# 2 The installation system



*Distribution switchboards, including the main LV switchboard (MLVS), are critical to the dependability of an electrical installation. They must comply with well-defined standards governing the design and construction of LV switchgear assemblies*

## 2.1 Distribution switchboards

A distribution switchboard is the point at which an incoming-power supply divides into separate circuits, each of which is controlled and protected by the fuses or switchgear of the switchboard. A distribution switchboard is divided into a number of functional units, each comprising all the electrical and mechanical elements that contribute to the fulfilment of a given function. It represents a key link in the dependability chain.

Consequently, the type of distribution switchboard must be perfectly adapted to its application. Its design and construction must comply with applicable standards and working practises.

The distribution switchboard enclosure provides dual protection:

- Protection of switchgear, indicating instruments, relays, fusegear, etc. against mechanical impacts, vibrations and other external influences likely to interfere with operational integrity (EMI, dust, moisture, vermin, etc.)
- The protection of human life against the possibility of direct and indirect electric shock (see degree of protection IP and the IK index in section 3.3 of Chapter E).

### Types of distribution switchboards

*The load requirements dictate the type of distribution switchboard to be installed*

Distribution switchboards may differ according to the kind of application and the design principle adopted (notably in the arrangement of the busbars).

**Distribution switchboards according to specific applications**

The principal types of distribution switchboards are:

- The main LV switchboard - MLVS - (see **Fig. E27a**)
- Motor control centres - MCC - (see **Fig. E27b**)
- Sub-distribution switchboards (see **Fig. E28**)
- Final distribution switchboards (see **Fig. E29**)

Distribution switchboards for specific applications (e.g. heating, lifts, industrial processes) can be located:

- Adjacent to the main LV switchboard, or
- Near the application concerned

Sub-distribution and final distribution switchboards are generally distributed throughout the site.

a b

*Fig. E27 : **[a]** A main LV switchboard - MLVS - (Prisma Plus P) with incoming circuits in the form of busways - **[b]** A LV motor control centre - MCC - (Okken)*

*Fig. E28 : A sub-distribution switchboard (Prisma Plus G)*

a b c

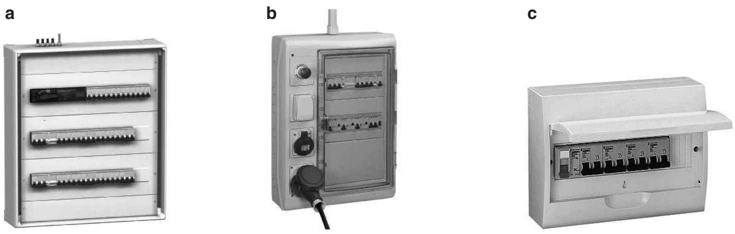


*Fig. E29 : Final distribution switchboards **[a]** Prisma Plus G Pack; **[b]** Kaedra; **[c]** mini-Pragma*

*A distinction is made between:*

*■ Traditional distribution switchboards in which switchgear and fusegear, etc. are fixed to a chassis at the rear of an enclosure*

*■ Functional distribution switchboards for specific applications, based on modular and standardised design.*

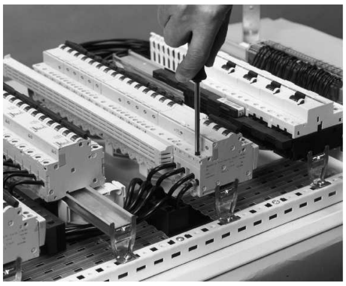


*Fig. E30 : Assembly of a final distribution switchboard with fixed functional units (Prisma Plus G)*

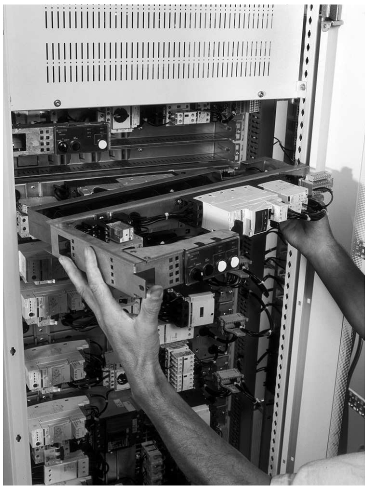


*Fig. E31 : Distribution switchboard with disconnectable functional units*

*Fig. E32 : Distribution switchboard with withdrawable functional units in drawers*

## Two technologies of distribution switchboards

### Traditional distribution switchboards

Switchgear and fusegear, etc. are normally located on a chassis at the rear of the enclosure. Indications and control devices (meters, lamps, pushbuttons, etc.) are mounted on the front face of the switchboard.

The placement of the components within the enclosure requires very careful study, taking into account the dimensions of each item, the connections to be made to it, and the clearances necessary to ensure safe and trouble-free operation. .

### Functional distribution switchboards

Generally dedicated to specific applications, these distribution switchboards are made up of functional modules that include switchgear devices together with standardised accessories for mounting and connections, ensuring a high level of reliability and a great capacity for last-minute and future changes.

■ Many advantages

The use of functional distribution switchboards has spread to all levels of LV electrical distribution, from the main LV switchboard (MLVS) to final distribution switchboards, due to their many advantages:

□ System modularity that makes it possible to integrate numerous functions in a single distribution switchboard, including protection, control, technical management and monitoring of electrical installations. Modular design also enhances distribution switchboard maintenance, operation and upgrades

□ Distribution switchboard design is fast because it simply involves adding functional modules

□ Prefabricated components can be mounted faster

□ Finally, these distribution switchboards are subjected to type tests that ensure a high degree of dependability.

The new Prisma Plus G and P ranges of functional distribution switchboards from Schneider Electric cover needs up to 3200 A and offer:

□ Flexibility and ease in building distribution switchboards

□ Certification of a distribution switchboard complying with standard IEC 60439 and the assurance of servicing under safe conditions

□ Time savings at all stages, from design to installation, operation and modifications or upgrades

□ Easy adaptation, for example to meet the specific work habits and standards in different countries

Figures E27a, E28 and E29 show examples of functional distribution switchboards ranging for all power ratings and figure E27b shows a high-power industrial functional distribution switchboard.

■ Main types of functional units

Three basic technologies are used in functional distribution switchboards.

□ Fixed functional units (see **Fig. E30**)

These units cannot be isolated from the supply so that any intervention for maintenance, modifications and so on, requires the shutdown of the entire distribution switchboard. Plug-in or withdrawable devices can however be used to minimise shutdown times and improve the availability of the rest of the installation.

□ Disconnectable functional units (see **Fig. E31**)

Each functional unit is mounted on a removable mounting plate and provided with a means of isolation on the upstream side (busbars) and disconnecting facilities on the downstream (outgoing circuit) side. The complete unit can therefore be removed for servicing, without requiring a general shutdown.

□ Drawer-type withdrawable functional units (see **Fig. E32**)

The switchgear and associated accessories for a complete function are mounted on a drawer-type horizontally withdrawable chassis. The function is generally complex and often concerns motor control.

Isolation is possible on both the upstream and downstream sides by the complete withdrawal of the drawer, allowing fast replacement of a faulty unit without de-energising the rest of the distribution switchboard.

*Compliance with applicable standards is essential in order to ensure an adequate degree of dependability*

*Three elements of standard IEC 60439-1 contribute significantly to dependability:*
- *Clear definition of functional units*
- *Forms of separation between adjacent functional units in accordance with user requirements*
- *Clearly defined routine tests and type tests*

## Standards

### Different standards

Certain types of distribution switchboards (in particular, functional distribution switchboards) must comply with specific standards according to the application or environment involved.

The reference international standard is IEC 60439-1 type-tested and partially type-tested assemblies

### Standard IEC 60439-1

- Categories of assemblies

Standard IEC 60439-1 distinguishes between two categories of assemblies:
- Type-tested LV switchgear and controlgear assemblies (TTA), which do not diverge significantly from an established type or system for which conformity is ensured by the type tests provided in the standard
- Partially type-tested LV switchgear and controlgear assemblies (PTTA), which may contain non-type-tested arrangements provided that the latter are derived from type-tested arrangements

When implemented in compliance with professional work standards and manufacturer instructions by qualified personnel, they offer the same level of safety and quality.

- Functional units

The same standard defines functional units:
- Part of an assembly comprising all the electrical and mechanical elements that contribute to the fulfilment of the same function
- The distribution switchboard includes an incoming functional unit and one or more functional units for outgoing circuits, depending on the operating requirements of the installation

What is more, distribution switchboard technologies use functional units that may be fixed, disconnectable or withdrawable (see section 3.1 of Chapter E).

- Forms (see **Fig. E33**)

Separation of functional units within the assembly is provided by forms that are specified for different types of operation.
The various forms are numbered from 1 to 4 with variations labelled “a” or “b”. Each step up (from 1 to 4) is cumulative, i.e. a form with a higher number includes the characteristics of forms with lower numbers. The standard distinguishes:
- Form 1: No separation
- Form 2: Separation of busbars from the functional units
- Form 3: Separation of busbars from the functional units and separation of all functional units, one from another, except at their output terminals
- Form 4: As for Form 3, but including separation of the outgoing terminals of all functional units, one from another

The decision on which form to implement results from an agreement between the manufacturer and the user.
The Prima Plus functional range offers solutions for forms 1, 2b, 3b, 4a, 4b.

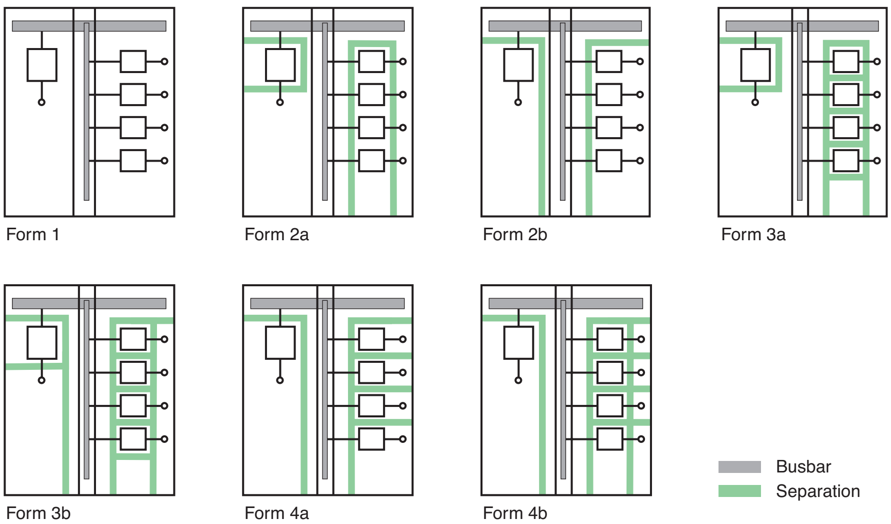



*Fig. E33 : Representation of different forms of LV functional distribution switchboards*

■ Type tests and routine tests
They ensure compliance of each distribution switchboard with the standard. The availability of test documents certified by independent organisations is a guarantee for users.

*Total accessibility of electrical information and intelligent distribution switchboards are now a reality*

### Remote monitoring and control of the electrical installation

Remote monitoring and control are no longer limited to large installations.
These functions are increasingly used and provide considerable cost savings.
The main potential advantages are:

■ Reductions in energy bills
■ Reductions in structural costs to maintain the installation in running order
■ Better use of the investment, notably concerning optimisation of the installation life cycle
■ Greater satisfaction for energy users (in a building or in process industries) due to improved power availability and/or quality

The above possibilities are all the more an option given the current deregulation of the electrical-energy sector.
Modbus is increasingly used as the open standard for communication within the distribution switchboard and between the distribution switchboard and customer power monitoring and control applications. Modbus exists in two forms, twisted pair (RS 485) and Ethernet-TCP/IP (IEEE 802.3).
The www.modbus.org site presents all bus specifications and constantly updates the list of products and companies using the open industrial standard.
The use of web technologies has largely contributed to wider use by drastically reducing the cost of accessing these functions through the use of an interface that is now universal (web pages) and a degree of openness and upgradeability that simply did not exist just a few years ago.

*Two types of distribution are possible:*
*■ By insulated wires and cables*
*■ By busbar trunking (busways)*

## 2.2 Cables and busway trunking

### Distribution by insulated conductors and cables

**Definitions**

■ Conductor

A conductor comprises a single metallic core with or without an insulating envelope.

■ Cable

A cable is made up of a number of conductors, electrically separated, but joined mechanically, generally enclosed in a protective flexible sheath.

■ Cableway

The term cableway refers to conductors and/or cables together with the means of support and protection, etc. for example : cable trays, ladders, ducts, trenches, and so on… are all “cableways”.

**Conductor marking**

Conductor identification must always respect the following three rules:

■ Rule 1
The double colour green and yellow is strictly reserved for the PE and PEN protection conductors.

■ Rule 2
□ When a circuit comprises a neutral conductor, it must be light blue or marked “1” for cables with more than five conductors
□ When a circuit does not have a neutral conductor, the light blue conductor may be used as a phase conductor if it is part of a cable with more than one conductor

■ Rule 3
Phase conductors may be any colour except:
□ Green and yellow
□ Green
□ Yellow
□ Light blue (see rule 2)

Conductors in a cable are identified either by their colour or by numbers (see **Fig. E34**).

| Number of conductors in circuit | Circuit | Fixed cableways | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Insulated conductors | | | | | Rigid and flexible multi-conductor cables | | | | |
| | | Ph | Ph | Pn | N | PE | Ph | Ph | Ph | N | PE |
| 1 | Protection or earth | | | | | G/Y | | | | | |
| 2 | Single-phase between phases | ■ | ■ | | | | BL | LB | | | |
| | Single-phase between phase and neutral | ■ | | | LB | | BL | | | LB | |
| | Single-phase between phase and neutral + protection conductor | ■ | | | G/Y | | BL | | | G/Y | |
| 3 | Three-phase without neutral | ■ | ■ | ■ | | | BL | B | LB | | |
| | 2 phases + neutral | ■ | ■ | | LB | | BL | B | | LB | |
| | 2 phases + protection conductor | ■ | ■ | | | G/Y | BL | LB | | | G/Y |
| | Single-phase between phase and neutral + protection conductor | ■ | | | LB | G/Y | BL | | | LB | G/Y |
| 4 | Three-phase with neutral | ■ | ■ | ■ | LB | | BL | B | BL | LB | |
| | Three-phase with neutral + protection conductor | ■ | ■ | ■ | | G/Y | BL | B | LB | | G/Y |
| | 2 phases + neutral + protection conductor | ■ | ■ | | LB | G/Y | BL | B | | LB | G/Y |
| | Three-phase with PEN conductor | ■ | ■ | ■ | G/Y | | BL | B | LB | G/Y | |
| 5 | Three-phase + neutral + protection conductor | ■ | ■ | ■ | LB | G/Y | BL | B | BL | LB | G/Y |
| > 5 | | Protection conductor: G/Y - Other conductors: BL: with numbering<br>The number “1” is reserved for the neutral conductor if it exists | | | | | | | | | |

G/Y: Green and yellow    BL: Black    ■ : As indicated in rule 3    LB: Light blue    B: Brown

*Fig. E34 : Conductor identification according to the type of circuit*

**Note**: If the circuit includes a protection conductor and if the available cable does not have a green and yellow conductor, the protection conductor may be:

- A separate green and yellow conductor
- The blue conductor if the circuit does not have a neutral conductor
- A black conductor if the circuit has a neutral conductor

In the last two cases, the conductor used must be marked by green and yellow bands or markings at the ends and on all visible lengths of the conductor.

Equipment power cords are marked similar to multi-conductor cables (see **Fig. E35**).

**Distribution and installation methods** (see **Fig. E36**)

Distribution takes place via cableways that carry single insulated conductors or cables and include a fixing system and mechanical protection.

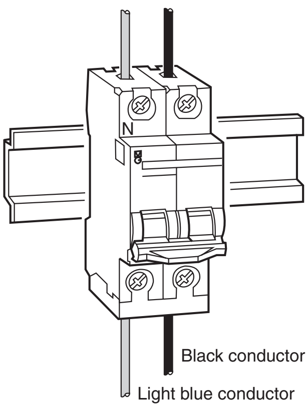



*Fig. E35 : Conductor identification on a circuit-breaker with a phase and a neutral*

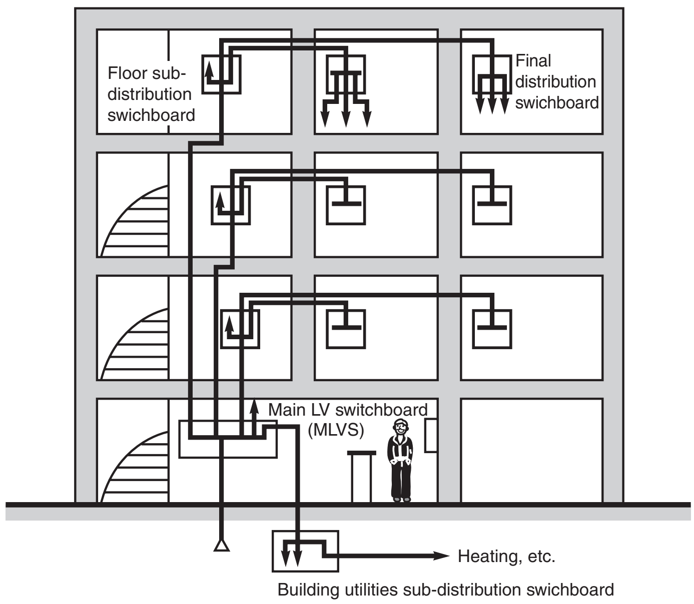



*Fig. E36 : Radial distribution using cables in a hotel*

*Busways, also referred to as busbar trunking systems, stand out for their ease of installation, flexibility and number of possible connection points*

## Busbar trunking (busways)

Busbar trunking is intended to distribute power (from 20 A to 5000 A) and lighting (in this application, the busbar trunking may play a dual role of supplying electrical power and physically holding the lights).

## Busbar trunking system components

A **busbar trunking** system comprises a set of conductors protected by an enclosure (see **Fig. E37**). Used for the transmission and distribution of electrical power, busbar trunking systems have all the necessary features for fitting: connectors, straights, angles, fixings, etc. The tap-off points placed at regular intervals make power available at every point in the installation.

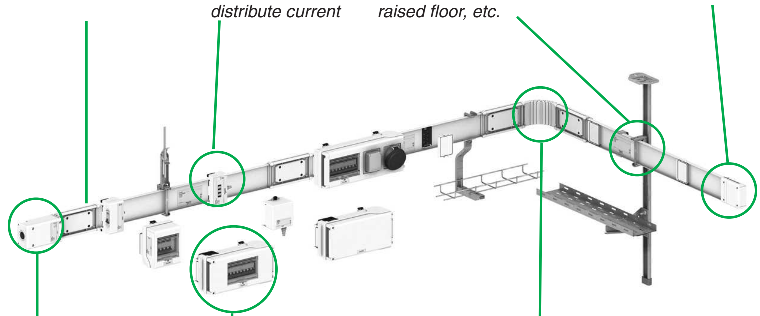



*Fig. E37 : Busbar trunking system design for distribution of currents from 25 to 4000 A.*

## The various types of busbar trunking:

Busbar trunking systems are present at every level in electrical distribution: from the link between the transformer and the low voltage switch switchboard (MLVS) to the distribution of power sockets and lighting to offices, or power distribution to workshops.

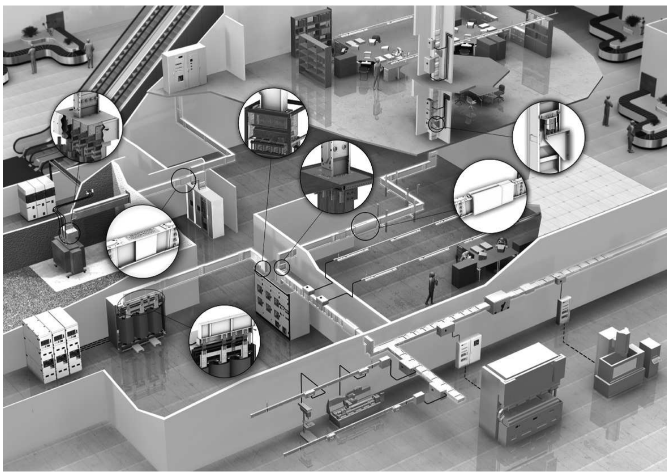


*Fig. E38 : Radial distribution using busways*

We talk about a distributed network architecture.

There are essentially three categories of busways.

■ Transformer to MLVS busbar trunking

Installation of the busway may be considered as permanent and will most likely never be modified. There are no tap-off points.

Frequently used for short runs, it is almost always used for ratings above 1,600 / 2,000 A, i.e. when the use of parallel cables makes installation impossible. Busways are also used between the MLVS and downstream distribution switchboards.

The characteristics of main-distribution busways authorize operational currents from 1,000 to 5,000 A and short-circuit withstands up to 150 kA.

■ Sub-distribution busbar trunking with low or high tap-off densities

Downstream of main-distribution busbar trunking , two types of applications must be supplied:

□ Mid-sized premises (industrial workshops with injection presses and metalwork machines or large supermarkets with heavy loads). The short-circuit and current levels can be fairly high (respectively 20 to 70 kA and 100 to 1,000 A)

□ Small sites (workshops with machine-tools, textile factories with small machines, supermarkets with small loads). The short-circuit and current levels are lower (respectively 10 to 40 kA and 40 to 400 A)

Sub-distribution using busbar trunking meets user needs in terms of:

□ Modifications and upgrades given the high number of tap-off points

□ Dependability and continuity of service because tap-off units can be connected under energized conditions in complete safety

The sub-distribution concept is also valid for vertical distribution in the form of 100 to 5,000 A risers in tall buildings.

■ Lighting distribution busbar trunking

Lighting circuits can be distributed using two types of busbar trunking according to whether the lighting fixtures are suspended from the busbar trunking or not.

□ busbar trunking designed for the suspension of lighting fixtures

These busways supply and support light fixtures (industrial reflectors, discharge lamps, etc.). They are used in industrial buildings, supermarkets, department stores and warehouses. The busbar trunkings are very rigid and are designed for one or two 25 A or 40 A circuits. They have tap-off outlets every 0.5 to 1 m.

□ busbar trunking not designed for the suspension of lighting fixtures

Similar to prefabricated cable systems, these busways are used to supply all types of lighting fixtures secured to the building structure. They are used in commercial buildings (offices, shops, restaurants, hotels, etc.), especially in false ceilings. The busbar trunking is flexible and designed for one 20 A circuit. It has tap-off outlets every 1.2 m to 3 m.

Busbar trunking systems are suited to the requirements of a large number of buildings.

■ Industrial buildings: garages, workshops, farm buildings, logistic centers, etc.

■ Commercial areas: stores, shopping malls, supermarkets, hotels, etc.

■ Tertiary buildings: offices, schools, hospitals, sports rooms, cruise liners, etc.

### Standards

Busbar trunking systems must meet all rules stated in IEC 439-2.

This defines the manufacturing arrangements to be complied with in the design of busbar trunking systems (e.g.: temperature rise characteristics, short-circuit withstand, mechanical strength, etc.) as well as test methods to check them.

Standard IEC 439-2 defines 13 compulsory type-tests on configurations or system components..

By assembling the system components on the site according to the assembly instructions, the contractor benefits from conformity with the standard.

### The advantages of busbar trunking systems

#### Flexibility

■ Easy to change configuration (on-site modification to change production line configuration or extend production areas).

■ Reusing components (components are kept intact): when an installation is subject to major modifications, the busbar trunking is easy to dismantle and reuse.

■ Power availability throughout the installation (possibility of having a tap-off point every meter).

■ Wide choice of tap-off units.

**Simplicity**

■ Design can be carried out independently from the distribution and layout of current consumers.
■ Performances are independent of implementation: the use of cables requires a lot of derating coefficients.
■ Clear distribution layout
■ Reduction of fitting time: the trunking system allows fitting times to be reduced by up to 50% compared with a traditional cable installation.
■ Manufacturer's guarantee.
■ Controlled execution times: the trunking system concept guarantees that there are no unexpected surprises when fitting. The fitting time is clearly known in advance and a quick solution can be provided to any problems on site with this adaptable and scalable equipment.
■ Easy to implement: modular components that are easy to handle, simple and quick to connect.

**Dependability**

■ Reliability guaranteed by being factory-built
■ Fool-proof units
■ Sequential assembly of straight components and tap-off units making it impossible to make any mistakes

**Continuity of service**

■ The large number of tap-off points makes it easy to supply power to any new current consumer. Connecting and disconnecting is quick and can be carried out in complete safety even when energized. These two operations (adding or modifying) take place without having to stop operations.
■ Quick and easy fault location since current consumers are near to the line
■ Maintenance is non existent or greatly reduced

**Major contribution to sustainable development**

■ Busbar trunking systems allow circuits to be combined. Compared with a traditional cable distribution system, consumption of copper raw materials and insulators is divided by 3 due to the busbar trunking distributed network concept (see **Fig. E39**).

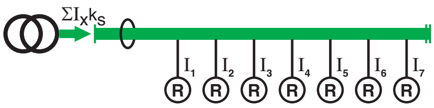
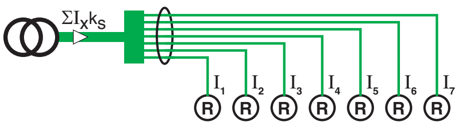
| Distribution type | Conductors | Insulators | Consumption |
|---|---|---|---|
| **Branched** | | | |
|   ks: clustering coefficient= 0.6 | Alu: 128 mm$^2$ Copper equivalent: 86 mm$^2$ | 4 kg | 1 000 Joules |
| **Centralized** | | | |
|   ks: clustering coefficient= 0.6 | Copper: 250 mm$^2$ | 12 kg | 1 600 Joules |

*Fig. E39 : Example: 30 m of Canalis KS 250A equipped with 10 25 A, four-pole feeders*

■ Reusable device and all of its components are fully recyclable.
■ Does not contain PVC and does not generate toxic gases or waste.
■ Reduction of risks due to exposure to electromagnetic fields.

## New functional features for Canalis

Busbar trunking systems are getting even better. Among the new features we can mention:
■ Increased performance with a IP55 protection index and new ratings of 160 A through to 1000 A (Ks).
■ New lighting offers with pre-cabled lights and new light ducts.
■ New fixing accessories. Quick fixing system, cable ducts, shared support with "VDI" (voice, data, images) circuits.

**Busbar trunking systems are perfectly integrated with the environment:**

- white color to enhance the working environment, naturally integrated in a range of electrical distribution products.
- conformity with European regulations on reducing hazardous materials (RoHS).

### Examples of Canalis busbar trunking systems

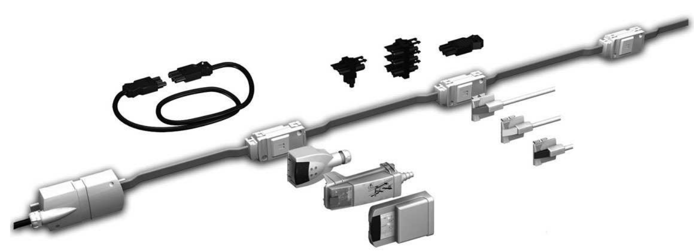


*Fig. E40 : Flexible busbar trunking not capable of supporting light fittings : Canalis KDP (20 A)*

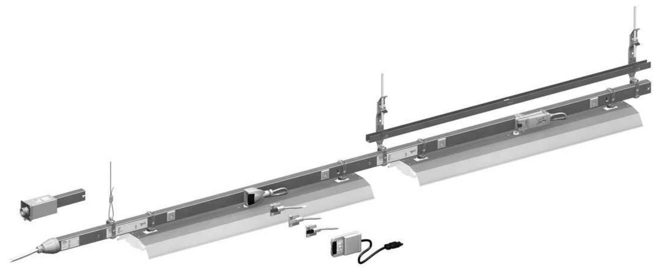


*Fig. E41 : Rigid busbar trunking able to support light fittings : Canalis KBA or KBB (25 and 40 A)*

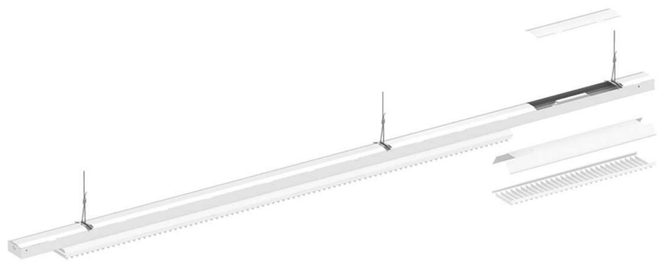


*Fig. E42 : Lighting duct : Canalis KBX (25 A)*

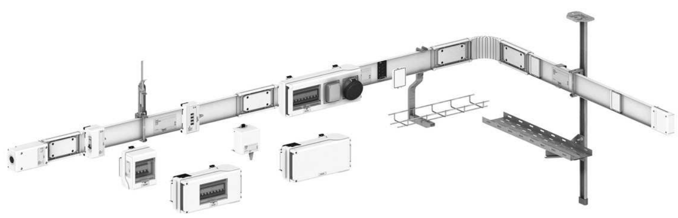


*Fig. E43 : A busway for medium power distribution : Canalis KN (40 up to 160 A)*

# 2 The installation system

*Fig. E44 : A busway for medium power distribution : Canalis KS (100 up to 1000 A)*



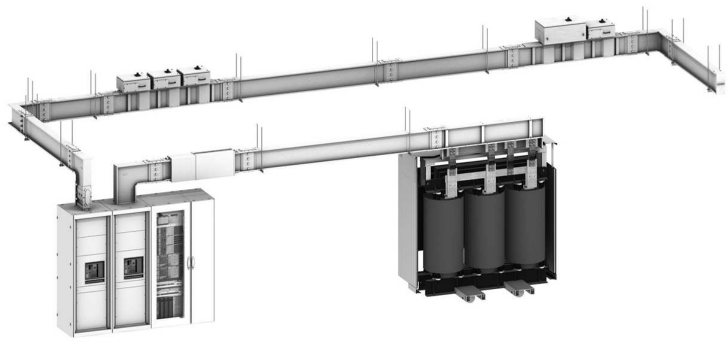


*Fig. E45 : A busway for high power distribution : Canalis KT (800 up to 1000 A)*