated current of the short-circuit: Icw.

The installation of a power busbar consists in the following steps:

- select the busbar material,
- size it (busbar section, number of busbars per phase) and define its position in the switchboard based on the client's incoming devices,
- install it in compliance with the creepage and clearance distances of the standard,
- fasten it according to good practice.

> *This topic is developed in the section "Definition of a power busbar" of this chapter.*

Foreword (contd.)

Standards Theory

3 The installation must ensure the protection of persons:

- against direct contact by installing the appropriate internal partitions (forms) or by installing live parts out of reach.

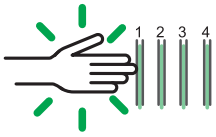
> *This point is discussed in the section "Partitioning a swithboard" of this chapter.*

- against indirect contact by creating an equipotential bonding inside the switchboard (PE/PEN protective conductor and earthing of the grounding electrode conductors).

> *This point is discussed in the section "Equipotentiel bonding" of this chapter.*

Example

Direct contact



Contact of persons with live parts of electrical materials (conductors or energized parts).

Indirect contact

Contact of persons with conductive parts that are accidentally powered as a result of an insulation failure.

4 The current of a power busbar is measured using a current transformer (CT) such as a busbar passing current transformer.

The main role of the current transformer is to lower the value of the current to be measured to a value that is acceptable for metering devices (usually 1 to 5 A).

> *The choice and rules for installing current transformers are described in the section "Current transformers" of this chapter.*

Definition of a power busbar

Choice of material

Standards Good practice

1 The materials most often used are copper and aluminum because they offer the following characteristics:

- excellent electrical conductivity,
- excellent heat dissipation,
- good corrosion resistance,
- ease of installation.

NFA 51-118
NFA 51-419
EN 1652
ISO 1634

2 **Choice of copper bars**

Use Cu-ETP copper only, that complies with the following specifications:

Standard	Description
General description of material	
EN 1652	Cu ETP R240
Standard international equivalent	
ISO 1634	Cu ETP HB

The bars must be:

- rectilinear,
- free of scratches, traces of impact, marks or rust,
- qualified and with a compliance certificate.

Example

Schneider Electric copper bars are of Cu-ETP type (H12) and are qualified and compliant with the standard.

Definition of a power busbar

Choice of material (contd.)

Standards Good practice

3 Choice of aluminum bars

When choosing aluminum bars, special attention must be paid:

- to the quality of the aluminum, which must provide a trade-off between mechanical withstand and electrical conductivity: aluminum is more resistive and has a lower mechanical resistance than copper of similar dimensions,
- to the quality of the surface coating (tin-plating) that guarantees excellent electrical contact and corrosion resistance,
- to heat stresses: the maximum utilization temperature is lower than that of copper (90°C for bare aluminum, 105°C for tin-plated aluminum and 140°C for copper),
- connection constraints.

Busbar sizing

Standards Good practice

1 Power busbars must be sized to withstand heat and dynamic stresses resulting from short-circuit currents that do not exceed the value of the rated short-circuit current.

Electrodynamic stress withstand depends mainly on the following:

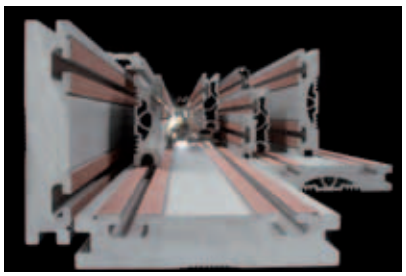
- the intensity of the default current,
- the shape and cross-section of the bars,
- their location in the switchboard,
- their fastening method.

Example

Schneider Electric is proposing a new innovative range of busbars.

They present the following advantages:

- *greater performance (a single busbar can withstand ratings of up to 4000 A),*
- *50 % lighter than copper bars that achieve similar sections,*
- *robust and flexibale- higher resistance to short-circuit currents (100 kA/1s),*
- *cheaper to mount and assemble,*
- *vertical or horizontal installation,*
- *a wide range of available profiles.*



Linergy LGYE busbars

Definition of a power busbar

Busbar sizing (contd.)

Standards

IEC 61439-1
§ 8.6.1

Tip

The various ratings and their names to be taken into account are defined in
IEC 60947-2 *and*
IEC 61439-1

The definition of ambient temperature surrounding a switchboard is mentioned in the chapter "Beyond Basics - Thermal management of a switchboard".

The rated Icw current is defined by IEC 61439-1 standard for a period of 1 second. Some local standards define it for a period of 3 seconds. In this case, this must be taken into account when calculating the busbar cross-section.

Good practice

2

Busbar manufacturers usually provide the information required for sizing power busbars. These figures must be used in calculating the cross-section of the busbar.

The busbar cross-section depends on:
- the rated current "**In**" to be conveyed in the busbar,
- the rated current of the short-circuit (permissible short-time withstand current): "**Icw**",
- the ambient temperature around the switchboard,
- the IP protection index of the enclosure,
- the rated diversity factor (RDF),
- the space reserved for future enhancements,
- the constraint defined by the trigger time of the protective device.

Caution: never under-size a busbar (risk of overheating).

Example

Schneider Electric provides tables derived from standard calculations and tests. These tables provide the cross-sections of the bars to use depending on the permissible current and the switchboard environment (ambient temperature around the switchboard and the required IP protection index). They allow optimum, fast and easy sizing of the busbars.

Type of bars	Rated current In (A)											
	Ambient temperature around the switchboard											
	25°C		30°C		35°C		40°C		45°C		50°C	
Cross section/phase	IP ≤ 31	IP > 31	IP ≤ 31	IP > 31	IP ≤ 31	IP > 31	IP ≤ 31	IP > 31	IP ≤ 31	IP > 31	IP ≤ 31	IP ≤ 31
1 bar 50 x 10 mm	1330	1220	1260	1160	1200	1080	1130	1010	1060	940	990	●
1 bar 60 x10 mm	1550	1400	1470	1320	1400	1250	1320	1160	1240	1070	1160	●
1 bar 80 x 10 mm	1990	1800	1890	1700	1800	1600	1700	1500	1600	1390	1500	●
2 bars 50 x 10 mm	2270	2090	2160	1980	2050	1850	1930	1740	1810	1610	1690	●
2 bars 60 x10 mm	2550	2270	2420	2140	2300	2000	2170	1870	2030	1720	1900	●
2 bars 80 x 10 mm	3110	2820	2970	2660	2820	2500	2660	2330	2500	2160	2330	●
2 bars 100 x 10 mm	3650	3280	3490	3100	3300	2900	3130	2720	2950	2510	2750	●

● Connection not possible because of the device's temperature operating restrictions.

Example: To ensure the transportation of a rated current In of 2300 A with an IP < 31 and an ambient temperature of 35°C around the switchboard, you must choose 2 bars with a cross-section of 60 x 10 mm for each phase. This table was calculated for a permissible short-circuit current of 85 kA/1s.

IEC 61439-1
§ 3.8.10
§ 5.3.3
Appendix E

IEC 61439-2
§ 5.3.3

3

Generally, not all the devices connected to a busbar are used at full load or at the same time. It is therefore not necessary to size the busbar to transport the sum of rated currents of all the devices continuously.

The rated current "In" in the busbar must be calculated:
- by adding up the rated currents of all the connected devices,
- by multiplying the result by the diversity factor (RDF) defined by IEC 61439-1.

The value of the diversity factor depends on the number of devices connected to the busbar:

Number of devices	Diversity factor
2 and 3	0.9
4 and 5	0.8
6 to 9	0.7
10 +	0.6

Definition of a power busbar

Position of the busbar in the switchboard

Standards Good practice

1 Always wear gloves when handling copper bars to prevent chemical deterioration resulting from contact with the skin (perspiration).

2 Install the bars edgewise when possible to favor heat dissipation by convection.

When the bars are installed flat, the permissible currents must be reduced (derating). Use the calculation elements defined for the edge bars by applying the derating coefficient recommended by the manufacturer.

Example

When using flat bars, e.g., derivations of incoming devices on busbars, Schneider Electric recommends a busbar derating of 0.8.

Under similar environmental and ambient temperature, two 80 x 5 mm bars may transport:

- up to 1600 A if the bars are edgewise,

- up to 1280 A (1600 x 0.8) if the bars are flat.

3 Install the main busbar preferably on the top of the switchboard.

If you install it at the bottom of the switchboard, you must take into account the fact that this position makes it heat the equipment located beneath it. Furthermore, for safety reasons, you must cover it to protect it from possible falls of metal objects *(> see section "Partitioning a switchboard").*

If it is installed in the middle of the switchboard, make sure that the manufacturers' guides authorize this type of assembly.

4 The order of the busbars is usually N, L1, L2 and L3:

- from the front to the rear of the switchboard,
- from the left to the right of the switchboard.

This order is not imposed by the standard. It is recommended for the following reasons:

- safety,
- ease of connection of switchgear,
- easier access to the Neutral bar.

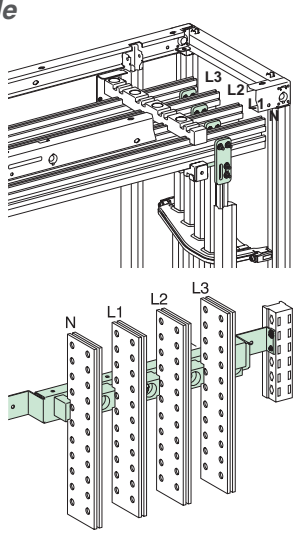
At any event, follow the order recommended in the technical guides.

Whatever the order chosen, the bars must be marked.

> See chapter 7 – "Labeling and marking".

Example

Prisma

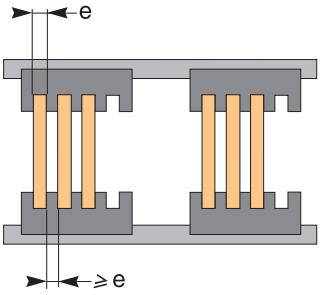


Definition of a power busbar

Position of the busbar in the switchboard (contd.)

Standards Good practice

5 If the installation requires several bars per phase, leave enough space between them (at least the thickness of the bar) to enable optimum ventilation of the busbar.



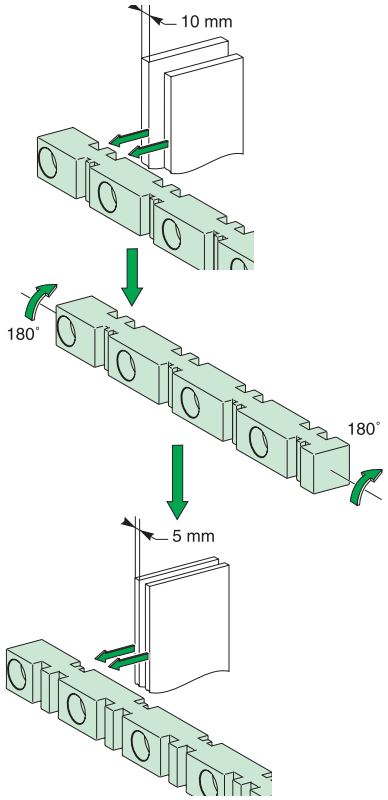
Depending on systems installation, other technical choices can be implemented. These were tested for validation.

Example

Prisma

Schneider Electric provides insulating brackets that have been specially designed for 5 mm or 10 mm thick bars.

The same bracket is used for the two bar thicknesses. Simply rotate them by 180° to adjust it to the bar thickness.



Okken Blokset

Some configurations do not follow this rule to optimize space and reduce assembly time. Bars may be flush jointed.

These configurations have been tested and the bar sections chosen accordingly.

IEC 61439-1

6 Install the busbars (bare or insulated) in such a way as to eliminate all risk of short-circuits, in particular by complying with:

- clearances,
- creepage distances,
- the number of supports to install,
- the rules for securing these supports.

Definition of a power busbar

Clearances and creepage distances

Standards

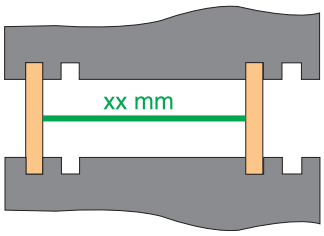
Theory

IEC 60664-1

IEC 61439-1

1 IEC 61439-1 standard defines the requirements applicable to clearances inside a switchboard. These requirements are based on the principles of IEC 60664-1 standard and enable the coordination of clearance inside the switchboard.
Clearance is the shortest distance in the air:

- between two live conductors,
- between a live conductor and the ground.



IEC 61439-1
Table 1

2 The standard provides a table giving the minimum clearance to comply with in order to observe the rated impulse withstand voltage Uimp declared by the manufacturer for a circuit.

The values given in the table are established according to non- homogeneous electrical fields and a pollution degree of 3 (the most unfavorable conditions). These ensure that impulse voltages can be withstood in an altitude range of 0 to 2000 m.

Rated impulse withstand voltage Uimp (kV)	Minimum clearance (mm)
< 2.5	1.5
4.0	3.0
6.5	5.5
8.0	8.0
12.0	14.0

Interpretation of the table:

- since a power busbar has a rated clearance voltage Ui of 1000 V, the declared rated impulse withstand voltage Uimp is 12 kV. The clearance must therefore be at least 14 mm,
- since a splitter has a rated clearance voltage Ui of 750 V, the declared rated impulse withstand voltage Uimp is 8 kV.

The clearance must therefore be at least 8 mm.

Tip

The degree of pollution 3 is defined precisely in the standard

Definition of a power busbar

Clearances and creepage distances (contd.)

Standards Theory

IEC 60664-1

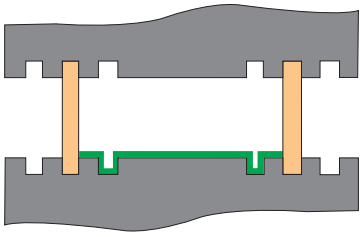
IEC 61439-1

3 IEC 61439-1 standard defines the requirements applicable to creepage distances inside a switchboard.

These requirements are based on the principles of IEC 60664-1 standard and enable the coordination of clearance inside the switchboard.

The creepage distance is the shortest distance along the surface of an insulation between:

- two live conductors,
- between a live conductor and the bounding surface.



IEC 61439-1

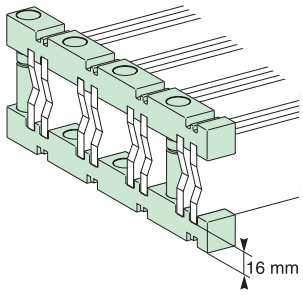
4 The standard defines creepage depending on:

- the rated clearance voltage Ui of the table,
- the type of insulating material (which defines the material group),
- the degree of pollution in the environment.

Example

Prisma

The tracking resistance index (IRC) of the material is 175 V. The material group is therefore IIIA. For a pollution degree 2, the standard recommends a creepage of at least 16 mm for a rated clearance voltage of up to 1600 V.



Rated clearance voltage Ui (V)	Degree of pollution	Minimum creepage (mm) 1	2			3			
	Material group	I	I	II	IIIa and IIIb	I	II	IIIa	IIIb
32		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
800		2.4	4	5.6	8	10	11	12.5	
1000		3.2	5	4.1	10	12.5	14	16	
1250		4.2	6.3	9	12.5	16	18	20	
1600		5.6	8	11	16	20	22	25	

Definition of a power busbar

Clearances and creepage distances (contd.)

Standards — Good practice

IEC 61439-1

1 The distance between two phases varies according to the switchboard architecture (equipment installed inside the switchboard, available space, etc.).

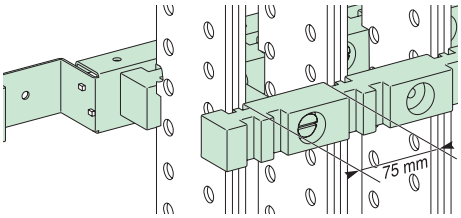
The switchboard designer must optimize this distance in order to:

- facilitate connections,
- ensure that the minimum clearance and creepage distances recommended by the standard are verified at all points of the switchboard.

Example

Prisma

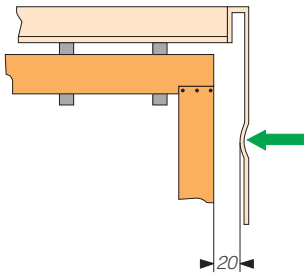
The bars are mounted on insulated supports and the distance between each phase is 75 mm.



Schneider Electric proposes two levels of busbars to facilitate connections.

2 For a service voltage of up to 1000 V, the clearance distance between a powered bare part (copper bar) and a covering panel that is likely to be deformed after an impact (for example, IK protection degree test), must be at least 20 mm.

If this is not possible, place an insulating barrier between them.



Example

Prisma

Schneider Electric has conducted tests on enclosures according to their IK impulse protection degree. These tests have ensured that the clearance distance was maintained.

IEC 61439-1
§ 8.3.2
Appendix F

3 Make sure that clearance and creepage distances are compliant with the standard, They must be measured using the methods given in Appendix F of the standard.

Example

Prisma

For a busbar with a rated clearance voltage Ui of 1000 V and a rated impulse withstand voltage Uimp is 12 kV, and there must be a clearance of at least 14 mm.

IEC 61439-1

4 The deformation of the enclosure or internal partitions that may result from a short-circuit must not permanently reduce clearance or creepage distances to values lower than those specified by the standard.

5 When installing a power busbar, always take the partitions and cover panels into account when observing clearance distances.

Definition of a power busbar

Fastening busbars

Standards

Good practice

Tip

The main function of supports is to hold them of short-circuit to avoid their relative motion.

Mobile supports contribute to short-circuits withstand in the same way as fixed supports.

1 The high electrodynamic stresses generated as a result of short-circuits and the ensuing damage (replacement of bars, interruption of the installation) justify the importance of fastening busbars properly.

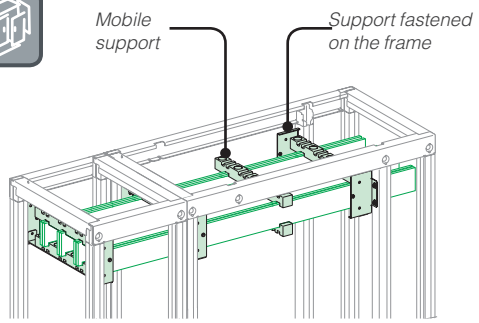
To ensure that busbars are held in place, they must be fastened using insulated supports.

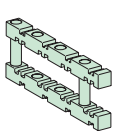
Supports must be of similar type, form and material.

When the position of the supports does not allow fastening on the frame, replace them with mobile supports.

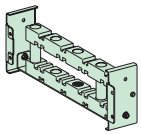
Example

Prisma





Mobile support



Fixed support

2 The number and center distance of the supports that must be installed depend on the:

- type of frame (width and depth of enclosure, cubicle type),
- dimensional characteristics of the bars (cross-section and width),
- the bar center distance,
- permissible rated short-time withstand current Icw.

Given the significant electrodynamic stresses generated by a short-circuit, you must comply with the numbers and center distances recommended by the manufacturer in the technical guides.

Example

Schneider Electric has developed bar supports that are specific to each switch board type. Schneider Electric provides tables that specify the number of supports to use for each configuration.

Okken Blokset

Number of bar supports				Quantity	
		(mm)	(mm)	Icw ≤ 50 kA	50 kA < Icw ≤ 100 kA
Device cubicle	standard	L650	P600	3	3
	Mono NT/NS	L450	P600	2	2
Connection compartment		L250	P600	1	1
		L350	P600	1	1
		L450	P600	2	2
		L650	P600	2	2

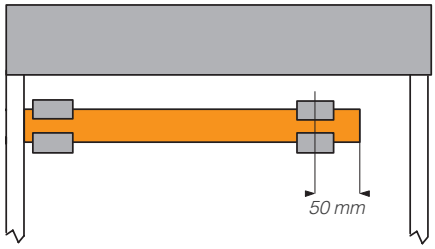
These tables have been created according to the electrodynamic stresses generated by a short-circuit, and validated through tests conducted in compliance with IEC 61439-1 standard.

3 To guarantee electrodynamic stress of bars in the event of a short-circuit, follow the instructions in the technical guide's with respect to the maximum distance between the center of the last support and the end of the bar.

Example

Okken Blokset

Schneider Electric recommends a maximum distance of 50 mm.



Definition of a power busbar

Fastening busbars (contd.)

Standards Good practice

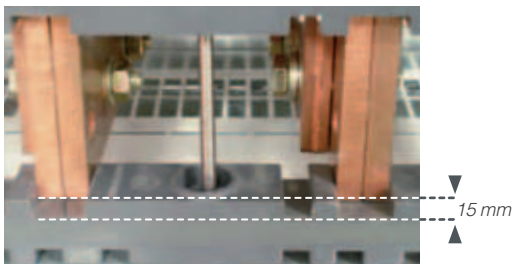
4 To ensure compliance with minimum clearances for metal cover parts (doors, panels, etc.), in some cases, you may need to recess the bar in the support.

Follow the instructions given in the technical guides.

Example

Okken Blokset

Schneider Electric recommends that the bars be recessed 15 mm in the support.



5 In the case of a vertical flat busbar, do not take the bottom support into account when calculating the number of supports required.

It will in no way contribute to improving electrodynamic resistance in the event of a short-circuit and must only be used to block the busbar.

Example

Prisma

In some cases (Linergy busbar provided by Schneider Electric), the bottom support is designed to contribute to electrodynamic resistance of busbars in the event of a short-circuit. It must be included in the calculation of the number of supports required.

Definition of a power busbar

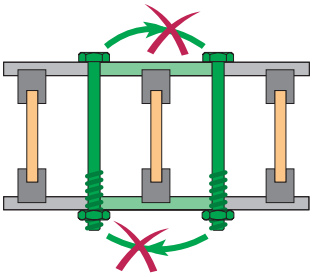
Fastening busbars (contd.)

Standards Good practice

Tip

Not all the stainless steel screws are non-magnetic. You must check this property with the supplier.

6 The current circulating in the bars generates induced currents (eddy currents) in conductors and surrounding metal. Given the high intensity of the current circulating in the bars, this phenomenon may lead to significant heating of these materials.



To avoid this phenomenon, you must break the induced current loop. Use one of the solutions below:

- supports in insulated materials,
- aluminum counter-supports,
- non-magnetic stainless steel fixing screws.

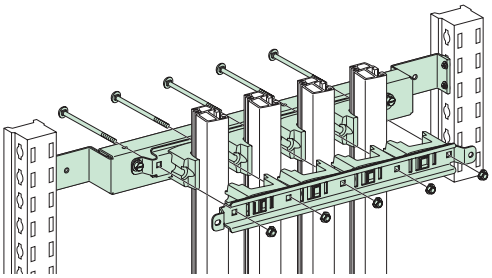
Non-compliance with these recommendations will result in:

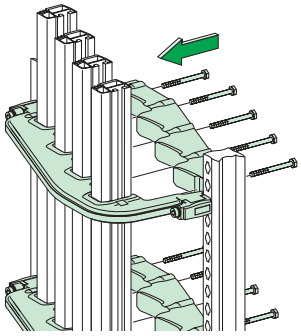
- the over-heating of the supports, counter-supports and fastening screws,
- vibrations that could break the supports.

Example

Schneider Electric supplies bar supports that are specific to each busbar type.

The counter-supports of bottom Linergy busbars are made of metal but the fixing screws are made of non-magnetic materials.





The supports of lateral Linergy busbars are fully insulated.

7 Before tightening the screws, make sure that the support and counter-support are aligned correctly. Check the conformity of the assembly.

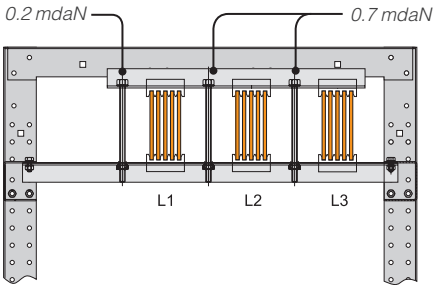
Always comply with the torques recommended in the technical guides.

If there are no instructions, apply the torque defined by standard according to the screw diameter.

> *See chapter "Beyond Basics - Assembly Techniques".*

Example

Schneider Electric gives the specific torques in its assembly guides.



Partitioning a switchboard

Principle

Standards Theory

1 There are several reasons for partitioning a switchboard:

- protect persons against direct contact with dangerous parts. The minimum degree of protection must be IPXXB,
- protect the switchboard against the penetration of solid foreign bodies. The minimum degree of protection must be IP2X,
- limit the propagation of an electric arc inside the switchboard by separating the busbars, equipment and connections,
- facilitate maintenance operations or switchboard upgrades.

IEC 61439-2 § 8.101

2 Partitioning rules are defined in standard IEC 61439-2. The definition of partitioning depends on conditions of use, maintenance and upgrade of the switchboard.
This definition is subject to agreement between the switchboard manufacturer and the end user.

It is based on three essential points:

- use products or components that comply with the standard, the various configurations of which have been tried and tested,
- comply with rules and guidelines laid down by the various manufacturer documents especially pertaining to choice and protection,
- conduct clearance, bonding continuity with a final inspection recorded in a contract document.

Full compliance with these recommendations can be validated by a compliance certificate.

IEC 61439-2

3 The standard defines 4 partitioning levels (forms) to ensure the protection of persons against direct contact. The form is a solution provided to an IP protection requirement and a client need (Operation, Maintenance, Upgrade).

Partitioning a switchboard

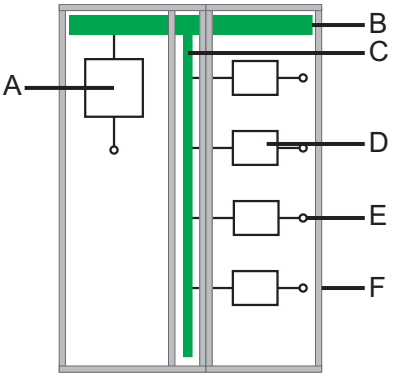
Principle (contd.)

Standards Theory

IEC 61439-2

4 Form 1

No separation inside the switchboard.



A = Incoming device
B = Main busbar
C = Distribution busbar
D = Outgoing device
E = Terminals for external conductors
F = Enclosure IP2X minimum

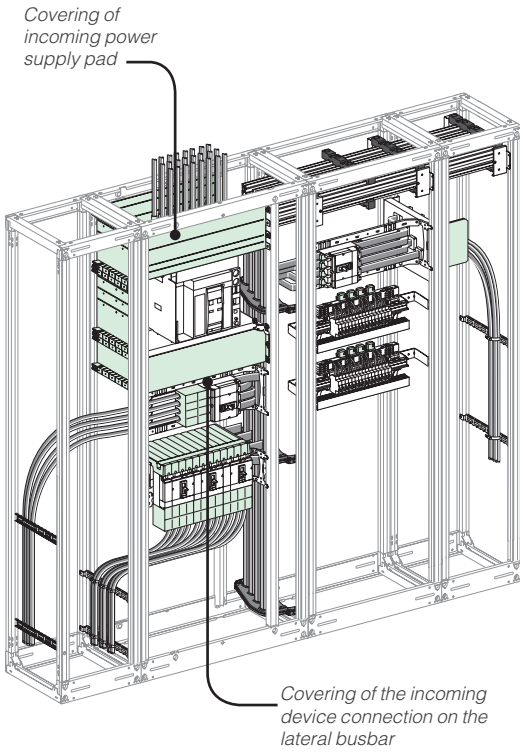
Example

Prisma

Schneider Electric proposes installations that go beyond the standard's recommendations.

Protection of people and equipment is provided from the onset by:

- *the presence of front plates that can only be opened by a specific tool,*
- *the locking of doors that give access to live parts,*
- *the systematic installation of terminal covers on the Compact NSX circuit-breakers, as well as on the Interpact INS and INV switches,*
- *the covering of the upstream and downstream pads of the incoming device, to ensure the operator's safety at all points of the switchboard when the device is open.*



Partitioning a switchboard

Principle (contd.)

Standards Theory

IEC 61439-2

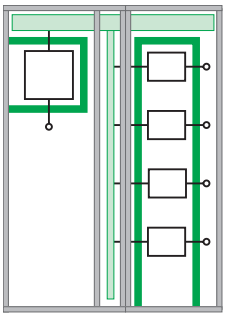
5 Form 2

Separation of busbars and functional units inside the switchboard:

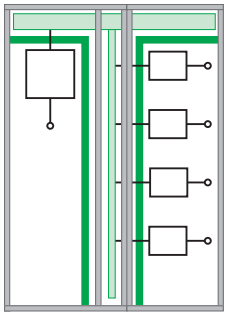
- protection of persons against contact with live parts upstream of outgoing devices,
- protection against ingress of solid foreign bodies.

There are two variants of form 2:

Form 2a: terminals for external conductors are not separated from the busbars.



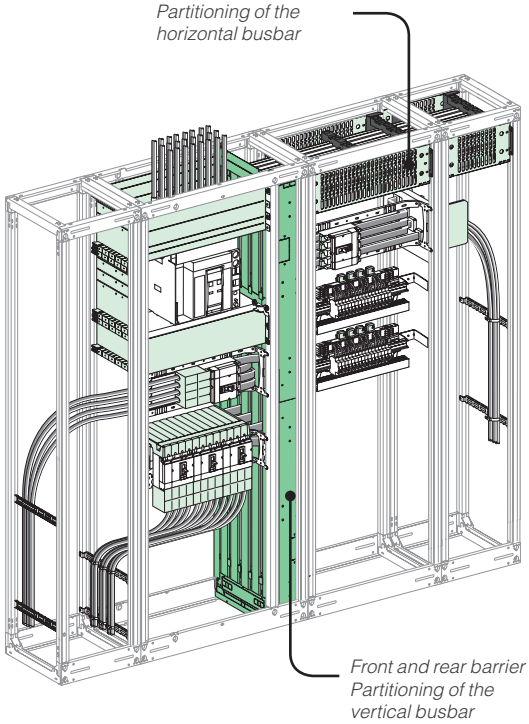
Form 2b: terminals for external conductors are separated from the busbars.



Example

Prisma

Schneider Electric proposes a form 2b that provides more safety than form 2a, since the connection terminals are separated from the busbars.



Partitioning a switchboard

Principle (contd.)

Standards Theory

IEC 61439-2

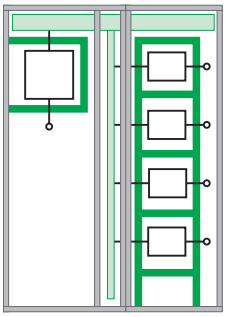
6 Form 3

Form 2 + Separation inside the switchboard of all functional units:

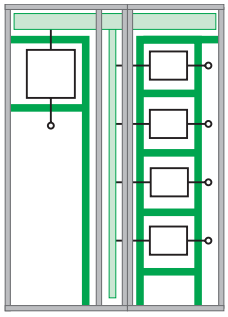
- protection of persons against contact with live parts upstream of outgoing devices,
- limitation of the risk of faults between each of the functional units (propagation of electric arcs).

There are two variants of form 3:

Form 3a: terminals for external conductors are not separated from the busbars.



Form 3b: terminals for external conductors are separated from the busbars.

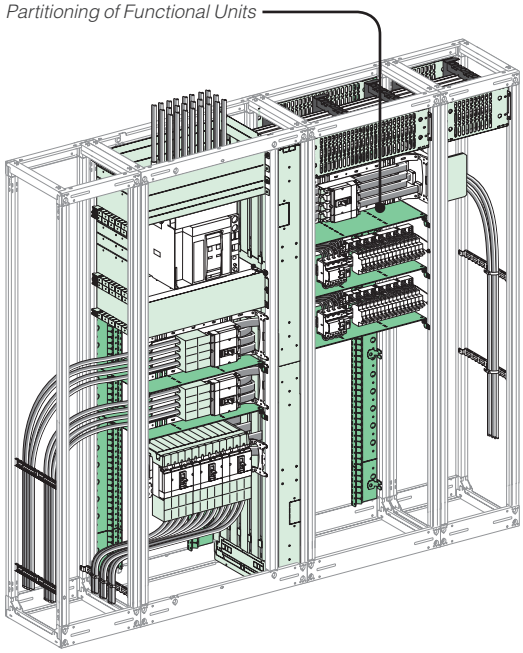


Example

Prisma

Schneider Electric proposes a form 3b that provides more safety than form 3a, since the connection terminals are separated from the busbars.

Partitioning of Functional Units



Principle (contd.)

Standards Theory

IEC 61439-2

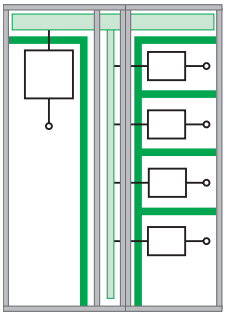
7 Form 4

Form 3 + Separation inside the switchboard of terminals for external conductors that are an integral part of each functional unit:

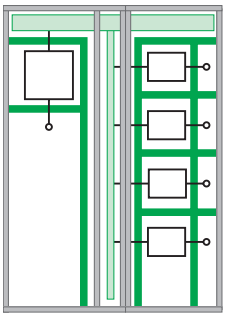
- protection of persons against contact with live parts upstream of outgoing devices,
- limitation of the risk of faults between each of the functional units (propagation of electric arcs).

There are two variants of form 4:

Form 4a: terminals for external conductors are in the same cubicle as the functional unit with which they are associated.



Form 4b: terminals for external conductors are not in the same cubicle as the functional unit with which they are associated, but in protected spaces or individual compartments that are separated and closed.

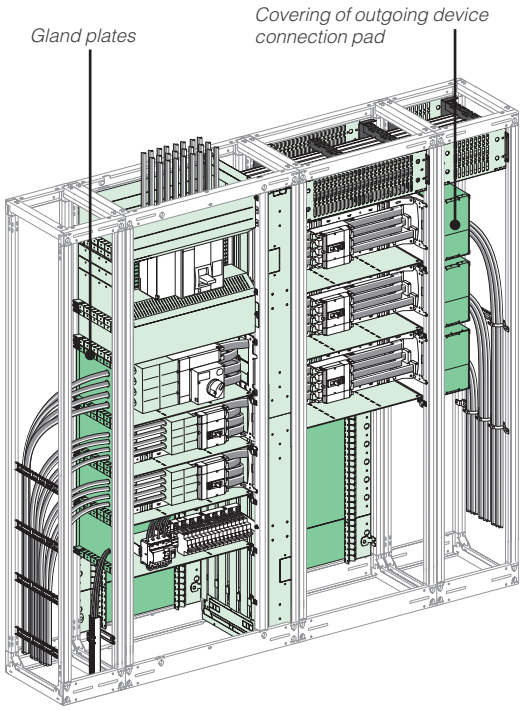


Example

Prisma

Schneider Electric proposes:

- *to fit the cubicle with gland plates to create form 4a,*
- *to cover the connection pad of outgoing devices to create a form 4b.*



The left cubicle represents form 4a.
The right cubicle represents form 4b.

Partitioning a switchboard

Installing partitions

Standards Good practice

IEC 61439-1

IEC 61439-2

1 Partitioning may be obtained by insulating the live parts:

- using separators, metal barriers, front plates, covers or terminal shields,
- by using devices with molded cases.

The entire switchboard must have a degree of protection of IP2X in accordance with IEC 61439-1 and 2.

If using metal barriers, make sure that clearances are complied with.

Example

Schneider Electric proposes different partitions for creating separations inside the cubicles and thus obtaining Form 2, 3 and 4 switchboards.

Form 2 configuration: the busbars are separated from the devices

2 Putting partitions in a switchboard reduces heat dissipation of the switchboard. It is therefore important to take this into account when defining the heat management solution for the switchboard.

Example

A form 4 switchboard dissipates less heat than a form 1 un-partitioned switchboard.

IEC 61439-1

3 Barriers must be robust enough to ensure that a possible mechanical stress on these components (reduction in clearance distance, or even accidental contact with live parts) does not cause an accident.

Installing partitions (contd.)

Standards Good practice

IEC 61439-1

4 If a busbar is installed at the bottom of the switchboard, you must use a form 2 to protect it from the possible drop of a metal object. Remember to stick a warning label ("do not walk" and "electrical hazard" symbol) on the top of the form.

"Do not walk"

"Electrical hazard"

IEC 61439-1

5 If using a disconnectable device, remember to install barriers that will prevent all access to live parts after removing the device (e.g., for a maintenance operation).

Exemple

Schneider Electric proposes insulated shutters that automatically block access to the connecting clamps when the device is in "withdrawn" or "test" position (degree of protection: IP20). When the device is removed from its frame, no live part can be accessed.

Equipotential bonding

Principle

Standards Theory

IEC 61439-1

1 Each switchboard must include equipotential bonding to protect persons and property against the effects of an electric shock (for instance, after a clearance fault).

This bonding is achieved through a protective conductor (PE/PEN) that connects all the switchboard conductive parts to the building's earth terminal.

The following must be connected to the protective conductor (PE/PEN):

- all the switchboard conductive parts,
- the earth conductors of incoming and outgoing cables,
- the secondary circuit of current transformers.

PE protective conductor

Standards Theory

IEC 61439-1
Appendix B

1 **The PE protective conductor** contributes to bringing all the switchboard conductive parts to the same potential.

It must be sufficiently sized and secured in the switchboard to withstand heat and electrodynamics stresses generated by a fault current of a duration of between 0.2 s and 5 s.

IEC 61439-1 standard gives a method for calculating the cross-section of the PE conductor:

$$S_P = \sqrt{I^2t/k}$$

Where:

- **S_P:** is the cross-section of the PE conductor in mm^2
- **I:** is the effective value of the phase-to-earth fault current = 60 % of the phase-to-phase fault current
- **t:** duration of the fault current in seconds
- **k:** a factor depending on the protective conductor material.

Example: k = 143 for a PVC-insulated copper conductor.

Example

Schneider Electric proposes a table for choosing the PE derived from the formula provided by the standard:

Icw (kA eff/1 s)	Profil Linergy Permissible current	Flat bar cross-section
< 40	630 A	25 x 5 mm
40 < Icw < 85	800 A	50 x 5 mm

Icw = permissible short-time rated current

In addition to the calculation method, type tests are conducted to ensure the performance of the protective conductor.

2 The cross-section of the PE conductor must be constant throughout the switchboard, in particular from one column to the next.In the case of a switchboard made up of several columns, all the PE busbars must be connected to each other (fish plates, bolts, etc.).

Caution: the cross-section of the fish plates must be at least equal to that of the PE conductor.

IEC 61439-1
§ 8.4.3.2.3

3 The PE conductor must never include an insulating device.

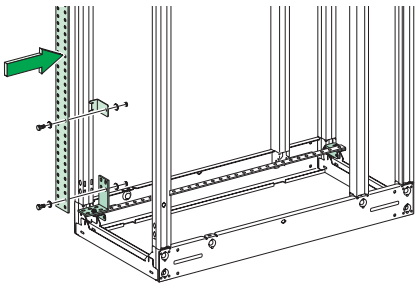
Equipotential bonding

PE protective conductor (contd.)

Standards Good practice

1 The PE conductor is usually installed in the cable compartment to facilitate the connection of incoming and outgoing devices. It can be produced using:

- a vertical, flat copper bar,

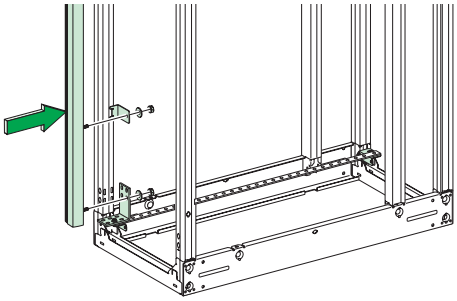


- a horizontal flat copper bar, secured to the top or bottom of the switchboard (opposite the main busbar).

Example

Prisma

The PE conductor may also be produced by a Linergy busbar.



2 The PE conductor must:

- be easily accessed to facilitate factory and on-site connections,
- be as close as possible to the connection pads of incoming and outgoing devices,
- be identified by visible marking in the middle and at both ends,
- be protected against possible deterioration (mechanical, chemical, etc.),
- not hamper the installation or the laying of client connection cables.

Example

The protective conductor is clearly identified by a label (PE) and yellow-green marking.

3 To avoid deformations arising from a short-circuit, secure the PE conductor to the frame by applying the same rules as those defined for busbars.

4 Make sure that the electrical continuity of the PE conductor is constant throughout the switchboard, in particular from one column to the next.

5 In the event of a corrosive environment, protect the copper of the PE conductor with the appropriate coating (nickel-plated bar, for example).

PEN protective conductor

Standards

Theory

IEC 61439

1 **The PEN protective conductor** is a live conductor that acts both as a PE conductor (earthing) and a neutral conductor. It must be sized as for a neutral conductor.

Its cross-section depends on that of the switchboard's power supply conductors:

- **for single-phase or three-phase circuits with a copper cross-section of Ø 16 mm²**, the cross-section must be equal to the phase conductor cross-section.
- **for three-phase circuits with a copper cross-section higher than Ø 16 mm²**, the cross-section is equal to the phase conductor cross-section Nevertheless, this diameter may be less, on condition that:
  - the current likely to flow through the neutral under normal operating conditions is lower than the permissible current in the conductor,
  - the power of the single-phase loads does not exceed 10 % of total power.

2 The cross-section of the PEN conductor must be constant throughout the switchboard, in particular from one column to the next.

Good practice

1 The PEN conductor is usually produced using a flat copper bar.

To facilitate circulation in the switchboard (e.g., for large bar cross-sections), the PEN conductor may be installed in place of the neutral.

It is usually installed in the cable compartment to facilitate the connection of incoming and outgoing devices.

Example

The PEN conductor may be produced using a Linergy busbar.

PEN protective conductor (contd.)

Standards Good practice

2 The PEN conductor must:
- be easily accessed to facilitate factory and on-site connections,
- be as close as possible to the connection pads of incoming and outgoing devices,
- be identified by visible marking in the middle and at both ends,
- be protected against possible deterioration (mechanical, chemical, etc.).

IEC 61439-1

IEC 61439-2

3 There are additional requirements for PEN conductors:
- their cross-section must be at least 10 mm² for copper and 16 mm² for aluminum,
- its cross-section may not be lower than the one required for a neutral conductor,
- there is no obligation to insulate it from conductive parts (except on premises where there is a risk of fire or explosion as a result of possible sparks),
- structural parts must not be used as PEN conductors,
- at the entry to the switchboard, the PEN conductor connection point must be near the connection pads of incoming devices,
- the transition from a TN-C to a TN-S earthing system must be made at a single point in the switchboard, via a marked neutral disconnection bar, accessible and removable to facilitate fault loop impedance measurements,
- it is prohibited to recreate a TN-C system from the point of transition to a TN-S system.

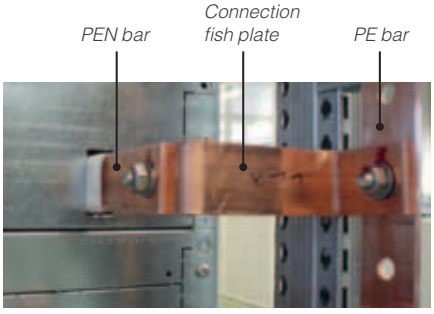
Tip

If the PEN conductor is not insulated, it becomes a PE conductor.

4 It is recommended to install the PEN conductor on insulators to avoid all current leakages from the frame.

In this case, you must connect it to the PE conductor with a removable fish plate (using a special tool) that can be accessed only by authorized personnel.

Example



Equipotential bonding

Connection to conductive parts

Standards Good practice

IEC 61439-1

1 All accessible conductive parts of the switchboard must be connected to the earthing circuit:

- by construction. Continuity is provided via the fastening systems (plate, relevant fasteners, claws),
- or via a protective conductor with a crosssection chosen from the table below:

Rated operating current I_e	Minimum cross section of a protective conductor
A	mm^2
$I_e \leq 20$	S (*)
$20 < I_e \leq 25$	2.5
$25 < I_e \leq 32$	4
$32 < I_e \leq 63$	6
$63 < I_e$	10

(*) S *is the cross-section of the phase conductor* (mm^2)

Example

Earthing wire

IEC 61439-1
§ 8.4.3.2.2

2 Conductive parts of the switchboard that do not represent a hazard need not be connected to a protective conductor.

Characterization of these conductive parts:

- cannot be touched on large surfaces or taken in the hand,
- are of small dimensions (less than 50 mm by 50 mm),
- are arranged so as to eliminate all risks of contact with live conductors.

Example: rivets, rating plates.

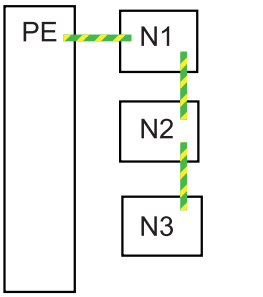
Equipotential bonding

Connection to conductive parts (contd.)

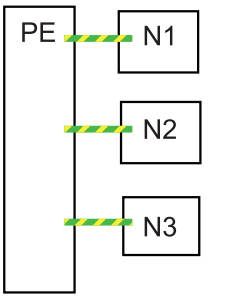
Standards Good practice

3 Wire the equipotential bonding in such a way that they can never be broken (for example, during a maintenance operation).

Example



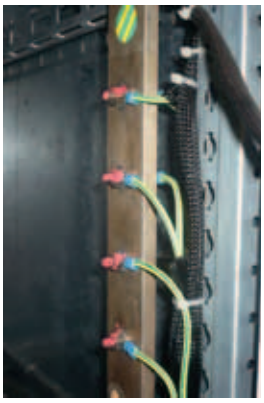
If device N1 is disconnected for a maintenance operation, the equipotential bonding is broken: devices N2 and N3 are no longer protected.



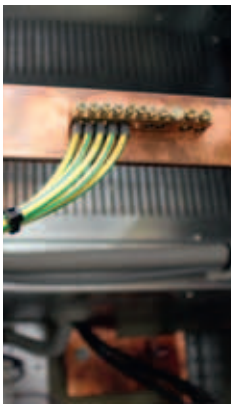
A device may be disconnected without breaking the equipotential bonding.

4 Connect a single earth cable per connection to the PE bar.

Example



2 cables per connection



A single cable per connection

Current transformers

Choosing a current transformer

Standards Theory

1. Define the transformation ratio Primary current/Secondary current.

   Primary current: standard current value of the current transformer immediately higher than the value of the primary current to be measured.

   Secondary current: the value of the secondary current depends on the characteristics, the metering device and the distance between the transformer and the device that it is powering.

2. Determine the power of the transformer in VA. Take the following into account:

   - the power consumed by the metering device connected to the transformer,
   - power losses in VA in the cables connecting to the metering device.

3. Choose the accuracy class required for the measurement depending on the application.

   Remember to take into account the error induced by the metering device itself.

4. Choose the transformer model according to the type and cross-section of the primary conductor on which it must be installed: busbar or cables.

Tip

Some Schneider Electric devices have built-in current transformers.

Masterpact NT 630 to 1600 A

All Masterpact circuit-breakers are fitted with a Micrologic control unit that is interchangeable on site.

Micrologic E control units measure the true efficient values (RMS) of currents. They provide continuous current measurements from 0.2 to 1.2 x In with an accuracy of 1.5 % (including sensors).

Current transformers

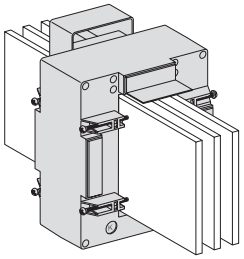
Rules for installing a current transformer

Standards Good practice

1. A current transformer may be crossed by:
   - one or more rigid bars,
   - an insulated flexible bar,
   - a cable.

Example

Schneider Electric transformers can be mounted on most busbar sections. Some models can be adapted to fit Linergy busbars.



2. Always install a current transformer:
   - in a location that is easy to access,
   - on a fish plate, a copper bonding or a bar that can be easily removed with the least possible restrictions,
   - by observing the minimum clearance distances.

Example

Dismountable vertical connections

3. Place the current transformer in such a way that its rating plate and the identification marking (in particular phase marking) are always visible.

4. Follow the current transformer mounting direction. The conventional direction of the primary current is engraved on the case.

   Although inverting the mounting direction will not harm the transformer, it will prevent the metering device from being read.

Rules for installing a current transformer (contd.)

Standards Good practice

5

You must follow the rules below for connecting the secondary circuit of a current transformer:

- the cables must have a cross-section of at least 2.5 mm^2,
- the cables must not pass too close to the power busbars and must be carefully fastened,
- the secondary circuit must be earthed using an earthing wire,
- always comply with the clearance distances plumb over the fastening screws of the transformer as well as on the secondary circuit connections.

6

The secondary circuit of a current transformer must never be open when the primary is energized.

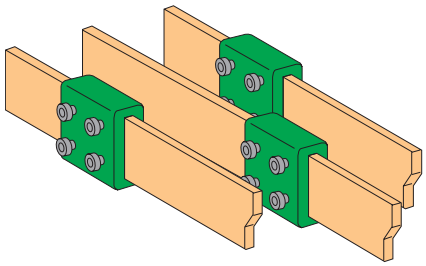
High voltages may appear on the secondary circuit terminals. They may be dangerous for staff and result in the deterioration of the transformer.

Always use round connectors to connect the secondary circuit to reduce the risks of accidental interruption of secondary circuit.

7

Stagger large current transformers:

- to ensure that clearance distances are complied with,
- to avoid making changes on the busbar (e.g., folding).



Special cases

Standards Good practice

1 When installing on vertical bars, block the current transformer with a bolt or secure it on a support to make sure that it does not slide downwards.

Example

2 When several busbars are used per phase, place a wedge between the bars to:

- support the torque of the transformer tightening screws when it is installed,
- avoid creep in the bars,
- limit vibrations that deteriorate or loosen the transformers.

The wedges must be made from insulated materials to avoid any deterioration in the event of falling and must be heat resistant enough to withstand maximum temperature of the busbars.

Anti-corrosion treatments

Principle

Standards Theory

Tip

In a normal atmosphere, the oxidation of copper in the form of oxides or carbonates forms a protective layer that prevents earth corrosion.

1

Corrosion is a physico-chemical process that takes place on the interface of a material, usually a metal, with its environment (liquid or gaseous oxidant), resulting in the alteration of this material.

The most well-known examples are:

- chemical alterations of metals in air such as iron and steel rust (transformation into iron oxide),
- or the formation of green rust on copper and its alloys (bronze, brass).

A natural and common phenomenon, the corrosion of metals and their alloys is testimony to their natural tendency to return to their original state of minerals under the action of atmospheric agents.

In the field of switchboards, there are three types of atmospheres that particularly speed up the corrosion process:

- **humid and/or saline atmosphere,**
- **industrial atmosphere:** more or less significant presence of sulphur dioxide or hydrogen sulphide in the air,
- **urban atmosphere:** presence of conductive dust or dust that can become conductive in a humid environment (e.g.: dust produced by district heating or traffic).

Principle (contd.)

Standards Theory

Tip

In dry premises where the presence of sulphur oxide or hydrogen sulphide is not detected, there is no point in conducting an anti-corrosion treatment.

2

The main chemical pollutants in the air that can alter copper and adversely affect the proper functioning of switchboards are:

- **sulphur dioxide (SO_2).**
Sulphur dioxide is mainly discharged during the combustion of fossil fuels that contain sulphur (crude oil, coal, petroleum, etc.). It is released more particularly in industries such as oil and chemical industries, foundries, boiler rooms and power plants.

- **hydrogen sulphur (H_2S).**
It is releases more particularly in industries such as blast furnaces, paper mills, refineries or water treatment plants.

When combined with humidity, these two chemical compounds become extremely corrosive because they are transformed into acids. The effects of corrosion soon become visible (in just a few months):

- degradation of copper conductors: corrosion of the silver-plating of the bars and growing of silver whiskers, crumbling of bare copper in certain places (powder effect),

- alteration of bare copper surfaces: meticulous preparation is required for making bolted contacts.

Poor contact as a result of insufficient preparation increases contact resistance, which increases the temperature and which further increases contact resistance.
This results an irreparable thermal runaway.

- alteration of the sliding contacts of pull-out devices that become black and overheat (silver plating),

- alteration of the active parts of the switchgear and controlgear (auxiliaries, circuit-breakers, contactors, etc.) resulting in malfunctions,

- corrosion of cables on the stripped areas resulting in breaks in contact.

Anti-corrosion treatments

Principle (contd.)

Standards

IEC 60721-3-3
Table 4

Tip

Manufacturers' technical guides and catalogues provide information about the resistance of the equipment in a corrosive environment.

Good practice

1 In places where the presence of sulphur dioxide (SO_2) or hydrogen sulphide (H_2S) can be detected, even discontinuously, the environment may be considered as corrosive, and it is strongly recommended to implement protective anti-corrosion.

The standard IEC 60721-3-3 defines the categories corresponding to the maximum values of sulphur dioxide (SO_2) and hydrogen sulphur (H_2S) that must not be exceeded to ensure that the equipment resists in a corrosive ambiance. As a rule, it is strongly recommended to carry on an anti-corrosion treatment when the concentration in SO_2 or H_2S is higher than 0.5 ppm.

2 An anti-corrosion treatment consists in putting in place all measures aimed at slowing down and eliminating the corrosion of metal materials in order to protect them.

The most commonly used of these measures to protect busbars consists in applying a coating:

- metallic (metal),
- organic (paints),
- mixed (metal + paints).

To be effective, an anti-corrosion coating must have:

- good resistance to acid vapours,
- good adherence to the surface to treat,
- sufficient thickness,
- good resistance to humidity*.

**given that humidity is an aggravating factor of the corrosion phenomenon, it is also advisable to also check the humidity in the switchboard.*

> *See "Thermal Management" page 266.*

3 **Stripping of surfaces**

Before any anti-corrosion protection you must prepare the surface of the metal. This is because the best treatments applied on a badly stripped or badly cleaned surface will be effective only for a very short period.

To ensure that the coating adheres well to the surface to treat, **it is imperative to:**

- degrease all surfaces to eliminate all traces of fats,
- strip all surfaces to eliminate all traces of rust.

The resources used may be:

- mechanic: brushing, sand blasting, grit blasting, etc.
- chemical: solvents, detergents, etc.

Anti-corrosion treatments

Coatings

Standards Good practice

Tip

The coated parts must be stored away from humidity and handled with gloves.

1

The coatings usually used in electrical switches are:

Metallic: tin (Sn), nickel (Ni) and silver (Ag).
Depending on their type, these metals are very resistant to corrosion and have other decisive advantages for the installation of switchboards:
- reliability and resistance over time of the quality of electrical contacts for Sn and Ag,
- high resistance to corrosion for Ni.

Organic (epoxy paint)
Aside from protecting against corrosion, epoxy paint improves heat dissipation -through radiation of the bars and limits the propagation of any internal arcs.
In an environment of pollution degree 3 as defined by standard IEC 61439-1, (switchboard environment conditions: presence of a conductive pollution or dry non-conductive pollution that becomes conductive due to condensation), the use of epoxy paint strongly limits the risk of sparking.

Mixed (metal + paint): it is possible to have two coatings - epoxy pain on a metallic protection.

Note: you must distinguish between live parts linked by permanent fasteners (bolts) and those fastened with sliding contacts.

2

Tin coating

Case of use	Recommended coating	Derating
Bolted connections (busbars, bar ends, transfer bars, fish plates, PE/PEN protective conductors)	Tin of thickness 12 µm	None or according to manufacturers' recommendations

Follow the instructions given in the manufacturer's specifications.

Deposit of tin is prohibited on bars on which switchgear and controlgear with sliding contacts are supposed to be connected (draw-out units fitted with jaws).

3

Nickel coating

Case of use	Recommended coating	Derating
Sliding contacts (draw-out modules)	Nickel of thickness 20 µm	20 %

Follow the instructions given in the manufacturer's specifications.

Anti-corrosion treatments

Coatings (contd.)

Standards Good practice

4 Silver coating of copper bars

Standard ISO 4521 recommends thickness between 2 and 5 µm. A layer less than 2 µm thick is porous, does not provide the expected protection and can lead to a loss in electrical conduction.

Silver protects the copper conductor from rust, but is attacked by compounds containing sulphur or sulphides. In these conditions, the silver becomes tarnished.

Although, conductibility is not affected by slight tarnishing, continued discolouring is a sign that there is a lot of sulphur in the ambient air. In this case, there is a strong risk that conductibility will be deteriorated.

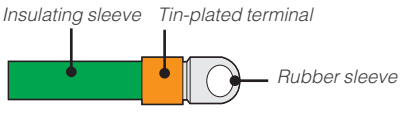
Never apply a silver coating on parts if there is hydrogen sulphide (H_2S) in the ambient air.

In such conditions, **we observe the formation of Ag^2S which covers the contacts and deteriorates performances** (increase in electrical resistance) or **creates malfunctions** in the case of contacts that are rarely handled.

5 Special case of cables

Protection of power cables

- Use copper cables with insulating sleeves.
- Use tin-plated terminals (tubular terminals). Rolled tubular terminals can be used only with tin-plated cables.
- Place a rubber sleeve that covers both the crimped part of the terminal and the sheath, to keep the copper part between the cable insulator and the terminal away from air.



Protection of control-command cables

Tin-plated cables must be used for command and control circuits.

Protection against internal arcing

Protection against internal arcing

Standards Good practice

Tip

Resistance to environmental conditions in compliance with the classes defined in IEC 60721-3-3 standard: 3K6/3Z2/3Z5/3Z83C23S3.

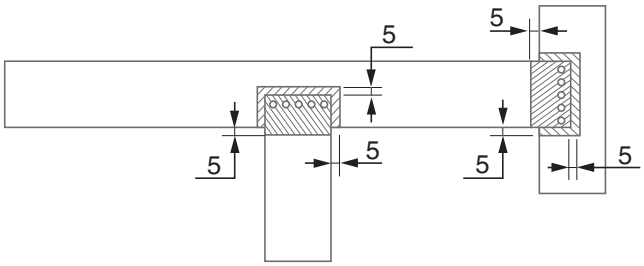
1 Epoxy coating of busbars

When internal arc resistance is required, one of the solutions consists in applying an epoxy paint coating to copper busbars:

- material: thermosetting epoxy on CuETP copper,
- thickness: 120 +/- 30 µm,
- maximum operating temperature: 150°C,
- paint adherence: in accordance with ISO 4628-1 to 6,
- cleaning of protected surfaces to ensure good electrical contact,
- no derating to be provided if epoxy coating is used alone.

2 Bar painting procedure

- Chemical degreasing of the bar.
- Protection of contact surfaces (hatched parts) with adhesive tape.



- Coating with an epoxy paint (thickness of coating equal to 120 µm + 30 µm).
- Stoving between 190 and 200°C for 20 minutes.
- Removal of the adhesive and thorough cleaning of the protected parts that could have been oxidised during stoving (use of red 3M abrasive tape or equivalent).
- After you have finished the connections, install protections to cover the parts that have been left bare.

Notes

Quality control check list

Note: the list of control points presented is not exhaustive.
It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

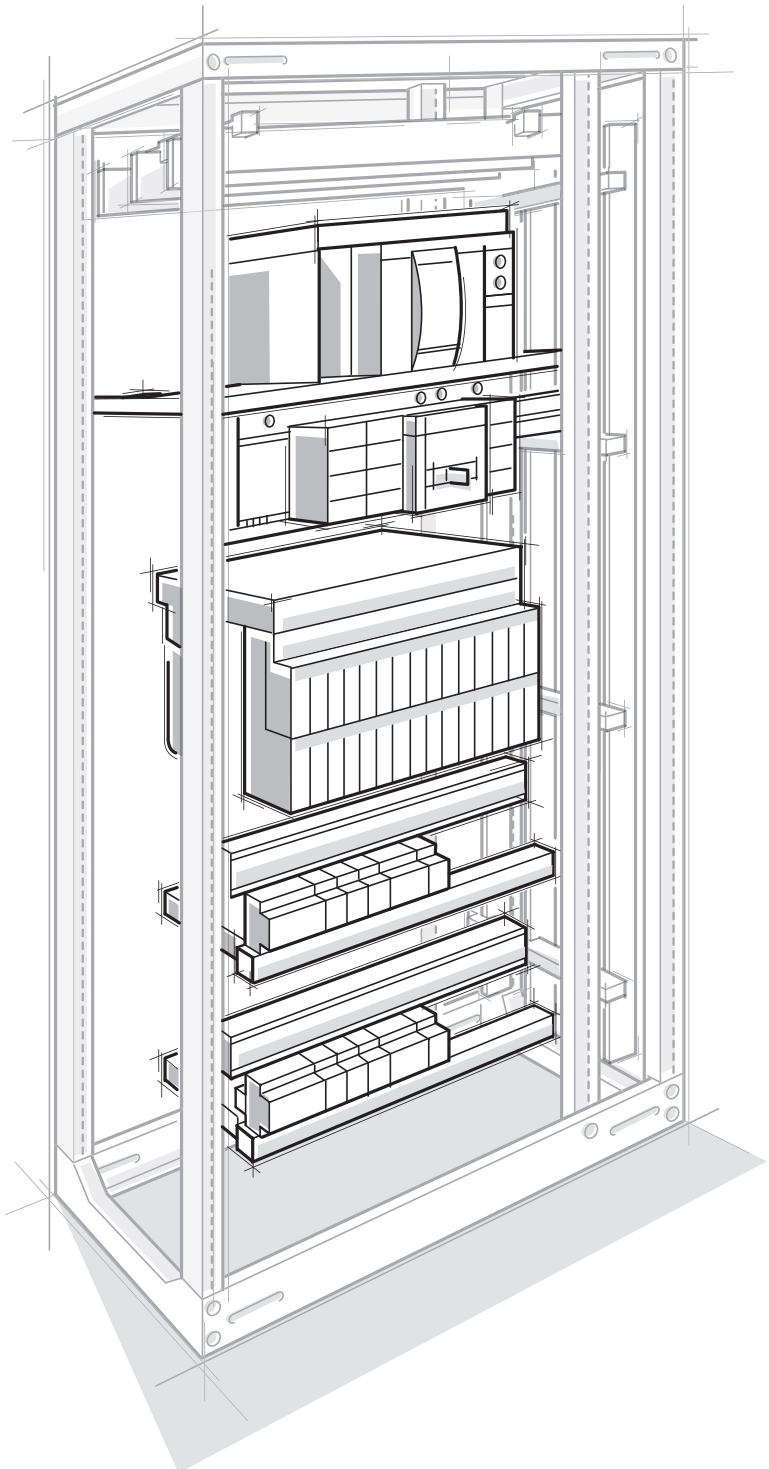
Minimum checks required	Control points	Control resources	Self-control
☑	> Busbar cross-section and number *Note: to be done preferably when the busbars are installed*	> Manufacturing file	☐
☑	> Manufacturing quality* *Note: to be done preferably after the bars are manufactured*	> Installation guide	☐
☑	> Order and identification of phases	> Technical documentation	☐
☑	> Creepage distance	> Visual inspection and installation guide	☐
☑	> Clearances	> Visual inspection and installation guide	☐
	> Fastening of busbars**	> Technical documentation	☐
☑	> Protection circuit***	> Manufacturing file, visual inspection, installation guide	☐
	> Conformity of partitioning forms	> Technical documentation, manufacturing file	☐
	> Conformity and installation (current transformer)	> Manufacturing file, installation guide	☐

(*) forming of bars (drilling, folding, cutting, etc.)
(**) number of supports, centre distance, etc.
(***) cross-section, identification, bonding continuity, etc.

Objectives

- Avoid risks of temperature rises
- Avoid electrical risks
- Avoid risks caused by electrodynamic stress
- Ensure the protection of persons
- Avoid the deterioration/destruction of equipment

Installing the devices



Foreword

Standards Theory

1 The layout of devices must be designed taking into account:

- the entry/exit direction (from the top or from the bottom) of the customer's wires,
- the space available in the switchboard,
- heat constraints inside the switchboard.

> *See the "Device Layout" section in this chapter.*

2 The devices in the switchboard must be mounted, scrupulously following the instructions given in the switchgear manufacturers' guides.

Special precautions must be taken when mounting door-mounted devices.

> *See the "Device Mounting" section in this chapter.*

IEC 61439-1 §8.4

3 Operations in switchboards must be carried out by qualified persons who comply with all required safety measures.

It is imperative to ensure the protection of operators against accidental direct contacts.

> *See the "Protection against direct contacts" section in this chapter.*

Device layout

Positioning rules

Standards

Good practice

IEC 61439-1
Table 6

1 Define the layout of devices in the column based on constraints related to:

- the entry and exit points of the customer's wires (from the top, the bottom of the column or other specific configuration) and the position of the main busbars in order to have the shortest possible connections,
- the routing of prefabricated wires or connections at the input and output of the switchboard,
- the space required for the device to work correctly (volume of device, safety perimeter, connection pads, radius of curvature of wires, control units, etc.),
- the accessibility of the various control units and connection zones (side, rear, etc.) of devices,
- heat dissipation of devices that contributes to increasing the internal temperature of the column,
- the mutual thermal and electromagnetic influence between the main busbars and the devices,
- the maintenance or upgrade of the system (for example, enable the opening of the motorised control of a circuit-breaker).

The resulting layout of the switchgear should also be studied to optimise connection zones, busbars, enclosure sizes, etc.

Example

The functional units defined by Schneider Electric have been defined, designed and tested to work together.

Schneider Electric proposes prefabricated links for most customer connections. These links have been tested and optimised (length and cross-section) to reduce temperature rise constraints.

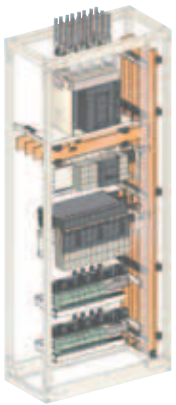
IEC 60480

2 Place devices with a high heat dissipation in the upper part of the switchboard to:

- avoid heating the entire switchgear installed in the column,
- maintain the performance of devices of lower power placed at the bottom to keep derating to a minimum,
- enable greater legibility of the electric layout.

Example

Schneider Electric recommends that, whenever possible, devices should be placed in the column from top to bottom of the most powerful to the least powerful.



Device layout

Positioning rules (contd.)

Standards

Good practice

Tip

To maintain the internal temperature of the switchboard within the operating limits of most devices (<70°C), a forced ventilation of cubicles may be necessary, to replace derating, in order to optimise the volume of copper and reduce the cost of the switchgear.

3 Several devices with a high heat dissipation may be installed in the same column if:

- the maximum internal temperature is observed (below the manufacturer's recommendations),
- the capacity of the busbars to convey the rated current is observed (see derating tables),
- the expected performance of each device is reached (see derating tables).

IEC 61439-1
Table 6

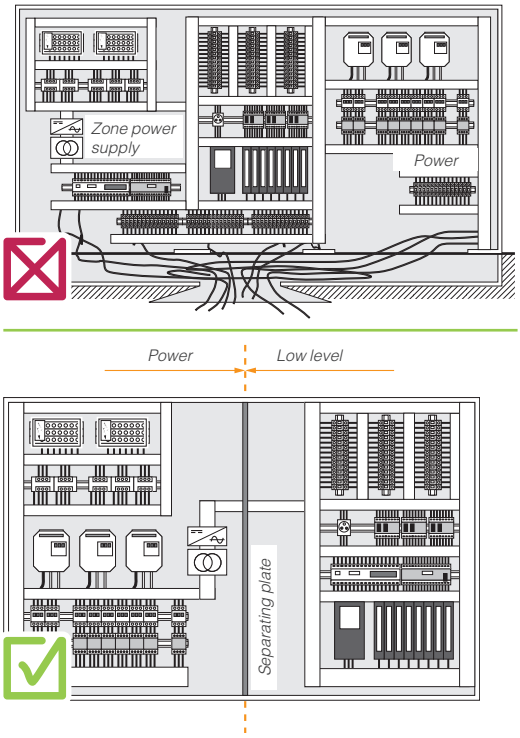
4 Comply with the temperature rise limits recommended by standard IEC 61439-1.

> *See the chapter "Beyond Basics - Thermal management of a switchboard".*

5 To avoid serious malfunctions, do not install devices that are sensitive to temperature rises (e.g., control/command devices) near devices with high heat dissipation.

It is recommended to separate the switchboard into two zones (high-power devices and low-power devices) to improve the efficiency of the installation.

Example



Device layout

Safety perimeter

Standards

IEC 61439-1

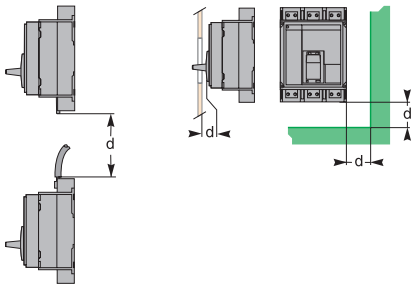
IEC 60947-x

Tip

For tables with a high operating voltage of 690 V, you may have to install additional barriers to reduce the risk of sparking in case of a short-circuit.

Good practice

1. Keep within the safety perimeter defined by the manufacturer for each device and make sure they are working properly:
   - minimum distance between two devices,
   - minimum distance of the device from surrounding components (frame, plate, etc.),
   - minimum distance from powered live bars.



Example

The various installation configurations proposed by Schneider Electric have been tested and validated.

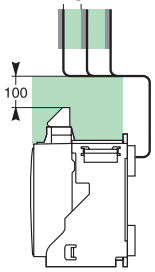
The Schneider Electric circuit-breakers are all class 2 circuit-breakers. They can therefore be placed side by side without any specific precautions.

Tip

The safety perimeter may be reduced by adding a cover, terminal cover, barrier, etc.

2. The safety perimeter is usually stated by the manufacturer in the device technical manual or the catalogues.

Example



Example of safety perimeter for a circuit-breaker of the fixed device Masterpact range: the minimum distance of the device from a powered bare busbar for an operating voltage of < 690 V is 100 mm.

3. The safety perimeter is a zone where it is forbidden to:
   - route wires other than those intended for the connection of the device itself,
   - install other devices.

4. Connect the devices with care.
In particular:
   - do not strip insulated flexible bars and connection cables too much, to avoid all risk of sparking between phases in the event of a short-circuit,
   - position the lugs correctly on the connection pads,
   - if necessary, install barriers, terminal covers or insulating sleeves between each phase.

Sleeves used for marking wires do not act as insulators.

Device layout

Ergonomics

Standards

Good practice

IEC 61439-1
§ 8.5.5

1. Position the devices in such a way that control units (knobs, pushbuttons, etc.) are located at a height of between 0.2 m and 2 m from the ground.

IEC 61439-1
§ 8.5.5

2. Provide for sufficient space adjacent to the terminal block connections to enable conductors to be grasped and prepared (placing of marks, crimping conductors, etc.).

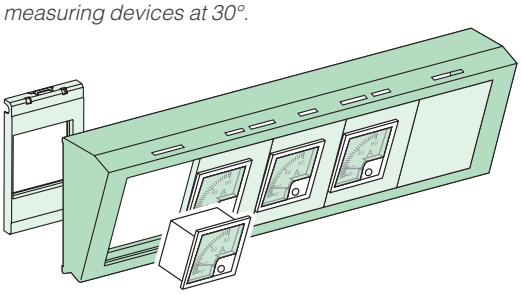
   With the exception of protective conductor terminals, always position terminals at least at 0.2 m from the floor.

IEC 61439-1
§ 8.5.5

3. Position measurement devices requiring a visual inspection at a height comprised between 0.2 m and 2.2 m from the ground. Their exact position must be determined in consultation with the switchboard user.

Example

To facilitate reading from the front panel, Schneider Electric proposes visors that make it possible to tilt measuring devices at 30°.



IEC 61439-1
§ 8.5.5

4. Position the emergency stop pushbuttons so that they are always accessible and at a height comprised between 0.8 m and 1.6 m from the floor.

Device layout

Cut-outs

Standards

Theory

IEC 61439-1

1 Standard IEC 61439-1 defines the spaces available in the assemblies.

Concept	Definition
Free space	Empty space in a column.
Unequipped space	Part of a column that contains only busbars.
Partially equipped space	Part of a column fully equipped except for functional units. They are defined by number of modules and by size.
Fully equipped space	Part of a column fully equipped with functional units that are not assigned to a specific use.

Good practice

1 As a general rule, provide for sufficient free space to enable upgrades to the installation. We recommend that you leave 30 % of free space.

Device layout

Maintainability/Scalability

Standards

IEC 61439

Good practice

1 The layout of devices must allow for future operations (scalability of the system and maintenance) such as:

- installing an auxiliary circuit,
- adding or replacing an outgoing device,
- easy access to connection points to detect a possible temperature rise.

Example

The design of the system, the installation and connection of Schneider Electric devices allow for all maintenance actions required during operation:

- *quick access to device adjustment units thanks to front plates and mobile panels, that are opened with quarter-turn screws,*
- *easy integration of devices,*
- *replacement or addition of outgoing devices facilitated by the use of connection accessories: splitters and combs.*

Tip

Maintenance actions can be organized in two complementary ways:
- preventive maintenance
- corrective maintenance.

2 Do not forget to take into account the constraints of maintenance from the implementation.

See the manufacturer's manuals to take into account access constraints related to:

- settings,
- corrective maintenance operations (replacement of the device or a neighbouring device),
- check of the circuit-breaker arc chamber for preventive maintenance,
- the replacement of components (cartridges, fuses, etc.),
- the replacement of a contactor reel,
- etc.

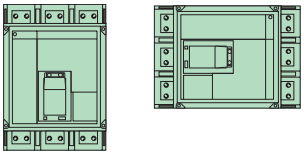
Mounting devices

General rules

Standards — Good practice

IEC 60947-x

1 Mount the devices in accordance with the instructions given in the manufacturers' technical manuals, complying with:
- mounting recommendations,
- safety instructions,
- mounting direction of devices (horizontal or upright).



Example
Flat-mounting of contactors is forbidden.

IEC 61439-1
§ 8.8 + table A1

2 Make sure that the cross-section of client cables (incoming/outgoing) is compatible with the capacity of connection pads of the device concerned.

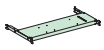
IEC 61439-1
§ 8.3.2

3 Install the devices on the appropriate plates. Mounting on a plate inside a column makes it possible to guarantee that the devices will occupy the optimum floor space and work optimally.

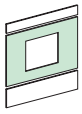
In particular, these plates must:
- be sufficiently rigid to bear the weight of the device and its connections,
- be designed and installed in such a way as to maintain the insulation distances recommended by standard IEC 61439-1 after the connection,
- withstand the effects of a short-circuit,
- enable easy connection of the device,
- withstand vibrations generated during a short-circuit.

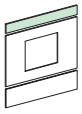
Example

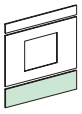
Schneider Electric has developed a functional unit around each device that includes:
- *a dedicated plate for installing the switchgear.*
- *a front panel for avoiding direct access to powered parts.*
- *prefabricated links to the busbar.*
- *appropriate systems for on-site connection.*



Plate


Cut-out plate


Upstream plate


Downstream plate

IEC 61439-1
§ 8.3.2

4 Make sure that the control units can move freely during operation.

A withdrawable device must not:
- block the closing of the door,

reduce insulation distances to below the limits recommended by standard IEC 61439-1 when the door is closed.

Example
Schneider Electric power devices are withdrawn via the front plate. The withdrawn device must not prevent the door from being closed.

Mounting devices

Door-mounted devices

Standards Good practice

1 Switchgear that has to be door-mounted must be chosen depending on the IP degree of protection of the table.

Install the accessories necessary for maintaining the IP degree of protection.

All devices mounted on a door must not lower the original IP.

> *See chapter 2 – "Assembly of enclosures".*

Example

Voltmeter with cover

2 Door-mounted switchgear - and in particular the accessible connecting points when open door - must have a protection index IP of more than IP2X except for those with an operating voltage not more than 50 V.

> *See chapter 2 – "Assembly of enclosures".*

EN 50-298

3 The door and its fastening system (hinges) must be sufficiently stiff to bear the weight of the switchgear.

Comply with the permissible weight on a door. See the switchgear manufacturers' manuals to know the weights of the devices and their installation constraints.

4 It is preferable to install the heavier devices on the hinge side of the door.

5 Make sure that there is electrical continuity between the equipped door and the frame.

> *See chapter 2 – "Assembling the enclosures".*

Mounting devices

Door-mounted devices (contd.)

Standards

Good practice

6 Make sure that the devices mounted on the doors do not disturb the operation of the other devices installed inside the switchboard.

Check that the closing of the door does not obstruct the movements of the device control units.

IEC 61439-1 § 8.3.2

7 Check that the minimum insulation distances recommended by the standard IEC 61439-1 are complied with.

8 When a door is used as a component of form, you must install a locking system that requires the door to be opened.

A key is not considered to be a tool.

Protection against direct contact

Protection against direct contact

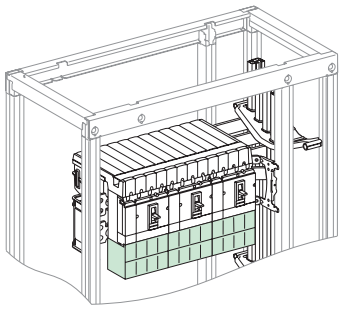
Standards Good practice

1. Check the manufacturers' instructions to provide for the protective systems to install around the switchgear (barrier, terminal cover, phase separators, etc.) to:
   - prohibit all access to live parts,
   - reduce the risk of sparking (insulation distance and safety perimeter).

Example

Schneider Electric recommends the use of terminal covers to meet the requirements for protection against direct contacts.

Terminal covers may be mandatory in some mounting configurations (optimisation of safety perimeters, high operating voltage ≥ 690 V).



Front connection: device terminal cover

2. Work inside a live switchboard is subject to regulations. It must be conducted by qualified persons and requires the installation of sufficiently rigid covers around the live parts. These covers should not prevent air from circulating properly around the devices.

3. To increase the safety of operators even further, the switchgear can be installed behind a protective front plate (that can be dismounted with a tool) leaving only control, test and setting units uncovered.

Notes

Quality control check list

Note: the list of control points presented is not exhaustive.

It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered..

Minimum checks required	Control points	Control resources	Self-control
☑	> Conformity of the switchgear and controlgear* (placing of equipment and conformity of front panel)	> Manufacturing file	☐
☑	> Mechanical operation	> Switchgear and controlgear guide	☐
☑	> Accessibility of switchgear and controlgear (maintenance and operation)	> Switchgear and controlgear guide	☐
☑	> Fixing of switchgear and controlgear	> Switchgear & controlgear and system guide	☐
☑	> Customer connection	> Manufacturing file	☐
☑	> Compliance with safety perimeters	> Switchgear and controlgear guide	☐
☑	> IP degree of protection	> Manufacturing file (IP conformity), installation guide	☐

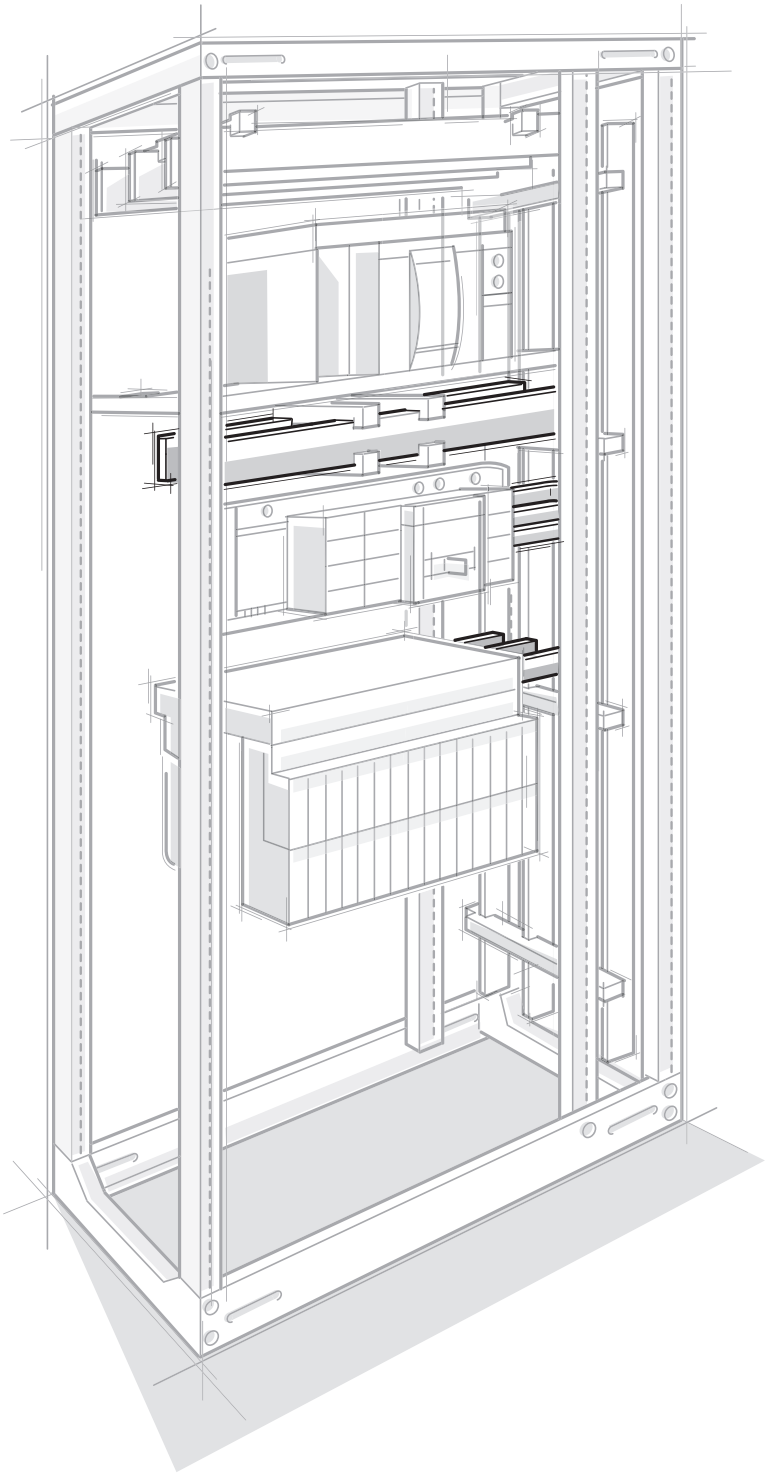
(*) type, calibre, number of poles, accessories, etc.

Objectives

- Guarantee that the installation complies with project specifications
- Check that the equipment is working properly
- Ensure the maintainability of the installation
- Avoid risks of mechanical deterioration
- Facilitate customer connections on site
- Ensure the protection of persons and property

Please photocopy the check list before completing it

Power connections



Foreword

Foreword

Standards Theory

1 Power connections can be obtained through:

- rigid bars (horizontal and vertical main busbars, transfer bars),
- insulated flexible bars,
- cables.

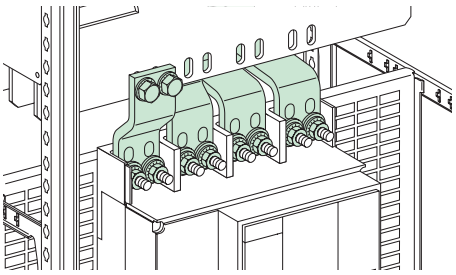
By convention, power circuits are circuits connected to conductors with a cross-section of over 6 mm^2.

The means of connection is chosen based on the switchgear electrical characteristics: (electrical power) and available space in the column.

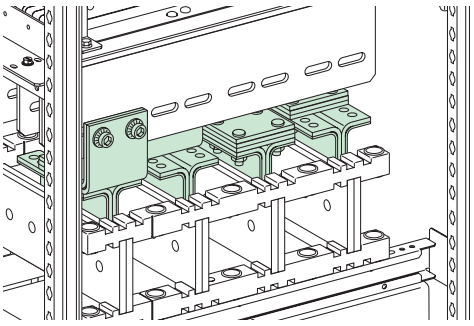
> *See the technical guides or manufacturer's data sheets to install the appropriate conductors.*

Example

Schneider Electric proposes many prefabricated connections for the connection of main busbars and incoming and outgoing devices. All these connections have been tested and validated.



Incoming directly on device by prefabricated electrical trunking



Incoming on busbars by prefabricated electrical trunking

2 All connections must be sufficiently sized to withstand electrical and thermal stresses.

Do not forget to take into account:

- the installation environment (pollution, ambient temperature, etc.),
- IP degree of protection of switchboard.

The conductor cross-section and the type of connection must be determined based on:

- the characteristics of the switchgear/ controlgear to be connected,
- the length of the connection,
- the thermal environment of the connection.

> *See:*
- the technical guides or manufacturer's data sheets to size the conductors.
- the chapter "Beyond Basics – Switchboard thermal management".
- the chapter 2 "Assembly of enclosures".

Foreword (contd.)

Standards Theory

3 The creation of rigid busbars requires (cutting, punching, drilling, and folding) that requires a real expertise in order not to weaken or damage the intrinsic characteristics of the bars.

> *See the "Forming of rigid busbars" section in this chapter.*

Tip

This sizing of a rigid busbar is developed in chapter 3 - Power busbars.

4 Rigid busbars must be assembled according to specific rules to ensure the quality of electrical contacts. The quality of a electrical contact depends on:

- the condition and size of the contact surfaces,
- the contact pressure.

> *See the "Assembly of rigid busbars" section in this chapter.*

5 Insulated flexible bars are primarily used for direct connections between transfer busbars and the switchgear/controlgear. Defining and installing them requires the same cares as for rigid busbars.

An incorrect choice and/or installation may:

- lead to a temperature rise,
- and disrupt or even damage connected or surrounding devices.

> *See the "Insulated flexible bars" section in this chapter.*

Foreword (contd.)

Standards Theory

6 Cables may be used for all power connections.

Nevertheless, connection becomes more difficult after a given power owing to:

- the limited space inside the switchboard,
- the large cable cross-section,
- the minimum radius of curvature to be complied with,
- the number of cables to install,
- the space needed for lugs.

> *See the "Cable connections" section in this chapter.*

Preparing of rigid bars

Principle

Standards Good practice

1 Rigid bars are formed using:
- shears or pendulum saws,
- punching machines,
- folding machines.

Make sure that:
- the machines have been adjusted correctly and that there is no clearance when they are used,
- the tools are in good condition and well sharpened,
- the tools do not deform the busbar during forming.

Cross-section of rigid bars

Standards Good practice

Tip

An adjustable stop is used for cutting to the desired length. It makes cutting easier.

1 **Measurements**

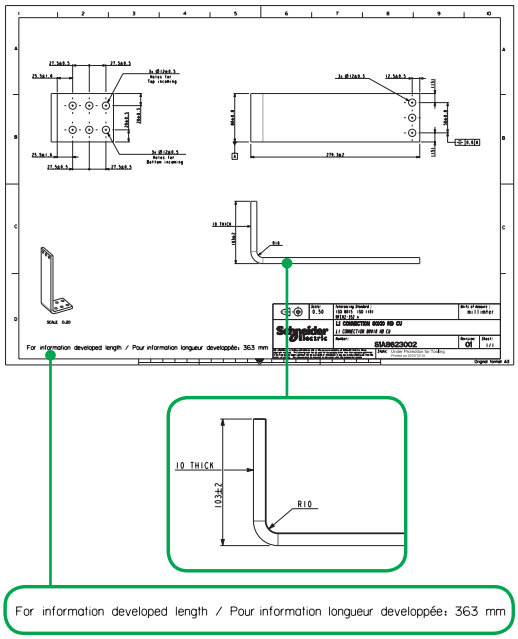
Measure the length to be cut preferably with an adjustable stop.

If you have to fold the bar, define its developed length without forgetting to take the bend allowance into account.

Example

Prisma

The bar drawings provided by Schneider Electric give the developed length, and take the bend allowance into account.



Preparing of rigid bars

Cross-section of rigid bars (contd.)

Standards Good practice

2 Tools required

Cut the bar using a machine or tool chosen according to the characteristics of the bar (material, cross-section).

The cutting tool must be sharpened and must not create deformations of the bar, parasitic stresses or temperature rises.

Make sure the work area is clean.

Sawing generates shavings that are likely to be projected in the surrounding area.

Particles derived from the cutting can also be easily disseminated through the shoes and clothing of operators. Consequently, it is preferable to carry out this operation outside the cabling workshop.

3 Installation

Install a guide perpendicular to the cutting tool to ensure that it is aligned and is held well in place during the cutting. A holder fitted with rollers is used to bring the bar opposite the cutting tool. A second holder fitted with a ruler and a stop is used to cut the bar to the desired length.

Cut bar neatly and without flashes.
No deformation must affect the surface of the bar.

The cut must be at 90° to the surface of the bar. This precaution makes it possible:

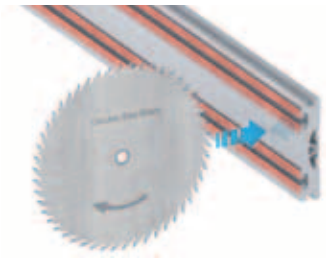
- to keep a constant alignment of holes during punching,
- to avoid the wrong alignment of bars when they are mounted.

The respect of these precautions will facilitate the introduction of the screw connection.

Example

Linergy LGYE and LGY bars

Bars must be cut by starting with the side of the HVOF copper contact track.



After sawing, check that there are no flashes or alterations on the copper contact track

☒ *Filings and flashes: non-compliant*

☑ *Clean contact surfaces: compliant*

4 Cleaning

After sawing, carefully remove any flashes on the edges of the bar. If the contact surfaces are rusted, it is recommended that you edge them by using a micro-abrasive cloth.

Preparing of rigid bars

Punching-Drilling of rigid bars

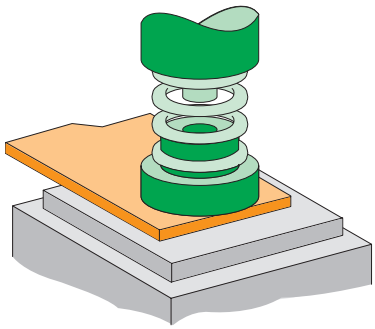
Standards Good practice

1

Tools required

It is preferable to use a punching machine.

The bar is punched with an appropriate tool fitted with a work holder that enables the punch to come up without deforming the bar.



The punching machine must be in good condition and perfectly sharpened. Regularly check that the punch is kept sharp and the punch/die working clearance to avoid creating flashes or deforming the copper through creep.

Nevertheless, you can use a drill to make the hole.

You must use the correct device for fastening into a vice. This device must:

- guide the drill,
- ensure the operator's safety by holding down the bar during drilling,
- prevent the deformation of the bar.

Preparing of rigid bars

Punching-Drilling of rigid bars (contd.)

Standards

Good practice

Tip

Line connection has the advantage of limiting zones that are not subjected to correct contact pressure to ensure that the vacuum existing between 2 connection points does not become a source of corrosion, and then temperature rise if there is humidity (contact e.m.f.).

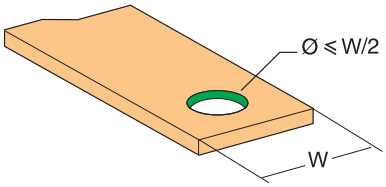
2 Punching diameter

Respect the plans of manufacturing for the achievement of drillings (number, diameter and location).

The punching diameter and the number of holes to make depend on the fasteners used and the width of the bar:

Diameter of fasteners	Maximum punching diameter
	(in mm)
M6	7
M8	10
M10	12
M12	14

- The diameter of drilling must always be lower than half the width **W** of the bar.



- To maintain a sufficiently large contact surface, do not punch the drilling too close to the ends of the bar since this could deform and weaken the bar as well as reduce the contact surface.

- If necessary, carefully remove any flashes after punching.

- All bars with holes that are too large as a result of drilling errors must be scrapped.

Example

Bars must be scrapped in case of drilling errors.

5

Preparing of rigid bars

Punching-Drilling rigid bars (contd.)

Standards Good practice

3 Marking of hole locations

When using machines that do not have digital controls, you must mark and pinpoint the location of the hole to be punched:

- Use a marker pen. If you are using a scriber, be careful not to deteriorate the contact surface during the tracing.

Do not use mine graph, particularly when drawing or cutting bores locations on insulating supports used for clamping bars between them.

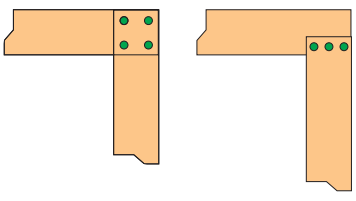
- Mark the position of the holes very precisely to avoid difficulties in inserting screws, in particular when the assembly to be made comprises several bars per phase.

4 Installation

Position the bar on a flat base that is clean and non-abrasive. To facilitate the electrical connection, punch in a row:

- to distribute pressure uniformly on the entire contact surface,
- to facilitate insertion and tightening of the terminal bolts.

Nevertheless, in some cases it may be necessary to completely cover the bars to maintain the minimum creepage or to meet certain mounting constraints.
An assembly that is correctly designed and mounted has the same resistance as that of an uninterrupted conductor and does not generate a hot spot.



- Carefully remove any flashes without creating an excessive chamfer edge.
If the chamfer is too large, it will reduce the contact surface accordingly knowing that the optimum contact pressure is mainly exerted around the head of the screw.

Example

In the Prisma Plus offering, to connect two flat busbars, (horizontal- vertical), the assembly points must be arranged diagonally and shifted from one bar to the other to comply with creepage and to enable them to be assembled on busbars that have been already mounted.

Preparing of rigid bars

Folding rigid bars

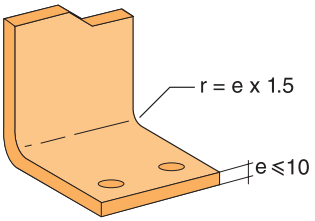
Standards Good practice

1 Tools required

Folding must be done carefully with the appropriate tool of good quality and in good condition. The tool must not be able to cause scratches or any other deformations on the bar to be folded.

2 Folding radius

As a general rule for copper, maintain a radius of at least 1.5 times the thickness of the bar to avoid cracks or crazing that may appear on the outer side of the fold.



For aluminium, you must provide for a radius curve of at least twice the thickness of the bar.

Example

The quality of copper (Cu-ETP H12) recommended by Schneider Electric makes it possible to make folds with a radius of at least the thickness of the bar (5 mm or 10 mm).

3 Be careful never to fold at the level or near a hole. This would weaken the bar, resulting in a risk of a temperature rise on the fold.

4 Never unfold a bar in the aim of reusing it even if you do not make the new fold at the same point.

NF A51-118

5 After folding

- Visually check the condition of the copper (no crazing, cracks or tears) on the fold. If in doubt, the checking criteria are set out in standard NF A51-118.
- Remove any traces of grease and marker.

Connecting rigid bars

Principle

Standards Good practice

1

The quality of rigid bar connection depends on:

- the quality of the fasteners used,
- compliance with the contact surface,
- the cleanliness of the contact surface,
- the contact pressure between the two bars,
- tightening to the recommended torque.

Check that:

- the bars are aligned,
- the connection holes comply with and are in alignment with the connection holes,
- there are no constraints on the bar supports.

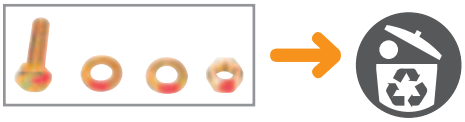
In the event of a connection on the switchgear, make sure that there are no constraints on the connection pads.

Fasteners

Standards Good practice

1

- Assemble the copper bars using the ungreased zinc-plated yellow dichromatic fasteners (Zn8C), Class 8.8.
- Choose the dimension, quality and number of screws depending on the dimensions of the bars to connect and the intensity of the current circulating in the bars.
- You **must** comply with the assembly number, diameter, centre distance and the tightening torque. Follow the instructions given in the manufacturer's technical guides.
- If you have to dismount a connection after the fasteners have been tightened, use new fasteners when mounting it again.



> *See the chapter "Beyond Basics – Assembly Techniques" to carry out an assembly according to good practice.*

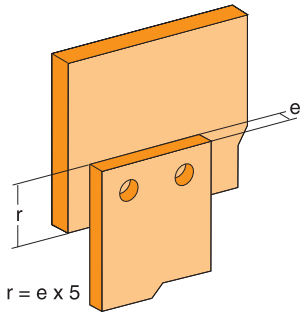
Connecting rigid bars

Contact surface

Standards Good practice

1 For copper bars up to 10 mm thick, you can apply the following rule: the overlap distance **r** must be at least equal to 5 times the thickness **e** of the secondary bar.

This is a general rule. Its main objective is to maintain the same temperature rise as that of a full bar, all the while ensuring the electrical connexion over time.



Example

Schneider Electric proposes bar covering solutions. All these connections have been tested, validated and optimised. Type tests have been conducted according to the IEC 61439-1 standard as well as under extreme conditions that reproduce the ageing of the contact point.

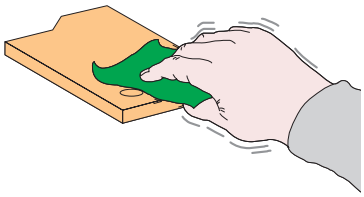
- For rigid copper bars with a thickness of 10 mm, a coating 2.5 times the thickness has been optimised.

- Linergy LGYE and LGY busbars are connected to flat busbars using prefabricated and tested copper connections and offer optimised covering surfaces.

2 **Cleaning contact surfaces**

Contact surfaces must be clean, dry, flat and free from significant scratches or flashes and/or traces of rust.

Use denatured alcohol to remove grease from the bar. If necessary, edge the contact surfaces slightly using a soft micro-abrasive cloth by rubbing on the bars lengthwise.



Do not use a product that requires rinsing.

Example

With Schneider Electric's Linergy LGYE and LGY bars, you no longer have to edge the contact surfaces. Their rough and hard surface ensures the quality of the electrical connection because of the multiplication of contact points.

Connecting rigid bars

Contact pressure

Standards Good practice

1 The contact pressure depends on:

- the number of tightening points.
- the type of fasteners used (quality, diameter).
- the tightening torque applied to the fasteners.

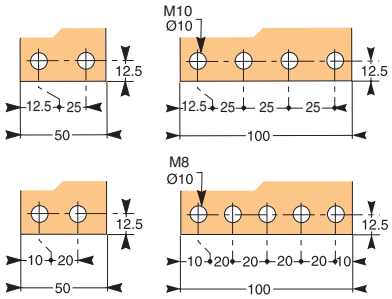
Adapt the number of tightening points of the bar to the size of the contact surface, knowing that the optimum contact pressure is exerted mainly around the head of the screw.

> *Follow the assembly rules set out in the chapter "Beyond Basics – Assembly techniques".*

> ***Example***

Schneider Electric has defined a number of tightening points in a row on a secondary bar, with M8 or M10 fasteners.

The quality of the electrical connection obtained with the class 8.8 fasteners has been tested and validated by lab tests.



2 During mounting, check the position of the bars between them as well as the alignment of the holes.

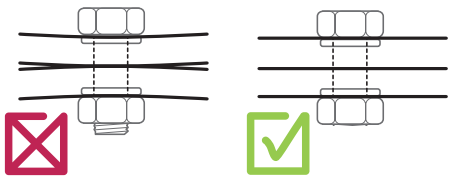
3 Use a calibrated and certified torque wrench to guarantee the contact pressure. The tightening torque depends on the diameter and quality of the fasteners.

You must absolutely follow the values of the tightening torque to be applied.

> *See the chapter "Beyond Basics – Assembly Techniques".*

Caution: an excessive tightening torque or an insufficient number of tightening points can result in:

- a creep in bars that will lead to an uneven distribution of contact pressure,
- an abnormal temperature rise of the connection,
- the going beyond of the elastic limit of the screw and therefore a risk of elongating the screw thread or even breaking it.



Connecting rigid bars

Conformity of the assembly

Standards Good practice

1 After tightening the torque, the operator applies a tinted acrylic varnish that is indelible and heat resistant. This means that he has conducted a complete self check of the assembly, i.e. he has verified and validated:

- the characteristics of the fasteners used,
- the compliance of the assembly (contact surfaces, direction of washers, etc.),
- the length of screws.

Affixing this marking certifies that the self-check has been completed.
The use of varnish also makes it possible to identify any loosening.

Do not adjust the tightening after applying varnish to the screw.
If the assembly has to dismounted, replace the screws with new screws.

Insulated Flexible Bars

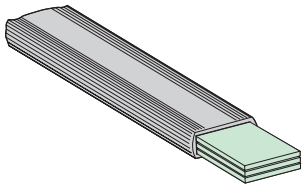
Principle

Standards Theory

1 Insulated flexible bars are primarily used for direct connections between transfer busbars and the switchgear.

They make it possible to adapt easily to all configurations. However, they can be difficult to install and may require special precautions.

2 Insulated flexible bars are made up of a stack of copper strips, durably protected by a special insulator or a halogen-free silicone insulator.



Insulator quality is a key factor that characterises the insulated flexible bar. Insulated flexible bars undergo stresses during installation. An altered or damaged insulator compromises the integrity of the bar.

3 Insulated flexible bars have the following advantages over cables:

- greater heat resistance of the insulator (insulated flexible bar 125°C, cable 105°C),
- a larger exchange surface and therefore better heat dissipation,
- for equivalent cross-sections, a current rating higher than cables and rigid bars,
- a limitation eddy currents thanks to their laminar structure,
- higher rigidity that provides better electrodynamic resistance to short-circuit currents,
- no intermediate part (lugs) which means that there is a direct connection between the device and the busbars resulting in fewer temperature rises and risks of errors,
- fast implementation of referenced prefabricated connections already cut to length, preformed and drilled.

Example

As from a level of current (usually above 125 A), Schneider Electric recommends the use of insulated flexible bars.

This is because currents of this magnitude require the use of cables with large cross-sections that are more difficult to install inside a switchboard because of:

- the minimum radius of curvature and the size of lugs that require greater available space inside the column,

- the need to use connection lugs.

Insulated Flexible Bars

Principle (contd.)

Standards Theory

IEC 60332-1

4 Insulated flexible bars must comply with the IEC 60332-1 standard, guaranteeing in particular:

- the electrical characteristics of the conductor core,
- the heat and fire resistance of the insulator.

5 **Never** use insulated flexible bars to create a main power busbar or connections between busbars.

Insulated Flexible Bars

Cross-section of insulated flexible bars

Standards

Good practice

IEC 61439-1

1

The cross-section of flexible bars depends on the conditions of use and installation. To obtain a switchboard that is compliant with IEC 61439-1, the cross-section must be chosen based on:

- the characteristics to the switchgear to connect (dissipated power, vertical or horizontal installation, fixed or drawout device, temperature rise generated by the device),
- the length of the bar required,
- the environment or the device to be connected is installed (positioning in the enclosure, dimensions of the other circuits, ambient temperature around the switchboard, switchboard ventilation mode, diversity factor (RDF)).

The instructions given by the switchgear manufacturer must be strictly followed.

Incorrect sizing may lead to temperature rises that are incompatible with the insulators, and may disrupt or even deteriorate connected or surrounding devices.

Example

Schneider Electric insulated flexible bars have been tested in a "switchboard tested" environment. They take into account the architecture of the switchboard where they are often close to a protective device (circuit-breaker or fuse) that generates calories.

A table of the choices of references by device type has been created based on knowledge of the switchboard and connect switchgear architecture.

- Copper flexible bars L = 1800 mm under insulating sheath.

- Rated insulation voltage: Ui = 1000 V.

The flexible bar cross-sections presented below take into account temperature rises due to the dissipated power of Schneider Electric devices in a Prisma Plus switchboard.

Connection between devices and busbars

Flexible bars are determined, taking into account the connected device regardless of the internal temperature of the switchboard.
The bar cross-sections given below take into account the derating curves of the devices.

Device	Cross-section (mm)
NSX100	20 x 2
NSX160/250	20 x 3 (1)
NSX400	32 x 5
NSX630	32 x 8
INS125/160	20 x 2
INS250	20 x 3
INS400	32 x 5
INS630	32 x 6
Linergy FM distribution block 200 A	20 x 3
Linergy FC distribution block 3P (2)	32 x 8
Linergy FC distribution block 4P (2)	32 x 8
Fupact 250	24 x 5
Fupact 400	32 x 5
Fupact 630	32 x 8

(1) To connect a Compact NSX250 circuit-breaker to Powerclip busbars, use a flexible bar with cross-section 24 x 5 mm (ref. 04746).

(2) The connection of a Linergy FC distribution block using insulated flexible bars is not compatible with Form 2 partitioning (ref. 04922).

Connection between busbars

Flexible bars designed for connections between busbars taking the following characteristics into account:
- a maximum temperature of 60°C inside the switchboard, which corresponds to the average temperature inside the switchboard when the ambient temperature surrounding the switchboard is 35°C.
- a maximum withstand temperature for the insulator of 125°C.

Maximum Ie (A)	Cross-section (mm)
200	20 x 2
250	20 x 3
400	24 x 5
520	32 x 5
580	32 x 6
660	32 x 8

Cross-section of insulated flexible bars (contd.)

Standards Good practice

2 The temperature withstand of the flexible bar insulator is usually 125°C. If it is only 105°C, use a flexible bar with the next higher cross-section.

3 Insulated flexible bars are formed using:
- shears or pendulum saws,
- punching machines.

Make sure that:
- the machine has been adjusted correctly and that there is no clearance when it is used,
- the tools are in good condition and well sharpened,
- the tools do not deform the busbar during forming.

Deformation during forming can result in the alteration of contact surfaces and the insulator.

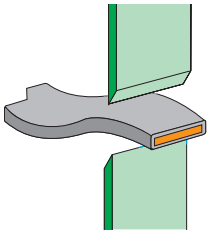
Insulated Flexible Bars

Cutting insulated flexible bars

Standards Good practice

1 **Tools required**

Cut the flexible bar preferably with shears to ensure a clean cut without flashes.



The cutting tool must be sharpened and must not create deformations of the bar, parasitic stresses or temperature rises.

2 **Measurements**

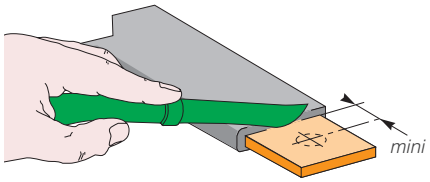
Define the length of the bar to cut and add a few centimetres to take into account the need to free the end of the bar after folding.

3 Be careful not to damage the insulator during cutting.

Stripping insulated flexible bars

Normes Good practice

1 Strip a flexible bar using a stripping tool or a sharp tool as close as possible to the connection point in order to limit the powered bare part.



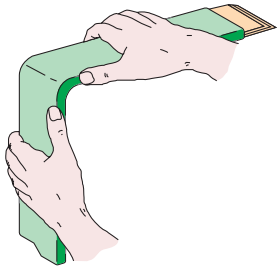
Make sure you do not damage the layers of the bar to avoid creating an incipient crack.

Insulated Flexible Bars

Folding insulated flexible bars

Standards Good practice

1. Fold the flexible bars by hand in order not to damage the insulator.

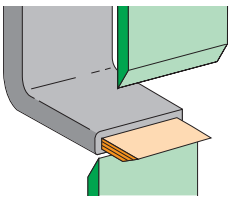


The radius of curvature must be at least equal to the thickness of the bar.

Do not try straightening a flexible bar with a mallet or a hammer.

2. If possible, make up for a fold in one direction with a fold in the opposite direction to limit the relative displacement of the layers.

3. **After forming**, use shears to free the layers that have moved from each other during the folding.



The shears should leave a clean cut without flashes. If possible, they should be reserved for this use.

Insulated Flexible Bars

Punching-Drilling insulated flexible bars

Standards Good practice

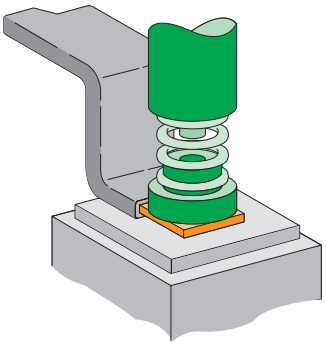
Tip

Punching or drilling must be done after folding.

1 **Tools required**

It is preferable to use a punching machine.

The flexible bar is punched with an appropriate tool fitted with a work holder to obtain a clean cut-out and to prevent the blades from coming up when the punch is withdrawn. This technique must be preferred because it creates little deformation and no filings.

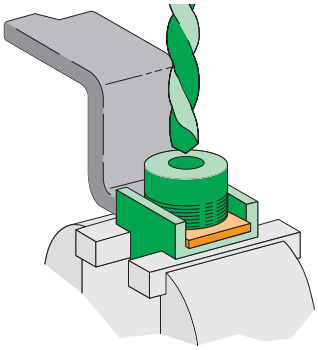


The punching machine must be in good condition and perfectly sharpened. Regularly check that the punch is kept sharp and the check punch/die working clearance to avoid creating flashes or deforming the copper through creep.

You may however use a drill to make the hole. This is a delicate technique. You must use the correct device for fastening into a vice.

This device must:

- guide the drill,
- ensure the operator's safety by holding down the bar during drilling,
- compress the layers to prevent filings from getting between them,
- prevent the deformation of the layers.



Make sure that no filing flashes are inserted between the copper layers of the insulated flexible bar.

Punching-Drilling insulated flexible bars (contd.)

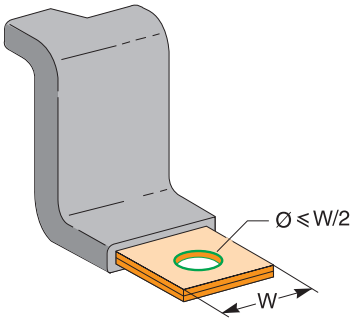
Standards Good practice

2 Punching diameter

- The punching diameter depends on the fasteners used and the width of the bar:

Diameter of fasteners	Maximum punching diameter
	(in mm)
M6	7
M8	10
M10	12
M12	14

- The diameter of the hole must always be lower than half the width **W** of the bar.



- Centre the drilling.

- All bars with holes that are too large as a result of drilling errors must be scrapped.

5

Insulated Flexible Bars

Connecting insulated flexible bars

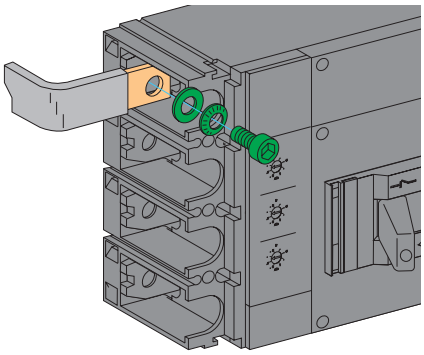
Standards Good practice

1 To connect a flexible bar to a copper bar, comply with the connection rules described in the chapter
> *"Beyond Basics – Assembly techniques".*

2 To connect a flexible bar to a device connection plate:

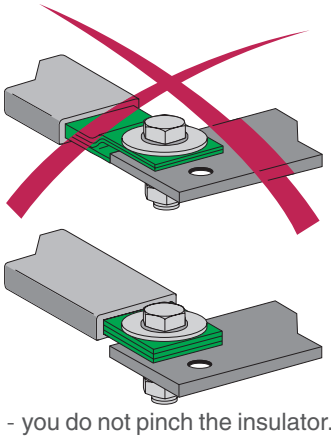
- use the fasteners provided with the device,
- follow the connection rules described in the chapter
  > *"Beyond Basics – Assembly techniques",*
- you **must** apply the tightening torque recommended in the device's technical manual,
- check that the screw length is sufficient if you're using a washer that is too thick (≥ 2 mm). Read the technical manual of the device.

Example



3 When tightening, make sure that

- you do not separate the layers of the flexible bar during the connection,



- you do not pinch the insulator.

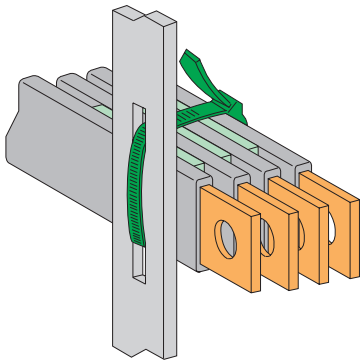
Insulated Flexible Bars

Connecting insulated flexible bars (contd.)

Standards Good practice

4 If the flexible bars are in a stack, make a separate bundle for each phase: N, L1, L2, and L3.

To enable proper ventilation of insulated flexible bars, insert an insulating and self-extinguishing wedge between each bar at tie level.



5 **Never** use insulated flexible bars for transfer connections between a non-limiting device and a busbar above a rated current In of 630 A.

The maximum permissible peak current must be lower than 45 kÂ.

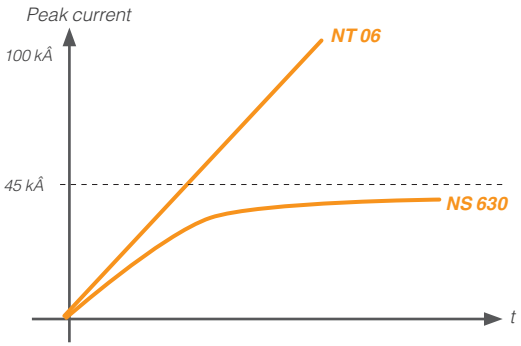
Tip

The electrodynamic forces exerted during a short-circuit are proportional to the square of the peak current intensity.

Example: if the peak current is multiplied by 5, the electrodynamic forces are multiplied by 25.

Example

Schneider Electric prohibits the use of insulated flexible bars for connecting Masterpact NT06 devices.



The devices of the NT 06 range are non-limiting devices, i.e. they allow a peak current of up to 100 kÂ to pass. Flexible bars are therefore prohibited.

Conversely devices of the NS630 range limit the peak current to 43 kÂ. Flexible bars can therefore be used.

Insulated Flexible Bars

Fastening insulated flexible bars

Standards Good practice

1. After the connection, fasten the flexible bars firmly on **insulating** supports, which are themselves fastened every 400 mm at most on the enclosure frame.

   It is **prohibited** to fasten flexible bars on metal supports.

2. Use the appropriate ties to fasten the flexible bars. They must:
   - be at least 9 mm long,
   - be able to bear an 80-kilo load.

   Do not use ties that are too thin or mechanically not very resistant, which could be damaged in case of short-circuit.

3. Do not fasten the flexible bars on sharp edges in order not to damage the insulator.

Fastening insulated flexible bars (contd.)

Standards Good practice

4 Maximum distance between rigid bar supports and ties insulated flexible bars.

The recommended distances between the ties must be **absolutely** complied with. This distance depends on the presumed short-circuit current of the switchboard.

The different tables below give the maximum distances to be kept between supports depending on the following:

- offerings,
- electrodynamic performance,
- cross-sections of the copper busbars used.

Note: *these figures are intended to help designers of configurations that are not described or included in the catalogues.*

Okken table:

115 mm centre distance between bars			
No. of bars	Dim. (mm)	50 kA/1s	100 kA/1s
1	80 x 10	580	
2	80 x 10	500	240
3	80 x 10	590	260
3	120 x 10	790	280

70 mm centre distance between bars				
No. of bars	Dim. (mm)	50 kA/1s	80 kA/1s	100 kA/1s
1	40 x 10	320		
	50 x 10	360		
	80 x 10	480	225	
	100 x 10	560	240	150

Insulated flexible bars with devices:

Type of device		Presumed Icc		
		N 50 kA	H 70 kA	S 100 kA
NSX100	ipk	19 kÂ	22 kÂ	24 kÂ
	maximum distance	350	260	220
NSX160	ipk	19 kÂ	22 kÂ	24 kÂ
	maximum distance	350	260	220
NSX250	ipk	21 kÂ	24 kÂ	26 kÂ
	maximum distance	280	210	180
NSX 400	ipk	32 kÂ	36 kÂ	42 kÂ
	maximum distance	150	120	90
NSX 630	ipk	37 kÂ	42 kÂ	47 kÂ
	maximum distance	110	90	55

Prisma table:

Bars of thickness 5 mm						
No. of bars	Dim. (mm)	Icw in kA/1s 15	25	30	40	50
1	60 x 5	800	450	400	300	
	80 x 5	950	550	450	350	250
2	60 x 5	1100	650	550	400	300
	80 x 5	1300	800	650	500	400

Bars of thickness 10 mm										
No. of bars	Dim. (mm)	Icw in kA/1s 25	30	40	50	60	65	75	85	100
1b	50 x 10	850	700	500	400	300	250			
	60 x 10	950	800	600	450	300	250	200		
	80 x 10	1100	950	700	500	350	300	200		
2b	50 x 10	750	650	450	350	300	300	250		
	60 x 10	850	700	550	400	350	300	250	250	200
	80 x 10	1050	900	650	500	450	400	350	300	200
	100 x 10	1250	1050	800	600	500	450	400	350	250
	120 x 10	1450	1200	900	700	600	550	450	350	250

Connecting with cables

Principle

Standards Theory

1 Cables may be used for all power connections.

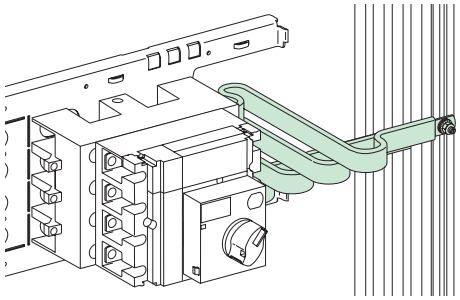
Nevertheless, connection becomes more difficult after a given power owing to:

- the large cable cross-section,
- the minimum radius of curvature to be complied with,
- the available volume inside a switchboard,
- the number of conductors.

Example

Prisma

After more than 125 A, Schneider Electric recommends the use of insulating flexible bars instead of cables to connect the distribution busbars with the devices.



2 By convention, power circuits use cables upper section over 6 mm^2.

Cable connections (conductor cross-section, connection type) must be defined based on:

- the characteristics of the switchgear/ controlgear to be connected,
- the length of the connection,
- the thermal environment of the connection.

> *See the chapter "Beyond Basics – Wiring Techniques".*

3 Cables must be formed using tools or machines in good working condition and correctly followed in calibration.

They must be connected according to trade practice to avoid all risks of temperature rise and/or deterioration of devices.

> *See the chapter "Beyond Basics – Wiring Techniques".*

Connecting with cables

General routing rules

Standards Good practice

1. Power cables can be routed inside the switchboard:
   - using cable strands,
   - by individual installation.

   Do not place power cables in ducts or straps.

2. Do not route cables between or too close to power busbars to avoid a temperature rise and deterioration of the insulator.

3. Avoid all risks of damage or cutting of the insulating sleeve:
   - do not route cables on parts with sharp edges.
   - cables that are routed through a hole in a sheet must be protected with grommets, cable glands, gaskets, plastic rings, etc.

Tip

A damaged insulating sheath increases the risk of sparking and therefore of a short-circuit.

Example

Cable glands are used to protect cables from the hole in the sheet.

4. Comply with the general wiring rules described in the chapter
   > *"Beyond Basics – Wiring Techniques".*

Tip

It is essential to comply with the permissible radius of curvature for each type of cable.

> See the chapter "Beyond Basics – Wiring Techniques".

Connecting with cables

Cable stranding

Standards Good practice

1 The number of cables allowed per strand depends on the cable cross-section.

Cable cross-section	Maximum number of cables per strand
≤ 10 mm²	8
16 to 35 mm²	4

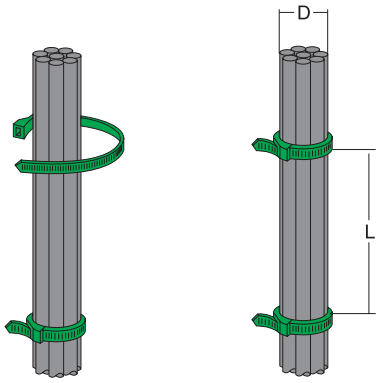
They must be assembled before being fastened to their support.

2 Choose ties that are adapted to the strand to be made. They must:

- be mechanically resistant enough to keep the cables fastened in case of a short-circuit.
- be of a length that is adapted to the strand circumference.
- be wide enough not to damage the cable insulating sleeve.

Centre distance recommended according to strand diameter:

Diameter D of strand	Distance L between ties	
(in mm)	Mini (in mm)	Maxi (in mm)
< 20	60	120
Between 20 and 30	70	140
Between 31 and 45	90	180
Between 46 and 75	125	200



3 Never run a strand in contact with or between power busbar conductors to avoid temperature rise and damage to insulators.

Connecting with cables

Fastening power cables

Standards

Good practice

1

You must fasten power cables on supports to make sure that they remain in place during a short-circuit.

Fit a sufficiently large number of ties to ensure that cables are properly held in place. The distance between ties depends on the electrodynamic forces produced in the event of a short-circuit and the type of tie used.

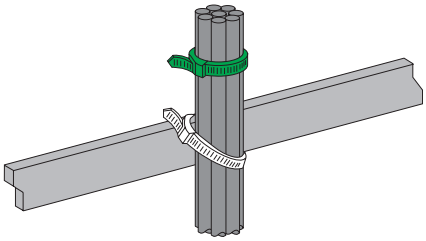
Recommended distance between ties:

Type of tie	Maxi. Ipk	Distance between ties
	(kÂ)	(in mm)
Width: 4.5 mm Load : 22 kg	10	200
	15	100
	20	50
Width: 9 mm Load: 80 kg	20	350
	25	200
	35	100
	45	70

Ties must be installed as close as possible to the cable connection points.

2

- If the cables don't meet the class 2 requirements, fasten them on insulation supports. If they are metal supports, insert an insulating wedge between the cable and each metal support.



- If cables meet the class 2 requirements, they may be fastened directly on metal supports.

Tip

Cables meeting the class 2 requirements cables with operating voltages that are lower than half their insulation voltage.

Example

Cables with a 1000 V insulation voltage meet the class 2 requirements if they are used in a switchboard with an operating voltage of 500 V. They may be fastened directly on the metal cable tie-bars.

5

Connecting to switchgear

General rules

Standards Good practice

1

Comply with the screw lengths recommended by the manufacturer for fastening a lug or flexible bar on the connection plate of a device.

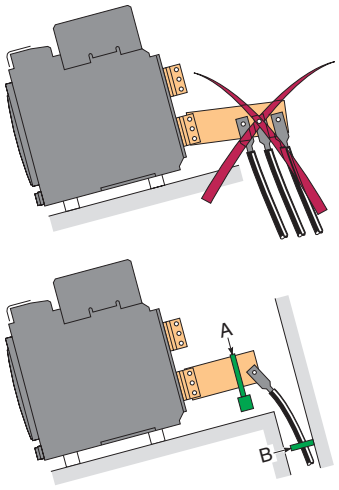
- If it is too short, the tightening will not be effective.
- If it is too long: there is a risk of damage to the bottom of the cage, which will result in non-compliance with insulation distances at the rear of the device.

2

Make sure that the connections do not exert a pull on the switchgear connection plates.

No conductor connected to the switchgear or a busbar must in no way lead to mechanical stresses resulting from its installation or electrodynamic forces.

Provide for supports (A) and fastening ties to avoid excessive mechanical stresses on device connection plates.



Prefer edgewise pads to reduce temperature rises at the connections.

3

You must comply with the tightening torques to be applied on the switchgear plates.

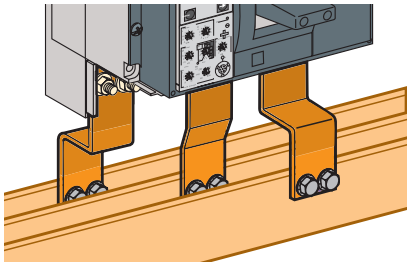
General rules (contd.)

Standards

Good practice

4 Transfer bars must have a larger cross-section than those recommended in the busbar calculation tables in order to allow for:

- temperature rises at the connection points to the device,
- derating due to the orientation of the bars (edgewise or flat bars).



Example

Schneider Electric recommends the following derating coefficients in relation to distribution busbars:

- 0.85 for edgewise transfer busbars,

- 0.75 for flat transfer busbars.

IEC 61439-1

5 To ensure that clearances are followed, place phase separators between each power connection phase.

Example

Notes

Quality control check list

Note: the list of control points presented is not exhaustive.
It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

Minimum checks required	Control points	Control resources	Self-control
☑	> Observance of conductor cross-sections	> Technical documentation	☐
☑	> Method of installing and fastening conductors	> Installation guide	☐
	> Cable characteristics (e.g. 1000 V, 105°C)	> Customer requirements (specifications)	☐
☑	> Quality of power connections*	> Installation guide	☐
☑	> Tightening to torque	> Torque wrench, switchgear and controlgear guide, installation guide	☐

(*) Surface state, drilling, conformity of fasteners, varnish, etc.

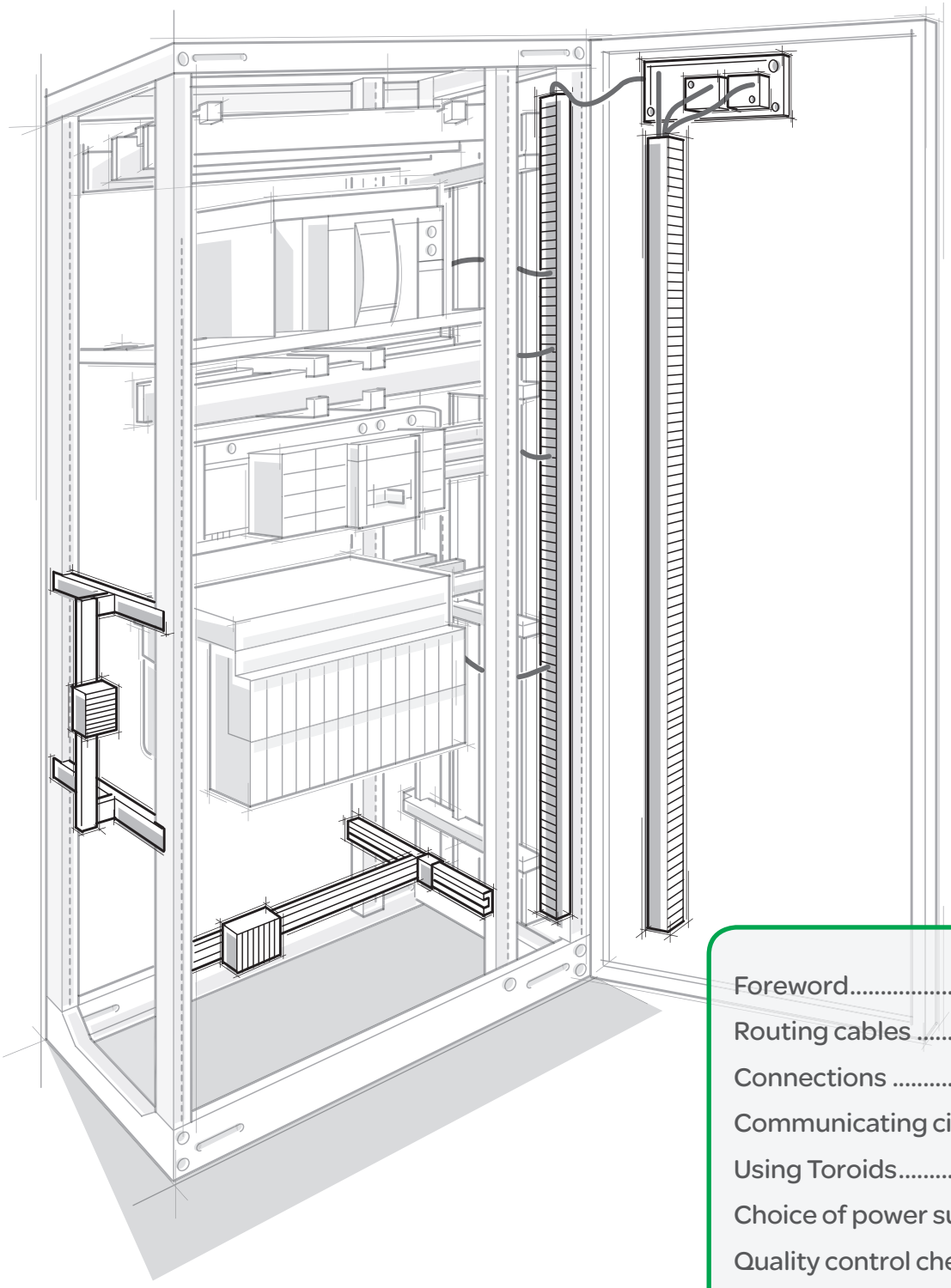
5

Please photocopy the check list before completing it

Objectives

- Avoid risks of temperature rises
- Avoid electrodynamic stresses
- Check the conformity of conductors:
  - with customer specifications (colours, type of core, minimum cross-section)
  - to switchgear and controlgear characteristics (cross-section, etc.)
- Avoid electrical risks

Auxiliary and low-power circuits



Foreword

Foreword

Standards Theory

1 Auxiliary and low-power circuits are:
- **control and monitoring circuits:** auxiliary power supplies, relays, contactor coils, circuit-breaker remote controls, PLC inputs/outputs,
- **communication circuits:** Ethernet network, RTU, Modbus, DeviceNet, Canopen.

2 By convention, auxiliary and low-power circuits use cables with cross-sections of under 6 mm^2.

The conductor cross-section and the type of connection must be determined based on:
- the characteristics of the switchgear to be connected,
- the length of the connection,
- the thermal environment of the conductors.

> *See the chapter "Beyond Basics – Wiring Techniques".*

3 Cables inside the switchboard can be routed using:
- ducts,
- straps,
- cable strands,
- by individual installation.

Ducts and straps must be preferred when there are a large number of auxiliary circuits. This choice provides the following advantages:
- improved efficiency in terms of heat exchanges,
- improved mechanical protection of cables,
- greater ease of installation,
- faster wiring,
- excellent scalability (easy to change and maintain).

Conversely, when there are few cables to connect, it may be more economically advisable to make strands.

Foreword (contd.)

Standards Theory

4 Cables must be prepared using tools or machines in good working condition that are correctly calibrated. They must be connected according to trade practice to avoid all risks of temperature rise that may cause serious damage.

> *See the "Connections" section in this chapter.*

5 Given their sensitivity to electromagnetic disturbance, the communication switchgear installed must meet the requirements of the relevant immunity and emission standards.

> *See the "Communication circuits" section in this chapter.*

6 Toroids are mounted on cables to detect leakage currents. They transmit a signal that is proportional to the current measured to the related receiver.

Toroids are fragile components. They must be installed in the switchboard according to professional good practice.

> *See the "Using Toroids" section in this chapter.*

Tip

The circuit of the current measuring devices are generally realized with a wiring section ≥ 2.5 mm².

To improve the safety of circuits, cables reinforced insulation are used to reduce the risk of mechanical damage.

Routing cables

General circulation rules

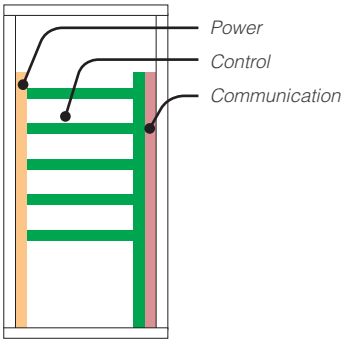
Standards Good practice

1 Use separate routings for auxiliary circuit and low power cables (cross-section ≤ 6 mm²) and power cables (cross-section > 6 mm²).

Moreover, given their sensitivity to electromagnetic disturbance, it is preferable to separate control/monitoring cables from communication cables.

Example

The routing of cables inside the enclosure may be organised as follows:



"Cable ladder" wire running.

2 Do not route cables between or too close to power bars to avoid all risks:

- of a temperature rise in the cable,
- damage to the insulator,
- electromagnetic disturbance.

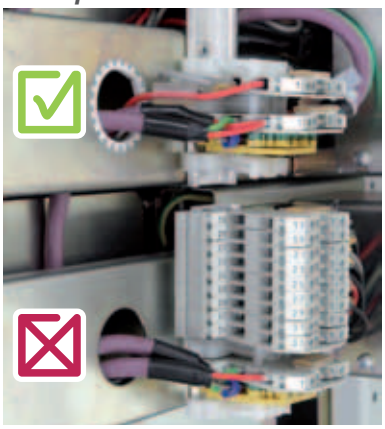
Example

The cables are routed too close to the power bars.

3 Avoid all risks of damage or cutting of the insulating sleeve:

- do not route cables on parts with sharp edges.
- protect cables that are routed through a hole in a sheet with grommets, cable glands, gaskets, plastic rings, etc.

Example



A plastic ring is used to protect cables from the hole in the sheet.

In the specific case of a cable routed in a form sheet, make sure that the degree of protection is IP2X. Use a membrane gland plate to do this.

Tip

The deterioration of the insulating sleeve of a conductor will result in the deterioration of its dielectric characteristics and increases the risk of sparking and therefore of a short-circuit.

IEC 61439-1

Routing cables

General circulation rules (contd.)

Standards Good practice

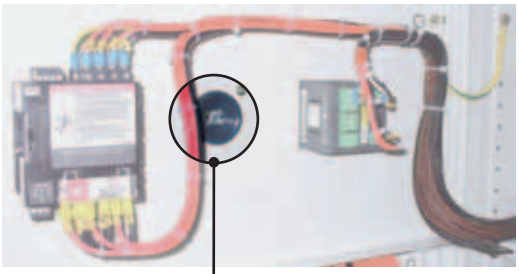
Tip

The safety perimeter of a device is defined in chapter 4 - Installing switchgear and control gear.

4 Do not route the cables:

- in the device safety perimeter, e.g., installation of ducts above the circuit-breaker gas evacuation areas,
- close to moving parts (handle, reset button, mechanical interlocking, rotary handle, etc.) where there is a risk of blocking the cable.

Example



The cables are routed too close to the rotary handle.

Tip

It is essential to comply with the permissible radius of curvature for each type of cable.

> See the chapter "Beyond Basics – Wiring Techniques".

5 Comply with the general wiring rules set out in the chapter

> *"Beyond Basics – Wiring Techniques".*

Routing cables

Cable routing in ducts

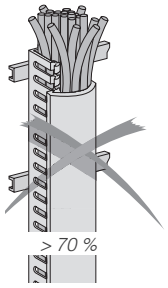
Standards Good practice

Tip

There are trunkings in halogen-free materials that do not generate toxic or corrosive gases in case of combustion.

1. Choose trunkings adapted to the cross-section and the number of cables that they are to hold.
   Provide for a reserve for future extensions.
   The final fill rate must not exceed 70 %.

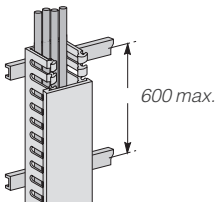
Example



2. Never install a trunking in contact with or between power busbar conductors.

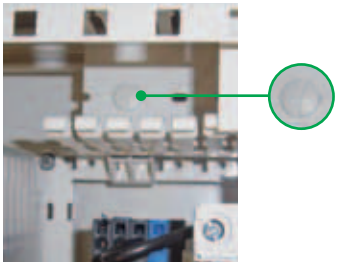
3. Define the number of fastening points of a trunking based on its mechanical characteristics and the fill rate. The trunking must be straight after fastening.
   At any event, the centre distance between fastening points must not be more than 600 mm.

Example



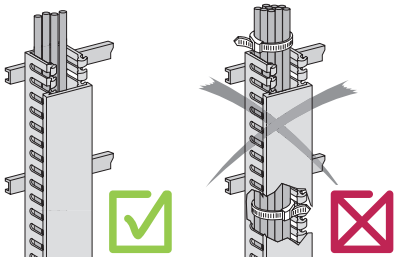
4. Fasten the trunking using rivets or plastic screws to reduce the risk of damaging the cables.

Example



5. Do not tie cables inside the trunkings to facilitate heat dissipation.
   Never stretch a wiring cable to avoid all risks of disconnecting the cable. As a rule, there must always be some slack between the duct outlet and the connection point.

Example



Routing cables

Cable routing in straps

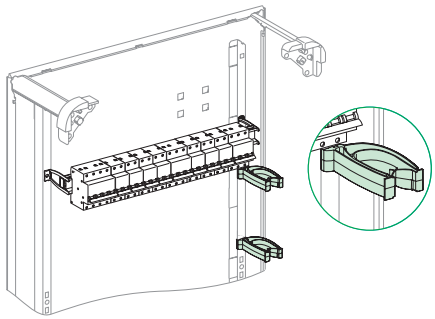
Standards Good practice

1. Cable straps are used to ensure faster installation, and facilitates the modification of operations and maintenance.
   Choose the size of the straps based on the number of cables that they are to hold.
   The final fill rate must not exceed 70 %.

2. Lock the straps on a modular rail or vertical mounting plate.
   Fit a sufficiently large number of straps to ensure that cables are properly held in place: 1 strap approximately every 8 centimetres.

Example

In Schneider Electric enclosures, the possibility of installing horizontal and vertical straps optimise cable running and make it easier to read.



3. Do not tie cables running inside the straps to facilitate heat dissipation.

Cable stranding

Standards Good practice

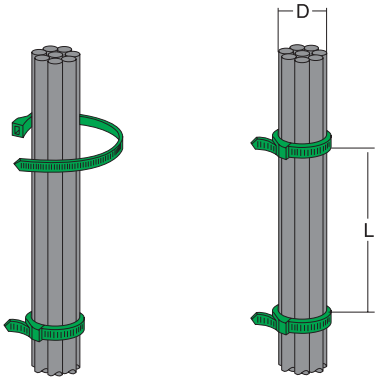
1 Choose ties that are adapted to the strand to be made. They must:

- be mechanically resistant enough to keep the cables fastened in case of a short-circuit,
- be of a length that is adapted to the strand circumference,
- be wide enough not to damage the cable insulating sleeve.

2 Fit a sufficiently large number of ties to ensure that cables are properly held in place.

Centre distance recommended according to strand diameter:

Diameter D of strand (in mm)	Distance L between ties	
	Mini (in mm)	Maxi (in mm)
< 20	60	120
Between 20 and 30	70	140
Between 31 and 45	90	180
Between 46 and 75	125	200



Routing cables

Strand fastening

Standards Good practice

1. Never run a strand in contact with or between power busbar conductors to avoid temperature rise and damage to insulators.

2. If the cables of the strand don't meet the class 2 requirements, fasten the strand on insulation supports. If they are metal supports, insert an insulating wedge between the strand and each metal support.

   If cables meet the class 2 requirements you may fasten them directly on metal supports.

3. Strands must be run flush with doors, panels, swivelling front panels or panels that hold the switchgear in such a way as to reduce the risks of damaging or pinching the cables to a minimum.

   The strand is protected mechanically by:
   - a tubular plastic sleeve,
   - a braided polyester sleeve,
   - a spiral bearing.

   Follow the recommendations below to mount the strand:
   - make sure that the strand allows the movement of the moving part without any risk of damage to the cables.
   - make sure that the cables are not subject to twisting or pulling. If necessary divide the strand to limit mechanical stresses.
   - comply with the permissible radius of curvature.
   - fasten the strand firmly on the fixed part (framework) as well as on the moving part (door, faceplate, panel, etc.).

Example

Routing cables

Routing between columns

Standards Good practice

Tip

You can interrupt a form to lay a trunking on condition that it is not possible to touch a live part with your hand or a tool.

1 There are two possible scenarios depending on the switchboard configuration:

- **limited number of columns and cables to connect:** it is preferable to connect the cables directly to the switchgear concerned. In this case, you have to protect conductors against risks of deterioration (strand protected by a polyester sleeve, cable tray or trunking),
- **large number of columns and cables to connect:** use terminal blocks to facilitate the installation and connection on site (faster and more reliable laying) and any maintenance operations.

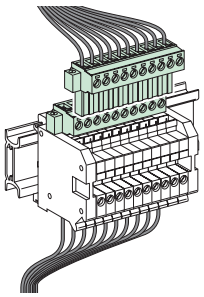
In both cases:

- connect the cables by following the wiring rules set out in the chapter
> *"Beyond Basics – Wiring techniques",*
- identify the cables with marks that are consistent with those of the switchboard to facilitate subsequent operations.

2 For voltage collector power supply, choose an appropriate cable cross-section that will limit voltage drops (usually 6 mm^2).

Example

Schneider Electric provides terminal blocks to be mounted on modular rails. They make it possible to connect cables of auxiliary circuits between two columns.



This type of terminal block can be disconnected. It enables fast connection and disconnection during maintenance.

Connections

General rules

Standards Good practice

1 Electrical connections must have absolute reliability to ensure that the switchboard is working properly.

A good quality connection means:

- a connection that is adapted to the cross-section of the conductor to connect,
- a conductor that has been stripped correctly,
- a crimping tool or machine that is in good condition and regularly calibrated,
- an operator qualified and trained for this operation.
- effective tightening.

2 Cables must be formed (stripped, crimped) according to professional good practice, using appropriate equipment in good working condition that is correctly calibrated.

The basic rules about stripping and crimping are set out in the chapter > *"Beyond Basics – Wiring techniques"*.

3 You may use different types of crimping connections:

- pre-insulated lugs,
- pre-insulated cable terminals,
- female clips,
- spade lugs.

The most frequently used different types of crimp connections and their uses are set out in the chapter > *"Beyond Basics – Wiring techniques"*.

Connecting current transformers

Standards Good practice

1

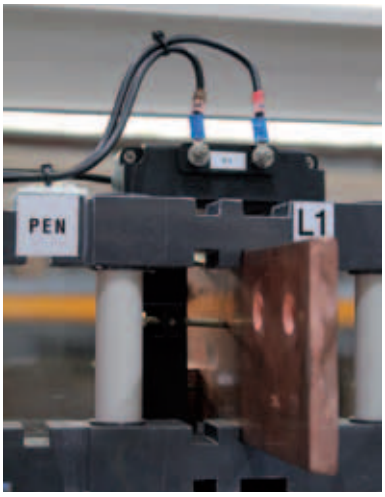
The secondary circuit of a current transformer must never be open when the primary is energized.

High voltages may appear on the secondary circuit terminals. They present a hazard to persons and result in the deterioration of the transformer.

Observe the following recommendations to limit the risks of interrupting the transformer's secondary circuit:

- always connect the secondary circuit using round lugs,
- never use the terminal block to connect the secondary circuit.

Example



2

Place the current transformer as close as possible to the measuring device to avoid having cables that are too long.

Communicating circuits

Principle

Standards Theory

1 The electromagnetic compatibility (EMC) of a switchboard is its ability to function in a disturbed environment while limiting its own disruptive emissions.

Electromagnetic disturbances are potential sources of malfunctioning for all electronic materials:

- regulators and measuring devices that deal with analogue signals,
- PLCs and communication interfaces that deal with digital signals.

Overall performance is obtained by:

- reducing disturbances at the source, which can also be from outside the switchboard,
- protecting information exchanged with the process throughout their routing in the switchboard,
- preserving the entry into the switchboard of radiated and conducted disturbances.

Communicating circuits

General rules

Standards Good practice

1 The earthing mesh inside a switchboard is an essential parameter. All metal structures will be interconnected with an electric contact.

Be careful of the various protective coatings, which are generally insulating.

2 The communication switchgear installed must meet the requirements of the relevant immunity and emission standards.

The wiring rules that follow are general ones. They do not replace the wiring guidelines given by the switchgear and controlgear manufacturer.

Example

Sensitivity of the various cable families

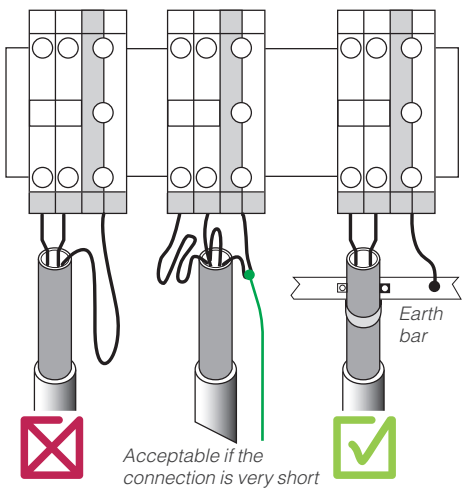
Family	Cables	Type of signal	EMC behaviour
1	Analogue	Power supply and measurement circuits of analogue sensors	Sensitive signals
2	Digital and Telecom	Digital circuits and data bus	These signals are sensitive. They are also disruptive for family 1
3	Relay	Dry-contact circuits with risks of re-priming	These signals are disruptive for families 1 and 2
4	Power supply	Power supply and power circuits	These signals are disruptive

Remark: *a shielded cable is neither disruptive nor sensitive.*

3 Use shielded cables or double shielded strands to protect circuits against radiated parasites.

The metal armour must be earthed correctly. All free conductors in a cable (except for the analogue cable) must be systematically earthed at both ends.

Example



Earthing terminals with metal fastening system with modular rail.

Wiring rules

Standards Good practice

1 **General wiring recommendations**

- Do not bend or damage the cables.
- Minimum bending radius:
10 x cable diameter.
- Avoid sharp angles of paths or passages of the cable.
- The connection of the shield of the cable must be as short as possible.
- Several shields can be connected together.
- Make a physical mark at the end of each cable.
- Identify the logical name and the address of each device.

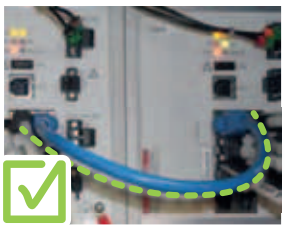
Wiring must be in accordance with the following colours:

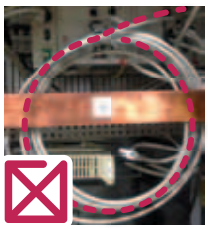
Wire type		Wire colour
AC Power		Black
Neutral		Light blue (RAL 5024)
Control wire	24 V DC	Dark blue (RAL 5013)
	0 V DC	Gray (RAL 7001)
	24 V AC	Red
	0 V AC	Ivory (RAL 1015)
Earth		Green/Yellow

2 Adjust the cable length to actual requirements. Cables must be as short as possible by avoiding the creation of loops that generate parasites currents resulting from magnetic fields.

Cables must be stripped as close as possible to the connection point.

Example





3 Avoid all earth loops: they are very sensitive to power magnetic fields.

Example

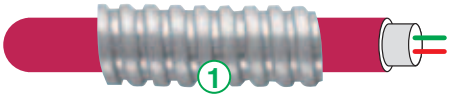
Communicating circuits

Wiring rules (contd.)

Standards Good practice

4 Never position communication cables close to busbars or power cables.

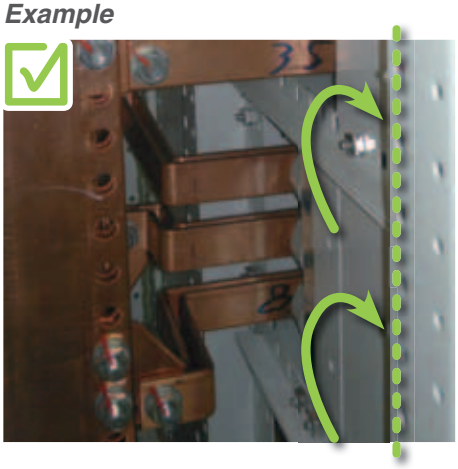
- Use a flexible metal tubing.

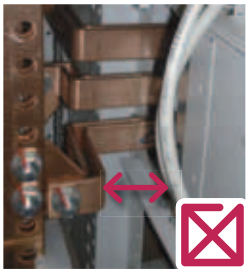


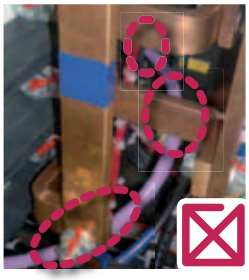
① *Metallic tubing*

- Secure the communication cable inside the metallic profile when possible, or stick it on metallic parts.

Example







5 The presence of many earth structures in switchboards provides optimum protection. When routing to moving parts (doors, front plate), route the communication cable close to a hinge or earthing wire.

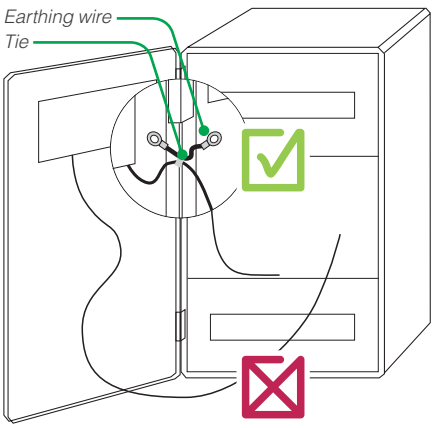
Example

Protective effect inside a switchboard:

- all the cables must be flattened against earthing structures,

- plastic cabling ducts can be used because they are installed on DIN rails connected to the switchboard earth.

Cables must be routed close to assembly points (hinges) or be doubled by an earthing wire.



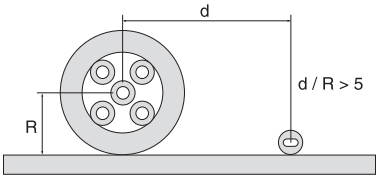
Wiring rules (contd.)

Standards Good practice

6 Divide the cables into three separate groups (power, command and communication) to let them be routed in separate paths. The routing of wires of groups 2 and 3 is tolerated in the same ducts. However, they should not be mixed in the same sheath or tightened into a single strand.

Example

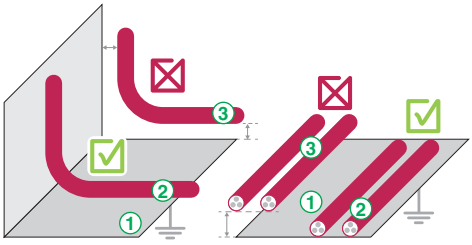
To maintain the protective effect, we advise that you observe a ratio of the distance (d) between cables to the radius (R) of the largest cable of over 5.



7 When communication cables have to cross over power cables (e.g. when drawer space is small), the angle between the two types of cables should be as close as possible to 90°.

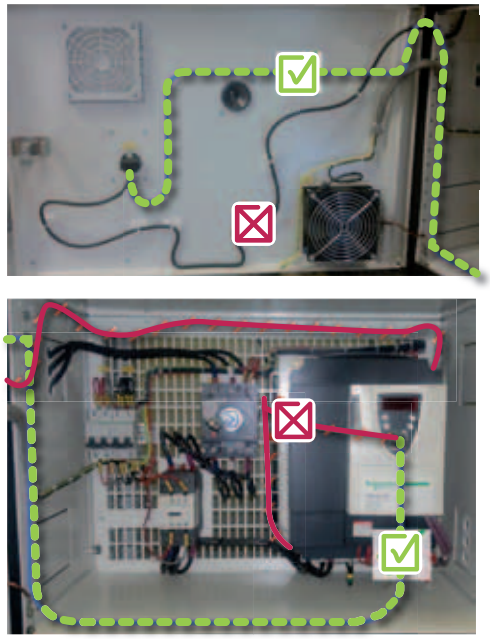
① *Power cable*
② *Communication cable*
③ *Right angle*
④ *Parallel cable routing (NOK)*

8 The best possible path for a communication cable is as close as possible to an earthed plane, i.e. on the steel plates of drawers and cubicles.



① *Earthed metal plane*
② *Communication cable laid on the metal parts*
③ *Communication cable far from the metal parts (NOK)*

Example



Communicating circuits

Screen continuity

Standards Good practice

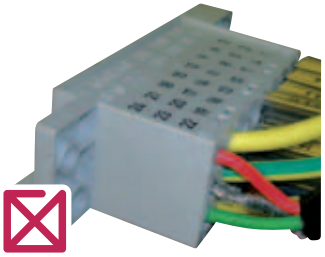
1 Do not use the connector pins to ensure screen continuity.

"Pig tails" are forbidden (very poor efficiency at high frequency).

Connect the cable screens directly on the metal plate:

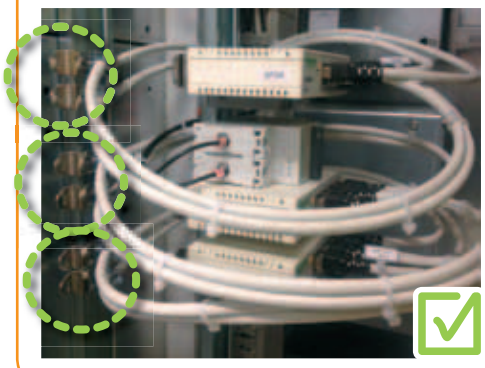
- to reduce the common impedance,
- to divert disturbances directly to earth (outside the products).

Example



2 **Drawer outer side**

Earthing clip DIN rail mounted.

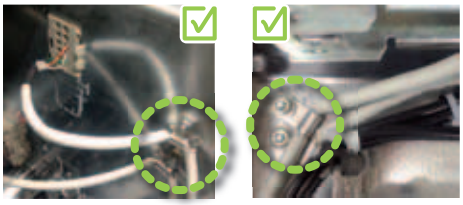


Screen continuity (contd.)

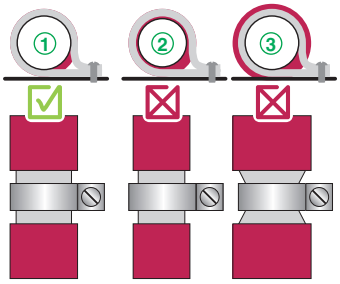
Standards Good practice

3 Drawer inner side

360° steel earthing clamp (do not use aluminium clamps).



Clamp diameter shall be adapted to the cable screen diameter.



① *Clamp adapted to screen diameter*
② *Clamp too large*
③ *Clamp too small*

4 Device with an open style connector

Add a heat shrink tubing at the screen cable end (to contain braid metallic particles).

5 Modbus tap earthing and bonding

Never let the Tap isolated.
Use a universal DIN rail fixing system.

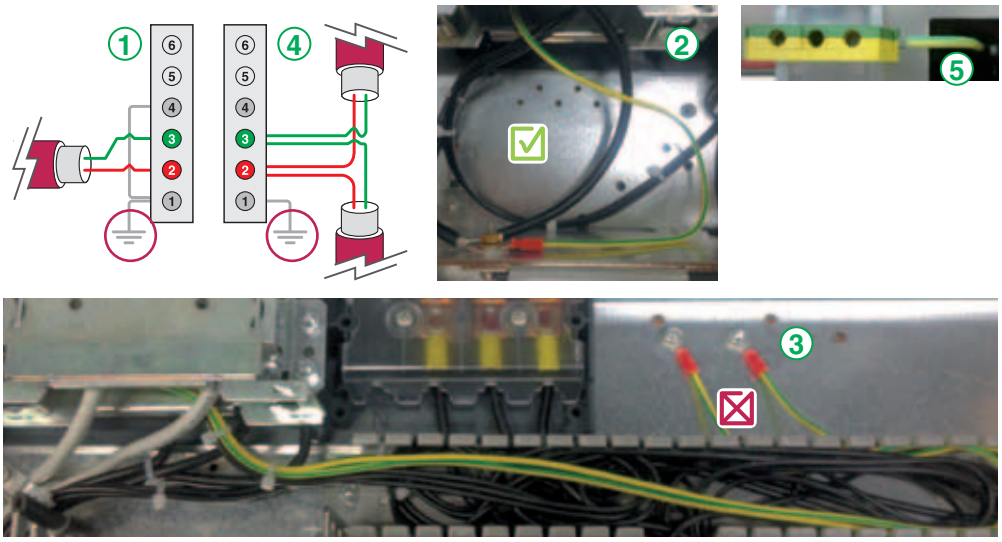
Communicating circuits

Earthing and bonding

Standards Good practice

1 Electrical continuity

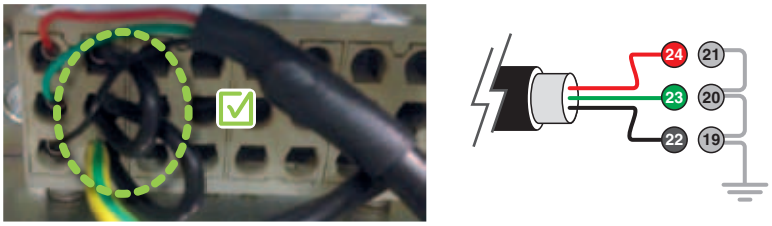
The electrical continuity between the drawer frame and the cubicle structure shall be obtained using the connector pins.
The connection length should be as short as possible.



① *Internal FU connector*
② *Connector earthing*
③ *Earthing connection too long*
④ *External FU connector*
⑤ *Earthing by a earth terminal DIN rail mounted*

2 Electromagnetic barrier

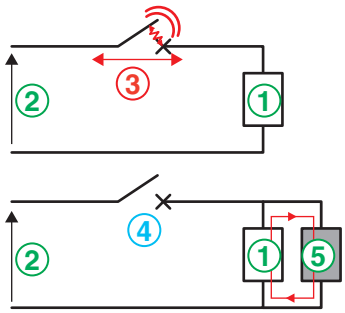
Connect together all the "earthing" contacts of the removable connector (= electromagnetic barrier) to the drawer earth.



Relays and contactor coils disturbances

Standards Good practice

1 AC and mostly DC coils relay, contactor, actuator could be very disturbing sources if no overvoltage protection is fitted in parallel with the coil.



1 *Coil relay*
2 *Un*
3 *Arcing voltage*
4 *NO arcing voltage*
5 *Transient Voltage Suppressor (TVS)*

2 For DC and AC applications, the relay/ contactor coils have to be protected to avoid significant disturbances. In this case, the energy stored inside the coil will be dissipated in the Transient Voltage Suppressor, as shown in the picture above on the right side.
Different types of Transient Voltage Suppressor (TVS) components could be used. The following table provides information.

Symbol	R-C network	For AC	For DC	Over-voltage limitation	Contact fall time
	R-C network	Y	Y	2 to 3 Un	1 to 2 times the standard time
	Metal Oxide Varistor	Y	Y	< 3 Un	1.1 to 1.5 times the standard time
	Transient Voltage Suppression Diode Bi directional	Y	Y	< 2 Un	1.1 to 1.5 times the standard time

To be efficient, the TVS shall be installed closely to the coil.

Wiring of Ethernet network

Standards Good practice

1 Although there are 4 twisted pairs of wires, 10 Base-T / 100 Base-T Ethernet uses only 2 pairs: White/Orange (pins 1 & 2) and White/Green (pins 3 & 6).

As a minimum, an Ethernet line cable must be screened (overall braided screen) and screened also by a foil (SF/UTP).

There are different Ethernet topologies, they can be used separately or mixed.

Rules	Standard Ethernet
Maximum number of devices per network	No limits
Transmission rate	10/100 Mbit/s and 1 Gbit/s
Maximum length	Twisted pair 100 m - Multi-mode Fibre optic: 2 km - Mono-mode Fibre optic > 2 km
Cable type	Depends on the transmission rate

Example

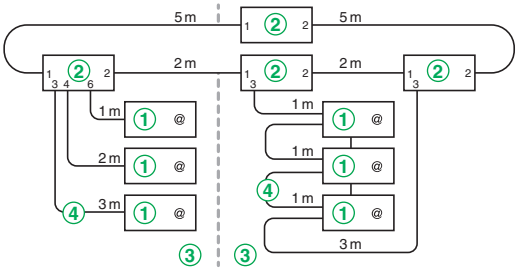
Rules	MotorSys™ iPMCC
Maximum number of devices per network	No limits (except 125 for flat network)
Transmission rate	100 Mbit/s
Maximum length	Ditto standard
Cable type	Cat 5e SFTP or Cat 6 SFTP

2 It is highly recommended to attach a communications wiring diagram in addition to the electrical wiring diagram.

Data to show in this diagram:

- network name and number of each link,
- name, address and location of the equipment,
- identify used ports for each switch,
- all the elements of the architecture (routers, switches, by-pass switch, etc.),
- cable length.

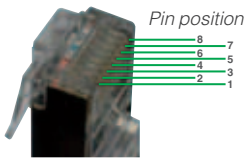
Example



① *Name of devices*
② *Names of the slaves*
③ *Name of the Network, number and location*
④ *Name of the Link, number and location*

3 **Detailed view of a good wiring**

Use straight cable through connection in accordance with TIA/EIA-568-B (T568B) for the number of pins, number of pairs and color coding.



Pin N°	Pair N°	Color
1	1	White/Orange
2	1	Orange
3	2	White/Green
4 & 5	3	
6	2	Green
7 & 8	4	

Wiring of Modbus RTU network

Standards Good practice

1 The Modbus RTU protocol, or Modbus SL, is based on a Master-Slave concept.

In the standard Modbus system, all the devices are connected to a main 3 wires cable. Two wires form a balanced twisted pair, on which bi-directional data are transmitted.

The Modbus topology is a main cable with devices connected directly (daisy chaining) or by short derivation cables.

The main cable, or bus, must be connected at its two ends with Line Terminations.

Generally speaking, the sum of all the derivation lengths must be lower than the length of the bus.

The "Common" circuit must be connected directly to the protective earth, preferably at one point only for the entire bus. In general, this point is chosen either on the master device or on the polarisation device.

A Modbus Serial Cable must be shielded. The shield must be connected to protective earth at both ends.

Rules	Standard Modbus RTU
Maximum number of devices per bus	32 (without repeater)
Bus speed	1200 bit/s to 115,2 kbit/s
Maximum bus length	1300 m (without repeaters) and depending on the transmission
Maximum length of the sum of the derivations	Depends on the transmission rate
Cable type	TIA/EIA - 485 standard
Location of the terminations	Line termination at the 2 extremities of the bus (R or RC)
Location of the polarisation	The polarisation is given by only one equipment at the beginning of the bus (in general: the master)

Example

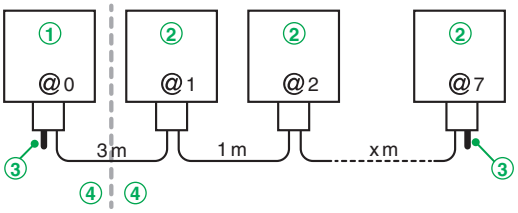
Rules	MotorSys™ iPMCC
Maximum number of devices per bus	8
Bus speed	19.2 kbit/s
Maximum bus length	1000 m
Maximum length of the sum of the derivations	40 m
Cable type	Ditto standard
Location of the terminations	Line termination at the 2 extremities of the bus (only R = 120 Ω)
Location of the polarisation	Ditto standard

2 It is highly recommended to attach a communications wiring diagram in addition to the electrical wiring diagram.

Data to show in this diagram:

- name, address and location of the equipment,
- all the elements of the architecture (copper and fibre optic repeaters, coupling, bridges),
- line termination (LT),
- cable length.

Example

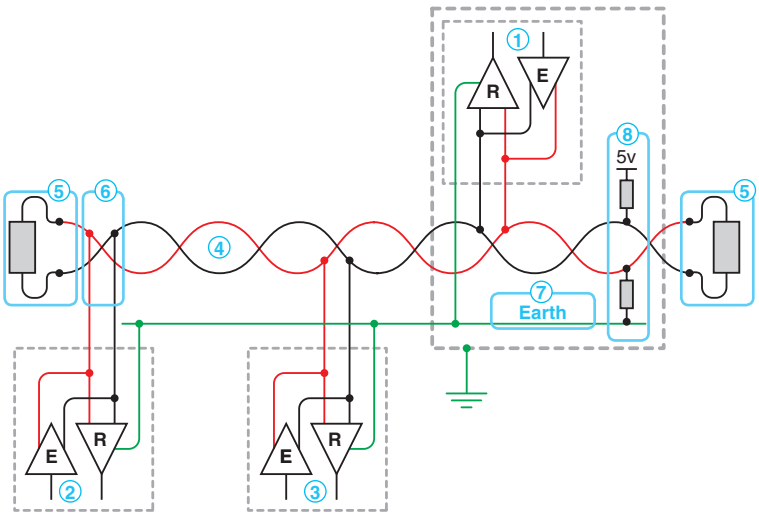


① *Name of the master*
② *Names of the slaves*
③ *Line termination*
④ *Name of the bus, number and location*

Wiring of Modbus RTU network (contd.)

Standards Good practice

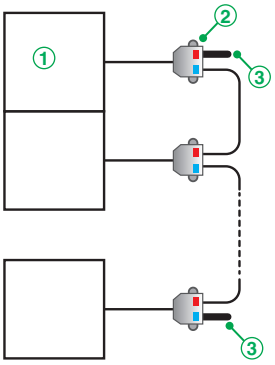
3 Detailed view of a good wiring



1. *Master*
2. *Slave 1*
3. *Slave n*
4. *Balanced twisted pair*
5. *Line termination at both ends of the bus*
6. *Length of the main line > sum of slave derivation lines*
7. *Earth signal to reference all the devices*
8. *Polarity resistor (usually built into the master)*

4 Recommended bus termination rules

The value of the resistor (Line Termination) must be adapted to the impedance of the cable.



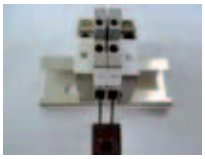
1. *Functional unit*
2. *T-coupling*
3. *Line termination*

Example

In MotorSys™ the line terminations must be of type "R" 120 Ohms.

Two ways are available in MotorSys™ iPMCC to terminate a Modbus RTU communication bus:

- direct connection of an R circuit onto terminals: RS485 Modbus line termination (120 Ω),



- Schneider Electric plug-in accessories: RS 485 Line Termination (120 Ω).

6

Wiring of Profibus DP network

Standards Good practice

1

Rules	Standard Profibus
Maximum number of devices per bus	128 (0, 126 & 127 are reserved)
Maximum number of devices per segment	32
Maximum number of repeaters per bus	Max 9 repeaters and 5 cascaded
Bus speed	9.6 kbit/s to 12 Mbit/s
Maximum bus length	Depends on the transmission rate (see standard IEC 61158)
Maximum length of the sum of the derivations	Depends on the transmission rate (see standard IEC 61158)
Cable type	Type "A" violet (see standard IEC 61158)
Location of the polarisation	The polarisation is given by the equipment where the termination is enabled

Reasons for segmenting a bus with repeaters are the following:

- connect more than 32 stations on the bus,
- maximum length of the sum of the derivations reached,
- need to isolate segments (ATV isolate from the rest of bus, etc.),
- need for derivation (drawer, etc.),
- need for removable connection to equipment.

Example

Rules	MotorSys™ iPMCC
Maximum number of devices per bus	Ditto standard
Maximum number of devices per segment	32 (varies according to the Profibus module and the choice of PLC)
Maximum number of repeaters per bus	Ditto standard
Bus Speed	1.5 Mbit/s
Maximum bus length	200 m
Maximum length of the sum of the derivations	6.7 m per segment
Cable type	Ditto standard
Location of the polarisation	The polarisation is given by a module "Active termination" external

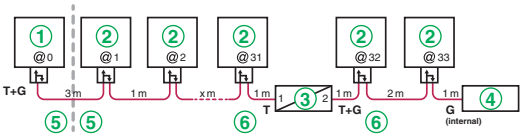
2

It is highly recommended to attach a communications wiring diagram in addition to the electrical wiring diagram.

Data to show in this diagram:

- network name and number of each segment,
- name, address and location of the equipment,
- differentiating active and passive stations (active),
- all the elements of the architecture (copper and fibre optic repeaters, coupling, bridges),
- connectors (G, T+G, etc.),
- cable IN and OUT at the connectors (arrows),
- terminations (T),
- cable length.

Example

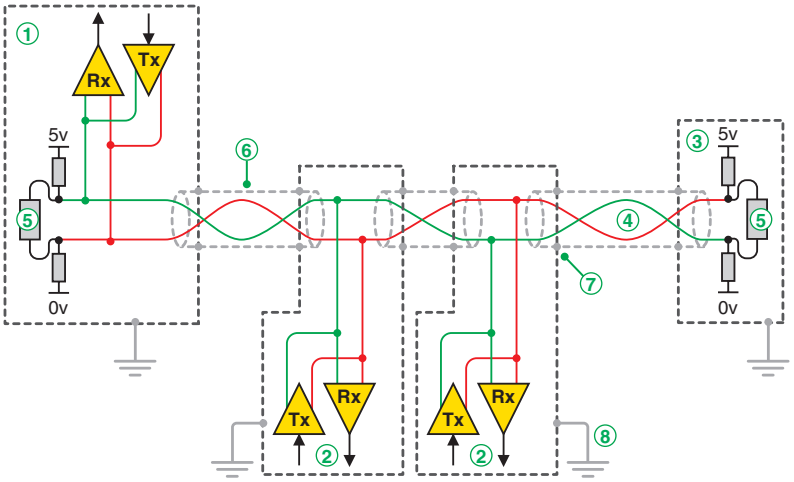


① *Name of the master*
② *Names of the slaves*
③ *Number of repeater*
④ *Active termination*
⑤ *Name of the bus, number and location*
⑥ *Name of the segment, number and location*

Wiring of Profibus DP network (contd.)

Standards Good practice

3 Detailed view of a good wiring



① *Master*
② *Slaves*
③ *Active termination*
④ *Balanced twisted pair*
⑤ *Line termination at both ends of the bus*
⑥ *Shielding*
⑦ *Continuity of shielding by connectors*
⑧ *Earthing of each equipment*

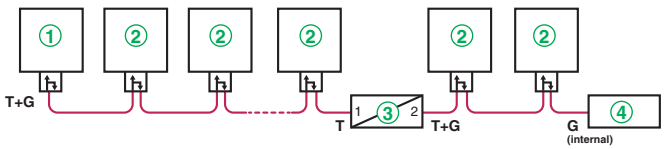
4 Recommended bus termination rules

Both line terminations (T) must be activated at each end of the segment.

For Profibus DP we recommend using connector with PG socket (T+G) for both end of line terminations (to allow connection to an analyser).

The installation of a module "active termination" at the end of the bus to ensure polarisation is **mandatory**.

We recommend placing the master in the first bus.



① *Name of the master*
② *Names of the slaves*
③ *Number of repeater*
④ *Active termination*

Wiring of DeviceNet network

Standards Good practice

1 The DeviceNet protocol is based on a Master-Slave concept.

In the standard DeviceNet system, all devices are connected to a main cable with drops constituted by 4 wires. One twisted pair (red and black) for 24V DC power; one twisted pair (blue and white) for signal, and a drain wire (bare).

The DeviceNet topology is a main cable with devices connected directly (daisy chaining) or by short derivation cables.

The main cable, or bus, must be connected at its two ends with Termination Resistors.

Generally speaking, the sum of all the derivation lengths must be lower than the length of the bus.

The "V-" circuit must be connected directly to protective earth at one point only for the entire bus. Generally this point is to be located on the master device or on the polarisation device. All devices must be galvanically isolated.

A DeviceNet Serial Cable must be shielded. The shield must be connected to protective earth at both ends.

Rules	Standard DeviceNet
Maximum number of devices per bus	1 master & 63 devices
Maximum number devices per segment	30
Bus speed	125 kbit/s to 500 kbit/s
Maximum bus length	Depends on the transmission rate
Maximum length of the sum of the derivations	Depends on the transmission rate
Cable type	Use only DeviceNet media that meet or exceed ODVA specifications
Location of the terminations	Termination resistor at the 2 extremities of the bus (R or RC)
Location of the polarisation	Use the power supply to power the DeviceNet cable system only. If a device requires a separate 24 V power source other than the DeviceNet power source, you should use an additional 24 V power source.

The following are the reasons for segmenting a bus with repeaters:
- connect more than 30 stations on the bus,
- maximum length of the sum of the derivations reached,
- need to isolate segments (ATV isolate from the rest of bus, etc.),
- need for derivation (drawer, etc.),
- need for removable connection to equipment.

Example

Rules	MotorSys™ iPMCC
Maximum number of devices per bus	Ditto standard
Maximum number devices per segment	30 (varies according to the DeviceNet module and the choice of PLC)
Bus speed	125 kbit/s
Maximum bus length	Between 100 m and 500 m depending on the cable section
Maximum length of the sum of the derivations	100 m (the sum of all drop lines should be less than the length of the main bus)
Cable type	Ditto standard
Location of the terminations	Line termination at the 2 extremities of the bus (only R = 121 Ω, 1 %, 1/4 W)
Location of the polarisation	Ditto standard

Wiring of DeviceNet network (contd.)

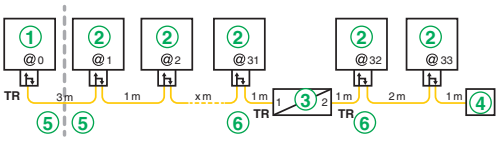
Standards Good practice

2 It is highly recommended to attach a communications wiring diagram in addition to the electrical wiring diagram.

Data to show in this diagram:

- network name and number of each segment,
- name, address and location of the equipment,
- all the elements of the architecture (copper and fibre optic repeaters, coupling, bridges),
- termination resistors (TR),
- cable length.

Example



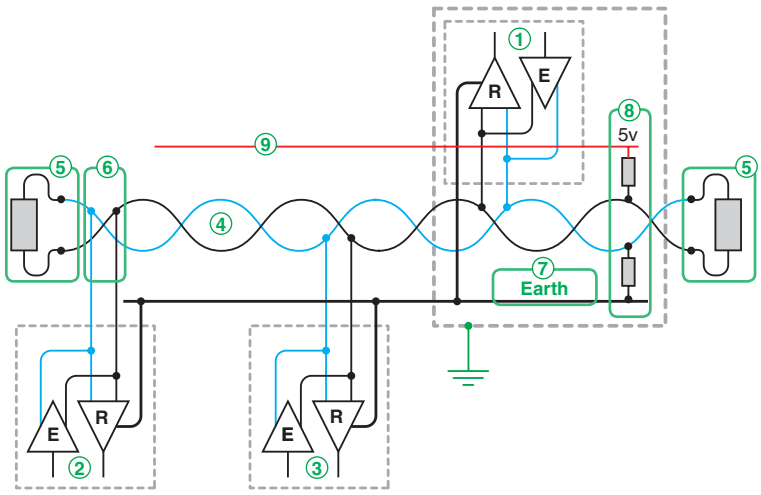
1 *Name of the master*
2 *Names of the slaves*
3 *Number of repeater*
4 *Termination Resistor*
5 *Name of the bus, number and location*
6 *Name of the segment, number and location*

6

Wiring of DeviceNet network (contd.)

Standards Good practice

3 **Detailed view of a good wiring**



1. *Master*
2. *Slave 1*
3. *Slave n*
4. *Balanced twisted pair*
5. *Termination Resistor at both ends of the bus*
6. *Length of the main line > sum of slaves derivation lines*
7. *Earth signal to reference all the devices*
8. *Polarity resistor (usually built into the master)*
9. *Optional CAN external positive supply*

Wiring of DeviceNet network (contd.)

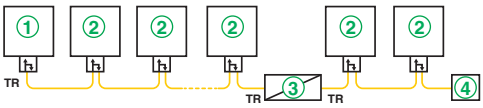
Standards Good practice

4 Recommended bus termination rules

The value of the resistor (Termination Resistor) must be adapted to the impedance of the cable.

Wiring a termination resistor outside the FU is **mandatory**.

Location of termination resistor:



① *Name of the master*
② *Names of the slaves*
③ *Number of repeater*
④ *Termination Resistor*

Example

In MotorSys™ the termination resistors must be of type "R" 120 Ohms, 1 %, 1/4 W.

6

Wiring of CANopen network

Standards Good practice

1 The CANopen protocol is based on a Master-Slave concept.

In the standard CANopen system, all devices are connected to a main cable with drops constituted by 4 wires. One twisted pair (red and black) for 24V DC power; one twisted pair (blue and white) for signal, and a drain wire (bare).

The CANopen topology is a main cable with devices connected directly (daisy chaining) or by short derivation cables.

The main cable, or bus, must be connected at its two ends with Termination resistors.

Generally speaking, the sum of all the derivation lengths must be lower than the length of the bus.

The "CAN earth" (V-) circuit must be connected directly to protective earth at one point only for the entire bus. Generally this point is to be located on the master device or on the polarisation device. All devices must be galvanically isolated.

A CANopen Serial Cable must be shielded. The shield must be connected to protective earth at both ends.

Rules	Standard CANopen
Maximum number of devices per bus	127
Maximum number devices per segment	30
Bus speed	10 kbit/s to 1 Mbit/s
Maximum bus length	Depends on the transmission rate
Maximum length of the sum of the derivations	Depends on the transmission rate
Cable type	Standard CANopen ISO11898-2
Location of the terminations	Termination resistor at the 2 extremities of the bus (R or RC)
Location of the polarisation	The polarisation is given by only one equipment at the beginning of the bus (in general: the master)

The following are the reasons for segmenting a bus with repeaters:

- connect more than 30 stations on the bus,
- maximum length of the sum of the derivations reached,
- need to isolate segments (ATV isolated from the rest of the bus, etc.),
- need for derivation (drawer, etc.),
- need for removable connection to equipment.

Example

Rules	MotorSys™ iPMCC
Maximum number of devices per bus	Ditto standard
Maximum number devices per segment	30 (varies according to the CANopen module and the choice of PLC)
Bus speed	500 kbit/s
Maximum bus length	100 m
Maximum length of the sum of the derivations	30 m
Cable type	Ditto standard
Location of the terminations	Termination resistor at the 2 extremities of the bus (only R = 120 Ω)
Location of the polarisation	Ditto standard

Wiring of CANopen network (contd.)

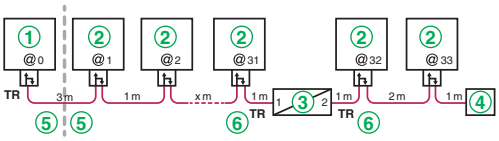
Standards Good practice

2 It is highly recommended to attach a communications wiring diagram in addition to the electrical wiring diagram.

Data to show in this diagram:

- network name and number of each segment,
- name, address and location of equipment,
- all the elements of the architecture (copper and fibre optic repeaters, coupling, bridges),
- connectors (G, T+G, etc.),
- cable IN and OUT at the connectors (arrows),
- termination resistors (TR),
- cable length.

Example

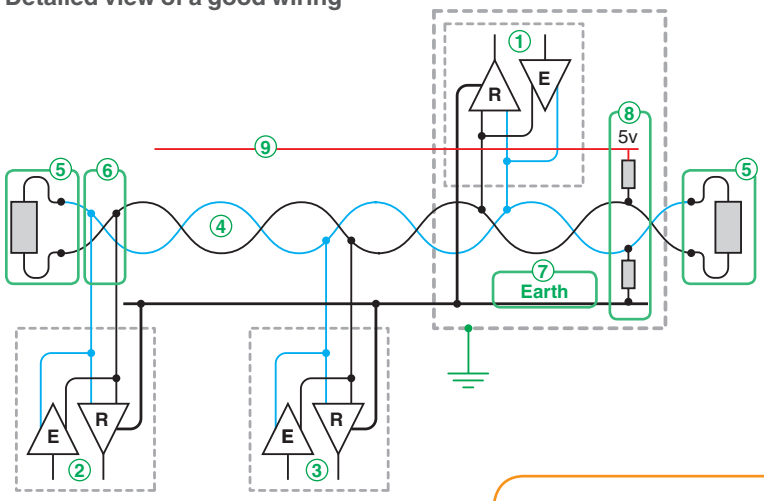


① *Name of the master*
② *Names of the slaves*
③ *Number of repeater*
④ *Termination Resistor*
⑤ *Name of the bus, number and location*
⑥ *Name of the segment, number and location*

Wiring of CANopen network (contd.)

Standards Good practice

3 Detailed view of a good wiring

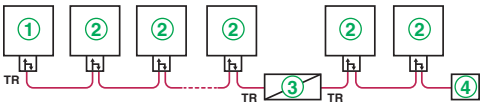


1. *Master*
2. *Slave 1*
3. *Slave n*
4. *Balanced twisted pair*
5. *Termination resistor at both ends of the bus*
6. *Length of the main line > sum of slaves derivation lines*
7. *Earth signal to reference all the devices*
8. *Polarity resistor (usually built into the master)*
9. *Optional CAN external positive supply*

4 Recommended bus termination rules

The value of the resistor (Termination Resistor) must be adapted to the impedance of the cable. Wiring a termination resistor outside the FU is **mandatory**.

We recommend using connector for CANopen with PG socket (T+G) to the bus master to allow connection to an analyser. We recommend placing the master in the first bus.



1. *Name of the master*
2. *Names of the slaves*
3. *Number of repeater*
4. *Termination Resistor*

Example

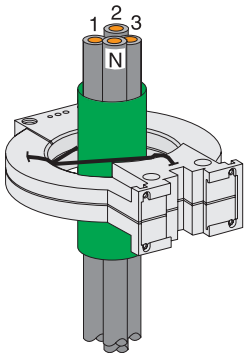
In MotorSys™ the termination resistors must be of type "R" 120 Ohms, 1 %, 1/4 W.

Using Toroids

Installation rules

Standards Good practice

1. Choose a toroid that is adapted to the cross-section of the cable on which it is to be installed.



Place a soft steel sleeve tube around the cable to significantly reduce interference signals caused by the asymmetrical configuration of conductors in the toroid.

2. Always install toroids in easily accessible locations by keeping the distance between the toroid and the measuring device as short as possible.

Make sure that the information marked on the toroid remains visible after installation.

3. Install the toroid on a straight length of cable.

4. Centre the cables in the toroid to be able to read the measurement correctly. Observe an angle of 90° between the cables and the toroid.

5. Position the toroid and block it to prevent rotation and translation before connecting it.

6. The connection between the toroid and the measuring device must never be interrupted.

Choice of power supply

A new guide for LV

equipment engineers

(front office/back office)

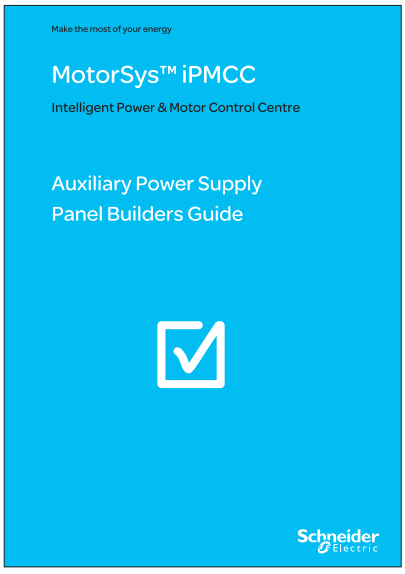
responsible for defining

auxiliary power supplies inside

the smart LV switchboard

(in particular iPMCC*),

will be available in 2013.



Discover an extract
of this guide
on page 222

For more information,
see your sales contact

** Intelligent Power & Motor Control Centres*

Quality control check list

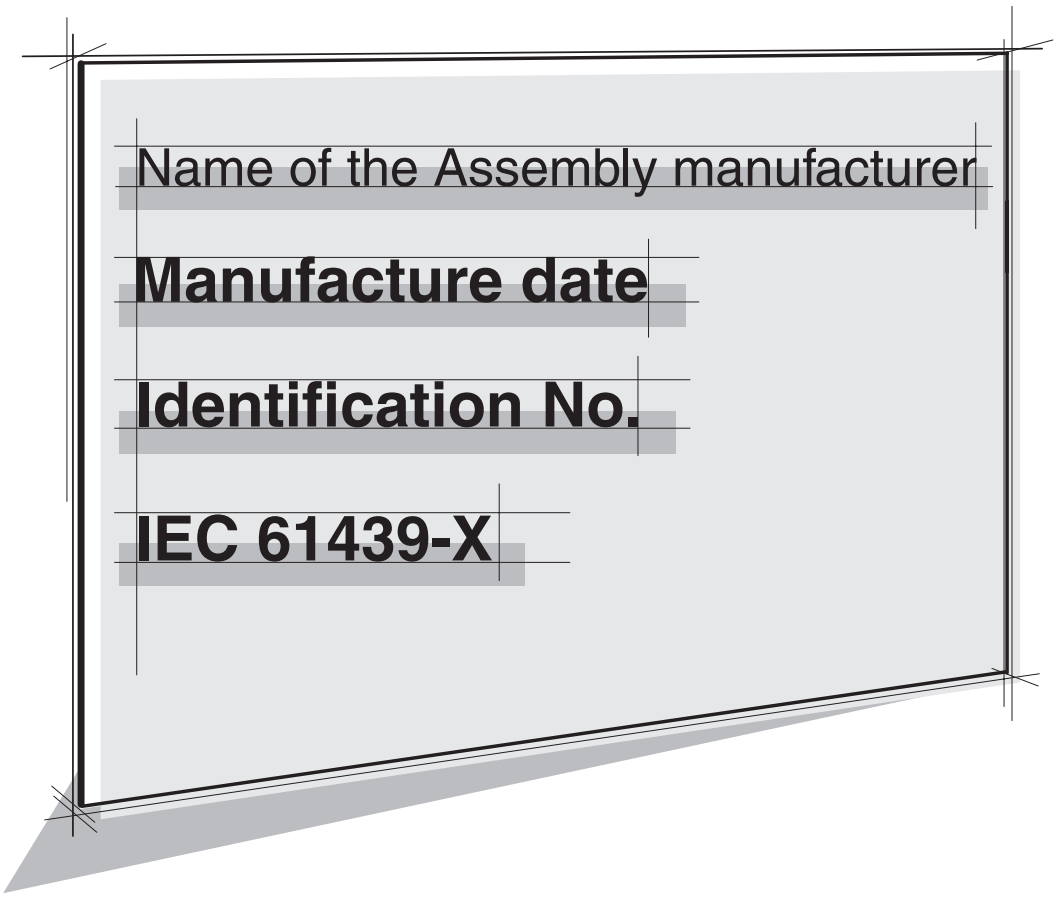
Note: the list of control points presented is not exhaustive.
It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

Minimum checks required	Control points	Control resources	Self-control
	> Compliance of wiring installation	> Installation guide	☐
☑	> Crimping quality	> Installation guide	☐
☑	> Connection quality	> Installation guide	☐
☑	> Compliance of communication cable installation	> Installation guide	☐
☑	> Wiring cross-section and characteristics	> Customer specifications, Installation guide	☐

Objectives

- Avoid communication "bugs"
- Avoid risks of temperature rises
- Guarantee correct electrical functioning
- Avoid electrical risks
- Guarantee compliance with customer specifications

Labelling and marking



Foreword

Foreword

Standards Theory

IEC 61439-1
§ 6.1

1 All switchboards must be identified in a durable, visible and legible manner when they are installed and operating.

It is also useful:

- to indicate the name of the switchboard,
- to identify each column.

> *See the "Identification of the Switchboard" section in this chapter.*

Example

IEC 61439-1
§ 6.3

IEC 61346-1

IEC 61346-2

IEC 61082

2 On the front panel of the switchboard, it is useful to indicate the function of each device and control device (pushbutton, indicator).

Inside the switchboard, it must be possible to identify:

- the devices,
- the individual circuits,
- the protective devices,
- the control devices (relays, contactors, indicators, etc.).

All the names used must comply with standards IEC 61346-1 and IEC 61346-2 and be identical to the one on the circuit drawings. These must comply with standard IEC 61082.

> *See the "Identification of the Switchgear" section in this chapter.*

IEC 61439-1
§ 8.6.5 and § 8.6.6

IEC 60445

IEC 60446

3 Conductors (busbars, cables, insulated flexible bars) and the terminals to which they are connected must comply with the indications of wiring diagrams and drawings. Identification must comply with standards IEC 60445 and IEC 60446.

The marking of the protective conductors (PE/PEN) and the neutral conductor must comply with the directives of standard IEC 61439-1 (§ 8.6.6).

> *See the "Identification of Conductors" section in this chapter.*

Foreword (contd.)

Standards Theory

4 The switchgear is marked using adhesive, screwed or riveted labels.

A wide range of materials are used to manufacture the labels: aluminium, stainless steel, brass, Plexiglas, double-layer plastics, PVC, vinyl, etc.

There are many marking techniques: laser engraving, mechanical engraving, silk screening or digital printing, depending on the aesthetic appearance desired and the constraints imposed by the material on which this is done.

> *See supplier catalogues.*

Whatever the materials and marking technique chosen:

- use good quality labels that are resistant and durable,
- to ensure lasting legibility, prefer dark-coloured texts on a light background.

To avoid all risks of short-circuits in case they drop inside the switchboard, do not use metal labels or labels made from conductive materials.

Example

Schneider Electric recommends the use of labels in double-layer plastic whenever possible for marking the front of switchgear. They are long-lasting and withstand acids, scratches and chemical agents.

Identification of the switchboard

Name plate

Standards **Good practice**

IEC 61439-1
§ 6.1

Tip

According to the standards, it is possible not to mark electrical characteristics (voltage, current, frequency, Isc withstand, earthing system, etc.) or mechanical characteristics (switchboard weight, IP degree of protection, etc.) on the name plate, but only on the documents given to the client, such as implementation drawings.

1 A name plate must be fixed on the front panel of each switchboard.

It should include the following at least:

- the name and address of the panelbuilder,
- the identity of the project or any other means of identification that will provide the electrical and mechanical characteristics of the switchboard,
- the date of manufacture,
- the reference of the standard IEC 61439 (1 and 2).

Also make sure to include the layout diagram with the change index "as built" inside the switchboard.

Example

2 The name plate can be completed with a flashcode on the front panel of the switchboard.

The flashcode is a small encoded pictogram made up of small squares. It can be . decoded by mobile telephones equipped with a flashcode reader. It may be used by clients to log on to a panelbuilder's web site to obtain technical information about their installation (update of drawing of plans, contract items, etc.).

Identification of the switchgear

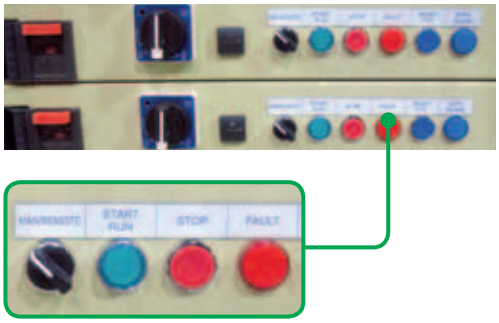
Marking on the front panel of the switchboard

Standards

Good practice

1 State the function of the device or control device concerned to enable users to clearly identify each device and its related circuit.

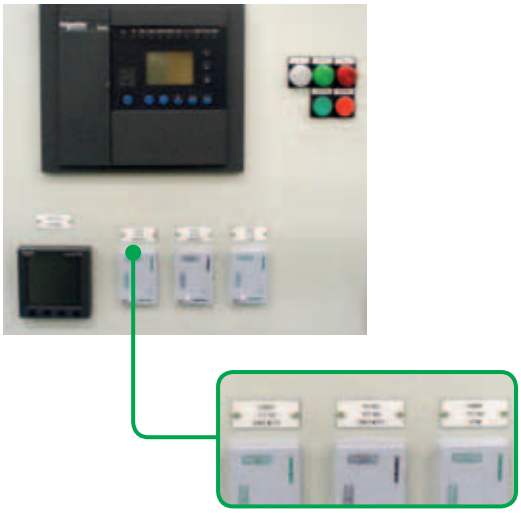
Example



2 Place the labels in a logical and visible place, as close as possible to the device or control device concerned.

Fasten the labels durably using clips, rivets or screws.

Example



Identification of the switchgear

Marking inside the switchboard

Standards

Good practice

1. This marking will enable maintenance technicians or wireworkers to clearly identify each device or control device (contactor, relay, etc.).

   To avoid all interpretations or mistakes during work inside the switchboard, use the same names as the ones on the switchboard wiring diagram.

2. Mark the devices without covering the information engraved on the device name plate.

   If it is not possible to carry out marking directly on the device, find a visible place as close as possible, that will enable the device to be identified without ambiguity.

   For aesthetic reasons, the marks must not be visible on the front panel of the switchboard.

Example

3. Mark the phases on the connection pads of devices to avoid all wiring errors.

   Mark the polarity (+ and -) for direct current circuits.

Example

7

Marking inside the switchboard (contd.)

Standards

Good practice

4 In the case of a drawout device (base- or frame-mounted), put the marks both on the mobile and fixed components.

5 Do not mark components that are liable to be removed such as device protective covers or terminal shields.

Identification of conductors and connection blocks

Identification of conductors and connection blocks

Standards

Theory

IEC 60445

and IEC 60446

1 There are different marking techniques:
- colour shrink-bands,
- coloured wires (identification of the various circuits),
- printer labels,
- polyamide sleeves,
- etc.

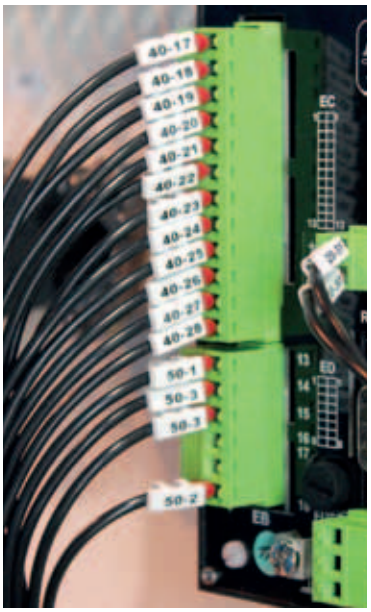
If there are no customer specifications, use the identification given by IEC 60445 and IEC 60446.

Tip

There are machines for cutting wires to length as well as cutting and stripping wires. Some machines mark the wires at each end. They cut down on the time needed to mark the wires and eliminate errors because they are controlled from data from the design department.

2 The marking of the wires maybe alphabetical, numerical or alphanumerical.

Example



Example of numerical marking

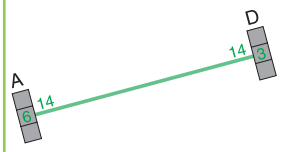
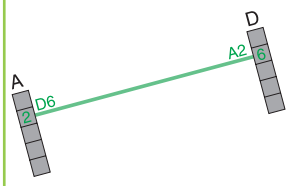
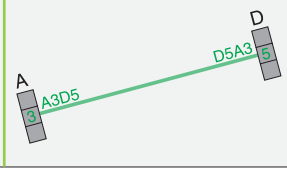
Identification of conductors and connection blocks

Identification of conductors and connection blocks (contd.)

Standards Theory

3 Several marking methods can be used.

This means that correct marking is essential for connection on site and switchboard maintenance. Since there are several solutions, it is important obtain confirmation from the customer about the method to be used.

Marking	Representation	Description
Equipotential marking		The two wire ends are marked with the same name or number, unrelated to the terminals.
Marking of wire entry point		The two ends of the wire are marked with a different name or number. Each wire-end indicates the terminal to which it must be connected.
Marking of wire exit point		The two ends of the wire are marked with a different name or number. The marking of each wire end indicates the connection point of the other wire end.
Marking of wire entry and exit points		The two ends of the wire are marked with a different name or number. Each wire end has the mark of the terminal on which it must be connected followed by the mark of the terminal on which the other wire end must be connected.

4 Pay special attention to the following points:

- use good quality mediums that are resistant and durable. They must always be visible, legible and correctly fixed throughout the operation of the switchboard,
- take the environment into account in choosing the medium. This is because an adhesive label may come unstuck or deteriorate (change in colour, deformation, etc.) if it is placed in a humid area or in an area where the temperature is high,
- markings must not be too long.

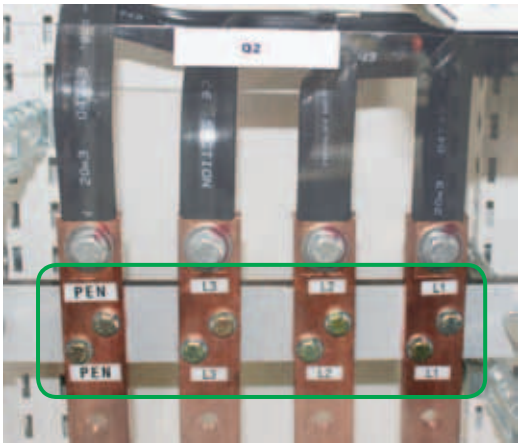
Identification of conductors and connection blocks

Marking of conductors

Standards Good practice

1 Whatever the conductor (bar, cable, insulated flexible bar), place the marking as close as possible to the connection point.

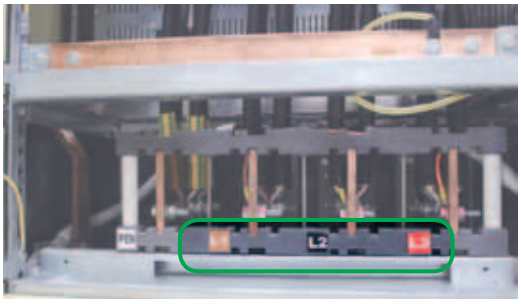
Example



2 Phases must at least be marked L1, L2, L3, at the end and at connection points.

There are no specific colour requirements. Continuous marking on the entire length of the bar is not required either.

Example



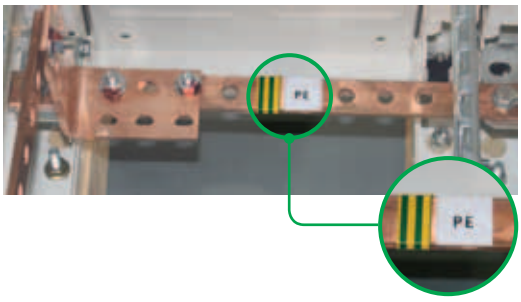
7

IEC 61439-1 § 8.6.6

3 The protective conductor (PE or PEN) must be easily distinguishable by its marking and/or colour. If identification is by colour alone, use **only green and yellow (double colouring).** Position this double marking at the ends.

When the protective conductor is an insulated single-conductor wire, you must **only use yellow/green wires.**

Example



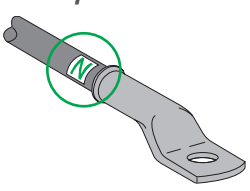
IEC 61439-1 § 8.6.6

4 All neutral conductors of the main circuit must be easy to identify by their marking and/or colour.

If the identification is done by colour, use **only light blue:**

- on the entire length for the wires,
- at the ends and connection for the bare bars or insulated flexible bars.

Example



Identification of conductors and connection blocks

Marking of conductors (contd.)

Standards

IEC 60446

Good practice

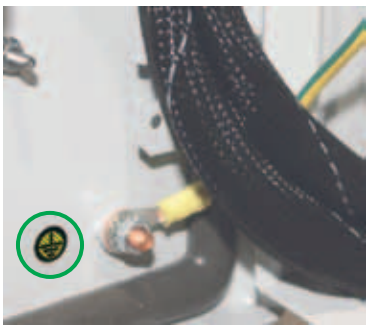
5 The marking of continuous circuits is based on the following colours:

- dark blue for the negative pole,
- red for the positive pole.

If you do not use colour wires, you must mark the cables at each end using a coloured sleeve.

6 The pin or connection point of the switchboard metal must be signalled with a standardised earth mark.

Example



Identification of conductors and connection blocks

Marking of terminal blocks

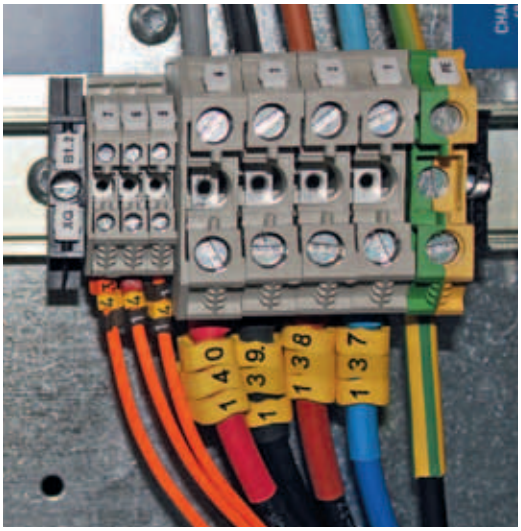
Standards

Good practice

1 All terminal blocks must be marked. Terminals must also be marked.

The entry and exit points of wires must be clearly indicated on the wire on a visible medium that cannot be altered over time.

Example



Warning labels

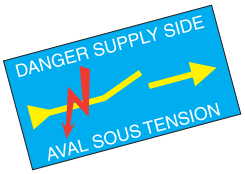
Warning labels

Standards

Good practice

1 Place a warning label on the devices powered by the lower connection terminals (live downstream terminals).
Position it on the right of the device:

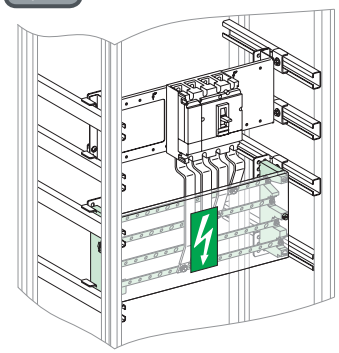
- on the door,
- near the connection areas.



The label must always be visible from the outside.

2 Place an **"electrical hazard"** warning label on barriers preventing access to live parts.

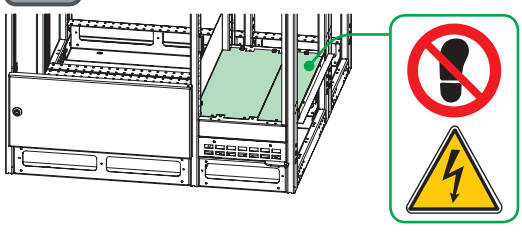
Example



"Electrical hazard" *label placed on the insulating barrier of a staged barrier splitter 160/630 A 4-pole.*

3 Place a warning label ("Do not walk" and "Electrical Hazard" symbols) on the protective form of a busbar installed at the bottom of the switchboard.

Example



Quality control check list

Note: the list of control points presented is not exhaustive.

It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

Minimum checks required	Control points	Control resources	Self-control
☑	> Marking and identification of the assembly*	> Standard 61439-1 and -2, customer specifications	☐
	> Marking of devices, pushbuttons, indicators, etc.	> Standard 61439-1 and -2, customer specifications	☐
	> Marking of conductors (control and power)	> Standard 61439-1 and -2, customer specifications	☐
	> Quality of labels and their attachment	> Standard 61439-1 and -2, customer specifications	☐
☑	> Instruction and warning labels	> Standard 61439-1 and -2, customer specifications	☐
☑	> Marking of wires and customer connection terminals	> Standard 61439-1 and -2, customer specifications and installation guide	☐

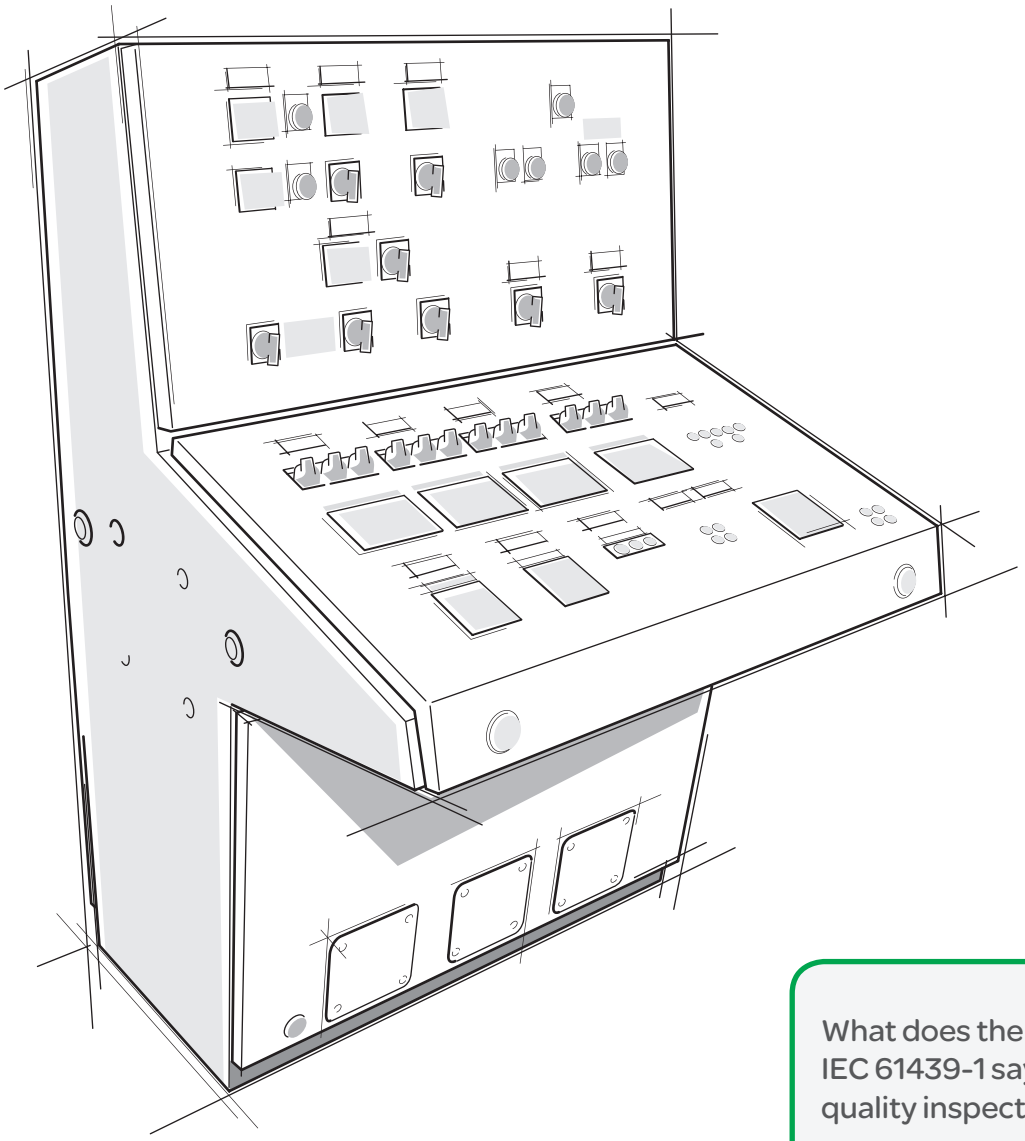
(*) What standard 61439-1 and -2 stipulated about assembly identification:

- *Identification of the name of the **assembly** manufacturer.*
- *Designation of the identification type or number, or any other means of identification that makes it possible to obtain the relevant information from the **assembly** manufacturer.*
- *Means of identification of the manufacturing date.*
- *IEC 61439-1 and -2 (the part specific to "-1 or -2" must be identified).*

Objectives

- Ensure equipment traceability
- Guarantee the compliance of identification with standard 61349-1 and -2
- Guarantee the durability of identifiers (e.g., labels)
- Facilitate maintenance operations and changes to the installation

Factory quality inspection



What does the standard IEC 61439-1 say about quality inspections

Routine verification

Routine verification is designed to **detect materials and manufacturing defects and to ensure that the manufactured assembly is working properly**. It is **performed on each assembly**.

Panelbuilders must determine whether routine is carried out during and/or after manufacturing.

If necessary, the routine verification must ensure that design verification is available.

Verification comprises two categories below:

1 "Construction" verifications (see sections 11.2 to 11.8 of the standard)

1. Degree of protection of enclosures
2. Clearances and creepage distances
3. Protection against electric shock and integrity of protective circuits
4. Incorporation of built-in components
5. Internal electrical circuits and connections
6. Terminals for external conductors
7. Mechanical operation

2 "Performance" verifications (see sections 11.9 to 11.10 of the standard)

1. Dielectric properties
2. Wiring, operational performance and function

What is the risk if the quality inspection is not conducted (during and/or after manufacturing)?

- Quality organisation does not comply with standard
- Customer not satisfied
- Hazardous installation
- Negative impact on the image of the panelbuilder and manufacturer
- Higher costs of intervention
- Operating loss (break in service continuity)
- Financial loss

Quality organisation recommended by Schneider Electric

Organise quality checks

Organise quality checks (self-checks) **throughout the switchboard assembly and installation process**, from acceptance of components until the delivery of the switchboard (see quality control check list opposite).

Benefits

- Increased accountability of operators
- Improved traceability
- Optimisation of installation rules

  E.g. busbar tightening must be checked at the end of manufacturing (involves the dismounting of sheets, resulting in a significant loss of time).

Conduct a final quality inspection

In a **secured area dedicated for this purpose** (in particular during electrical checks).

Note: the final quality inspection must be performed by qualified and authorised personnel.

Documents required for the final inspection

- Check lists of quality checks (self-checks) conducted throughout the switchboard assembly and installation process
- Final inspection report

  (See example provided in the guide on page 206)

  Note: to be completed depending on the customer's specifications and requirements.
- Other useful documents: notification of non-compliance, check list of missing components, quality measurements, etc. *(See examples provided in the guide on page 201)*
- Manufacturing file
- Switchgear guide
- Technical documentation

> To find out more about the final quality inspection, see the "Quality inspection guide" written by our experts.

Check list of checks to be made during the final quality inspection

Make sure that self-checks have been performed throughout the assembly and installation process or validated (e.g. by the line controller).

Control points	Control resources	Final control
Compliance checks		
> Identification & column numbers > Type > Dimensions > Compliance of front panel, block diagram > Handling devices	> Assembly drawing file > Customer specifications	☑
Visual checks		
> Paint (colour, homogeneity, finishing) > No scratches and deformations	> Visual inspection	☑
Frame, structure		
> Functioning of doors, swivelling front panels > Locks (type, functioning) > IP degree of protection	> Operating test > Specifications, visual inspection > Visual Inspection, technical guide	☑
Switchgear		
> Position > Fastening > Characteristics: nominal range, breaking capacity > Identification and marking > Safety perimeter > Mechanical operation > Mechanical indication (test position, connected, etc.) > Plugging-in and withdrawing procedure > Striker pin > Accessibility of switchgear > Ability to connect on terminals or pads > Accessibility for connection > Locking, foolproofing	> Visual inspection > Visual inspection > Specifications, visual inspection > Specifications, visual inspection > Technical guide > Operating test > Operating test > Operating test > Operating test > Visual inspection > Visual inspection > Visual inspection > Visual inspection	☑
Busbars		
> Busbar cross-section > Coating and internal arc device > Busbar support (fastening device and number) > Marking > Compliance of joint blocks	> Technical guide > Customer drawings and specifications file > Technical guide > Customer drawings and specifications file > Technical guide	☑
Cables & flexible bars		
> Cross-section and characteristics of conductors > Compliance of installation mode (fastening, sharp edges, etc.) > Auxiliary Power separation > EMC protection	> Technical guide > Technical guide > Assembly and installation guide and communication guide > Assembly and installation guide and communication guide	☑
Connection		
> Compliance and quality of bolted connections (e.g. covering and fastener type) > Torque and marking > Crimping quality	> Technical guide	☑
Protection of persons		
> Earth bar (cross-section and fastening) > Earthing braids > Forms > Bonding continuity > IP of measuring devices (fastened on doors) > Blanking shutters > Terminal guards and covers > Fastening of protective barriers	> Technical guide and assembly technical guide	☑
Safety distances		
> Clearance > Creepage distances	> Assembly and installation guide and visual inspection > Installation and assembly guide	☑
Dielectric check (power circuit)		
	> Insulation tester	☑

Please photocopy the check list before completing it

Check list of checks to be made during the final quality inspection

Control points	Control resources	Final control
Insulation check (power circuit)		
	> Megohmmeter	☑
Electrical compliance		
> Phase order	> Phasing test	☑
> Voltages, control polarities	> Electric tests, voltmeter	
> Distribution of polarities (inter-column connections)	> Electric tests, voltmeter	
Functional tests:	> Test consoles, injection test bench, etc.	
> Operating sequence (controls and signalling)		
> Checking of source transfer		
> Electrical and mechanical inter-locking		
> Checking of opening/closing orders of units		
> Trip tests (defects)		
> Information report (OF-SDE-SD)		
> Signalling (indicator lights, etc.)		
> Injection on protection and measurements (values, etc.)		
Measurement and protection:	> Electric tests	
> Protection tests (fault tripping, etc.)		
> Injection on measuring devices (Pa, PWH, etc.)		
> CT winding direction		
Device settings (circuit monitors, protections, etc.)	> Technical documentation	
Automation and communication:	> Customer specifications	
> Equipment addressing		
> Network tests (read/write)		
> Verification of PLC inputs/outputs		
> Validation of the PLC (according to functional specifications)		
Cleaning and preparation of columns		
Documentation related to switchboard		
> Switchboard building drawings		
> Installation and maintenance documents		
> Switchgear guides		
> List of shortages		
Packaging		
> Compliance of the package	> Packing list	
> Compliance of packaging	> Contract terms	

Objectives

- Avoid having to repeat the process from the beginning
- Meet the customer's specifications to the letter
- Provide a product of high quality, without defect, from the design phase to delivery

Please photocopy the check list before completing it

CE-marking (European community)

Declaration of conformity

Standards **Good practice**

IEC 61439-1

IEC 61439-2

1 The panelbuilder issues the declaration of conformity for the equipment.

It is obliged to prepare the equipment technical file that attests to this conformity.

To facilitate the issue of the declaration of conformity, by easily producing all the evidence, the panelbuilder must:

- use a switchboard system tested according to IEC 60439-1 standards,
- comply with assembly and installation instructions,
- have an ISO 9000 type quality organisation.

Example

The Prisma Plus system is compliant and has the CE-mark on the packaging.

Recommendation

The CE-mark on the equipment or its packaging is not indispensable. It may appear only on the documents that come with the equipment.

Append a declaration to these documents informing the customer that the relevant directives have been complied with.

- *For each project, **issue and archive** an "CE declaration of conformity" (example below).*
- ***Create a technical file comprising:***
  - *the description of the equipment,*
  - *proof of compliance with directives (inspection and individual equipment test reports , list of products used with the CE-mark).*
- ***Access to these documents must be restricted only for audit authorities,** for the legal 10-year period after the sale.*

Declaration of conformity CE

Certificate of conformity / *Certificat de conformité* CE

Manufacturer's name / *Nom du fabriquant* : .....

Manufacturer's address / *Adresse du fabricant* : .....

Customer / *Client* : .....

Site : .....

.....

Description of equipment / *Désignation du matériel* : .....

.....

Low voltage switchboard project no.:
Tableau électrique basse tension projet n° :

We declare that, with exceptions or exemptions above listed, the mentioned equipment complies with the requirements of the directives:

Nous déclarons que, sauf exceptions ou dérogations énumérées ci-dessus, la fourniture citée ci-dessus satisfait aux dispositions des directives :

- Low voltage / *Basse tension* N° 2006/95/EC

- EMC / *CEM* N° 2004/108/EC

and is compliant with the standard / *et est conforme aux normes et documents normatifs suivants* :

- IEC 61439-1

Last year of appending the "CE" mark /
Dernière année d'apposition du marquage "CE" :

Date :

.....

Operational Director / *Directeur des opérations*
Name / *Nom :*

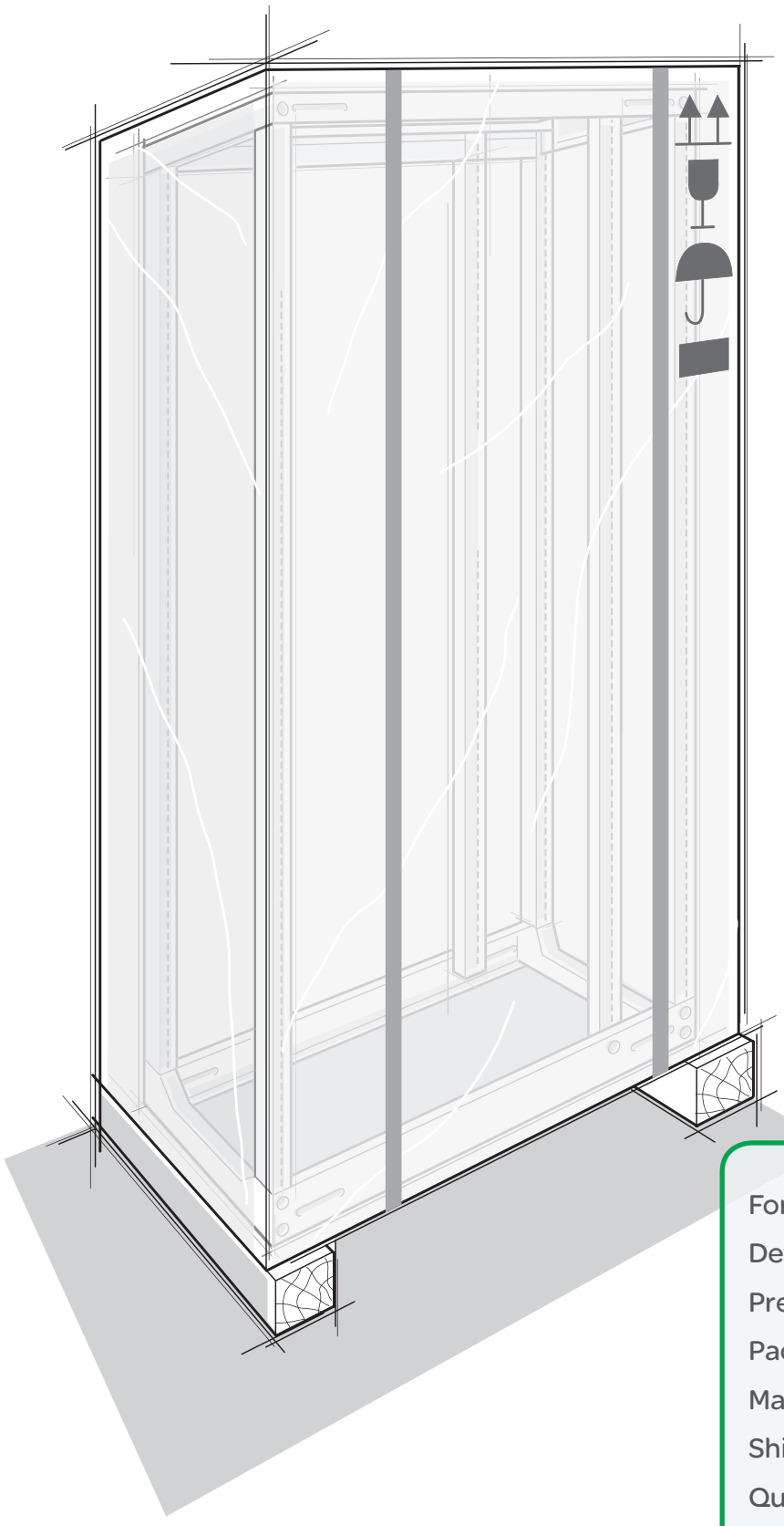
.....

Signing / *Signature* :

This certificate is compliant with EN 45014 / Ce certificat respecte les exigences de la norme EN 45014.

Notes

Packing



Foreword

Standards

Theory

Tip

Certain criteria related to the customer and shipping on site justify the choice of an appropriate packing that complies with the specifications defined by the SEI (Industrial Packing Union) and designed by industrial packing professionals.

1

The packing must effectively protect the equipment against mechanical impacts and risks of rust and corrosion during transport, loading, unloading and storage.

The packing must also provide excellent protection of the front panel and include essential information (total weight, dimensions of crate, shipping address, etc.).

To be able to choose the most appropriate packing, you must take the following factors into account:

- final shipping destination,
- environment in which the equipment is to be stored (temperature, humidity, bad weather, dust, impacts),
- storage period at departure and arrival,
- handling processes (fork lift, cranes, gantries, etc.),
- mode of transport used (truck, container, boat, air, etc.), transport conditions and transit countries,
- weight of the equipment,
- level of fragility of the equipment,
- type of covering (paint, stainless steel, etc.),
- centre of gravity,
- any lifting points or lack of lifting points.

The person in charge of the proposal is responsible for listing packing requirements and transport and handling constraints.

Example

As a rule, Schneider Electric recommends that switchboards be shipped column by column.

However, shipping may be done in batches of two columns placed side by side. In this case, the customer must give its consent in writing and special measures must be taken to:

- avoid any deformation of the assembly during transport or handling,

- ensure site accessibility,

- disconnect the columns on the site if necessary.

Definition

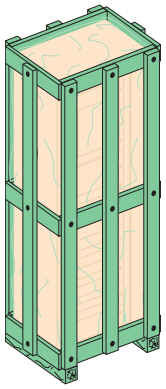
Definition of packing

Standards Theory

1 Packing categories 3 (crates) and 4 (cases) are the ones that are most often used for packing switchboards.

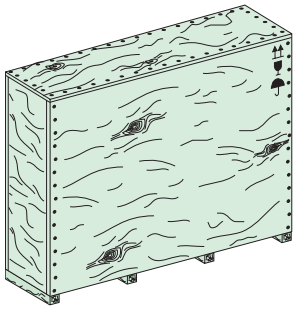
Transport, climate and storage conditions define the protection to be provided to the equipment:

- **SEI3b packing:** the columns are protected by a cover or polyethylene film in a crate made from planks or plywood. The storage duration is less than three months.



SEI3b packing

- **SEI4c packing:** this type of packing is used for particularly difficult transport, climate and storage conditions (export, maritime transport, long storage, etc.). The columns are protected under a heat-welded vacuum cover filled with bagged desiccants. The assembly is installed in a ventilated wooden or plywood case. Generally the case and its contents must not weigh more than 5 tonnes. The storage duration is more than three months.



SEI4c packing

Tip

The specifications provided by the SEI define several packing categories numbered 1, 2, 3, 4, 7 and 8. Each category corresponds to a certain type of equipment and possibly to a related mode of transport.

Some polyethylene films cannot be used for packing electronic components because of possible electrostatic problems.

Definition

Definition of packing (contd.)

Standards Theory

2 A packaging case is determined by its bundling: length, width and height (always in this order). The dimensions are always given in **cm**.

The determination of the bundling of a packing must take into account the internal volume required to protect and cushion the equipment.

3 Cushioning is essential to protect the equipment against mechanical impacts. It consists in securing the equipment inside the case along its length, width and height.

If the equipment is to be handled with a forklift, it is essential to pay special attention to the constitution of the bottom of the case.

If a sling is used, it is essential to have cushioning under the lid to avoid deformation that may be caused by the tightening of the slings or straps during lifting.

4 The material used for the case (cardboard, wood, plywood, etc.) depends on the destination and transport mode chosen.

When the equipment is very heavy or when it is transported by boat, it will be preferable to use wooden cases that will protect the equipment better from impacts.

5 The cases must be ventilated and filled with double lids to avoid the ingress of runoff water or rainwater from the roof.
The internal walls must be covered with impermeable Kraft paper that can resist humidity.

Preparation

Preparation before packing

Standards

Good practice

1. No equipment must be packed without the express permission of the quality inspector in charge of the project.

2. Before it is packed, the switchboard must be dusted and cleaned both inside and outside:
   - use a vacuum cleaner to remove dust from inside and outside the column,
   - clean the outer sides of the column with a neutral solvent that will not damage the paint and plastics,
   - check the status of accessories (absence of marks or dirt, etc.) and clean them if necessary,
   - retouch the paintwork if necessary.

   Do not blow clean since this may project and cause to accumulate particles, shavings or other debris in a zone that is energised.

Example

Dust removal with a vacuum cleaner

3. Before closing the doors, make sure that all the barriers (forms), cable gland plates and other accessories that may have been removed to facilitate inspection or cleaning operations have been put back correctly.

4. After cleaning, check that no foreign bodies have been left inside the switchboard (tools, screws and bolts) that could prevent it from working properly.

5. Collect all the documents related to the switchboard together:
   - a set of drawings updated at the end of inspection,
   - the list of separate accessories and equipments (fasteners, wiring, etc.)
   - switchgear technical manuals,
   - installation guides,
   - assembly manuals:
     - for the switchgear,
     - for the enclosure,
   - the list of any missing items.

Packing

Packing

Standards

Good practice

Tip

Procedures may differ depending on the organisation in force with each panelbuilder and the constraints imposed in each country.

1. Follow the instructions about workshop procedures and special specifications for packing switchgear and accessories likely to be delivered separately:
   - all equipment that cannot be delivered with the assembly because it is too heavy or cumbersome (voltage transformer, rectifier, high-power circuit-breaker, battery, prefabricated connections, etc.),
   - wires for connecting several columns,
   - additional fasteners (coupling of columns, joint blocks, etc.),
   - any panels to be installed after connection on site (roof panels),
   - prefabricated busbar trunking systems,
   - movable components (ventilation grids, plates, internal arc barriers, etc.).

   Depending on the procedures defined by the panelbuilder and in agreement with the customer, some cover panel components such as roofs and ventilation grids cannot be mounted in their final location but simply secured inside the columns. Make sure that the accessories or detachable components are correctly held in place and do not risk damaging the column during handling or transport.

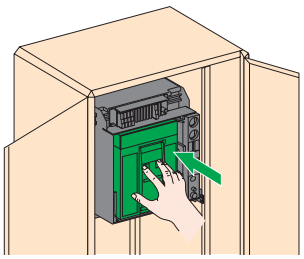
   Accessories such as fasteners, joints that ensure the IP degree of protection, replacement parts, device technical manuals or all other documents (drawings, specifications, etc.) may be delivered separately. A delivery note listing all the components in detail must be associated with each shipment.

2. Check that withdrawable devices are inserted and locked correctly.

   Check that all the components are fixed correctly. Close the door and lock it (if possible).

   Accessories for closing and moving the doors must remain accessible and must be secured safely and visibly.

Example



Packing

Packing (contd.)

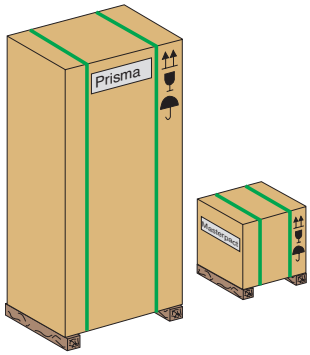
Standards

Good practice

3 It is advisable to pack heavy devices separately to avoid all risks of deforming the supports and thus ensure that the columns are much more stable during handling.

Clearly identify on each device, the column in which it must be installed.

Example



NFH0321

4 Pack the column or columns depending on the type of cover chosen:

Polyethylene cover (SEI3b packing):

- protect the column or columns with a polyethylene cover or film,
- if necessary, place protections at the corners of the side, bottom and top parts,
- protect protruding devices or accessories (indicators, door knobs, etc.),
- position the wooden case,
- mark the case.

Heat-welded cover (SEI4c packing):

- protect the column or columns with a heat-welded cover,
- protect protruding devices or accessories (indicators, door knobs, etc.),
- place as many bagged desiccants as necessary. They must comply with the standard NFH0321. When the bags can be regenerated, the regeneration conditions are marked on them. The bags must have a status indicator,
- take out the air from the cover using a vacuum cleaner and close the cover completely by heat-welding using the appropriate clip,
- position the wooden case,
- mark the case.

Note: *in the case of very long storage periods, you must schedule regular inspections to check and replace the desiccant bags.*

Tip

Additional protections may be installed on door-mounted switchgear (indicators, measuring devices).

Marking

Marking the cases

Standards Good practice

1. The cases must have the essential marking information (total weight, dimensions, shipping address, etc.).

2. Handling, transport and storage conditions must be painted on each case in compliance with international practice.

The main symbols used are as follows:

Symbol	Description	Meaning
	Fragile	The contents of the case are fragile. Handle with care.
	Use no hooks	It is prohibited to use hooks for lifting the case.
	Top	Indicates the "Top" direction of the case.
	Sling here	Indicates the position where the slings must be placed to raise the case.
	Keep dry	The case must be kept in a dry environment.
	Centre of gravity	Indicates the position of the centre of gravity of the case and its contents.
	No forklift here	Indicates that the use of forklifts is prohibited.

Shipping

Shipping

Standards

Good practice

1. The quality inspector must check the compliance of the packing before authorising its transport.

2. Send the shipping file by post to the customer.
It must include:
- a copy of the delivery slip,
- a set of drawings updated at the end of inspection,
- the list of separate accessories and equipments (fasteners, wiring, etc.),
- installation guides,
- switchgear technical manuals,
- assembly manuals:
  • for the switchgear,
  • for the enclosure,
- the list of any missing items.

Note: *inspection and test reports will be provided upon request.*

Example

Tip

Specific documents may be requested depending on the country of destination. See customer requirements and local practices.

3. Before shipping, make sure that the customer is ready to receive the equipment and define together the delivery and acceptance procedures (place, equipment used on site, delivery date, name, telephone number, email address, etc. of the person in charge to contact).

4. Check with the client that the persons (qualification, access authorisation, etc.) and the packed equipment can access the site (height and width of doors, height of ceiling, etc.).

5. Check with the customer that the weight of the assembly does not exceed the permissible weight of handling accessories (lifting rings) and transportation appliances used.

> *See chapter 10 – "Handling and transport".*

Quality control check list

Note: the list of control points presented is not exhaustive.

It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

Minimum checks required	Control points	Control resources	Self-control
☑	> Type of packaging	> Installation guide, customer specifications	☐
☑	> Contents of the package	> Packing list	☐
☑	> Cleaning inside the enclosure		☐
☑	> Accessories delivered separately	> Packing list	☐
☑	> Plug-in devices		☐
☑	> Indications and symbols linked to transportation (Fragile, Top/Bottom, etc.)	> Procedure/Standards	☐
☑	> Presence and conformity of shipping documents	> Project file	☐

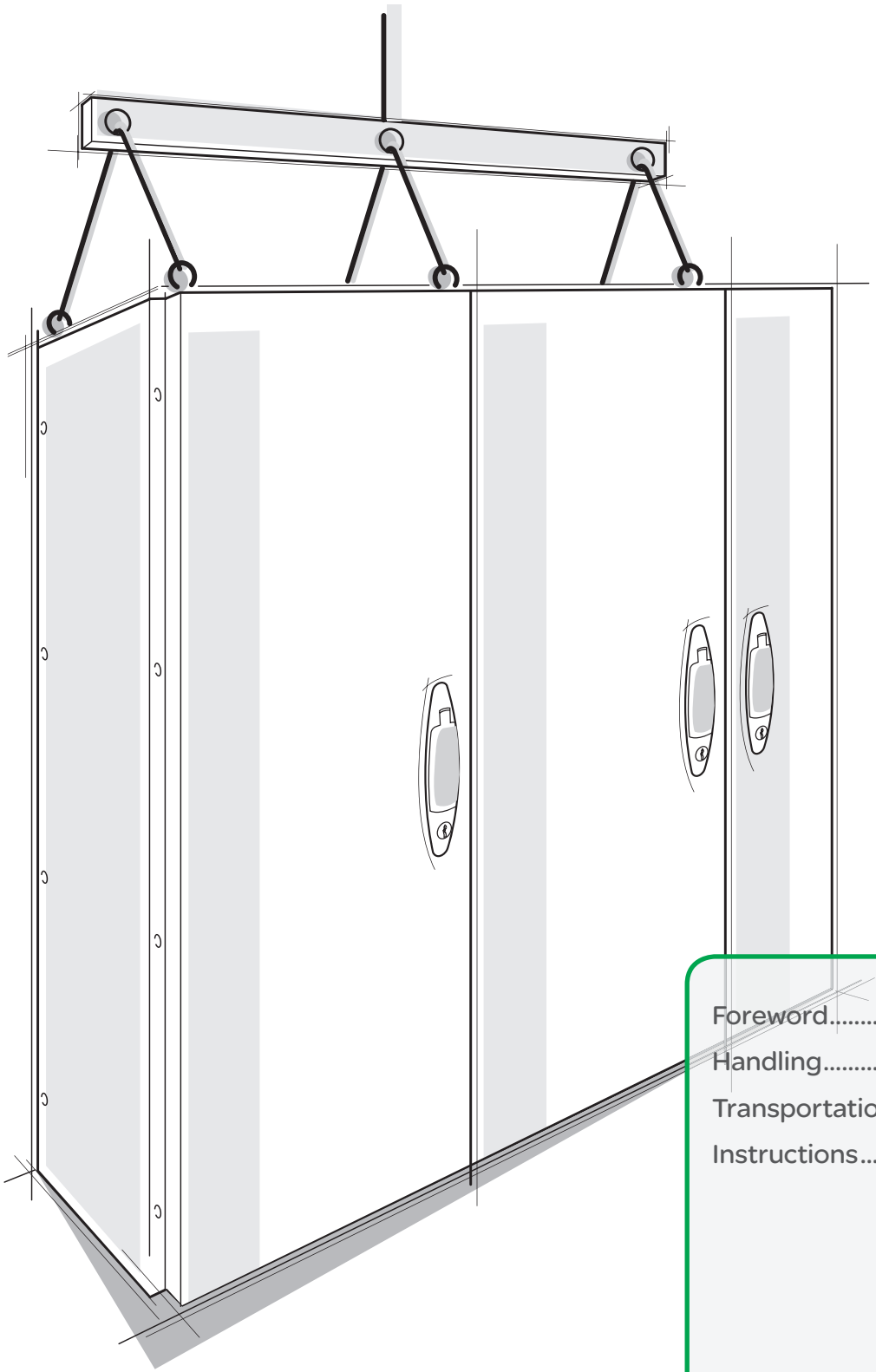
(*) the packaging must be adapted to the destination and its environment, the means of transportation used, etc.

Please photocopy the check list before completing it

Objectives

- Ensure effective protection suited to the equipment
- Ensure the effective identification of transport instructions (inform and warn)
- Ensure traceability
- Guarantee transportation and storage without damage to the equipment

Handling and transportation



Foreword

Standards Theory

1 Columns are designed to work in an upright position. Their architecture is designed to bear mechanical loads resulting from the weight of the switchgear and conductors for upright installation. Columns must therefore be handled and transported vertically to avoid abnormal mechanical stresses during transportation.

They must be moved with great care before or after they are unpacked. This is because the centre of gravity of most equipment is often situated in the upper part and this increases the risk of tipping over backwards or forward of the assembly during handling. There is also a risk of tipping over to the side for assemblies that are not very wide. Take all the necessary measures to limit these risks.

Avoid moving the columns in jerky movements.

Never park close to the charge when loading or unloading.

Handling with a forklift or pallet truck

Standards

Good practice

Tip

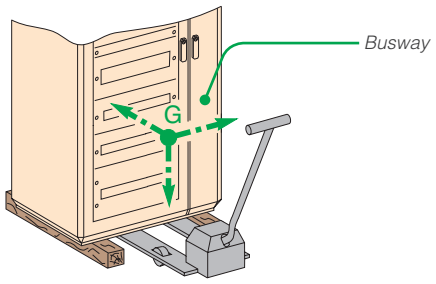
Each column can also be placed on a pallet to make it easy to move during or after the manufacturing process.

1. Installing rafters under each column ensures the following:
   - improved stability during mounting and wiring,
   - easy handling with a pallet truck or forklift,
   - prevention of damage to the protective paintwork of the enclosure,
   - prevention of damage to the surface coating of the workshop floor,
   - placing the packaging on the rafters for transportation.

2. The forks of the lifting equipment must be positioned on the equipment to be transported according to:
   - the position of its centre of gravity,
   - the most resistant structural or assembly components.

Example

For a column comprising a busway, the lifting points are shifted towards the position of the busbars.

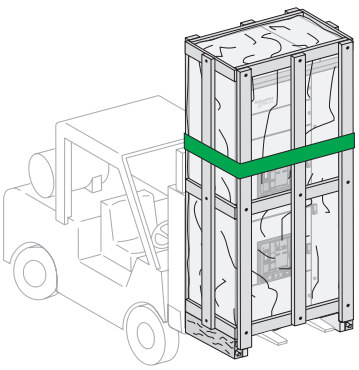


G: position of the centre of gravity

3. The columns must be lifted with care and strapped to the handling system.

   It is advisable to have two operators if there are obstacles or difficult areas involved in moving the column. The second operator visually checks that the column is in place and anticipates any risks on the way.

Example



Handling using a gantry crane or overhead travelling crane

Standards Good practice

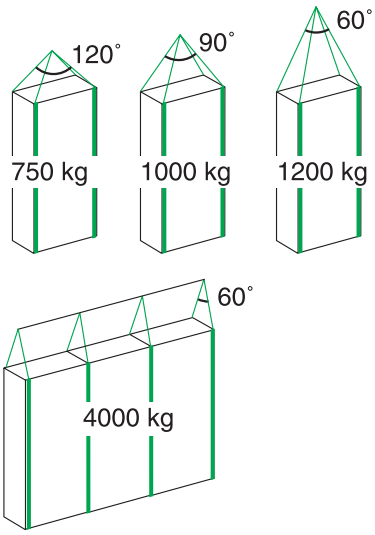
1 If a gantry crane or overhead travelling crane is used requiring lifting the column from the top, use slings that are resistant enough and in good condition.

They must be attached to the lifting rings specific to the cabinet and laid out as recommended by the manufacturer.

Adjust the length of the slings to fit the dimensions of the switchboard in such a way as to ensure that the angle formed is not greater than 60°.

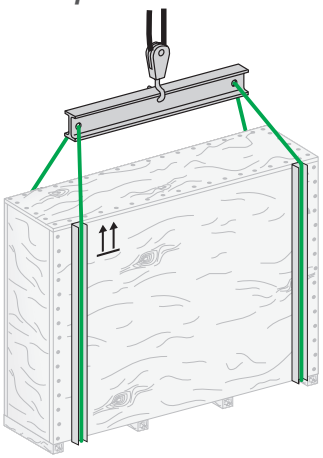
Example

The maximum load that can be withstood by the lifting rings is given in the assembly manuals.



2 As a rule, handling is carried out one column at a time. When adjacent cubicles cannot be separated, check the quality of mechanical connections between them and use a lifting beam.

Example



Transportation

Standards Good practice

1 The column must be transported up to the place of installation or storage only by an experienced and qualified carrier. Depending on the commercial agreement (MADU) and the regulations in force in the country of destination, the carrier may be held liable if any damage is observed upon delivery.

2 For export, apply the regulations in force in the country of destination, in particular with respect to the type of packaging authorised. Find out about customs formalities.

3 In addition to the forces due to oscillations and impacts, it is necessary to take into account: risk of falling, overturning, tipping over and collision. To avoid possible damage, we recommend that you do not exceed the values below:

Risk	Recommended values
Vertical bumps	- Type of transport: road/air/ river and sea - Permissible stress: amplitude between 200 and 300 m/s^2 (i.e. 20 to 30 g)
Free fall	- Road and air transport: maximum height of fall = 100 mm - River or sea transport: height of drop. = 300 mm
Vibrations (own frequency)	- Road transport: < 9 Hz max., 7.5 mm amplitude - Air and sea transport: < 200 Hz, max. 40 m/s^2 (i.e. 4 g)
Horizontal stress	- Road transport: < 2.7 m/s - Air and maritime transport: non applicable

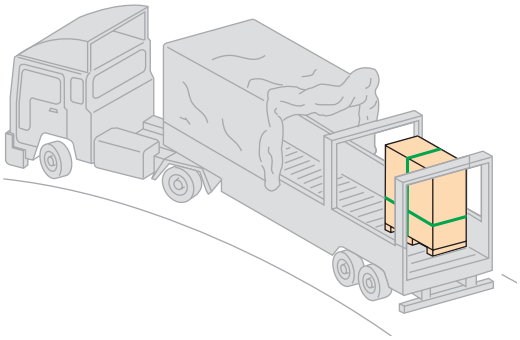
Transportation (contd.)

Standards Good practice

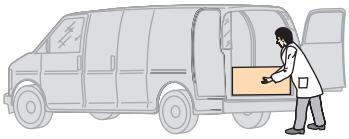
4 Chock the packaging to avoid shifting during transport. Use straps or steel cables. For steel cables, use intermediate wedges (for example, wood) to avoid damaging the cases through the rubbing or tightening of the cable.

When loading or unloading the cases, the transport vehicle must be on a stable ground, with the parking brake pulled up. Make sure that the floor is stable.

Example

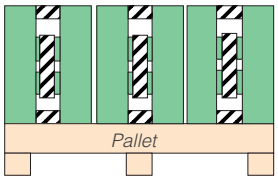


After loading, check that the case is properly chocked and fastened into the truck, to avoid all damage during transport.



Enclosures should preferably be laid flat for transport. Make sure to place the front panels of the enclosures (fragile side) towards the top. Do not stack the cases.

If it is not possible to transport the enclosures horizontally, you can place them upright on a pallet by protecting the front panels with the appropriate cushioning material and by covering the case with plastic film.

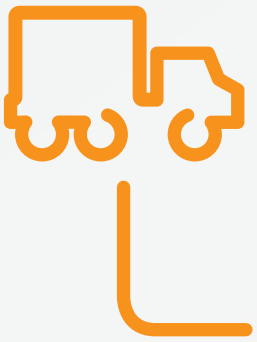


5 **Recommendations for carriers:**
Schneider Electric recommends that you check the following with the carrier:

- that the cases are properly chocked throughout transport,
- that the truck will not stop in areas where the climatic conditions do not comply with the climatic constraints for the storage of the cases.

Notes

Instructions



Apply the safety instructions and work rules that apply to the company and/or production unit.

On-site installation and commissioning

Introduction

This chapter will deal only with operations that the panelbuilder may have to perform on site for its customers.

Installation operations specific to customer connections, cable ways, etc. and relative to the installer will not be concerned.

As part of the service provided to the client, panelbuilders may have to perform on-site installation or commissioning operations of the switchboard that they have supplied (receiving and acceptance of equipment on site, installation of switchboards, joint blocks).

Precautions to take upstream of the order

> Draw up a quotation, making sure that:
  - the limits of the services have been clearly defined,
  - all the reference documents are known
  (access conditions to sites for industries, for example).
> Determine the logistics resources to put in place (unloading, handling).
> Determine whether inspections and tests must be conducted on site.
> Determine the necessary qualifications and authorisations.
> Take specific quality assurance requirements into account.

Reception and handling of equipment upon delivery on site

Reception of equipment

When the equipment arrives and before it is handled, make sure that the cases and packaging used for transportation are in good condition and that there are no packages missing. Should the packaging show any signs of impact or wrong handling, make sure, in the presence of an authorised agent of the transport company, that the contents of the package has apparently not been damaged.

Unloading

Unload small packages using handling equipment and accessories adapted to the package to be unloaded.

Unload the crates and/or packages with a bridge crane, crane or winch, using "Estrope" type slings in braided synthetic fibre provided by the carrier or the customer.

Floor handling

Use a specially adapted cart to handle the columns between the unloading point and the place of storage before unpacking and mounting.

Protection of switchboards and commissioning

Protection of switchboards before installation

When the equipment has to be stored before being mounted, it is advisable to take the necessary measures to avoid all risks of deteriorating the supply.

1 Standard packaging (cover and/or cardboard box)

- Make sure that the room has the atmospheric conditions to ensure that there are no sudden temperature variations and that the room is sufficiently ventilated to avoid condensation.
- Make sure that the room is not dusty.
- Make sure that the floor is flat and covered in such a way that it is not subject to latent humidity.
- Place the equipment vertically on pallets or shims to facilitate air circulation and grasping by handling equipment.
- Place and fasten the protective covers so as to:
  - drain the water (possible leaks),
  - retain dust deposits,
  - ensure the circulation of air.
- Do not change the protection status after (lifting, tearing).
- Use additional components to protect the sides that are exposed to impacts close to access ways in the storage area.
- Mark the stored material in such a way as find it easily with excessive handling or be obliged to reduce the initial packing conditions.
- Check regularly that the measures taken will make it possible to keep their initial quality status.

2 Maritime packaging (SEI4c) or semi-maritime packaging (SEI3c)

- Make sure that the room has the atmospheric conditions to ensure that there are no sudden temperature variations and that the room is sufficiently ventilated to avoid condensation.
- Make sure that the floor is flat and covered in such a way that it is not subject to latent humidity.
- Place the equipment in such a way as to facilitate air circulation and grasping by handling equipment.
- Use additional components to protect the sides that are exposed to impacts close to access ways in the storage area.
- Mark the stored material in such a way as find it easily with excessive handling or be obliged to reduce the initial packing conditions.
- Check regularly that the measures taken will make it possible to keep their initial quality status.

Protection of switchboards and commissioning

Protection of switchboards after installation and before they are turned on

If the premises are very dusty, keep the switchboards dust-free by covering them with a cover or plastic sheet.

Provide for additional protection on the sides exposed to traffic and impacts.

If the switchboards are to be stored for a long time, heat the inside of column with 100 to 200 W heaters installed in the cable compartment.

Commissioning

Preliminary checks

Principles

> Carry out all the inspection and testing operations according to an on-site verification programme.

> Draw up the report and have it signed.

Precaution and measures

Before powering on the switchboards:
Remove all the special protections (sheets, dust protection covers, etc.) that would have been used during the switchboard connection period.

Mechanical verifications

> Clean the switchboard, make sure that there are no foreign bodies that will have an adverse effect on the correct functioning of the assembly (falling cables, fasteners, metal waste, tools, etc.).

> Check all the mechanical links (floor mounting, etc.) and electrical connections (installation and connection of conductors, mechanical stresses on connection pads, etc.).

> Check the repositioning of all the covering components, cable gland plates, etc. (conformity of the IP) or blocking of cable routing shafts.

> Check clearances, in particular at the junction block of the busbars, client cable connection lugs and also when putting back partitioning barriers, covering panels, etc.

> Check the mechanical operation of the switchgear and controlgear, safety devices (interlocking, etc.).

Electrical verification and tests

> Check the continuity of the protective conductor (inter-cell link).

> Carry out an overall measurement of the switchboard insulation and (disconnect the earth plugs of the switchboard as well as all equipment that are sensitive to these tests).

> Check the order of the phases (power supply and feeder).

> Power on the switchboard and check the operating sequences of circuits.

Power up

> Reconnect the assembly to the earth.

> Make sure that all the devices are in open position.

> If required, carry out adjustments to the devices (thermal releases or other monitoring and control devices).

> Gradually power on the circuits.

Quality control check list

Control resources	Self-control
Before commissioning	
Packaging & Storage	
> Check that the cases and packaging have not been damaged during transportation.	☐
> Remove the packaging as close as possible to the place of installation.	☐
Storage precautions: *Store the switchboard in a dry, ventilated place, protected from: bad weather, extreme temperatures (hot/cold), steam, dust, chemical agents, etc.*	
Preparation of the place of installation	
> The place where the switchboard is installed must be clean and have a slope of < 2 mm/m.	☐
> Observe a minimum space behind the switchboard to allow natural ventilation.	☐
> Observe a minimum space in front of the switchboard to allow the doors to be opened fully.	☐
If the connection is from the rear: > Observe a minimum space in front of the switchboard to allow the doors to be opened fully.	☐
If the connection is from the top: > Observe a minimum space on top of the switchboard to allow the connection of fishplates (horizontal busbars).	☐
If the connection is from the bottom: > Provide for sufficient space for connecting the cables, with a minimum radius of curvature (6 to 8 times the external diameter of the cables).	☐
Identification	
> Check the switchboard identification.	☐
> Check the cable identification.	☐
Fastening & assembly	
> Comply with the floor mounting points.	☐
> Use coupling kits between columns.	☐
> Comply with the degree of protection (IP).	☐
Electrical connections & power cables	
> Check the quality of the fishplate connection (horizontal busbar).	☐
> Check the quality of the connection between protective conductors.	☐
> Check routing of auxiliary cables between the columns.	☐
> Check the earth TI.	☐
> Observe the clearances (14 mm/min).	☐
> Clamp the cables as close as possible to the connections.	☐
> Check the wiring per circuit and clamp the cables onto cable tie-bars.	☐
> Insert the cable gland plates (cable glands).	☐
> Check that the cables are not in contact with the busbar.	☐
> Check that the cables are protected from sharp edges.	☐
> Observe a minimum radius of curvature 6 to 8 times the outer diameter of the cable.	☐
> Check the crimping and connection quality.	☐
> Use class 8.8 fasteners (torque recommended).	☐
> Using marking varnish to validate the electric tightening.	☐
> Observe the forms. *Note: if aluminium cables are used = use bimetal lugs or interfaces.*	☐
Other verifications	
> Mechanical locking of the switchgear and controlgear.	☐
> Visual inspection of outer surfaces and paintings. Make any retouches as needed.	☐
> Greasing of clamps.	☐
> Recording of verifications made (name, date, remarks, etc.).	☐

Please photocopy the check list before completing it

Quality control check list

Note: the list of control points presented is not exhaustive.

It lists the minimum checks required and may be completed depending on the organisation in the workshop and/or recurrences of defects encountered.

Control resources	Self-control
Commissioning (first powering on)	
The switchboard must imperatively be commissioned by a qualified technician	
> Check that the earthing accessories have been dismounted.	
> Measure insulation (minimum 500 V CA and 1000 Ohm/V). *Note: if a dielectric measurement is required, apply a derating coefficient.*	☐
> Check that the phase rotation is correct.	☐
> Power on the power circuits one after the other.	☐
> Do all the protection settings (electronic control units, etc.).	☐
> Make sure that the loads are supplied with power and are working correctly.	☐
> Make sure that the devices (control, measurement, protection, remote reporting, etc.) are working.	☐
> Check that the interlocking mechanisms are working.	☐
> Carry out communication settings and tests (for iMCC switchboards).	☐

Please photocopy the check list before completing it

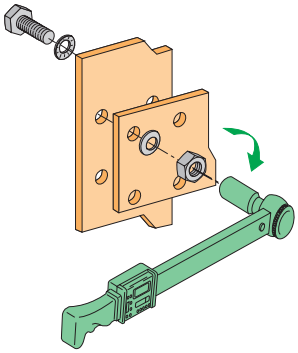
Appendices
Removable sheets

Contents

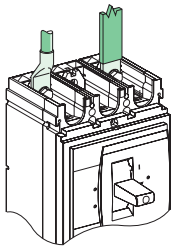
Sheet "Tightening torques"

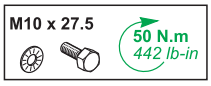
1

Use a torque wrench duly calibrated by a certified body to be sure that you are applying the tightening torque that guarantees the right contact pressure (2 to 3 daN/mm²).



Tighten the nut for a bolt and the screw for a threaded hole.





You must comply with the tightening torques given by the manufacturers in the technical manual.

The tightening torque depends on the diameter and quality of the fasteners.
If there are no recommendations, use the table below. It shows the tightening torques that apply to ISO steel thread screws and non-lubricated stainless screws with the following characteristics:

Class 8.8	Re = 64 daN/mm²	Rr = 80 daN/mm²	Complies with standard E 25 030

Nominal Ø	Thread	Cross-section resist. average πr²	Max. drilling Ø	Axial force in screw	Tightening torque at 80% of elastic limit (m.daN) for stainless steel screws compliant with T.04121-9 lubricated or steel - Class 8.8 non lubricated					
(mm)	(mm)	(mm²)	(mm)	(daN)	Nut with washer		Notched base nut		Nylstop nut with washer	
					Grower + Flat	Contact	Steel	Copper or al.	Flat	Contact
3	0.5	5.03	3.4	150	0.1	0.15	0.15	0.17	0.12	0.17
4	0.7	8.78	4.5	250	0.25	0.35	0.35	0.41	0.28	0.38
5	0.8	14.2	5.5	380	0.5	0.7	0.8	0.93	0.55	0.75
6	1	20.1	6.6	600	0.85	1.3	1.35	1.55	1	1.45
8	1.25	36.6	9	1000	1.9	2.8	2.5	2.9	2.2	3.1
10	1.5	58	11	1500	3.75	5	5	5.9	4.15	5.4
12	1.75	84.3	14	2400	6.2	7.5	7.9	9.2	7	8.3
14	2	115	16	3300	9.8	12	12.5	14.6	11	13.2
16	2	157	18	4500	15.5	18.5	18	21	17	20
18	2.5	192	20	5500	21	26	27	31	23	28
20	2.5	245	22	7100	29	37	39	45	33	41

Reminder: *1 m daN = 1 m kgf*

Do not torque self-forming screws.

Mechanical assembly alone

Notched base nuts and Nylstop nuts must be used for electrical assemblies.

2

After tightening the torque, apply a tinted acrylic varnish that is indelible and heat resistant.

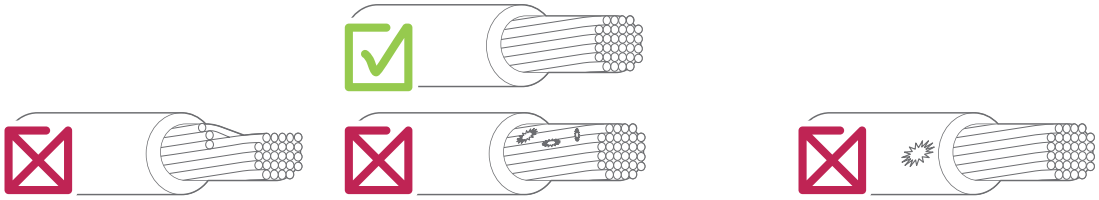
Do not adjust the tightening after applying varnish to the screw.

If the assembly has to dismounted, replace the screws with new screws.

Please photocopy the check list before completing it

Sheet "Crimping"

1 Always check the stripping quality **before crimping**.



Conductor strands cut

Insulator particles on the bare part of the conductor

Insulating sleeve damaged

2 Choose a crimping tool that is adapted to the terminal type and the conductor cross-section.

It is crucial for the tool to be adjusted, serviced and regularly inspected to obtain good quality crimping.

3 Scrupulously apply the operating modes and safety instructions given in the crimping tool user guides.

Use of a manual crimping tool:
each operator must use only the tool assigned to him.
If the tool is dropped, it is essential to have it checked by the competent service.

1/3

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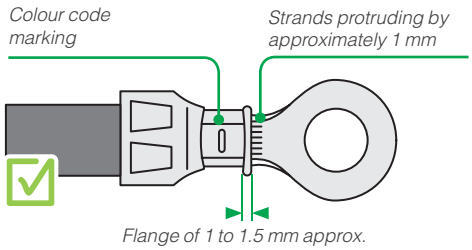
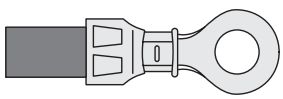
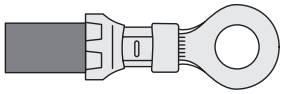
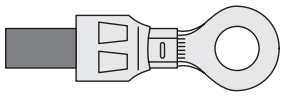
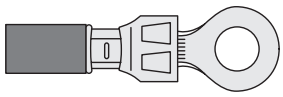
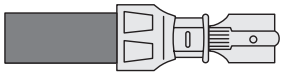
Sheet "Crimping"

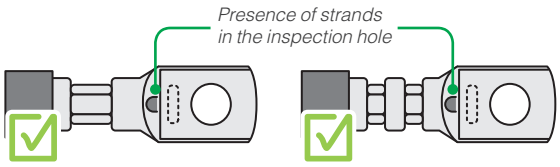
4 Carry out a visual inspection of crimping.

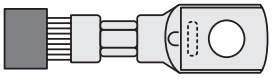
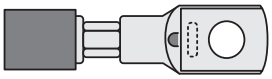
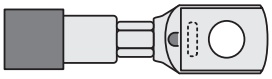
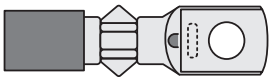
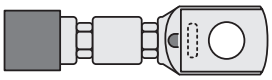
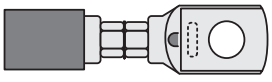
Pre-insulated terminals



Defect	Cause
	☒ Conductor not sufficiently stripped. The strands cannot be seen from the terminal side.
	☒ Crimping too much in the rear: terminal inserted too far into the tool.
	☒ Crimping too much in the front: terminal not inserted far enough into the tool.
	☒ Inverted crimping mark: terminal inserted the other way round into the tool.
	☒ Conductor over-stripped. The strands have spilled over to the terminal contact zone.

Tubular lugs



Defect	Cause
	☒ Conductor not sufficiently inserted into the terminal: the cable does not appear in the inspection hole.
	☒ Crimping too much in the rear: terminal inserted too far into the tool.
	☒ Crimping too much in the front: terminal not inserted far enough into the tool.
	☒ Die worn-out our unsuited: terminal pinched, appearance of lugs.
	☒ Crimping marks not centred on the barrel.
	☒ Crimping marks not centred on the barrel.

2/3

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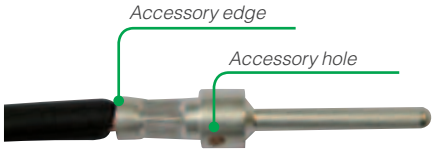
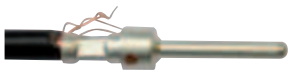
Sheet "Crimping"

4 Carry out a visual inspection of crimping (contd.).

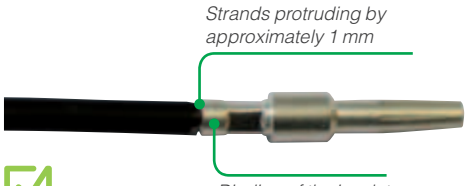
Male contacts



☑ *Crimping mark centred between the edge and the accessory hole*

Defect	Cause
	☒ *There are strands of the conductor core outside the barrel.*
	☒ *End fitting not well positioned, crimping not properly centred.*
	☒ *Conductor over-stripped.*

Female contacts



☑

Defect	Cause
	☒ *Stripping too long.*
	☒ *End piece not correctly positioned in the crimping tool.*
	☒ *There are strands of the conductor core outside the barrel.*

3/3

Please photocopy the check list before completing it

Model form "Routine verification - testing report"

Manufacturer of the assembly / *fabricant d'ensembles* : .....

Adress / *Adresse* : .....

Original Manufacturer / *fabricant d'origine* : .....

Routine verification - testing report / *Procès verbal de contrôle final*

Customer / *Client* : .....

Report No : .....

Project / *Affaire* : .....

Customer ref. / *Réf. client* : .....

.....

.....

Switchboard identification / *Nom du tableau* : .....

Project ref. / *Réf. projet* : .....

.....

.....

Equipment / *Équipement* : .....

Rev. Index : .....

Quantity / *Quantité* : .....

Drawing No / *Plan n°* : .....

Checking program / *Programme de vérification*

Routine verification tests are carried out in compliance with the Std. IEC 61439-2
La vérification individuelle de série est faite en conformité avec la Norme CEI EN 61439-2

1. Construction	Done / *Fait*
a. degree of protection of enclosures / *degré de protection*	V
b. clearances and creepage distances / *distances d'isolement et les lignes de fuite*	V
c. protection against electric shock and integrity of protective circuits / *protection contre les chocs électriques et intégrité des circuits de protection*	V & T
if electrical control indicate meter reference Ohm Value / *si control électrique indiquer la réf. de l'appareil de mesure*	.....
d. incorporation of built-in components / *intégration de composants incorporés*	V
e. internal electrical circuits and connections / *circuits électriques internes et connexions*	V & T
f. terminals for external conductors / *bornes pour conducteurs externes*	V
g. mechanical operation / *fonctionnement mécanique*	T

V : visual / *visuel*
T : test

2. Performance / *Performance*

a. dielectric properties / *propriétés diélectriques* — T

Meter Réf. .....

Circuits / *Circuits*		Main circuits / *Circuits principaux*	Auxiliaries / *Auxiliaires*
Rated insulation voltage Ui / *Tension isolement*	V		
Dielectric test voltage / *Test tension diélectrique*	V		

Option: up to 250 A, dielectric test can be replaced by insulating tests under 500 V:
Variante : jusqu'à 250 A, mesure de l'isolement sous 500 V possible .....

Circuit / *Circuit*		Main circuits / *Circuits principaux*	Auxiliaries / *Auxiliaires*
Applied voltage / *Tension nominale*			
Insulation value / *Valeur d'isolement*			

b. wiring, operational performance and function / *câblage, performance et fonctionnement opérationnel* — T

Comments / *Observation* :

Having passed the above tests, the LV switchgear assembly under consideration is in compliance with the Std. IEC 61439-2 (CEI EN 61439-2).
Ayant passé les tests ci-dessus, l'ensembles d'appareillage BT fabriqué est conforme aux exigences de la Norme CEI EN 61439-2.

.....

.....

Customer representative / *Représentant client*	**Quality inspector / *Inspecteur qualité***	**Quality manager / *Responsable qualité***
.....	.....	.....
Date	**Date**	**Visa** .....
Visa	**Visa**	.....

Please photocopy the check list before completing it

Model form "Non-quality record board"

Please photocopy the check list before completing it

Non-quality record board / *Enregistrement des défauts qualité*

Quality inspector / *Inspecteur qualité* : ....

Manufacturing / *Fabrication* : ....

Product / *Produit* : ....

Quantity / *Quantité* : ....

....

Number of faulty column / *Nombre de colonnes défectueuses* : ....

Number of drawer / *Nombre de tiroirs* : ....

Project name / *Nom du projet* : ....

....

Job number / *Numéro d'affaire* : ....

....

Customer / *Client* : ....

....

Date : ....

Location and type of fault / *Localisation et type de défaut* **A:** minor fault / *défaut mineur* **B:** major fault / *défaut majeur* **C:** critical fault / *défaut critique*	A	B	C	A	B	C	**Repair action / *Action de remise en conformité*** Repaired / *Réparé*		Checked by / *Vérifié par*
	Design, tendering / *Bureau d'étude et chiffrage*			Manufacturing / *Fabrication*			By / *Par*	Duration / *Temps*	Q.I. / *Inspecteur qualité*
Sum of faults / *Total des défauts*							Page:		

Model form "Corrective action request"

Corrective action request / *Demande d'action corrective*

Action request of / *Action corrective concernant* : .....

Date : .....

From / *De* : ..... **To / *A* :** .....

Copy to / *Copie à* : .....

Non-conformity / *Non-conformité :*

detected by customer / *détectée chez le client* ☐ detected internally / *détectée avant livraison* ☐

Concerned product / *Produit concerné* : ..... **Project name & No / *Nom et numéro du projet* :**

....

Issued by / *Editée par* : ..... **Date :** ..... **Customer / *Client* :** .....

Description of the non-conformity / *Description de la non conformité* :

.....

.....

.....

.....

.....

.....

Suggestions :

.....

.....

.....

Answer / *Réponse*

Corrective actions / *Action correctives*	Performed by / *Réalisée par*	Date

Corrective action settled / *Action corrective achevée* : ☐ **Date :** ..... **Quality as surance / *Assurance qualité***
Signing / *Signature* :

Please photocopy the check list before completing it

Model form
"Missing parts list"

Missing parts list / *Liste des composants non expédiés avec l'affaire*

Project number / *N° d'affaire* : .....

Item / *Poste*	Description / *Désignation*	Quantity / *Quantité*

Quality control / *Contrôle qualité* :

.....

Quality inspector / *Inspecteur qualité* :

.....

Date : .....

Please photocopy the check list before completing it

Beyond Basics...

Contents

Presentation of IEC 61439 Standard

Foreword

IEC 61439-x is the International Electrotechnical Commission standard which covers low voltage switchgear and controlgear assemblies. This standard series gives details on the requirements of these products through testing and other verification methods. It is a replacement for IEC 60439-x.

The new series of IEC 61439-x Standard

Towards end of 2012, all IEC 60439-x, well-proven references for certification in high-safety applications, will move into new IEC 61439-x:

> The general intention is to cover better all the assemblies.

> The **Assembly system** concept and tight verification criteria have now replaced the terms "type tested assembly" and "partially type tested assembly", which were often unfairly used.

> Safety and performance in electrical assemblies are improved by clarifying or increasing many requirements.

> It presents the same structure as the IEC 60947 series (Low Voltage Switchgears and Controlgears).

Standard structure

IEC 61439-x – LV Switchgear and Controlgear Assemblies

General Rules

> IEC 61439-1
(Ed 2 – 2011-08)

Power Switchgear and Controlgear Assemblies	Distribution Boards intended to be used by des ordinary people (DBO)	Specific requirements for construction sites assemblies	Assemblies for public distribution networks	Busbar trunking systems	Assembly for specific public installations Such as: marinas, campgrounds, markets and similar locations, charging station for electric vehicles.
> IEC 61439-2 (Ed 2 – 2011-08)	**> IEC 61439-3** (Ed 1 – 2012-02)	**> IEC 61439-4** (Ed 1 – 2012)	**> IEC 61439-5** (Ed 1 – 2010-11)	**> IEC 61439-6** (Ed 1 – 2012-05)	**> IEC 61439-7** (Ed 1 – 2012)

Main gaps regarding the former IEC 60439-x series:

> **IEC 61439-2** is to be read in conjunction with IEC 61439-1 Ed2, instead of IEC 60439-1 alone, and (coming) IEC 61439-6 (Ed1) is to be read in conjunction with IEC 61439-1 Ed2, instead of IEC 60439-2 with IEC 60439-1.

> **IEC 61439-2 to -7** quote the applicable clauses of Part 1 and specific requirements, where the requirements of IEC 60439-1 applied to Part 2 to 5 except if not otherwise indicated.

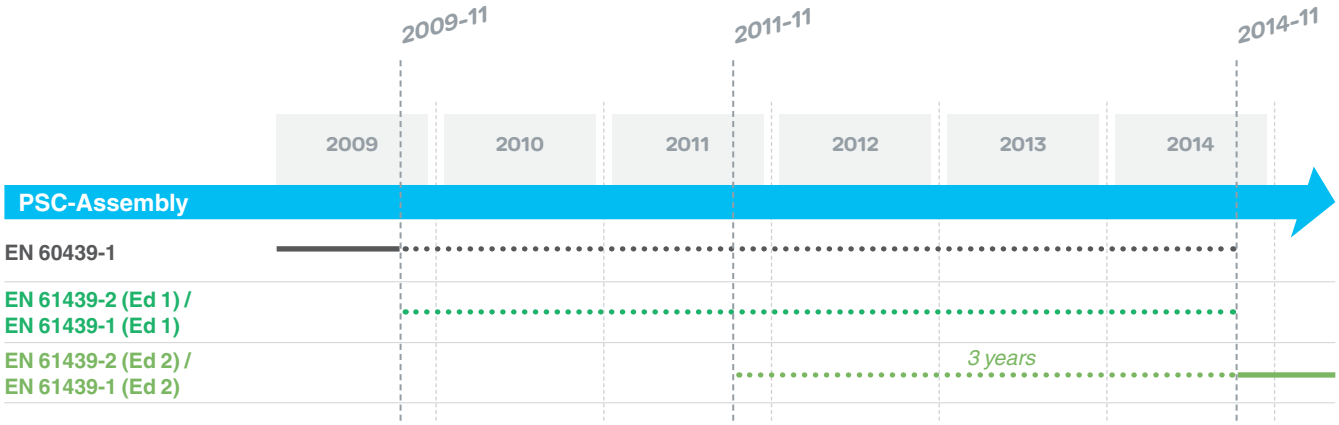
> **Ed 2 (2011-08) of IEC 61439-1 and -2** have already replaced Ed 1 (2009-01) of IEC 61439-1 and -2 (both withdrawed).

> Transitional periods may apply when implemented as regional, e.g. European, or national standards (e.g. NF EN 61439, BS EN 61439…).

> Tests identical to those in the IEC 60439 series need not be repeated.

Foreword

European EN 60439 to EN 61439: time schedule



Note: National Committees will need additional delays to translate EN to National Standards.

Scope

IEC 61439-1

Common to all LV Switchgear and Controlgear Assemblies ("Assemblies")

- **"Combination of one or more LV switching devices,** with associated control, measuring, signalling, protective and regulating equipment, with all the internal electrical and mechanical interconnections and structural parts" (according to 3.1.1 of IEC 61439-1).
- **To distribute and/or control energy** ("in connection with the generation, transmission, distribution and conversion of electric energy, and for the control of electric energy consuming equipment", according to the scope of IEC 61439-1).

IEC 61439-2

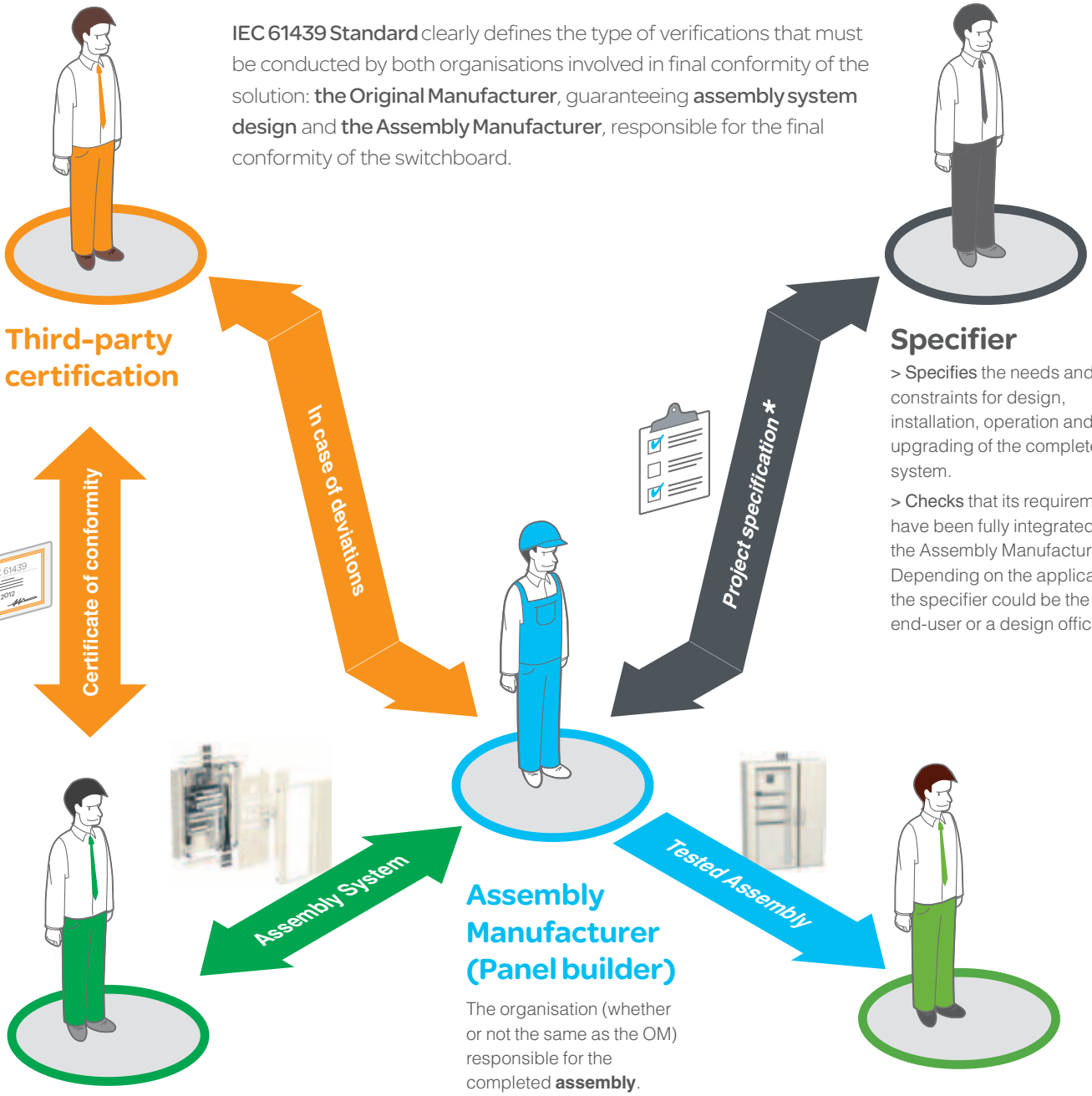
PSC-Assemblies i.e. Power Switchgear and Controlgear Assemblies

- Known as switchboards, distribution boards, panel boards, Motor Control Centres (MCCs), Power CC, Power Switchgear and Controlgear assembly (PSC-Assembly)…
- To distribute and/or control energy
- Any types of loads
- Industrial, commercial and similar applications
- Not to be operated by ordinary persons.

Responsibilities

Original Manufacturer and Assembly Manufacturer: both involved in tested assemblies

IEC 61439 Standard clearly defines the type of verifications that must be conducted by both organisations involved in final conformity of the solution: **the Original Manufacturer**, guaranteeing **assembly system design** and **the Assembly Manufacturer**, responsible for the final conformity of the switchboard.



Specifier

> **Specifies** the needs and constraints for design, installation, operation and upgrading of the complete system.

> **Checks** that its requirements have been fully integrated by the Assembly Manufacturer. Depending on the application, the specifier could be the end-user or a design office.

Assembly Manufacturer (Panel builder)

The organisation (whether or not the same as the OM) responsible for the completed **assembly**.

He is responsible for **"Routine verifications"** on each panel produced, according to the standard.

If he derivates from the instructions of the original manufacturer he has to carry out again design verifications.

Original Manufacturer

The organisation that has carried out the original design and the associated verification of an **assembly system**.

He is responsible for the **"Design verifications"** listed by IEC 61439-2 including many electrical tests.

End-User

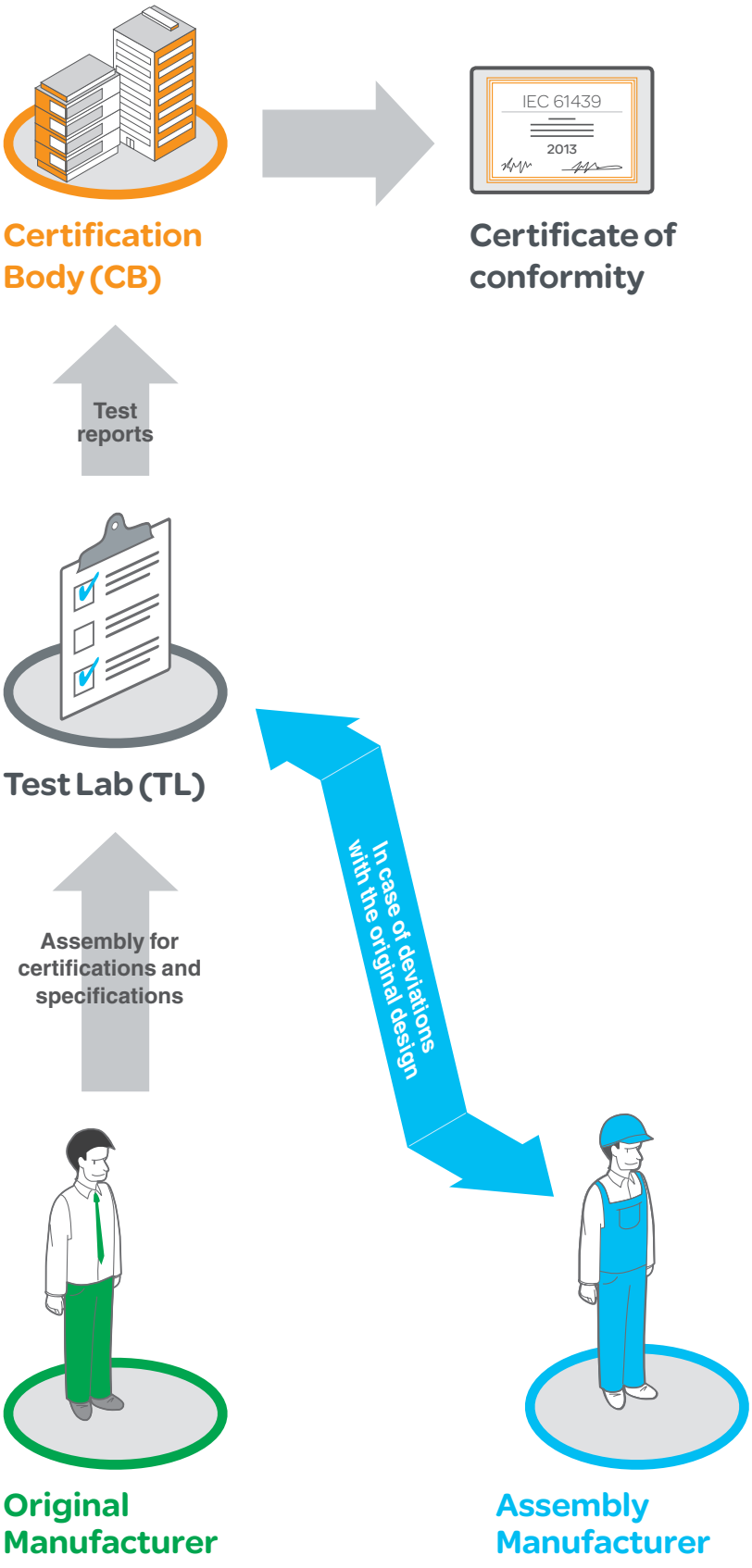
Should ask for a certified LV switchboard.

By systematically requesting routine verifications, he ensures that the assembly system used is compliant.

** Schneider Electric has developed a specification guide.*

Responsibilities

Process to obtain a certificate of conformity



Responsibilities

Assembly System

Full range of mechanical and electrical components as defined by the Original Manufacturer (enclosures, busbars, functional units, including switchgear and control gear, terminals, etc.), which must be assembled in accordance with the Original Manufacturer's instructions, either in its factory, or on the installation site, in order to produce various Assemblies.

Note: an Assembly may be designed, manufactured and verified on a one-off basis.

Original Manufacturer

Organization that has carried out the original design and the associated verification in accordance with the relevant Assembly standard.
He is responsible for the "Design verifications" listed by IEC 61439-2 including many electrical tests.

Assembly Manufacturer

- **Organization taking the responsibility** for the completed Assembly especially through the routine verification.
- For an Assembly verified by an Original Manufacturer and manufactured or assembled by a separate Assembly Manufacturer, design verification need not be repeated, provided all the Original Manufacturer's instructions are met in full.
- In respect of his own arrangements, including the selection of the appropriate components from the Assembly system, the Assembly Manufacturer is deemed to be the Original Manufacturer.
- In this last case, the Assembly manufacturer has to carry out design verification again.

Third-party certification

Among all possibilities to give proof of confidence (starting from selfdeclaration of conformity), **third-party certification** is the only-one to create and maintain a high level of trust, because done neither by the Original Manufacturer; nor by the end-user.

The independent third-party main role is therefore to ensure the decision to declare compliance of a Assembly, after testing, is taken independently from the Test Laboratory (TL), from the Original Manufacturer, or/and from the End-User. This process is governed by International guide ISO/IEC 65. It implies a full control over the results of the Test Laboratory by the Certification Body (CB), and this control can request the presence of a representative from the CB who witnesses tests.

It does exist various Certification systems:

- International Certification (e.g.: IECEE)
- Regional Certification (e.g.: ENEC, LOVAG)
- National Certification (e.g.: ASEFA, ASTA, BSI, CESI, KEMA/DEKRA, LCIE, VDE, etc.)

*Note: the Regional and the National have their own international impact, through mutual recognition agreements, and related **certificates of conformity** are widely accepted.*

10 User-Functions

For each of the following 10 functions, the standard IEC 61439 requires design verifications from the system manufacturer - mainly through type-tests - and routine verifications on each panel from the Panel Builder to achieve 3 basic goals: safety, continuity of service and compliance with end-user requirements.

Safety

> Voltage stress withstand capability

Needs & design requirements	Design verification	Routine verification
Insulation to withstand long-term voltages, transient and temporary overvoltages guaranteed through clearances, creepage distances and solid insulation.	> Measurement of clearances and creepage distances (10.4) > Power frequency dielectric **test** (10.9.2) > Impulse withstand voltage **test**, when clearances are greater than specified values (10.9.3)	> Visual inspection of clearances (subject to design conditions and creepage distances) (11.3) > Power frequency dielectric test (11.3)

> Current-carrying capability

Needs & design requirements	Design verification	Routine verification
Protect against burns by limiting excessive temperatures: > when any single circuit is continuously loaded to its rated current and > when any circuit is continuously loaded to its rated current multiplied by its rated diversity factor	> Temperature rise tests (10.10.2) > Or comparison with a **tested reference** design, under restrictive conditions (10.10.3) > Or, under very restrictive conditions, calculations with safety margins (including 20 % derating of devices) (10.10.4)	> Visual inspection (11.6) > Random verification of tightness (11.6)

> Short-circuit withstand capability

Needs & design requirements	Design verification	Routine verification
Withstand short-circuit thanks to short-circuit protection devices, short-circuit coordination, and capability to withstand the stresses resulting from short-circuit currents in all conductors.	> Short-circuit **tests** (Icc and Icw) of the main circuit, including the neutral conductor, and of the protection circuit (10.11.5) > Or comparison with a **tested reference** design under restrictive conditions (10.10.3 and table13)	> Visual inspection (11.6)

> Protection against electric shock

Needs & design requirements	Design verification	Routine verification
Hazardous live parts are not accessible (basic insulation protection) and accessible conductive parts are not hazardous for life (fault protection, and continuity of protective equipotential bonding).	> IPXXB **test** (10.3) and verification of insulating materials (10.2.3) > Mechanical operation **tests** (10.13) > Verification of dielectric properties (10.9) > Measurement of the resistance between each exposed conductive part and the PE terminal (10.5.2) > Short-circuit strength of the protection circuit (10.5.3)	> Visual inspection of basic and fault protection (11.4) > Random verification of tightness of the protective circuit connections (11.4)

> Protection against fire or explosion hazard

Needs & design requirements	Design verification	Routine verification
Protect persons against the fire hazard: resistance to internal glowing faulty elements, through selection of materials and various design provisions.	> Glow wire test (10.2.3.3) > Special test according to IEC TR 61641, where specified	None

Continuity of service

> Maintenance and modification capability

Needs & design requirements	Design verification	Routine verification
Capability to preserve continuity of supply without impairing safety during Assembly maintenance or modification. Through basic and fault protection and optional removable parts.	> IP tests (10.3) > Mechanical operation tests (especially for removable parts) (10.13)	> Effectiveness of mechanical actuating elements (11.8) > Check protection of persons against electric shocks (11.4)

> Compatibilité Electromagnétique

Needs & design requirements	Design verification	Routine verification
Properly function and avoid generation of EMC disturbances through incorporation of electronic devices complying with the relevant EMC standard, and their correct installation.	> EMC tests according to product standards or generic EMC standards	None

Compliance with end-user requirements

> Capability to operate the electrical installation

Needs & design requirements	Design verification	Routine verification
Properly function, according to: > The The electrical diagram and the specifications (voltages, co-ordination, etc.) by selecting, installing and wiring the appropriate switching devices. > The specified operating facilities (Access to Man-Machine Interfaces, etc.) through accessibility and identification.	> By inspection (10.6) > Impulse withstand voltage test of isolating distance for optional withdrawable units	> Visual inspection (11.5) > Effectiveness of mechanical actuating elements and function test (where relevant) (11.8) and (11.10)

> Capability to be installed on site

Needs & design requirements	Design verification	Routine verification
> Be capable to be erected and connected through selection or design of the enclosure and the external terminals, and by means of provisions and documentation. > Withstand handling, transport, storage and installation constraints.	> By inspection (10.8) > Lifting test, taken from IEC 62208 (10.2.5)	> Number, type and identification of terminals for external conductors (11.7)

> Protection of the Assembly against environmental conditions

Needs & design requirements	Design verification	Routine verification
Protect the Assembly against mechanical and atmospheric conditions through selection of materials and various design provisions.	> IP test (10.3) > IK test (10.2.6) > Corrosion test (10.2.2) > UV test (outdoor only) (10.2.4)	None

Questions/Answers

1 My customer asks me for a certification 60439. Is it possible?

Possible but not relevant as the new 61439 is already valid.

2 What is the difference between the standard IEC 61439 and the national standards (such as NF EN 61439, BS EN 61439 etc.)?

As a general rule, the national standards correspond to a translation from the IEC standard in the country. However, certain specific national requirements can be introduced (e.g.: BSEN form 4 type 7).

3 Do I have to be in accordance with the standard IEC 61439?

As a general rule, no. However, certain countries or the customer impose the compliance to the standard. In every case, the compliance to the standard is a proof of quality and a guarantee in case of conflict.

4 If I go for the calculation route, where are the formulae?

All the design rules and formulae are either included in the new Standard or included in documents that are referenced in the Standard.

***Attention:** Only formulae included in the new Standard are applicable.*

5 I have a software of calculation not validated with regard to the reference documents. May I use the results as a proof of compliance?

No

6 Do I have to use a specific engraving machine for the Marking of the switchboard?

The standard do not define which technique has to be used for the Marking of the switchboard but precise that this Marking has to stay readable until the end of life to the assembly.

Several methods of engraving or printing can be used to fix this issue.

Questions/Answers

7 Mixing between "X" switchgear manufacturer and "Y" assembly manufacturer.

What are the options and check list to be done?
When I am forced to choose a "X" company switchgear and mount it in a "Y" company assembly system, what are the issues I need to check?

Please refer to specific clauses in the IEC 61439 standard if it is possible.

The certificate obtained from the "Original Manufacturer" covers only the offer and the architecture for which it was delivered and verified.

8 As user of a tested system (e.g.: Prisma), what does 61439 change for me?

Nothing at the level of the product but just to be more precise in the routine verification reporting.

9 Form 4 Separation.

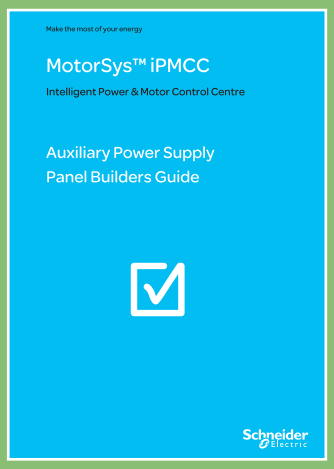
It seems that the new standard section for forms of separation indicates that it is possible to pass an MCCB cassette as internal separation, thus removing requirement of individual section partitions (i.e. Sectional doors and covers removed!).

Yes, the standard precises that the forms of separation can be achieved by means of partitions, barriers, shutters, insulation of live parts, or integral housing of a device as the role of these forms is mainly the insulation between functional units and between connections.

10 The IEC 61439-2 standard is valid for AC and DC applications. Under what conditions can we say that the AC tests are valid for DC application?

AC tests are not applicable to a DC application and vice-versa.

Extract of the "Auxiliary Power Supply" guide (introduction)



This chapter is an extract of the technical information that can be found in the Auxiliary Power Supply guide.

This document is intended for LV equipment engineers responsible for defining auxiliary power supplies inside the smart LV switchboard (iPMCC).

It will be available in 2013.

For more information, see your sales contact.

Introduction

A new Guide

The goal of this new guide is to define good practices for Auxiliary Power Supply in MotorSys™ iPMCC solutions. These good practices are presented in the context of auxiliary power supply architectures.

The Scope

The scope of the document is part of the definition of these auxiliary power supply architectures. i.e., only recommended and accepted architectures are described.

Consequently, a solution that is not described in this document is a not-recommended-nor-accepted one; i.e., it should be considered as forbidden.

Criteria for selecting Architectures

We've taken into account the architecture of the Main Power Supply architecture, as well as the Auxiliary voltage:

> AC or DC
> Internal or External source to the switchboard
> Level of Dependability required
> Upstream or Downstream to the Circuit-Breaker

All these criteria have been integrated in the Selection Tool accessible from the Flash Magazine version of this document.

Pre-requisites

This document is not a learning handbook. It is assumed that the reader is a skilled Low Voltage Panel Builder.

Although the vocation of this guide is not to remind the state of the art, a short reminder on Earthing Schemes is done, due to its outstanding importance.

A link with the Communications Architectures must be done, at least in terms of Dependability.

If the communications are on Ethernet, it is assumed that the reader knows the last published version of the "Ethernet Validated Architectures – System Integrators Guide" (rev.4.0). It is also assumed that the Okken and / or Blokset Cabling and Wiring Guide rev.3.1 is well known and strictly applied.

The Annexes

In order to facilitate understanding, we remind some international standards. We also described in detail 3 examples based on architectures that we recommend.

A last word

In an effort to be clear and understandable by skilled Panel Builders in all countries, we have tried to maximise diagrams and minimise text.

We also introduced a short Glossary in order to clarify the use of some terminology in this document and eliminate any possible ambiguity.

However, as it is the 1st release, we will be happy to receive as much feedback as possible.

General principles

> The choice of the power supply AC or DC is a very important point

1 Principle

If electrical equipment/apparatus is to operate correctly, it requires electrical energy to be supplied at a voltage that is within a specified range around the rated value. A significant part of the equipment in use today, especially electronic and computer devices, require good power quality.

Correct equipment operation requires the level of electromagnetic influence on equipment to be maintained below certain limits. Equipment is influenced by disturbances on the supply and by other equipment in the installation, as well as itself influencing the supply.

These problems are summarised in the EN 61000 series of EMC standards, in which limits of conducted disturbances are characterized.

2 AC power supply

AC power supply has to comply with EN 50160 standard.

The following disturbances are more and more common on all the AC power networks around the world:

- Voltage magnitude variations
- Rapid voltage changes
- Supply voltage dips
- Short interruptions of supply voltage
- Long interruption of supply voltage
- Temporary, power frequency overvoltages
- Transient overvoltages
- Supply voltage unbalance
- Harmonic voltage and current.

Electronic apparatus directly fed by a power network *(e.g. motor feeder)* could be disturbed by these disturbances.

The use of PS and/or power conditioners/regulators is recommended to minimize such disturbances.

3 DC power supply

The use of DC power supply allows a better power supply quality if a converter (AC/DC or DC/DC) with a galvanic isolation is used.

An AC/DC converter allows freeing of disturbances from the AC power supply network such as harmonics, voltage variations and dips, transient overvoltages, frequency variation, medium and high frequency disturbances, what doesn't allow a simple isolation transformer.

The past experience shows a real benefit using DC power supply by providing a higher immunity regarding upstream AC disturbances.

More details are provided along this document.

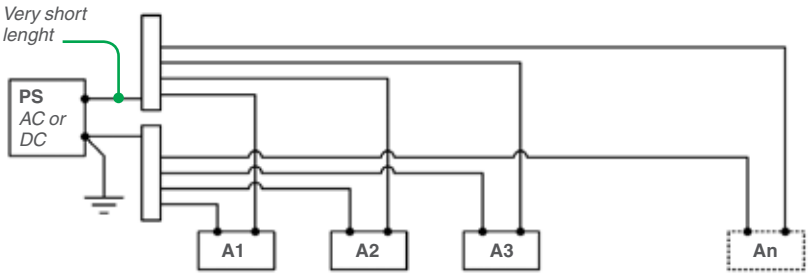
AC-DC Recommendations

AC-DC distribution

To minimise EMC* disturbances due to common impedance, the different power supply distribution systems have to be designed as follows.
This recommendation is valid for the protection relays, PLC's power supplies, PLC's IO boards, E/O converters, communication modules, etc.

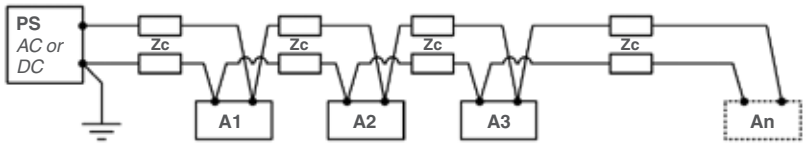
The first diagram shows how to design a power distribution (DC or AC).
In this configuration, the common impedance is minimised. Only the link between the main power supply (PS) and the terminal distribution (TD) is common impedance. If this length is very short, the common impedance is low. The cabling of each unit (A1 to An) shall be done with twisted pair cables to avoid loops and radiated emissions.
It is possible (as a compromise) to feed 3 or 4 apparatus by line if the current consumption is low (< to 500 mA) and the total length is < to 5 m.

Recommended



The following diagram shows the worst case. All the apparatus are connected in series. Zc represents the common impedance due to the cabling length. If one apparatus (A2 to An) generates some current transients, an undesired common mode voltage develops between the disturbing apparatus and the main power supply, which is critical for low level or fast electronic circuits.

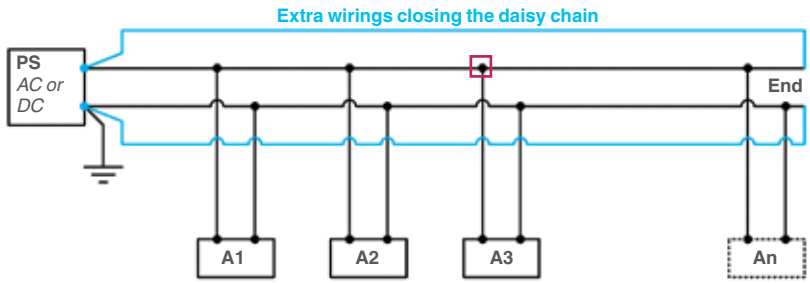
Not recommended



If one (e.g. the red square on the following drawing) or some connections along the daisy chain are not well tighten, all the downstream (3 to N in the following drawing) loads could be disturbed,

The loads at the end of the daisy chain could have lower power supply voltages due to the impedance of the long cablings.

Accepted



** Electromagnetic Current*

To fix such issue, the end of the daisy chain shall be supplied as shown in blue lines on the previous page drawing. In such condition, only the load (A3) shall be impacted and the global impedance of the whole daisy chain will be lower.

It is recommended to ground the 0 V from DC power supply a t only one point (just at the Power Supply output) only in the following conditions:

> The DC power supply distribution shall stay inside the cabinet/cubicle or the same adjacent group of cabinets without any cabling going far away in the process,

> All the components/apparatus fed by the power supply + or - shall be isolated from the earth (otherwise that will create unexpected ground loops and common mode impedance with unwanted stray currents circulating everywhere – *e.g. PLC inputs, non isolated sensors wiring, communication inputs* – and it is so difficult to manage and fix such kind of problems when the process is running).

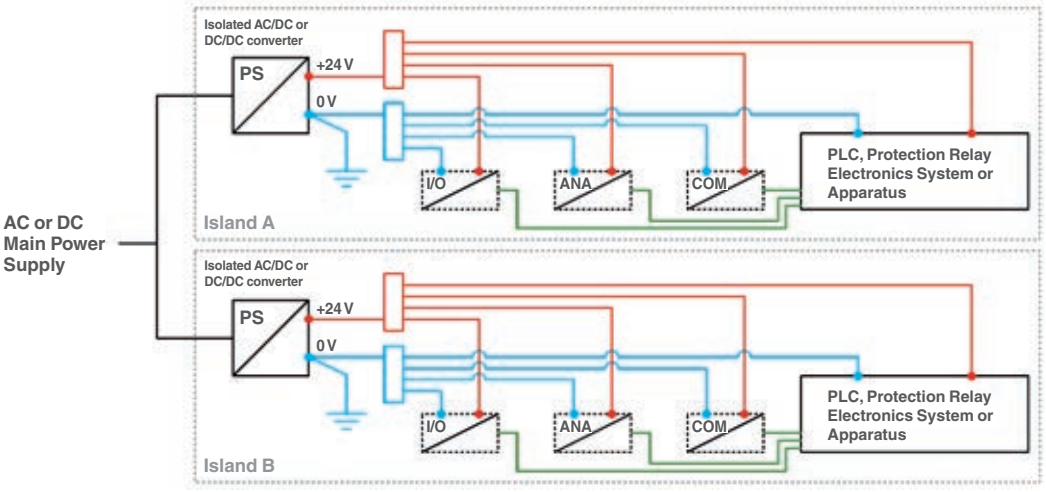
Functional Island philosophy

When non isolated Power Supplies (PS) and/or multiple inputs are used, one faulty Power Supply or input could run troubles on the other ones.
To minimize such issues, IT or TN-S earthing system shall be used inside the islands (small zones, rooms, cubicles) with galvanic isolation solutions *(e.g. AC/DC or DC/DC Converters, transformers, relays, opto-couplers, optical fibre, etc.)*.

> In this case, one faulty island doesn't disturb the whole network,

> It is easier to found the fault and provides a higher level of **availability.**

The I/O with high current capacity shall be protected against short-circuit and 24 V DC to ground fault.
0 V could be earthed at the AC/DC or DC/DC converter output, only if only one connection to earth is done (no downstream connection to earth is allowed).



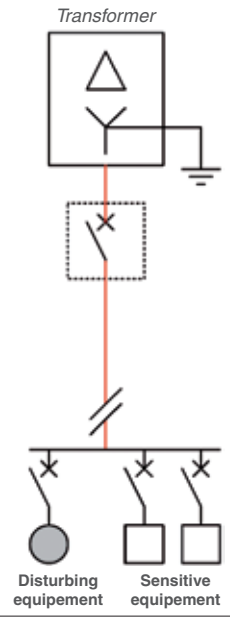
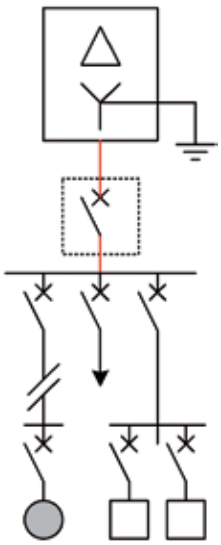
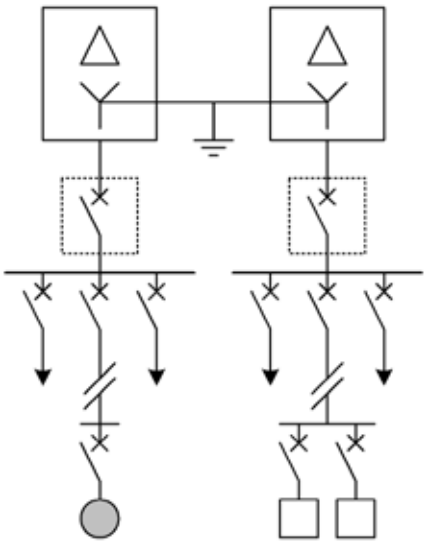
2 Non linear load consideration

The non linear loads *(e.g. fluorescent lamps, AC/DC power supply converters, etc.)* generate harmonic currents which create harmonic voltages on the supply network. This may overload the neutral conductor.

It may be necessary to:

> Oversize the HV/LV or LV/LV transformers in view of a low impedance source,

> Use star power distribution for the different applications by means of different feeders or transformers (lighting, motors, sensitive equipments, etc.),

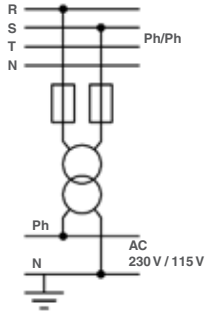
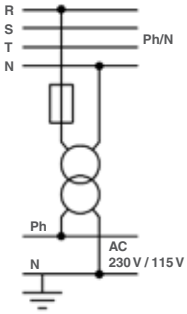
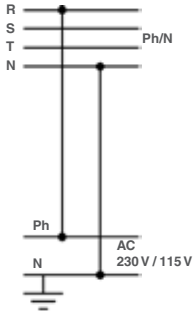
Very long cabling (high common impedance – red line)	Shortest cabling (low common impedance – red line)	Separeted and isolated circuits
		
Not recommended	Accepted	Excellent

> Use adequate cross section for the neutral conductor, at least identical to the one of the phase conductor, based on the equal sharing of the loads between phases and on the tripling of the third harmonic in the neutral conductor,

> Equalise the loads (sharing) between phases.

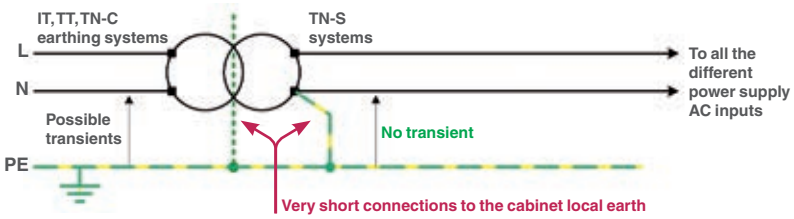
AC-DC Recommendations

3 AC distribution

Isolated Auxiliary power supply with TN-S earthing system. Phase to phase power supply to minimize neutral voltage fluctuation in TN-C or IT earthing system	Isolated Auxiliary power supply with TN-S earthing system	Auxiliary power supply connected directly between Phase to Neutral from the main power supply network
		
☑ Excellent	☑ Accepted	☒ Not recommended
Advantages		
- Upstream/Downstream galvanic separation - Voltage stepdown possibility if required - Adaptation de la tension possible - Earthing system modification possibility ("TN-S") - Disturbances are minimized	- Upstream/Downstream galvanic separation - Voltage stepdown possibility if required - Earthing sytem modification possibility ("TN-S")	
Disadvantages		
	- Neutral voltage fluctuations are possible, that could disturb the auxiliary power supply	- No Upstream/Downstream galvanic separation - No voltage stepdown possibility - All the main power supply disturbances are seen by the auxiliary power supply - Earthing system modification is not possible
Remarks		
TN-S earthing system required a very short connexion between Neutral and Earth. IT earthing system is not recommended at the transformer secondary side.	TN-S earthing system required a very short connexion between Neutral and Earth. IT earthing system is not recommended at the transformer secondary side.	This solution is not recommended.

4 Transformer use

It is recommended to have different separated transformers in each cabinet or group of cabinets to feed the PLC and associated apparatus.
The earthing system at the secondary of the transformer shall be in TN-S (neutral directly connected to the cabinet main earth bar.
In this case common mode between different circuits is avoided.
In case of downstream fault (secondary side of the transformers) on one circuit all the others are safe.



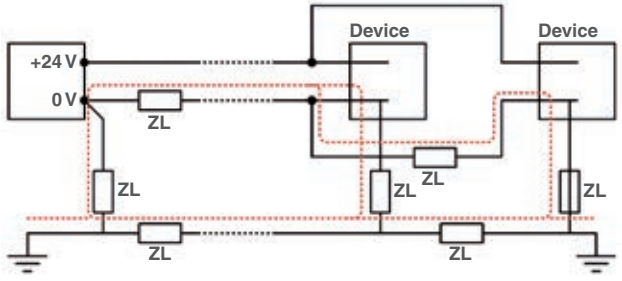
Transformer with an electrostatic shield could be used *(e.g. Schneider Electric reference: ABL6TS63U or other models adapted to the power needs).*

5 DC distribution

The 24 V DC power supply in each cubicle is common for the PLC's, discrete I/O, release relay, analog outputs, etc. If this power supply is also distributed outside the cubicles into different other cabinets, any disturbance or issue on the 24 V DC cabling could affect one or some apparatus connected on this network.

The 24 V DC potential reference (0 V) shall not be connected directly to the earth in different points. This situation is not recommended.

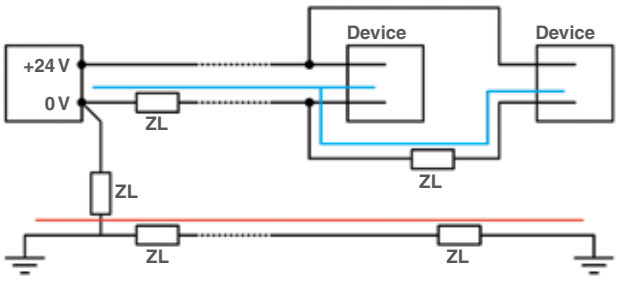
Multiple connections between the 0 V and earth create ground loops and/or common impedance and in this situation, the 0 V could be disturbed by LF and HF disturbances (50/60 Hz, harmonics, transients, etc).



Inside the red line, a part of the DC current flows and also disturbances coming from outside or from disturbing apparatus (relays, contactors, coils, converters, etc.). ZL is the line impedance of the wiring. Depending of the value of these impedances (mainly the length) and also from the di/dt, the potential differences between the different apparatus could be very high. In this case the 0 V reference along the power supply network is not equipotential and troubles could appear.

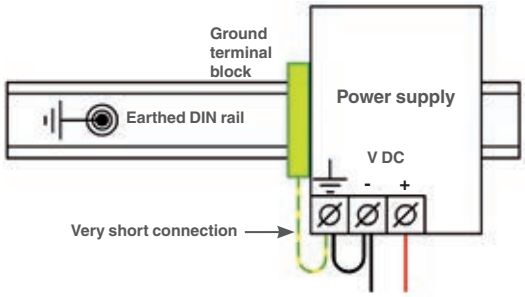
Only one 0 V connection to the earth is recommended. This connection shall be located at the output of the AC/DC converter and shall be as short as possible.

AC-DC Recommendations



The connection between the 0 V and the earth or ground shall be as short as possible to minimize ZL.

Example of short cabling connections:



It is recommended to use different separate isolated DC power supplies for the PLC, analog I/O, logic I/O, communication modules. This situation is easiest to manage and avoid a lot of installation issues. Otherwise, for remote IO's design and the attached DC 24V supply systems, always provide isolation between PE and 0V24 of the equipment.

But in any case, if the power supply (AC and/or DC) is isolated from the earth, an isolation monitoring device (IMD) is required. In case of earth fault, the maintenance staff is well informed and they can fix quickly this problem. Without, a lot of troubles could appear and nobody can quickly point out the issue.

6 Choice of TeSys T power supply for a 24 V DC solution

> AC/DC Converter features with galvanic isolation
> AC Input: 230 V AC (+15 / -20 %),
> DC Output DC: 24 V DC (±10 %)
> Input to output isolation: 4 kV AC mini - 50 Hz.

It is also recommended to limit the number of TeSys T per power supply converters and to split the installation in several sections (islands).

Schneider Electric products: ABL8RP range.

References	Voltage IN	Voltage OUT	Current	TeSys T / Converter
ABL8RPS24100	200-500 V AC	24 V DC	10 A	24
ABL8RPS24050	200-500 V AC	24 V DC	5 A	12
ABL8RPS24030	200-500 V AC	24 V DC	3 A	8

7 AC TeSys T power choice

> AC/AC Converter features with galvanic isolation
> AC Input: 230 V AC (+15/-20%),
> AC Output DC: 115 V AC (+15/-20%)
> Input to output isolation: 4 kV AC mini - 50 Hz.

Assembly techniques

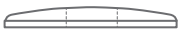
This chapter describes the various electrical and mechanical assembly techniques that are most often used in electrical distribution switchboards.

Assembly fasteners

Assembly fasteners

Standards Theory

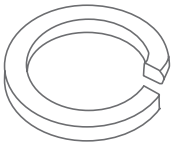
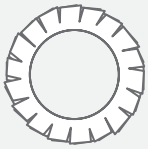
1 The table below presents the various assembly components that can be used in electrical distribution switchboards. It shows their normal use and their properties.

Description	Representation	Use	Properties
Threaded rod		Mechanical and electrical assemblies	
Hexagon head screw		Mechanical and electrical assemblies	
Hexagon nut		Mechanical and electrical assemblies	
Nylstop™ nut with plastic safety washer		Mechanical assemblies alone ⚠ **Prohibited for electrical assemblies**	- Self-locking nut with an unthreaded nylon washer. - Deteriorates at high temperatures. - Risk of creep and premature ageing.
Notched base Thiant™ nut		Mechanical assemblies alone ⚠ **Prohibited for electrical assemblies**	- Non-elastic bolt. - Small contact surface.
Flat washer		Mechanical and electrical assemblies ⚠ **Mandatory for connecting insulated flexible bars**	- Increases the pressure surface of the nut on a part made in a material that risks deformation. - Contact pressure spread over a wider area. - To be effective, it must have an external diameter that is clearly larger than the diameter of the hole. - Used with a serrated conical washer to offset an oval or oblong hole and to increase the contact surface. - Does not have a locking function.
Serrated conical washer also called **a contact washer**		**Recommended by Schneider Electric for electrical assemblies**	- **Spring lock washer:** ensures excellent mechanical resistance of the fastened item by pushing into the item and the nut. - Contact pressure better distributed because of their elasticity. - Works by deforming plastic: it must therefore be replaced with a new washer if it comes loose or is dismounted.

Assembly fasteners

Assembly fasteners (contd.)

Standards Theory

Description	Representation	Use	Properties
A split washer also called **a Grower washer**		Mechanical assemblies. For electrical assemblies, must be associated with a flat washer	- **Spring lock washer:** ensures excellent mechanical resistance of the fastened item by pushing into the item and the nut. - Prevents the assembly from becoming loose over time. - The electrical contact is not as good as with a serrated conical washer. - Cheaper than the serrated conical washer. - Can be dismantled several times (can be dismantled 3 or 4 times before being replaced with a new washer.
Star or **serrated washer**		Mechanical assemblies. No electrical assemblies	- **Lock washer.** - Less resistant than the Grower because it has a greater tendency to be crushed. - Can ensure the function of earthing continuity.
Spring washer also called **a Belleville washer**		Mechanical assemblies	- **Spring lock washer:** ensures excellent mechanical resistance of the fastened item by pushing into the item and the nut. - Behaves in the axial direction as a very stiff spring. - Small size. - Efficient in a disturbed environment (expansions, vibrations). - Combines the effects of a flat washer and a lock washer on fragile materials such as aluminium. - More expensive than the serrated conical washer.
Contact washer		⚠ **Mandatory** by Schneider Electric to ensure earthing continuity	- Grips the paint up to the metal and thus ensure excellent electrical continuity. - Mechanical locking.

Assembly fasteners

Fastener characteristics

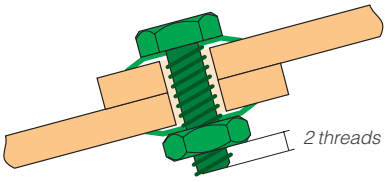
Standards Good practice

1 Use ungreased zinc-plated yellow dichromatic fasteners (Zn8C), Class 8.8, for mechanical and electrical assemblies.

After it is tightened to the recommended torque, it retains all the mechanical characteristics (elasticity) over time, without deforming the material, regardless of the temperature conditions inside the switchboard.

2 For screw + washer units, choose a washer with a hardness at least equivalent to that of the screw.

3 The length of the screws must correspond to the total thickness of the components to assemble + the thickness of new washers (not compressed) + the thickness of the nut + 2 threads.



When more than one bar must be assembled together, you can use the table below to determine the length of the screws:

Number of bars to assemble	Minimum length	Maximum length
	(mm)	(mm)
2	25	30
3	30	40
4	35	40
5	40	50
6 and 7	50	60
8 and 9	60	70

Table established for bars 5 mm thick.
For 10 mm bars, add 10 mm to the values of the table above.

Tip

In some special cases (e.g., corrosive environment) the screw may be set flush with the nut. Nevertheless, the screw bevel must always be located outside the bolt.

Assembly fasteners

Fastener characteristics (contd.)

Standards Good practice

4 The bolts used for electrical assemblies must provide and maintain a constant pressure > 25 MPa.

The choice of fasteners and the assembly technique to use must take into account:

- dilations/contractions of conductors dues to temperature rises or cooling,
- electrodynamic forces (generated by the rated current and short-circuit currents),
- the vibratory environment that may loosen the fasteners.

5 **In the event of a high current (≥ 4000 A),** losses by hysteresis and by parasite eddy currents increase significantly and this in turn increases the temperature.

To prevent the fastening point from becoming an additional source of temperature rise, you **must** use non-magnetic screws when there is a high current (≥ 4000 A).

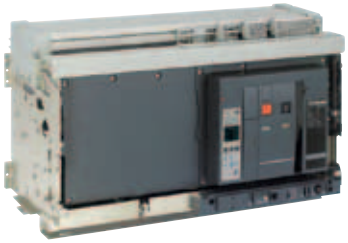
The main advantage of non-magnetic screws is that:

- they have a higher resistivity than basic steel (the heat dissipation due to eddy currents at the fastening points is inversely proportional to the resistivity of the fasteners).
- no hysteresis losses.

The use of stainless steel is also recommended in case of a corrosive environment.
Do not remove lubricate the screws.

Example

Schneider Electric recommends that you use stainless steel, class A4-80 screws on the connections of the MASTERPACT NW 40 to NW63.

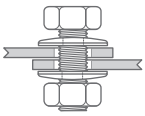
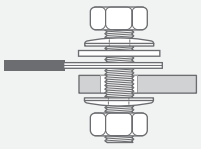
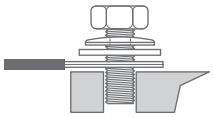
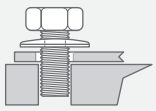
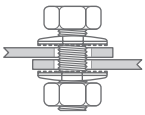
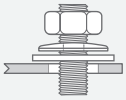
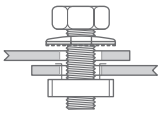


For Okken switchboards, during the installation of current transformers on dipole Masterpact NW40 to 63 circuit-breakers, you must secure the joined bars derived from the poles. In this case, stainless steel fasteners are used through these electric joints where the current transported can be as high as 4000 A or more.

Assembly fasteners

Types of frequently used assemblies

Standards Theory

Assembly	Representation	Stacking
Rigid copper on rigid copper bar		- Hexagon head screw - Serrated conical washer (contact washer) - Rigid bar - Rigid bar - Serrated conical washer (contact washer) - Hexagon nut
Flexible insulated bar on rigid copper bar		- Hexagon head screw - Serrated conical washer (contact washer) - Flat washer - Insulated flexible bar - Rigid bar - Serrated conical washer (contact washer) - Hexagon nut
Flexible insulated bar on device connection plate		- Hexagon head screw - Serrated conical washer (contact washer) - Thick flat washer (2 mm) - Insulated flexible bar - Device connection plate (threaded hole)
Rigid copper on device connection plate		- Hexagon head screw - Serrated conical washer (contact washer) - Rigid bar - Device connection plate (threaded hole)
Electrical bonding continuity		- Hexagon head screw - Contact washer - Covering - Covering - Contact washer - Hexagon nut
Special case: oblong holes		- When the holes where the screw is to pass is oblong, place a thick flat washer (2 mm) between the bar and the serrated conical washer (contact washer). - The diameter of the flat washer must be at least double the diameter of the hole.
Cage nut		- The cage nut must be adapted to the thickness of the component to be fastened. - The nut ensures earthing continuity only when a contact cage nut is used

Assembly fasteners

General installation rules

Standards

Good practice

1. Operators must be able to insert the screws easily into their housing without any excessive force. This precaution makes it possible:
   - to avoid damaging the threads,
   - to ensure that the screw can be tightened without friction constraints.

2. Comply with:
   - the stacking order given in the table above,
   - direction of mounting of washers.

IEC 61439-1

3. Always ensure that clearances have been complied with, in particular on the switchgear and controlgear connection plates or bar ends.

Tightening torques

Tightening torques

Standards Good practice

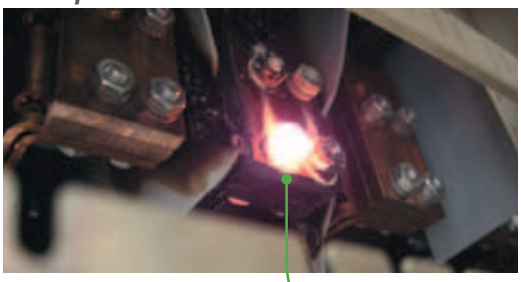
1

You will obtain an **assembly of excellent quality** if you strictly apply the guidelines provided by the manufacturers in the technical manuals, especially concerning the tightening torques to apply.

An incorrect tightening can result in:

- deterioration of the power supply conductor,
- spurious tripping of the protective device,
- overheating on the connection point which can start a fire in the switchboard.

Example



Overheating on the bolt due to an incorrect tightening

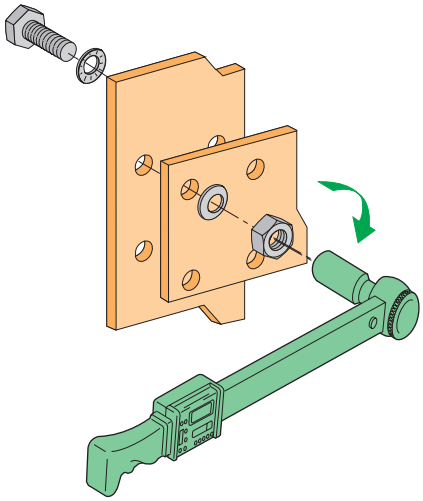
Tip

You must check the calibration of the torque wrenches regularly.

> See chapter 8 - "Quality Inspection".

2

Use a torque wrench duly calibrated by a certified body to be sure that you are applying the tightening torque that guarantees the right contact pressure (2 to 3 daN/mm²).



Tighten the nut for a bolt and the screw for a threaded hole.

Example

If you do not have a torque wrench, you can use self-breaking nuts to ensure that the tightening torque is applied.

Tightening torques

Tightening torques (contd.)

Standards Good practice

3 The tightening torque depends on the diameter and quality of the fasteners.

If there are no recommendations, use the table below. It shows the tightening torques that apply to ISO steel thread screws and non-lubricated stainless screws with the following characteristics:

- class 8.8
- Re = 64 daN/mm²
- Rr = 80 daN/mm²
- Complies with standard E 25 030.

Nominal Ø	Thread	Cross-section resist. average πr²	Max. drilling Ø	Axial force in screw	Tightening torque at 80% of elastic limit (m.daN) for stainless steel screws compliant with T.04121-9 lubricated or steel - Class 8.8 non lubricated					
(mm)	(mm)	(mm²)	(mm)	(daN)	Nut with washer		Notched base nut		Nylstop nut with washer	
					Grower + Flat	Contact	Steel	Copper or Al.	Flat	Contact
3	0.5	5.03	3.4	150	0.1	0.15	0.15	0.17	0.12	0.17
4	0.7	8.78	4.5	250	0.25	0.35	0.35	0.41	0.28	0.38
5	0.8	14.2	5.5	380	0.5	0.7	0.8	0.93	0.55	0.75
6	1	20.1	6.6	600	0.85	1.3	1.35	1.55	1	1.45
8	1.25	36.6	9	1000	1.9	2.8	2.5	2.9	2.2	3.1
10	1.5	58	11	1500	3.75	5	5	5.9	4.15	5.4
12	1.75	84.3	14	2400	6.2	7.5	7.9	9.2	7	8.3
14	2	115	16	3300	9.8	12	12.5	14.6	11	13.2
16	2	157	18	4500	15.5	18.5	18	21	17	20
18	2.5	192	20	5500	21	26	27	31	23	28
20	2.5	245	22	7100	29	37	39	45	33	41

Reminder: *1 m daN = 1 m kgf*

Mechanical assembly alone

Notched base nuts and Nylstop nuts must be used for electrical assemblies.

Tightening torques

Tightening torques (contd.)

Standards Good practice

4 For screw, threaded rod or nut – whose height x diameter = 0.8 – made up of material in the table below, multiply the torque, obtained in the previous table, by the coefficient A.

For a tapped hole (in the same materials as above), you can usually apply the screw torque on condition that you provide for a sufficient length of threads, so:

- **1 x d** in steel
- **1.5 x d** in cast-iron and copper alloy (unless specific treatment of threads)

d = normal screw diameter

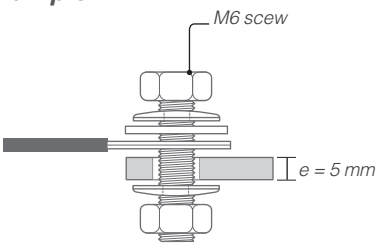
If this length is not sufficient, apply the coefficient A in the table below.
If no coefficient, use the empirical rule:

- **A = RE / 48**

RE is the value of the elastic limit of the material considered.

Material	A
Copper ETP H12	0.4
AZ5 GU	0.65
Brass	of about 0.50
Bronze	of about 0.65
Screw cage	0.5
Cage nut	0.5

Example



The tightening torque usually recommended for a class 8.8 M6 screw with a contact washer is 1.3 m.daN.

In the example above, the screw diameter is larger than the thickness of the copper bar on which the flexible bar is fastened. You must therefore apply the correction factor. The tightening torque to apply will therefore be 1.3 x 0.4 = 0.52 m.daN.

5 When the tightening force is applied directly on a switchgear or controlgear plate, comply with the tightening torque recommended in the device technical manual.

6 Do not torque the **self-forming** screws. Snug them up in order not to damage the threads.

Do not use self-forming screws for electrical assemblies.

Tightening torques

Tightening torques (contd.)

Standards Good practice

7

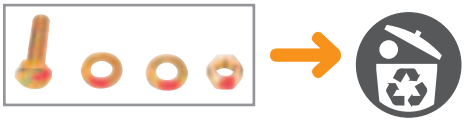
You must absolutely comply with tightening torque:

- Excessive torquing will elongate and weaken the screw thread more or less and this could make it break in the event of a short-circuit.
- Insufficient tightening will result in a contact pressure that is not sufficient or is unevenly distributed. This could result in a temperature rise on the connection.

8

If you have to dismount a connection after the fasteners have been tightened (screws, washers, nuts), you must use **new fasteners** when mounting it again.

This is because the initial elastic characteristics of fasteners are lost when an assembly is dismounted (in particular the elasticity of contact washers).



Conformity of the assembly

Standards Good practice

1

After tightening the torque, the operator applies a tinted acrylic varnish that is indelible and heat resistant. This means that he has conducted a complete self check of the assembly, i.e. he has verified and validated:

- the characteristics of the fasteners used,
- the compliance of the assembly (contact surfaces, direction of washers, etc.),
- the length of screws.

Affixing this marking certifies that the self-check has been completed.

The use of varnish also makes it possible to identify any loosening.

Do not adjust the tightening after applying varnish to the screw.
If the assembly has to dismounted, replace the screws with new screws.

Lubricating screws

Standards Good practice

Tip

In some cases, it may be necessary to lubricate the screws. This particularity is clearly specified in the switchgear/controlgear manuals.

1

Using grease has a beneficial effect for assemblies at the mechanical level:
- reduction of friction during tightening,
- reduction of the risk of the bolt breaking,
- increase in the bolt's life cycle.

However, in switchboards this can present significant risks to equipment:
- if it is applied carelessly,
- limitation of tightening torques to 80 % of the elastic limit,
- risk of thinning of the grease (drip point) in the zone with the highest temperature and therefore weakening (or even disappearance) of grease,
- risk of lubricant runs on contact zones that become insulating,
- deterioration, or even destruction, of plastic components that come in contact with incompatible grease,
- risk of flammability of unsuitable grease.

Furthermore, the use of highly advanced metal machining techniques, combined with extra high-quality materials, today gives excellent surface states of screw threads, thus eliminating the need for grease.

In conclusion, given the risks, it is generally not advisable to grease screws.

Particular case - Other assembly techniques

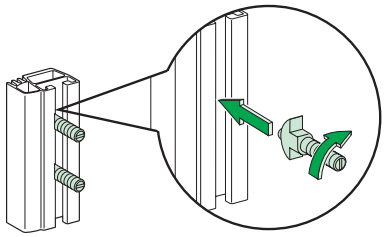
Standards Good practice

1

Connections to Linergy busbars are obtained using a specific screw.

This screw has a head that can slide into the grooves of profiles and be held in place at all levels thanks to a bearing and spring system.

Choose a screw of the appropriate length and monitor the position of the marking slot at the end of the screw. After the screw has been mounted, the slot must be horizontal to be able to tighten the screw, which will guarantee that the screw has been locked in this position.



Wiring techniques

Wiring techniques

Foreword

Standards Theory

1

Electrical connections must ensure absolute reliability to ensure that the switchboard will work properly.

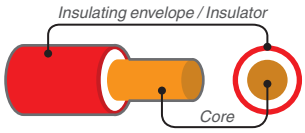
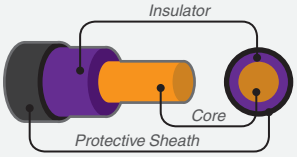
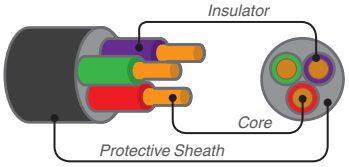
The following is required to obtain a good quality connection:

- a conductor with an appropriate cross-section,
- a connection that is adapted to the cross-section of the conductor to be connected,
- a conductor that has been stripped correctly,
- an appropriate and clean stripping/ crimping tool or machine that is in good condition and regularly calibrated,
- an operator qualified and trained for this operation.

Wiring techniques

Definitions

Standards Theory

Description	Representation	Definition
Insulated conductor		An insulated conductor is made up of a conductor core and its insulating envelope.
Single-pole cable		A single-pole cable is an insulated conductor with an additional protective sheath.
Multi-pole cable		A multi-pole cable is a set of insulated conductors brought together in a protective sheath.
Crimp connections	 *Pre-insulated ring connectors*  *Pre-insulated spade terminal*  *Tubular terminal*  *Pre-insulated female clip*  *Pre-insulated end*	A crimp connection is an intermediate piece used to connect a cable to switchgear. This means of connection must ensure the following performances: - perfect conductibility, - good traction resistance, - good corrosion resistance, - good vibration resistance, - must not be a source of a temperature rise or a voltage drop. You may use different types of crimp connections: - pre-insulated terminals, - tubular terminals, - pre-insulated cable terminals, - female clips.
Crimping		Mechanical compression of the barrel of a terminal around the conductor of an electric wire. This type of connection has a low resistance, high conductibility and is long-lasting. A second crimping can be added to the insulator to increase its resistance to vibrations.
Barrel		Rear end of a terminal. The barrel can be crimped onto the conductor, the insulator or both. There are different types of barrels (insulated or non-insulated, open or in a single piece, with or without an insulating sleeve, colour-coded, etc.) to fit as diverse a range of applications as possible. > *See the suppliers' catalogues.*
Tab		Front end of a terminal that is fastened to the component to be connected. There are different types of tabs (round, rectangular, snap-on spade, female clip, etc.) to fit as diverse a range of applications as possible. > *See the suppliers' catalogues.*
Crimping mark		Portion of a crimping die that shapes the barrel during crimping.

Wiring techniques

Technical characteristics of cables

Standards Theory

Characteristics	Core	Insulating sleeve
Material	- Copper - Brass - Bronze - Aluminium	- Polymer without halogen - Polymer with halogen depending on the room where the switchboard is installed
Conductor type	- Single-strand - Multi-strand	Not applicable
Electrical characteristics	- Electrical conductivity - Resistivity - Insulation voltage	Dielectric strength
Mechanical characteristics	- Flexible - Rigid - Permissible radius of curvature	- Traction resistance - Compression tensile strength - Resistance to vibrations and impacts - Ageing stability - Corrosion resistance
Thermal characteristics	Maximum operating temperature	Maximum operating temperature
Colour	Not applicable	> **Recommended colour: black** if there are no client specifications > **Reserved colours:** - Neutral: sky blue - Earth: yellow/green - Direct current: dark blue (pole -)

> *See supplier catalogues for the choice of cables.*

Wiring techniques

Cable sizing

Standards Theory

1 The cross-section of a conductor must be determined according to:

- the characteristics of the switchgear/ controlgear to be connected,
- the length of the connection to be made,
- the thermal environment of the connection.

2 The conductor cross-section must therefore be chosen according to:

- the intensity to be transported,
- the installation mode (singly or in strands),
- the ambient temperature around the conductors,
- the IP index of protection of the switchboard.

The following tables take into account the installation conditions related to the type of device (admissible temperatures on the connection pads, etc.).

They are used to monitor the temperature derating values of the switchgear controlgear installed in each cubicle covering IP ≤ 55.

- Internal temperature of the switchboard: 60°C.
- Connections by copper cables.

Circuit-breaker connection

Cable cross-section (mm²)	Permissible current (A)			
	Individual flanging of cables		Flanging of cables in strands	
	IP ≤ 31	IP > 31	IP ≤ 31	IP > 31
1.5	16	14	14	12
2.5	25	25	22	20
4	32	29	28	24
6	40	39	36	33
10	63	55	55	50
16	90	77	80	70
25	110	100	100	93
35	135	125	125	120
50	180	150		
70	230	190		
95	275	230		

Connection to other devices

Cable cross-section (mm²)	Permissible current (A)			
	Individual flanging of cables		Flanging of cables in strands	
	IP ≤ 31	IP > 31	IP ≤ 31	IP > 31
1.5	13	12	12	10
2.5	23	21	20	19
4	28	26	25	22
6	36	35	32	30
10	55	50	50	46
16	80	70	72	63
25	100	90	90	84
35	120	115	110	103
50	165	135		
70	210	176		
95	250	210		

Wiring techniques

General wiring rules

Standards Good practice

1. All intermediate connections between two connection points (terminals, devices) with splices, dominoes or welds are strictly prohibited.

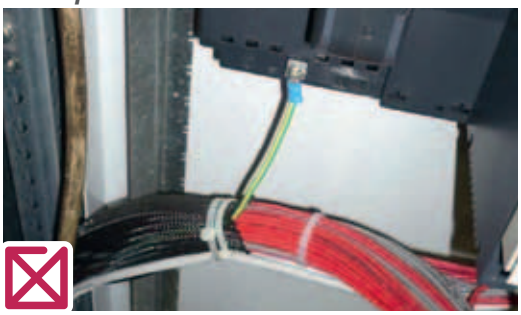
   All connections inside a duct are also strictly prohibited.

2. Never tin-plate multiple strand conductors before they are connected to avoid weakening the conductor core or the risk of tightening creep).

3. Make sure that there is no tensile stress or compressive stress exerted on the switchgear connection points.

   This could compromise the reliability of the electrical connection.

Example



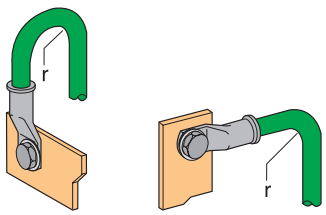
The earth cable too short exerts on the connexion point a mechanical stress due to the weight of the strand.

4. Always make sure that the cables are not damaged by mechanical or thermal stresses.

5. Comply with the permissible radius of curvature for each cable type.

   In particular:

   - observe a **minimum** radius of curvature 6 to 8 times the outer diameter of the cable,



   - do not use the tools to bend the cables.

   Failure to observe this recommendation may result in an abnormal temperature rise in the conductors.

Tip

The values of the permissible curvature radii are given by the cable suppliers.

They depend on the type:
- of core (copper or aluminium),
- of insulator.

Wiring techniques

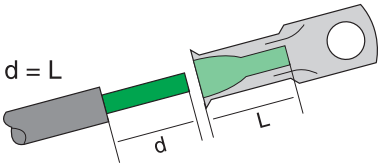
Stripping of conductors

Standards Good practice

1. Use an appropriate hand tool that is in good condition or a stripping machine that is regularly inspected.

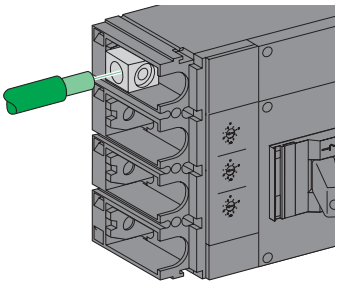
2. Observe the stripping length of a conductor depending on its use:

- placing in a terminal to be crimped:



The stripping length is equal to the depth of the terminal to be crimped.

- placing in the cage of a device:

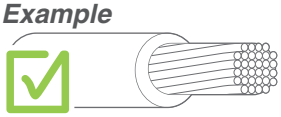


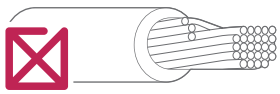
The stripping length is equal to the depth of the cage of the device.

3. Make sure that:

- the duct is neatly cut,
- the conductor is not damaged,
- the strands of a multiple-strand cable are not damaged or cut,
- there is no insulating particle on the bare section of the conductor,
- the insulating sleeve is not damaged (cut or crushed).

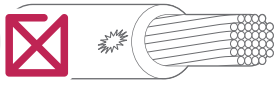
Example





Strands of conductor cut

Insulating particles on the stripped section of the conductor



Insulating sleeve damaged

Wiring techniques

Installation of terminal blocks

Standards Theory

1

Terminal blocks are groups of terminals intended to facilitate the internal connection to the switchboard and to the site.

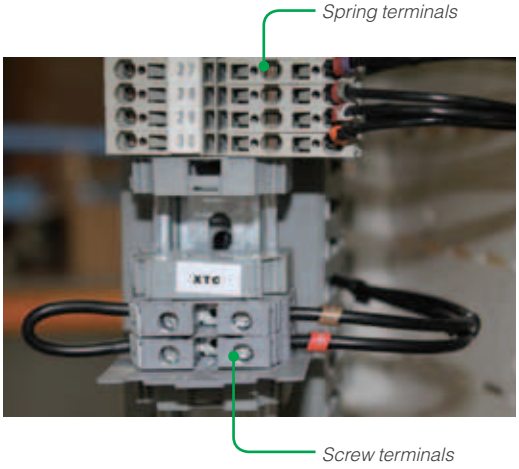
Various technologies can be implemented:

- spring terminals,
- screw terminals,
- blocking screw terminals,
- specific terminals (isolating, insulating displacement, stirrup, etc.).

The cross-section of the cables to connect and the client specifications determine the choice of the type of terminal block to use.

> *See supplier catalogues.*

Example



2

Regardless of their type, terminal blocks must:

- be adapted to the cross-section of the conductors that are connected or liable to be connected (client cables),
- bear thermal stress in the event of a short-circuit.

Wiring techniques

Installation of terminal blocks (contd.)

Standards Good practice

IEC 60445

1

Install the terminal blocks to ensure that:

- they can be easily accessed to enable internal connections under the right conditions,
- cables outside the switchboard can be connected easily,
- the radius of curvature recommended for each cable type is observed.
- the connection to the PE/PEN protective conductor is facilitated by installing a bar specific to the neighbourhood of the dedicated terminals,
- modifications can be made on site.

Terminal blocks must be marked to make sure that they are identified without any possible error.

Example

2

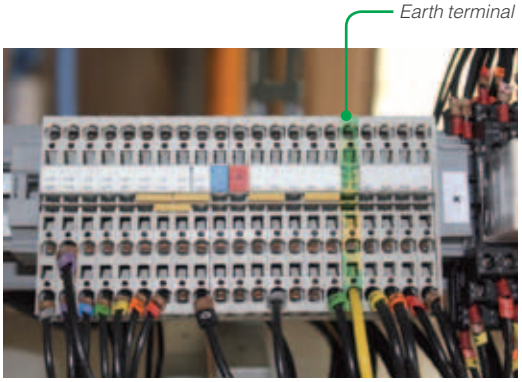
Use a separation stop to physically separate:

- power terminal blocks,
- control/command terminal blocks,
- communication terminal blocks.

Carefully mark each terminal block to facilitate its identification.

Make sure that the rail on which the terminal blocks are fastened (yellow-green blocks) is itself connected correctly to the switchboard earth.

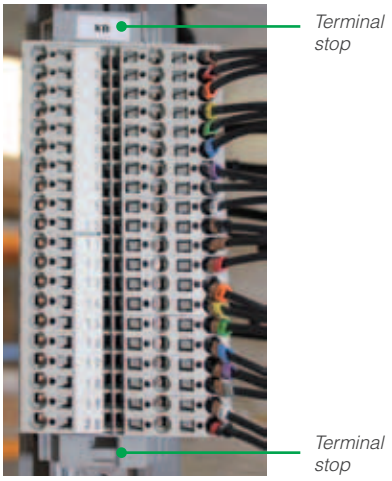
Example



3

Place a terminal stop at each end of a terminal block to keep the terminals in place, in particular when the terminal block is placed vertically.

Example



Wiring techniques

Installation of terminal blocks (contd.)

Standards Good practice

IEC 60947-7

IEC 61439-1

4 Spring terminals

Spring terminals allow reliable and fast connections. The cable is tightened without screws. Electrical contact is obtained through a spring blade that blocks the single stranded or multi-stranded conductor against a special form that prevents withdrawal.

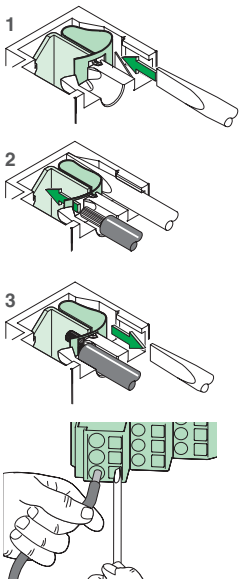
The contact pressure adapts automatically to the conductor cross-section and does not depend on the operator. The connections are unaffected by vibrations and thermal variations and do not require any maintenance.

Follow the recommendations below to install spring terminals:

- make sure to strip a wire length that corresponds exactly to the depth of the terminal
- use only a flat screwdriver with a cylindrical cross-section to open the spring,
- there must be only one conductor per spring terminal.
- do not use end caps in the spring terminals.

Example

Schneider Electric has conducted tests on the terminals alone and combined with Schneider Electric devices. The terminals comply with the standards IEC 60947-7 and (cable resistance tests) and IEC 61439-1 (temperature rise tests and electrodynamic tests).



IEC 60947-7

IEC 61439-1

Tip

If you install two conductors per cage, they must have the same type of core and the same cross-section.

Some specifications require that only one conductor be installed per terminal.

5 Screw terminals

Screw terminals are used for connecting cables with larger cross-sections.

Follow the recommendations below to install screw terminals:

- make sure that you have stripped a length of wire corresponding exactly to the depth of the terminal or the cage of the device that is going to use it.
- observe the torques recommended by the supplier. Too much tightening could damage the conductor core.
- do not place more than two conductors per cage.
- prefer to use an end splice on a multi-strand conductor to avoid a risk of shearing and dispersing the strands when the conductor is placed inside the cage.

After tightening, make sure that there is no damage on the:

- conductor core (cut strand, excess deformation, copper creep).
- insulating duct (cut, crushed).

Example

Schneider Electric has conducted tests on the terminals alone and combined with Schneider Electric devices. The terminals comply with the standards IEC 60947-7 and (cable resistance tests) and IEC 61439-1 (temperature rise tests and electrodynamic tests).

Crimp connections

Crimp connections

Standards Theory

1 Crimping technology has been developed to replace welding. It makes it possible to obtain lasting and good quality connections between a connection component (terminal, end piece) and an electric wire at a relatively low cost price.

Crimping is more reliable than welding because it does not deform the molecular structure of copper. Its guarantees a longer connection life and eliminates the point resulting from high welding temperatures.

2 A crimp connection is an intermediate piece used to connect a cable to switchgear. This means of connection must provide the following performances:

- perfect conductibility
- good traction resistance
- good corrosion resistance
- good vibration resistance
- must not be a source of a temperature rise or a voltage drop.

To ensure such performance, use:

- a crimping connection of a quality suited to the application,
- a conductor that is correctly stripped and has a cross-section suited to the application,
- a crimping tool or machine that is in good condition, is regularly calibrated and suited to the connection to be crimped,
- a qualified operator who has received training in industrial crimping techniques.

NFC 20.130

NFC 63-023

3 You may use different types of crimp connections:

- pre-insulated cable ends,
- pre-insulated terminals,
- female clips,
- spade terminals.

Crimp connections

End pieces

Standards Good practice

1 For corrosive environments or multiple strand conductors it is recommended that you use end pieces.

Choose the end pieces based on the following:

- the cross-section of the conductor to be fitted,
- the characteristics of the terminal or device cage (cross-section and depth).

> *See the end-piece supplier's catalogues and the switchgear/controlgear manuals.*

2 Follow the recommendations below to install the end pieces:

- observe the stripping length of the conductors,
- all the strands of a multiple strand conductor must be placed in the end piece barrel,
- the cage of a device can be fitted with only one conductor equipped with an end piece.

An end piece that is not well chosen or is badly crimped increases the risks of temperature rises.

Example

The terminal cages of some Schneider Electric devices have been designed to hold two bare flexible cables (without end pieces) of identical cross-section.

Tests conducted show that the cage terminal and live cable combination gives the best results (tear and temperature rise resistant). The absence of an end piece increases the contact surfaces.

Crimp connections

Crimp terminals

Standards Good practice

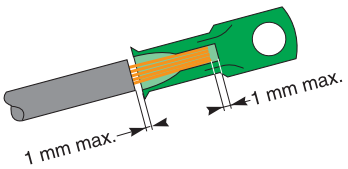
1 Choose the terminals based on the following:
- the cross-section of the conductor to be fitted,
- the diameter of the fastening screw.

> *See the suppliers' catalogues.*

A terminal that is not well chosen or is badly crimped increases the risks of temperature rises.

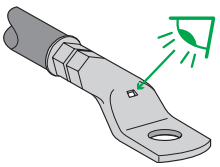
2 Follow the recommendations below to install the terminals:
- observe the stripping length of the conductors,
- do not install more than one terminal by connection point,
- do not place two conductors in the same terminal,
- do not fold the conductor into the terminal.

3 All the strands of a multiple strand conductor must be placed in the terminal barrel as follows:

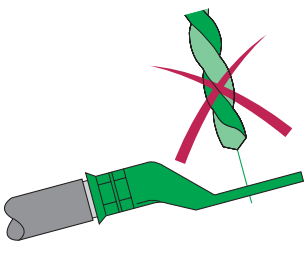


Example

Schneider Electric recommends the use of open-barrel terminals that make it possible to view the insertion of the cable.



4 Do not machine a terminal twice (drill, file or bend).

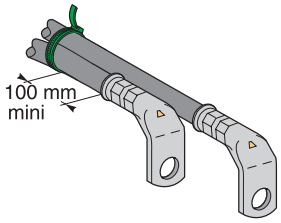


Crimp terminals (contd.)

Standards Good practice

5 Do not tie cables together near the terminals to avoid damaging the insulator and all risks of a sparkover.

Leave a minimum distance of 100 mm.



Crimp connections

Special cases

Standards Good practice

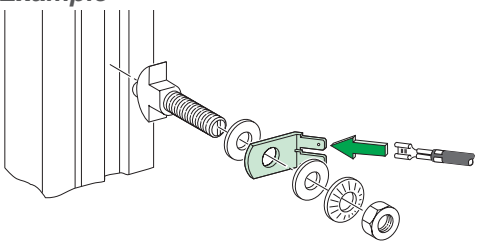
1 **Female clips**

Female clips must be used only with low-power auxiliary circuits.

Make sure that the clip's width corresponds to the width of the tab on which it will be connected.

When placing the clip on the tab, make sure that the lug on the clip is properly positioned in the tab orifice (lock function).

Example



Taps for Fast-on clips 6.35 mm.

2 **Spade terminals**

You must first check with the manufacturer of the device to be connected before using spade terminals.

Warning: never use spade terminals to connect current auxiliary circuits.

3 If you're connecting aluminium cables to copper pads, use interfaces or bimetal terminals.

Crimping

Crimping

Standards Theory

1 Crimping technology is usually recommended for obtaining quality electrical connections between a wire and a terminal.

2 **Some useful definitions:**

Description	Definition
Crimping	Mechanical compression of the barrel of a terminal around the conductor of an electric wire. This type of connection has a low resistance, high conductivity and is long-lasting. A second crimping can be added to the insulator to increase its resistance to vibrations.
Connections to crimp	A crimping connection provides the link between a cable and electrical equipment. This type of connection must ensure the following performances: - perfect conductivity, - good tensile strength, - good corrosion resistance, - good vibration strength, - should not produce a temperature rise or voltage drop. You may use different types of crimp connections: - pre-insulated terminals, - tubular terminals, - pre-insulated cable ends, - female clips.  *Pre-insulated terminal*  *Pre-insulated spade terminal*  *Tubular terminal*  *Pre-insulated female clip*  *Pre-insulated end fitting*
Barrel	Rear end of a terminal The barrel can be crimped onto the conductor, the insulator or both. There are different types of barrels (insulated or non-insulated, open or in a single piece, with or without an insulating sleeve, colour-coded, etc.) to fit as diverse a range of applications as possible. > *See the supplier catalogues*
Tab	Front end of a terminal that is fastened to the component to be connected. There are different types of tabs (round, rectangular, snap-on spade, female clip, etc.) to fit as diverse a range of applications as possible. > *See the supplier catalogues.*
Mark	Portion of a crimping die that shapes the barrel during crimping.

Tip

A colour code is used for the terminal insulator.

It makes it possible to identify the maximum capacity of the terminal at a first glance:

> Red
*For cable cross-sections of up to **1.5 mm²***

> Blue
*For cable cross-sections of up to **2.5 mm²***

> Yellow
*For cable cross-sections of up to **6 mm²**.*

4

Crimping

Crimping procedure

Standards Good practice

1 There are various crimping tools:
- hand tools (tools with one or more die sets, pneumatic tools),
- semi-automatic tools (compression tools),
- fully automated machines for stripping and crimping on a single machine.

The choice of tool and process to implement is determined by the type of application and the volume of connections to make.

2 Regardless of the process chosen:
- The conductor cross-section must be suited to the application.
- The terminal must be of good quality and adapted to the conductor cross-section and the application.
- The crimping tool must be adapted to the terminal type and the conductor cross-section. It is crucial for the tool to be adjusted, serviced and regularly inspected to obtain good quality crimping.
- The operator must have received training in crimping techniques.

3 Before starting a crimping operation, the stripping quality must be checked.

> *See the "Stripping conductors" section in this chapter, page 250.*

4 **Use of a compression tool or automatic machine**
- Mount the tools adapted to the terminals and wires used on the compression tool or the machine.
- Make sure that the tools are clean and in good condition.
- Comply scrupulously with the operating modes and safety instructions given in the machine and tool user guides.

Example

Automatic machine

Crimping

Crimping procedure (contd.)

Standards Good practice

Tip

Each operator must use only the tool assigned to him.

If the tool is dropped, it is essential to have it checked by the competent service.

5 **Use of a manual crimping tool**

As a general rule, follow the tool supplier's instructions.

- Check from its data sheet that the crimping tool is designed for the wire cross-section and terminal used.
- If necessary, select the die adapted to the wire and the terminal to be crimped.
- Open the tool and insert the terminal.
- Close the tool slightly to hold the terminal and insert the wire.
- Tighten the tool **as far as possible** until the no-return rack is released.
- Open the tool and remove the crimped assembly.

6 After crimping, you must perform a visual inspection.

7 Carry out regular tensile tests on a sample of crimped terminals to check the crimping quality.

Example

Tensile tests

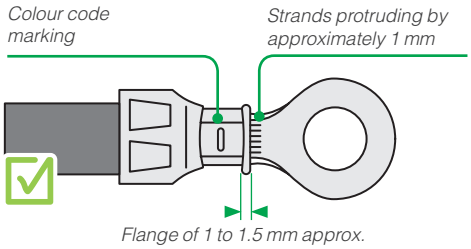
Crimping

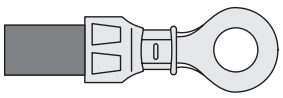
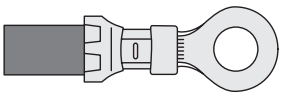
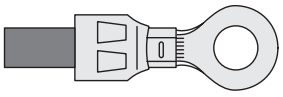
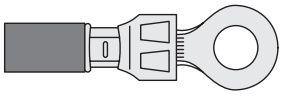
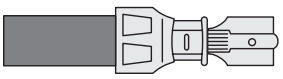
Inspecting pre-insulated terminals

Standards Good practice

1

Pre-insulated terminals



Defect	Cause
	Conductor not sufficiently stripped. The strands cannot be seen from the terminal side.
	Crimping too much in the rear: terminal inserted too far into the tool.
	Crimping too much in the front: terminal not inserted far enough into the tool.
	Inverted crimping mark: terminal inserted the other way round into the tool.
	Conductor over-stripped. The strands have spilled over to the terminal contact zone.

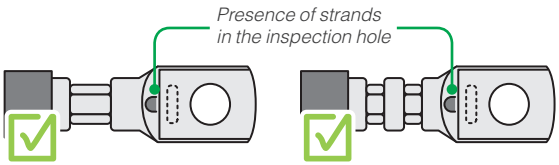
Crimping

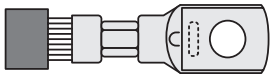
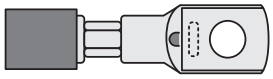
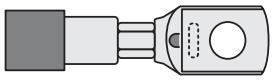
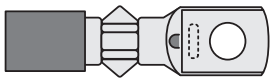
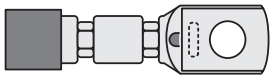
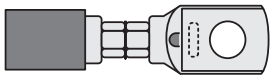
Inspecting tubular lugs

Standards Good practice

1

Tubular lugs



Defect	Cause
	☒ *Conductor not sufficiently inserted into the terminal: the cable does not appear in the inspection hole.*
	☒ *Crimping too much in the rear: terminal inserted too far into the tool.*
	☒ *Crimping too much in the front: terminal not inserted far enough into the tool.*
	☒ *Die worn-out our unsuited: terminal pinched, appearance of lugs.*
	☒ *Crimping marks not centred on the barrel.*
	☒ *Crimping marks not centred on the barrel.*

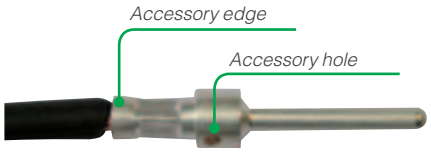
Crimping

Male and female contacts

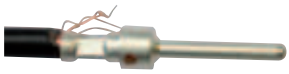
Standards Good practice

1

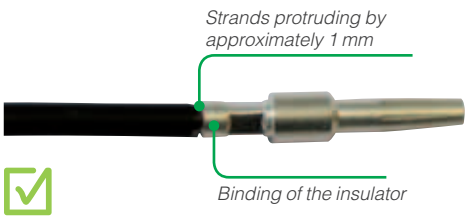
Male contacts



Crimping mark centred between the edge and the accessory hole

Defect	Cause
	There are strands of the conductor core outside the barrel.
	End fitting not well positioned, crimping not properly centred.
	Conductor over-stripped.

Female contacts



Defect	Cause
	Stripping too long.
	End piece not correctly positioned in the crimping tool.
	There are strands of the conductor core outside the barrel.

Notes

Thermal management of switchboards

Foreword

Standards Theory

Tip

Overheating of an electric circuit is when there is a temperature rise in relation to the ambient air.

1

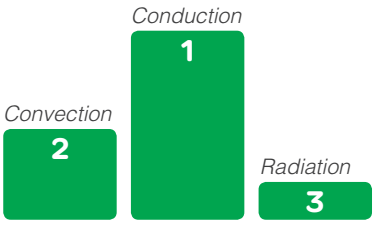
When current passes through an electrical conductor (busbar, insulated flexible bar, wire, etc.) or through a device, they heat up (Joule effect) and this results in a temperature rise inside the switchboard.

Internal temperature = external temperature + temperature rise

However, the devices installed inside an electrical distribution switchboard are designed to operate within a temperature range of -10°C and +70°C.

It is therefore imperative to:
- maintain the internal temperature within this range in order not to affect the performance of devices,
- ensure a balance between the installed dissipated power and the capacity of the enclosure to evacuate its calories.

Heat is transferred in switchboards:
- mainly by conduction,
- by convection,
- and by radiation.



> *See the "Heat exchanges" section in this chapter.*

The thermal behaviour of the switchboard determines its functioning and longevity.

2

The thermal management solution must also be defined by taking into account:

- environmental conditions around the switchboard: ambient temperature, hygrometry, pollution and altitude,

> *See the "Environmental conditions" section in this chapter.*

- the IP degree of protection and any partitioning of the switchboard (forms 1, 2, 3 or 4).

> *See the "Confinement of the Switchboard" section in this chapter.*

Foreword

Foreword (contd.)

Standards Theory

IEC 61439-1
§ 10.10.2.3.3

3

When the temperature rise due to the Joule effect becomes too high, there is a risk of accidental triggering of protective devices or even burns to users, and certainly a more rapid ageing of equipment.

To prevent these risks, IEC 61439-1 specifies the temperature rise limits for each part of the switchboard.

> *See the "Temperature rise limits" section in this chapter.*

4

A large majority of shut-downs or malfunctions of electrical installations and devices inside electric switchboards are for thermal reasons:

- internal thermal audit not conducted.
- climate conditions outside the switchboard not checked.
- difficult or harsh environmental conditions (pollution).

The challenges of thermal management are therefore to:

- prevent major incidents (fire),
- ensure the protection of people and equipment,
- ensure service continuity,
- prevent shut-downs and malfunctions caused by temperature rises in electrical circuits,
- increase the life cycle of switchboard components,
- reduce maintenance costs or costs related to the shut-down of the facility.

Heat exchanges

Principle

Standards Theory

1 There are three modes of transfer of heat inside a switchboard:

- conduction,
- convection,
- radiation.

Controlling these phenomena makes it possible to:

- reduce temperature rises inside the switchboard,
- optimise the performance of the devices installed in the switchboard.

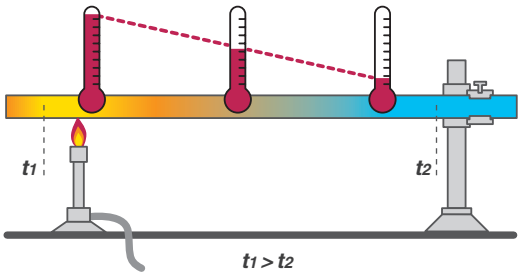
Conduction

Standards Theory

1 Conduction is the transfer of heat caused by the difference in temperature between two regions of the same environment or two environments in contact without the movement of matter.

It is a slow phenomenon that can be interpreted as the cumulative transmission of heat agitation.

Example



Conduction (contd.)

Standards Good practice

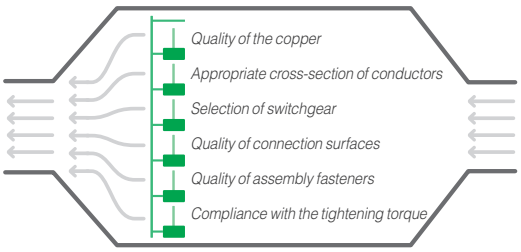
1

The heat transfer mode that acts spontaneously inside a switchboard and has the strongest impact on the thermal balance of the assembly is conduction.
It is therefore essential not to alter heat dissipation by **induction** by:

- selecting materials of excellent quality (copper or aluminium),
- correctly defining the cross-section of conductors (main busbars, insulated flexible bars, cables),
- selecting devices with known and tested characteristics that are compatible with the enclosure in which they will be installed,
- carefully preparing the connection surfaces (cleanliness, condition) and complying with covering rules (covering 3 to 5 times the thickness of the bar),
- using the appropriate fasteners (class 8.8 ungreased zinc-plated dichromatic fasteners (Zn8C)),
- complying with recommended tightening torques to obtain a good contact pressure.

All these recommendations interact on the quality of heat exchanges via conduction inside the switchboard.

Example

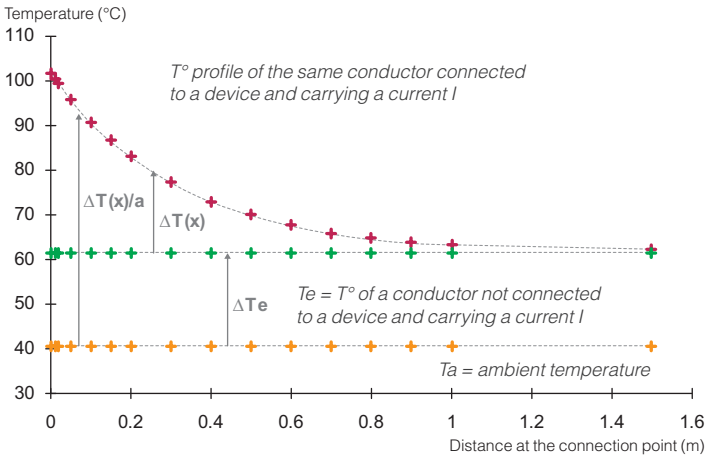


Like a motorway toll plaza where the flow of vehicles is regulated and optimised by the number of toll booths open, heat dissipation by conduction in a switchboard depends on all these recommendations that must all be complied with.

Non-compliance with one of them results in a "tailback" and significantly increases the risks of temperature rises.

2

A cable connected to a device makes it possible to evacuate calories. The cable cross-section must therefore be chosen with this characteristic in mind.
(See figure below)



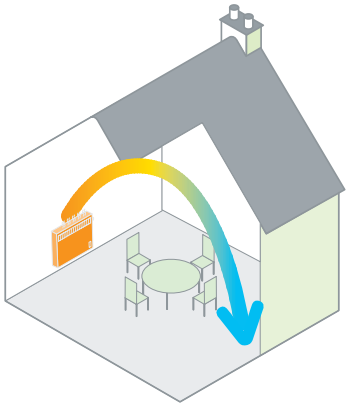
Heat exchanges

Convection

Standards Theory

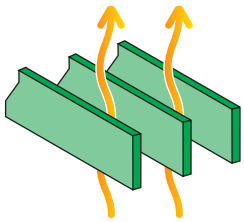
1 Convection is a heat transfer mode that takes place only in gaseous and liquid environments. Unlike conduction, it involves a movement of matter in the environment.

Example

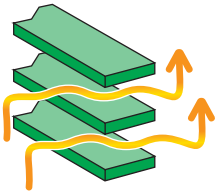


Good practice

1 To favour heat dissipation by **convection**, it is essential to install the bars edgewise.



Example



When using flat bars, e.g., derivations of incoming devices on busbars, Schneider Electric recommends a busbar derating of 0.8.

2 To correct the thermal status of the switchboard, there are several possibilities based on heat dissipation by convection:

- natural ventilation,
- forced ventilation,
- air-conditioning.

Convection (contd.)

Standards Good practice

Tip

Natural ventilation ensures the correct operation of switchboards in most cases.

3 Natural ventilation

Natural ventilation or natural convection is the switchboard heat exchange solution that is usually sufficient when the calorific value to dissipate is low and the equipment is installed in an environment with little pollution.

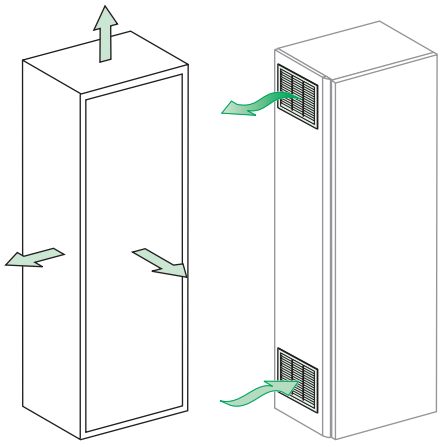
Switchboard systems are examined per construction to encourage the circulation of air inside the column.

If ventilation grids are installed on the upper and lower part of the switchboard, the cross-section of the upper opening must be at least 1.1 times the cross-section of the lower opening.

Make sure that no equipment (switchgear, metal parts, etc.) do not block the circulation of air from the ventilation louvred openings (grids, etc.). These should be compatible with the degree of protection required by the column.

Example

Prisma



IP > 31 *IP ≤ 31*

4 Forced ventilation

Some conditions (high protection rating, installation of switchgear with very high heat dissipation such as soft starters, condenser batteries, etc.) generate high temperature rises that require the use of forced ventilation.

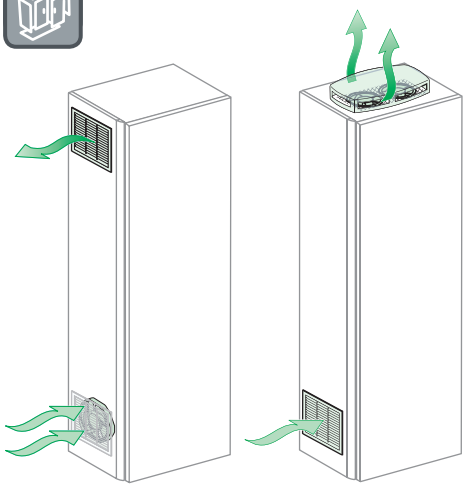
This solution is used to evacuate a larger quantity of heat, by extraction or drive of large quantities of air. This is done when the equipment is installed in an environment that is not very polluted.

The forced ventilation solution improves heat exchanges within the switchboard and therefore has effects on the optimisation of the switchgear, the conductors and the volume of the enclosure in certain cases.

For polluted environments, the switchboard must be installed in an electrical room fitted with filters to avoid injecting the polluted air into the column.

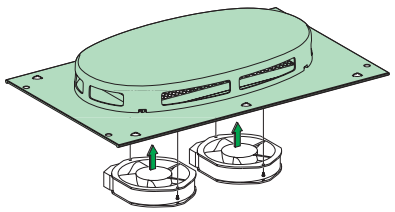
Example

Prisma



IP ≤ 54 *IP ≤ 54*

Schneider Electric proposes ventilation kits to be mounted on the enclosure roof.



Heat exchanges

Convection (contd.)

Standards Good practice

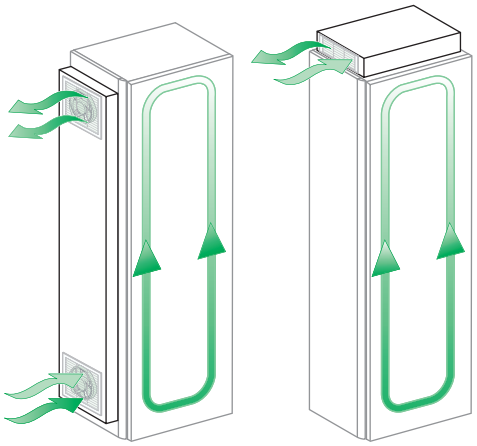
5

In some cases (control/command switchboards), the quantity of heat to evacuate is much higher.
In this case there are several solutions:

- **Air-Air exchangers** are fitted with an aluminium exchange battery that separates the internal and external air circuits and prevent the ingress of dust.
- **Air-Water** exchangers lower the internal temperature of the enclosure through an exchange battery supplied in cold water. The temperature inside the enclosure is regulated by a thermostat that opens and closes a solenoid valve.
- **Air-conditioners** are systems that effectively cool the enclosure, independently of outside air. They serve to prevent hot spots. Cooling units may be used in more severe environments where the temperature may go up to 55°C. Devices integrate a regulation of the temperature of the envelope as well as an alarm function that reports an operating defect.

Example

Prisma



IP > 31 *IP > 31*

Schneider Electric can propose these solutions ***upon specific request***.

Heat exchanges

Radiation

Standards

Theory

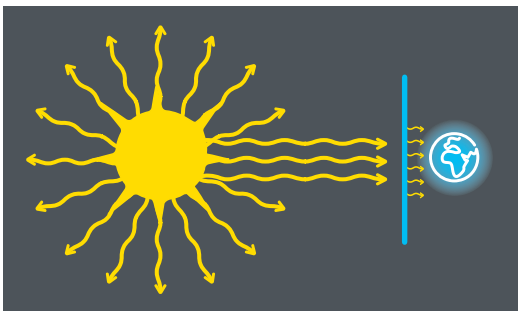
1 Heat is propagated in the form of electromagnetic waves emitted by a hot body.

This phenomenon is practically immediate and, unlike conduction and convection, does not require a material medium for transporting the calories.

The power radiated by a body is proportional to its emissivity coefficient (comprised between 0 and 1) depending on the surface state of the material:

- Aluminium bar: 0.05
- Anodised aluminium: 0.7 to 0.8
- Polished copper: 0.03
- Weathered copper: 0.3 to 0.7
- Tin-plated or silver-plated copper: 0.3
- Painted copper: 0.9
- Insulated copper: 0.9

Example



Example of universal and vital radiation: solar radiation.

Good practice

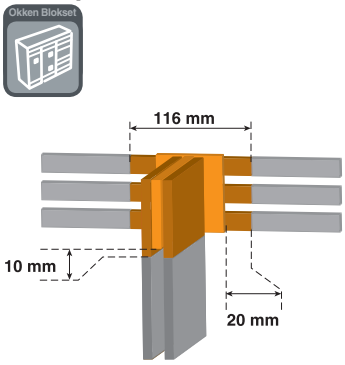
1 For the same conductor cross-section, an epoxy paint coating can improve the conductor's capacity to transport current by 15 %.

2 To improve the radiation power of main busbars and thus reduce temperature rises, it is recommended to paint the bars with epoxy paint.

Connection surfaces must not be painted to ensure a good electrical contact.

Provide for an additional resist around the connection zone. The size of this resist depends on the bar cross-section and the type of connection (horizontal/vertical busbar connection, joining of two horizontal busbars).

Example



Epoxy protection on H-BB/V-BB115 connections. Provide for a 116 mm resist on the 40 x 10 bars of the horizontal busbar for a connection with the vertical busbar.

Environmental conditions

Principle

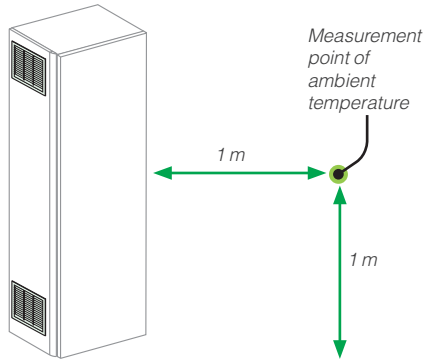
Standards Theory

1 A switchboard is designed to operate in well-defined environmental conditions: ambient temperature, hygrometry, altitude, degree of pollution.

Definition of ambient temperature

Standards Theory

1 Ambient temperature is the temperature measured at a distance and a height of 1 m from the switchboard.



IEC 61439-1 § 10.10.2.3.4

2 The ambient air temperature must be measured using at least two thermometers or thermocouples evenly distributed around the enclosure at approximately half its height and at a distance of approximately 1 m from the enclosure.

Thermometers and thermocouples must be protected from draught and heat radiation.

IEC 61439-1 § 7.1.1

3 The ambient air temperature for an internal installation must comply with the following conditions:

- daily average of under +35°C,
- lower limit: -5°C,
- upper limit: +40°C.

Environmental conditions

Hygrometry

Standards Theory

IEC 61439-1
§ 7.1.2

1 The air must be clean and with a relative humidity that will not exceed 50 % at a maximum temperature of +40°C.

Altitude

Standards Theory

IEC 61439-1
§ 7.1.4

1 Precautions must be taken for switchboards that are to be installed at an altitude of over 2000 m.

It is important to take into account the reduction in electric strength of air, the breaking capacity of devices and the cooling capacity affected by the air density.

Environmental conditions

Degree of pollution

Standards Theory

IEC 60664-1

1

Pollution is defined as the introduction of solid, liquid or gaseous foreign bodies that can reduce the dielectric strength or resistivity of the insulator surface.

There are four levels of pollution:

Level	Description
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 becomes conductive due to condensation is to be expected.
Pollution degree 4	The pollution generates persistent conductivity caused by conductive dust, rain or other humid conditions.

Generally, unless otherwise specified, assemblies for industrial applications are intended to be used in an environment with a pollution degree 3.

Pollution degree 4 does not apply to the inside of an assembly that complies with IEC 61439-1.

IEC 61439-1
§ 7.1.3 + table 2

2

Creepage distances and clearances must be determined according to:

- the rated clearance voltage Ui of the table,
- the type of insulating material (which defines the material group),
- the pollution degree in the environment.

> *See chapter 3 "Main busbars".*

Temperature rise limits

Temperature rise limits

Standards Theory

IEC 61439-1
Table 6

1 The standard specifies temperature rise limits for each section of the switchboard *(> see table 6 of standard 61439-1).*

Temperature rises must not cause damage to the components through which the current passes or to adjacent components.

Example

- The temperature of a metal manual control device should never exceed 50°C (35°C + 15 K).

- The temperature of an external metal surface should never exceed 65°C (35°C + 30 K).

IEC 61439-1
Table 6

2 Temperature rise limits must be specified by the original manufacturer. They must meet the specifications of standard IEC 61439-1. They must be checked using one or more of the methods below:

- tests with current,
- deductions of characteristics based on a design subject to tests for similar solutions,
- calculations.

3 **Some temperature values to comply with:**

140°C	for main busbars (bare copper) (35°C + 105 K)
125°C	for insulated flexible busbars (35°C + 90 K)
105°C	for terminals for insulated external conductors (35°C + 70 K)
65°C	for external metal surfaces (35°C + 30 K)
60°C	for manual control devices in insulating material (35°C + 25 K)

Tip

35°C is the ambient temperature value taken as a reference and the value expressed in K is the maximum permissible temperature rise.

Confinement of the switchboard

Standards Good practice

1 The degree of protection IP of a switchboard has a direct impact on its heat-dissipating capacity.

The higher the IP degree of protection, the more the switchboard is confined and the less it is able to evacuate heat. The temperature inside the switchboard will therefore rise.

To maintain the temperature inside the switchboard within the operating limits of the devices, it may be necessary to limit the permissible current in the devices: this is called derating.

Assembly builders provide tables that give the in situ performance of enclosures, devices and related conductors depending on the switchboard characteristics and environmental conditions.

These values must be taken into account when selecting busbars and the switchgear.

In some cases, it is necessary to apply an additional derating coefficient compared with the values given in the tables:

- 0.8 for flat bars,
- 0.8 for nickel-plated bars.

Example

An IP55 protection rating confines much more than an IP30 rating:
> see standard IEC 60529.

For each type of switchgear, Schneider Electric provides derating tables (see the catalogues):

Permissible current (A)

Type of switchgear	IP31					IP41/54				
	35°C	40°C	45°C	50°C	55°C	35°C	40°C	45°C	50°C	55°C
NW08 N/H/L	800	800	800	800	800	800	800	800	800	800
NW10 N/H/L	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
NW12 N1	1250	1250	1250	1250	1200	1250	1250	1250	1250	1200
NW16 N1	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600
NW20 H	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
NW25 H	2500	2500	2500	2500	2430	2500	2500	2500	2500	2430
NW32 H	3200	3200	3200	3120	3050	3200	3200	3200	3120	3050

Derating table of NWxx devices depending on the IP rating of the switchboard and the ambient temperature around the switchboard.

IEC 61439-2 § 8.101

2 The partitions installed for the forms limit heat dissipation through natural convection. They may cause temperature rises on devices and their connections (hottest points).

Example

A complete partition (form 4) dissipates less heat than a non-partitioned switchboard (form 1):
> see standard IEC 61439-2 § 8.101.

Internal temperature of the switchboard too low

Internal temperature of the switchboard too low

Standards

Good practice

IEC 61439-1
§ 8.2.2

1 For switchboards that are intended to be used in very humid locations and temperatures with wide variations, the appropriate measures must be taken (airing and/or internal heating, drainage holes, etc.) must be taken to prevent harmful condensation inside the switchboard.

Always make sure that the IP degree of protection is maintained.

2 The most common method for raising the internal temperature of a switchboard is heating with resistances.
It makes it possible:

- to avoid the formation of condensation water by limiting temperature variations,
- to protect the installation from frost.

Take the following precautions when installing heating resistances:

- heating resistances must not be installed too close to the switchgear.
- lay out and clamp the conductors in such a manner that they are sufficiently far from the heating element.

3 The air must be clean and its relative humidity must not exceed 50 % at a maximum temperature of +40°C.
Higher levels of relative humidity may be accepted at lower temperatures, e.g. 90 % at +20°C. You must take into account the slight condensation that may occur occasionally as a result of temperature variations.

Reference documents

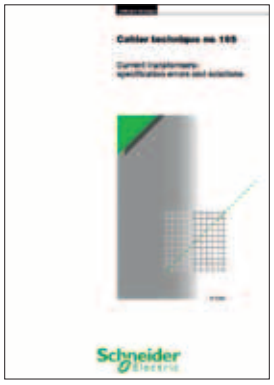
Publications

Documents on IEC 61 439

IEC 61439-1&2 standard
Ref.: DESWED101028EN

Quality inspection guide
Ref.: DESWED101005EN

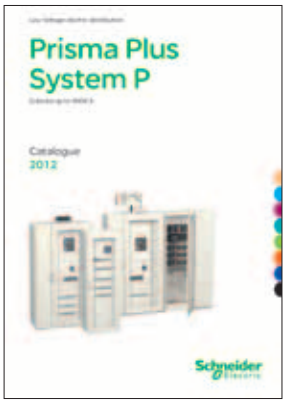
Cahiers techniques



Available on our website

Product catalogue

Prisma G catalogue
Ref.: DESW015EN



Prisma P catalogue
Ref.: DESW016EN

Prisma PH catalogue

Universal Enclosures catalogue
Ref.: UE12MK01EN

Blokset Installation guide
Ref.: DESY014EN

Okken catalogue
Ref.: DESY013EN

Okken 70-M catalogue
Ref.: DESWED211001EN

Publications

Technical guide

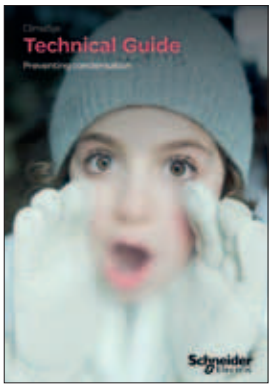
How to reduce damage to components through effective thermal management
Ref.: CPTG001

How to prevent machine malfunctions and electronic damage due to voltage surges?
Ref.: CPTG002

How to protect a machine from malfunctions due to electromagnetic disturbance
Ref.: CPTG003

How can the deterioration of electrical equipment installed in an outdoor enclosure be prevented?
Ref.: CPTG004

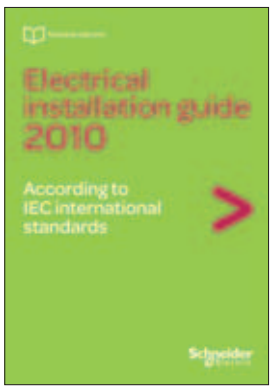
How to ensure trouble-free approval of your UL-compliant control panels
Ref.: CPTG005



Preventing condensation
Ref.: UE12MK03EN

How to choose the right cable entry for your enclosure
Ref.: UE12MK04EN

Solutions for Continuity of Service in Prisma Plus electrical installations
Ref.: COM-POWER-LVIS01EN



Electrical installation guide 2010
Ref.: EIGED306001EN

Online consultations

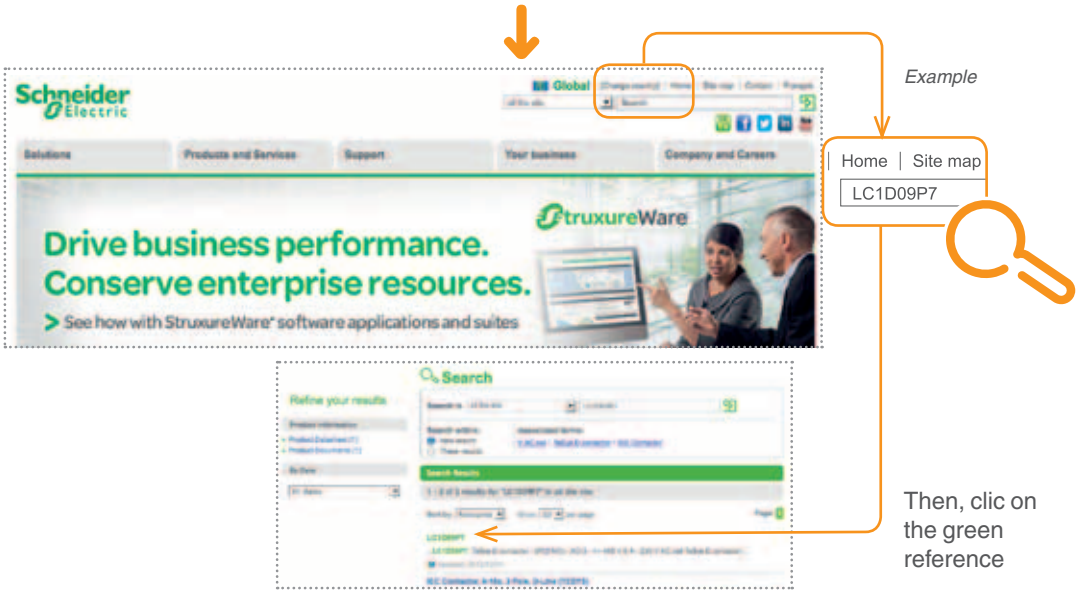
All technical information about products listed in this guide are now available on: www.schneider-electric.com

Browse the "product datasheet" to check out:

> Characteristics
> Dimensions
> And also links to user guides, curves, CAD files…

1

From the home page, type the product reference into the "Search" box.



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2

The product datasheet appears with the technical data and product characteristics at the bottom of the page.

Access to related downloads

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Notes

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