WORKSHOP SPECIFICATIONS

CONSTRUCTION AND CERTIFICATION OF ASSEMBLIES IN ACCORDANCE WITH IEC 61439-1 & 2

THE GLOBAL SPECIALIST IN ELECTRICAL AND DIGITAL BUILDING INFRASTRUCTURES

legrand®

The new standards IEC 61439-1 and IEC 61439-2 replaced the previous standard IEC 60439-1 in January 2009.
All new assemblies must comply with these new standards.
Standard IEC 61439-1 defines the general rules for low voltage switchgear assemblies. It gives the definitions and indicates the conditions of use, construction requirements, technical characteristics and verification requirements.
IEC 61439-2 is a product standard which defines the specific requirements (assembly rules).
The new IEC 61439 series of standards thus defines the construction of low voltage switchgear assemblies and their inspection more precisely, specifying the responsibilities of those involved and differentiating between the role of the original manufacturer (Legrand) and that of the assembly manufacturer (panel builder).
Legrand, as the original manufacturer, is responsible for carrying out the 13 design verifications defined in Annex D of standard IEC 61439-1, leading to the issuing of certificates of conformity.
The assembly manufacturer builds the electrical enclosure in accordance with the assembly rules specified in this guide.
The assembly manufacturer conducts the 10 individual routine verifications on each assembly produced, leading to the assembly manufacturer drawing up a declaration of conformity and approving the assembly.
The purpose of these workshop specifications is to assist assembly manufacturers by defining the main construction rules and detailing the IEC 61439 (August 2011 version) certification procedure.

CONTENTS

CONSTRUCTION OF ASSEMBLIES

Construction rules for metal assemblies

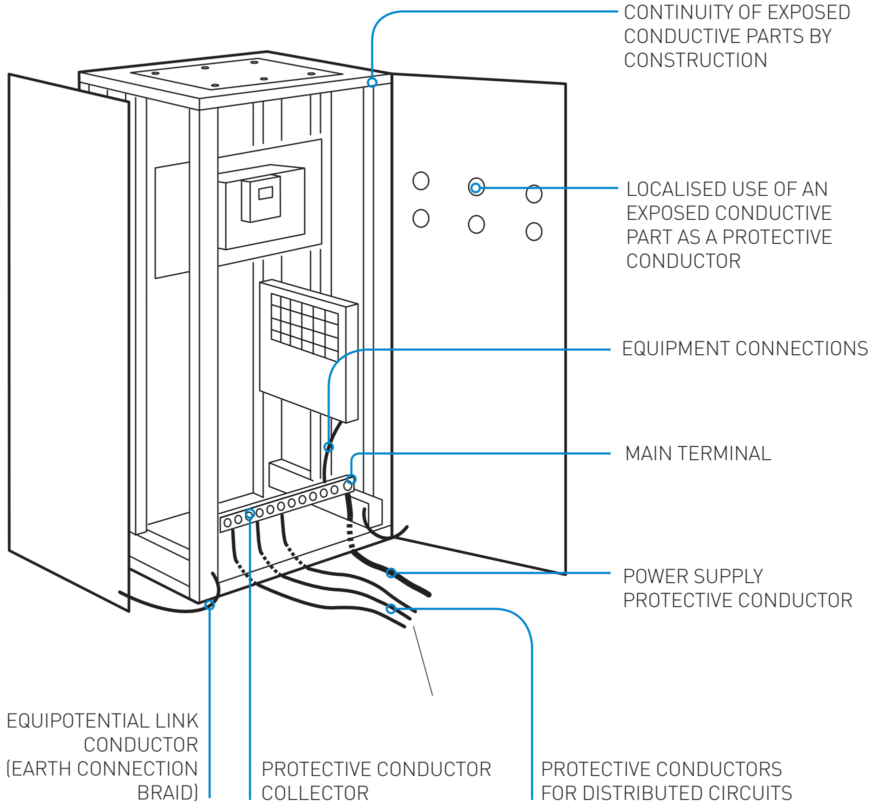
The rules described below summarise the requirements of IEC 60204-1, IEC 61439-2, IEC 60364 and IEC 1140 standards and common sense construction recommendations.

All metal parts that can be directly accessed by the user are considered to be exposed conductive parts, even if they are covered with paint or coatings, unless these prove to have insulating qualities that are known and have been tested at the thickness applied (example: film bonded to the part). The concept of exposed conductive parts is also extended to the following:

- All metal parts that are inaccessible to the user but can be accessed by a worker, even a qualified worker, including after dismantling, due to the fact that their layouts or dimensions lead to an appreciable risk of contact (examples: rails, plates, device supports, etc.).
- All intermediate metal parts that are inaccessible but are in mechanical contact with the exposed conductive parts, due to the fact that they can spread a voltage (example: mechanism transmissions).

Parts that are totally inaccessible (to staff using them or working on them), exposed conductive parts which, due to their small size (less than 50 x 50 mm) cannot come into contact with the body (unless they can be gripped by the fingers or held in the hand), contactor cores, electromagnets, etc. are not considered to be exposed conductive parts and do not have to be connected to a protective conductor.

CONNECTING EXPOSED CONDUCTIVE PARTS



CONNECTING THE PROTECTIVE CONDUCTOR

The protective conductor collector, marked with the symbol ⏚, is connected to the chassis or the main structure. It has a terminal for connecting the protective conductor of the power supply. This terminal must be sized to take a conductor with the cross-section defined in the table below. The protective conductors of the load circuits are connected to the same collector. Their tap-off at the same screw point is not permitted. With the exception of the collector bars of power assemblies designed to be connected via terminals, a single tapped hole or a tab for solder connector is not considered to be adequate. It is not permitted to scrape off paint or remove a coating.

MINIMUM CROSS-SECTION OF THE PROTECTIVE CONDUCTOR (IEC 61439-1, SECTION 8.8, TABLE 5)

CROSS-SECTION OF PHASE CONDUCTORS S_{PH} (mm²)	MINIMUM CROSS-SECTION OF THE CORRESPONDING PROTECTIVE CONDUCTOR S_{PE} (mm²)
$S_{ph} < 16$	S_{ph}
$16 < S_{ph} < 35$	16
$35 < S_{ph} < 400$	$S_{ph}/2$
$400 < S_{ph} < 800$	200
$S_{ph} < 800$	$S_{ph}/4$

EQUIPOTENTIALITY OF EXPOSED CONDUCTIVE PARTS

Exposed conductive parts must be electrically connected to one another so that no dangerous voltage can arise between exposed conductive parts that are accessible simultaneously. This continuity can be obtained by construction or by using equipotential link conductors.

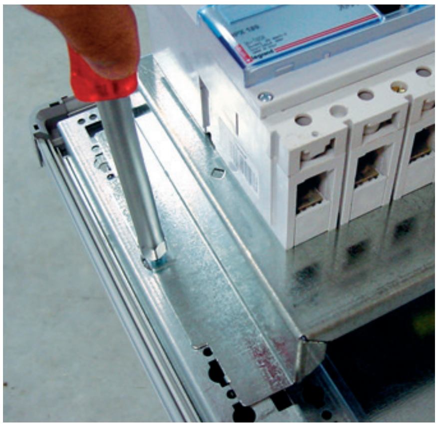
CONTINUITY OF EXPOSED CONDUCTIVE PARTS BY CONSTRUCTION

The connections between the various components in the assembly must be effectively protected against mechanical and chemical damage. The electrochemical compatibility of the metals must be checked. The removal of a component must not lead to discontinuity of the connection. The exposed conductive parts must not therefore be connected "in series".

As far as possible the electrical connection must be dependent on the mechanical fixing (for example, common screw), in such a way that the second function cannot be achieved without the first.

Redundancy of the connection points is recommended. For covers, plates and similar parts, metal fixings, screws, bolts and rivets are considered to be adequate if all traces of paint have been removed and if no electrical equipment (without its own protective conductor) is fixed onto them.

Systems using clips, pins, washers with pins or grooved rivets that pierce the surface coating must be checked in accordance with the continuity test (see page 55).

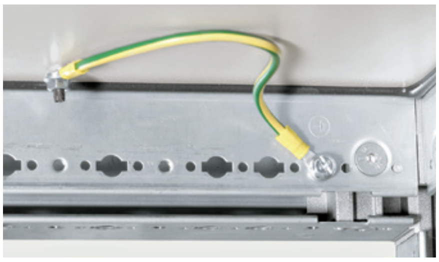


XL³ equipment provides continuity of exposed conductive parts by construction

CONTINUITY OF EXPOSED CONDUCTIVE PARTS VIA EQUIPOTENTIAL LINK CONDUCTORS

When the exposed conductive parts (door, protective screen, closing panel, etc.) do not have any devices or equipment fixed on them, the equipotential connection of these exposed conductive parts must be provided using a conductor, minimum cross-section 2.5 mm² if it is protected mechanically (conductor in a multicore cable, conductor insulated in a protective sheath, with the conductor attached along its entire run, etc.). This cross-section must be increased to 4 mm² if the link conductor is not protected or if it is subject to repeated operations (opening of a door, handling). The connections of this conductor must themselves have a reliable contact with the connected exposed conductive parts (paint removed, protection against corrosion and loosening). The continuity must be checked in accordance with the methods described on page 55.

NB: The equipotential connections created by conductors are generally independent of the mechanical functions and may for this reason not be re-connected after maintenance work has been carried out. To limit the risk of this happening, the links must if possible be close to the fixings and must be unambiguously labelled: green/yellow conductors or marked at both ends using these colours and presence of the symbol ⏚ close to the connections.



Equipotential link between the roof and the structure of an XL³ 4000 enclosure

MINIMUM CROSS-SECTIONS OF EQUIPOTENTIAL LINK CONDUCTORS (IEC 61439-1)

RATED OPERATING CURRENT (A)	MINIMUM CROSS-SECTION OF THE EQUIPOTENTIAL LINK CONDUCTOR (mm²)
Ie ≤ 25	2.5
25 < Ie ≤ 32	4
32 < Ie ≤ 63	6
63 < Ie ≤ 80	10
80 < Ie ≤ 160	16
160 < Ie ≤ 200	25
200 < Ie ≤ 250	35

CONNECTING EQUIPMENT

When devices or equipment are fixed on exposed conductive parts, and in particular when these parts are removable (doors, panels, plates, etc.), the equipment that is attached must be connected directly with a protective conductor if it has a terminal for this purpose. The cross-section of this conductor must be chosen according to that of the phase conductors supplying the device concerned, in accordance with the table on the previous page. PE conductor terminals must not be used for any other functions (for example, mechanical fixing).

USING THE EXPOSED CONDUCTIVE PARTS AS PROTECTIVE CONDUCTORS

This type of use is permitted as long as a number of precautions are taken, but localised or specific application must nevertheless be distinguished from general or systematic application according to how widely this measure is used.

Exposed conductive parts used as protective conductors must have a conductance that is sufficient and equivalent to that which would result from the use of copper conductors. This characteristic must be checked using the tests described on page 55 (continuity of exposed conductive parts and resistance to overcurrents).

Any links between the various parts must be protected against mechanical, chemical and electrodynamic damage. The risk of dismantling a part which would lead to the protective circuit being broken must be limited:

- Either by combining an essential function with the electrical connection so that the device or equipment cannot operate normally or so that it is obviously incomplete on visual inspection
- Or by limiting the number of parts that make up the protective circuit to only one in the case of localised application of the measure
- Or by only using the structure, frame or main chassis of the device or equipment in the case of generalised application

LOCALISED USE OF AN EXPOSED CONDUCTIVE PART AS A PROTECTIVE CONDUCTOR

This measure is generally used when one or more devices that do not have a connection terminal for their own protective conductor (indicators with metal bases, metal operating mechanisms, etc.) are fixed onto a part such as a cover, panel, door, etc.

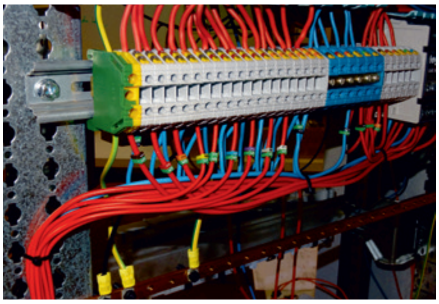
In addition to the general rules that have already been defined, the following precautions must also be taken:
- The electric contact between the support component and the device(es) must be treated to ensure it is reliable (paint removed, protection against corrosion, resistance to loosening, etc.)
- The additional equipotential link between the support component and the main protective circuit (whether this is created using exposed conductive parts or conductors) must be sized according to the maximum current, which is equal to the sum of the currents of each of the devices attached, in accordance with the table on page 28.
The value of the short-circuit current (see page 24) must be limited to that corresponding to the power supply of the most powerful device attached.

GENERALISED USE OF THE EXPOSED CONDUCTIVE PARTS AS PROTECTIVE CONDUCTORS

This measure can be applied when there is a continuous conductive structure large enough to interconnect the other exposed conductive parts and the equipotential link conductors. Connection devices or means of connection must therefore be provided accordingly, including for devices that may be installed in the future (as is the case with sets of enclosures, for example).
The equivalent cross-section S must allow any short circuit current to be carried, calculated based on the maximum current limited by the device protecting the equipment's power supply and the breaking time of this device.
If the possible fault loop, or even the protective device, is not known (which is generally the case with "empty" enclosures and cabinets), a check must be carried out to ensure that the equivalent conductive cross-section of the material used is at least equal to that of the copper protective conductor required for the installed power (see table on page 30). In practice, the copper equivalent cross-section for the materials used can be checked using the formula:

S material = n x S copper

(only valid for similar temperature and installation conditions). Where:
n: 1.5 for aluminium
n: 2.8 for iron
n: 5.4 for lead
n: 2 for brass (Cu Zn 36/40).
S: cross-section of the protective conductor in mm^2



Fixing rails (DIN rails) can be used as protective conductors as long as they are totally interconnected by their assembly and connected using appropriate Viking 3 terminal blocks.
Viking 3 terminal blocks for protective conductors have been specially designed and tested for the defined use. They comply with standard IEC 60947-7-2.
The equivalent conductivity of the rails used conforms to the determination rules in standards IEC 60364 and IEC 60947-7-2. It is certified by report LCIE 285380.

TYPE OF RAIL ACCORDING TO STANDARD IEC 60715	COPPER PE CONDUCTOR EQUIVALENT CROSS-SECTION (mm^2)
TH 35 x 5.5	10
TH 35 x 7.5	16
TH 35 x 15 Legrand (1.5 mm thick)	35
TH 35 x 15 standard (2 mm thick)	50
G 32	35

Construction rules for totally insulated assemblies

Only enclosures made of insulating materials can be referred to as having "total insulation protection".

This does not preclude metal enclosures from also being able to provide equivalent insulation according to IEC 60364-4-41.

GENERAL DESIGNING RULES FOR TOTALLY INSULATED ASSEMBLIES

- The basic insulation of the devices is doubled by supplementary insulation provided by the enclosure. This is double insulation.
- It must be possible to test the physical separation of the two insulations separately
- The metal parts are not connected to the protective conductors
- The protective conductors are considered to be live parts
- The conductors must be prevented from coming into contact with the surrounding metal parts if they become detached accidentally

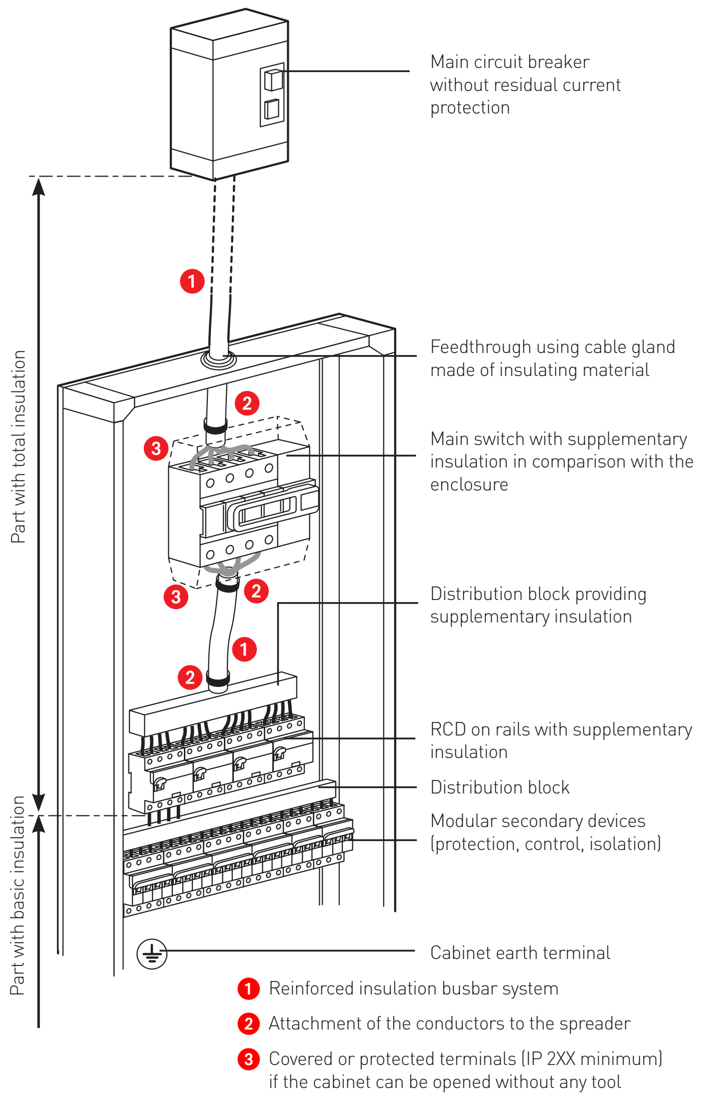
CONSTRUCTION RULES

- The panel must be built so that no voltage can be transmitted from the inside to the outside.
- The devices must be completely enclosed by insulated equipment. The symbol ⧈ must be visible from the outside.
- The enclosure must be made of an insulating material that can withstand the electrical, mechanical and thermal stresses to which it may be subjected, must withstand ageing and be fire resistant.
- The enclosure must not have holes at any point with conductive parts passing through them, so that no voltage may be transmitted to the outside of the enclosure. Mechanical parts such as the mechanisms of control devices, irrespective of their size, must therefore be insulated inside the enclosure. It must not be possible to replace insulating screws with metal screws if this adversely affects the insulation.

- The enclosure must have at least IP 3XD protection in installation position.
- The chassis and internal metal parts must not be connected to the protective circuit. This also applies to devices with a PE conductor terminal. A ⏚ mark must be affixed on the outside and the inside of the enclosure.
- It is recommended that particular care is taken with the wiring, including attaching all the conductors close to the connections, or better still, routing them in insulated ducting which will provide optimum safety if work has to be carried out.
- If a PE conductor has to pass through the panel, it must be connected on the terminals provided, clearly identified and isolated from the rest of the assembly. These conductors must then be treated in the same way as live conductors.
- If the doors or panels of the assembly can be removed without the use of a key or a tool, an obstacle made of insulated material, which cannot be removed without the use of a tool, must be provided to prevent any accidental contact with the live parts and also with the live conductive parts of the assembly.
- In addition, the wall fixing screws must not be in contact with the internal chassis (insulated washer) and must be protected against any contact (clip-on cover on the head).

According to some national requirements, assemblies can be treated with partial insulation designed to obtain total insulation when an installation is supplied by a non residual current connection device.

The installation must be built in exactly the same way as a totally insulated assembly up to the output terminals of the residual current devices which provide effective protection against indirect contact.



Selection and assembly of enclosures

A comprehensive range of enclosures, from the XL^3 160 "fully modular" cabinet to the XL^3 6300 enclosure

The selection of enclosures to create a distribution assembly depends first of all on the volume needed to install the devices and distribution systems (busbars, distribution blocks, optimised or IS (increased safety) distribution systems) and their connections. To make this selection easier, Legrand's XL^3 range is segmented according to the maximum current of the main device that can be installed in the enclosure under standard conditions. Heat balance data may however be necessary if the conditions are unfavourable.

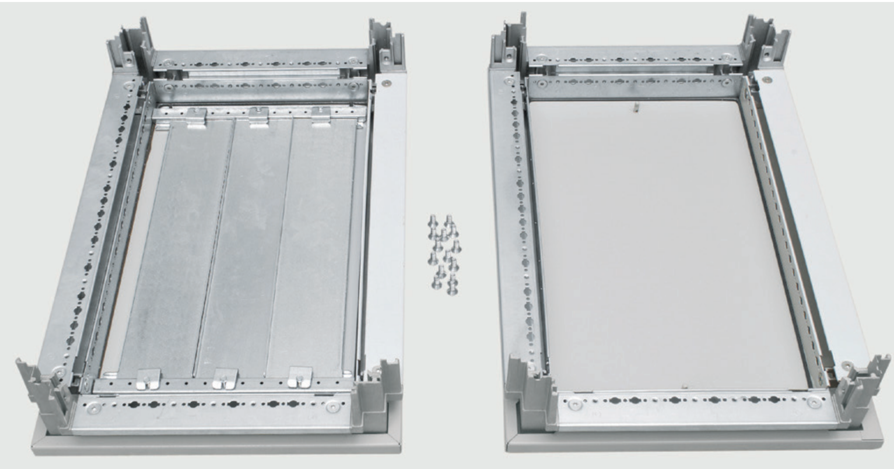
Depending on their version and installation method, the sizes of devices or rows of devices are defined by their faceplate height. The capacity of an enclosure is therefore directly dependent on its faceplate height. The volume required for the connections must be taken into account, in particular for the main device (compliance with bend radii of the incoming conductors).
Internal (in 36 module enclosures) or external cable sleeves promote heat dissipation and make the wiring of assemblies a great deal easier. They also enable side-mounted busbars to be installed in limited depth enclosures.
Each enclosure model in the XL^3 range offers a variety of standard or optimised distribution solutions appropriate for its volume.
For XL^3 4000/6300 enclosures, the size of busbar to be installed will largely

CHARACTERISTICS OF XL^3 ENCLOSURES		XL^3 160		
Version		Insulated	Metal	Flush-mounting
Maximum current of the device		160 A	160 A	160 A
Short-time withstand current Icw 1 s		-	-	-
Fire resistance according to IEC 60695-2-1		750°C/5 s	750°C/5 s	750°C/5 s
Protection against solid bodies and liquids	Without door	IP 30	IP 30	IP 30
	With door	IP 40	IP 40	IP 40
	With door and seal	IP 43	IP 43	-
Protection against mechanical impact	Without door	IK 04	IK 07	IK 04
	With door	IK 07	IK 08	IK 08
Equipment width (number of modules)		24	24	24
Total width (mm)		575	575	670
Number of modular rows or faceplate height (mm)		2 to 6	2 to 6	3 to 6
Total height (mm)		450 to 1050	450 to 1050	695 to 1145
Total depth (mm)		147	147	100
Colour		RAL 7035		

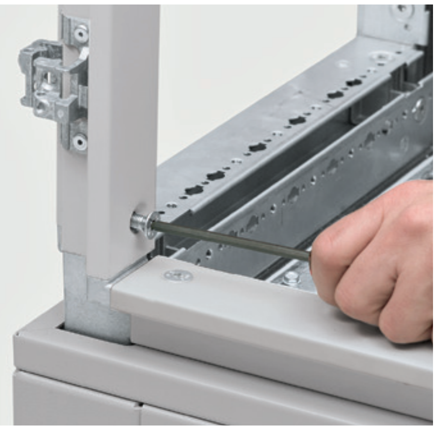
determine the depth of the enclosure. These enclosures can also be fitted with internal separations (form 2a to form 4b) so that they can meet all requirements.
When the installation conditions are particularly severe (installation outdoors, damp or corrosive atmosphere, etc.), enclosures from the Atlantic, Marina or Altis ranges can be used.
The full testing carried out by Legrand on enclosures, equipment and devices ensures they provide the stated performance levels and simplifies the certification of assemblies.

Legrand XL^3 enclosures are designed to meet all power distribution requirements up to 6300 A. From the XL^3 160 cabinet to the XL^3 6300 enclosure, they all offer optimum performance levels and very easy installation.
XL^3 enclosures are divided into five ranges according to the maximum current-carrying capacity: XL^3 160, XL^3 400, XL^3 800, XL^3 4000 and XL^3 6300.
Each range is available in a wide range of sizes and versions (insulated, metal, IP 30 and IP 55).

XL^3 400			XL^3 800				XL^3 4000		XL^3 6300
Insulated	Metal	IP 55	Metal		IP 55		Metal		Metal
400 A	400 A	250 A	800 A		630 A		4000 A		6300 A
25 kA	25 kA	25 kA	25 kA		25 kA		110 kA		110 kA
750°C/5 s	750°C/5 s	750°C/5 s	750°C/5 s		750°C/5 s		750°C/30 s		750°C/30 s
IP 30	IP 30	-	IP 30		-		IP 30		IP 30
IP 40	IP 40	-	IP 40		-		-		-
IP 43	IP 43	IP 55	IP 43		IP 55		IP 55		-
IK 04	IK 07	-	IK 07		-		IK 07		IK 07
IK 07	IK 08	IK 08	IK 08		IK 08		IK 08		-
24	24	24	24	36	24	36	24	36	36
575	575	650	660	910	700	950	725	975	1425
550 to 1750	550 to 1150	400 to 1000	1000 to 1800		1000 to 1800		1800 and 2000		2000
600 to 1900	600 to 1200	615 to 1115	1050 to 1950		1095 to 1995		2000 and 2200		2200
147	147	100	230		250		475, 725, 975		475, 725, 975
RAL 7035			RAL 7035				RAL 7035		RAL 7035



From size XL³ 400 upwards, Legrand enclosures are supplied flat and must be assembled by the panel builder.



The structure and equipment must be assembled in accordance with the instructions in the guides which accompany the products.
Particular care must be taken to comply with the tightening torques indicated.

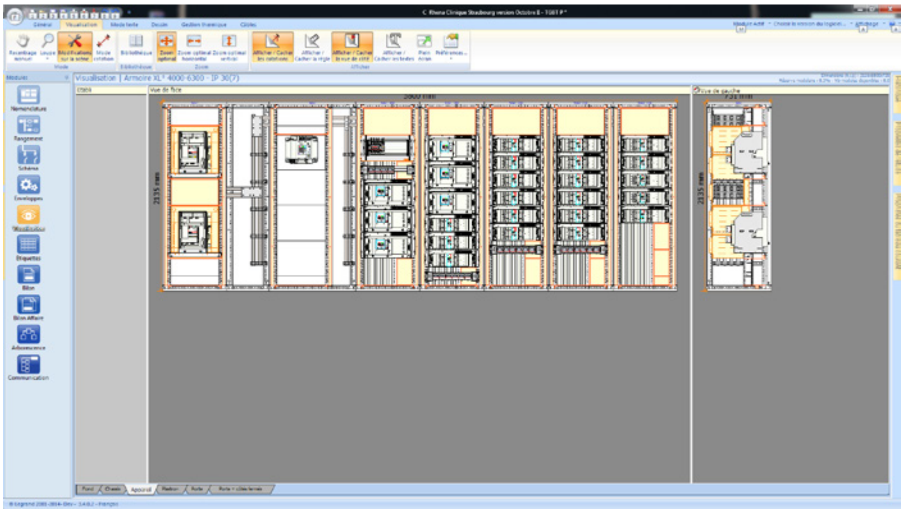
Enclosures must be joined using the appropriate Legrand accessories.

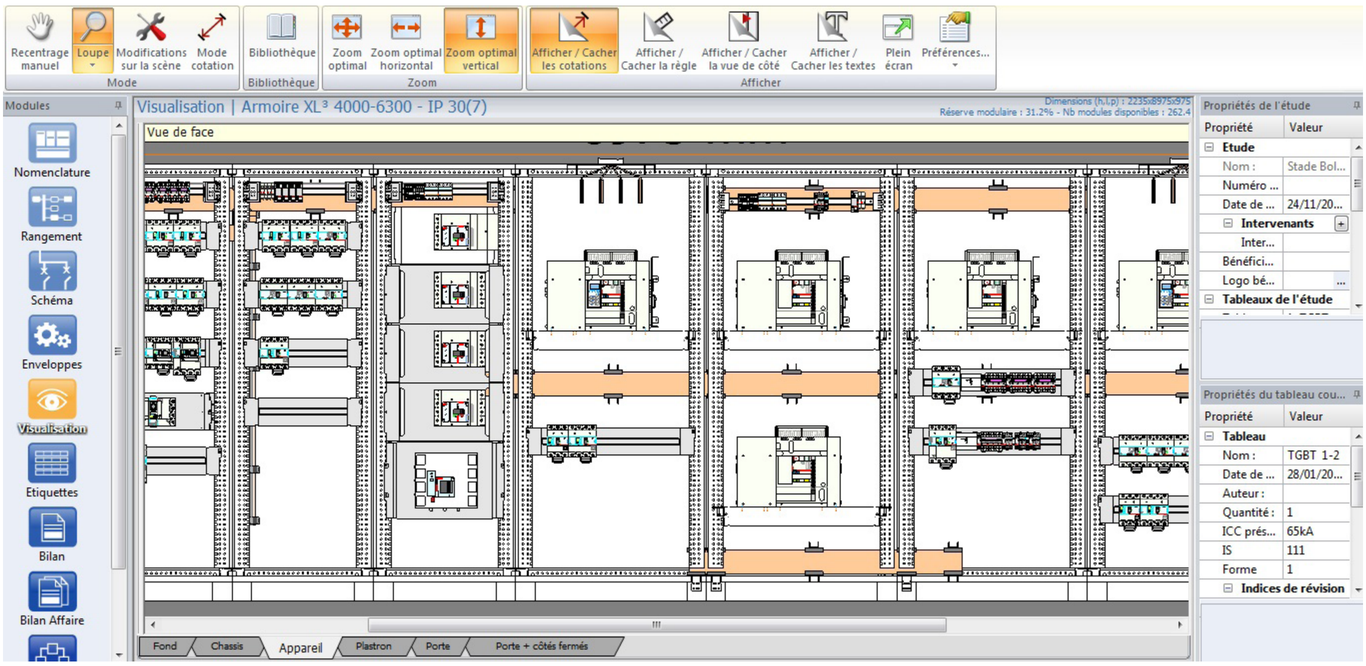
The XL³ workshop specifications detail the assembly instructions and provide additional information for the selection and installation of equipment, accessories and distribution systems.
The workshop specifications can be downloaded from :
http://www.export.legrand.com/EN
The list is provided in the Appendix on p.106

XLPRO³ 6300

The user-friendly XLPRO³ 6300 software provides assistance with the design of electrical panels of all powers. Its database includes all Legrand products connected with distribution, together with their characteristics and prices.

It automatically determines the enclosures required and the layout of the panel based on the devices and distribution systems to be installed and the wide range of customisable parameters. Its graphic interface and modular design make it particularly easy to use and enable it to be adapted to different ways of working.





Using rigid copper bars

Wiring using rigid busbars is selected when high currents are to be carried. This wiring method provides better cooling than using insulated conductors and enables there to be a higher current density, but it has the drawback of there being bare live parts and requires complex, time-consuming forming.
Creating busbars involves machining, bending and shaping which all require a high degree of expertise to avoid weakening the bars or creating stray stresses. The same applies to connections between bars, whose quality depends on the sizes and conditions of the contact areas, and the pressure of this contact.

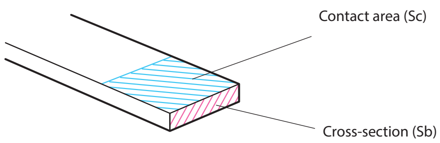
It is advisable to place the neutral bar at the front of the busbar. This provides:
- Additional safety
- Easy connection of circuits supplied between phases and neutral
- Easier identification of the neutral earthing system
- Reduction of the radiated magnetic field

SELECTING AND SIZING BUSBARS
→ See XL³ 4000/6300 workshop specifications p. 40 and XLPRO³

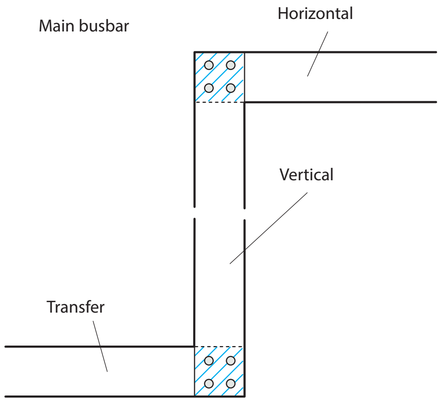
DIMENSIONS OF THE CONTACT AREAS

The contact area (Sc) must be at least 5 times the cross-section of the bar (Sb).

$$Sc > 5 \times Sb$$

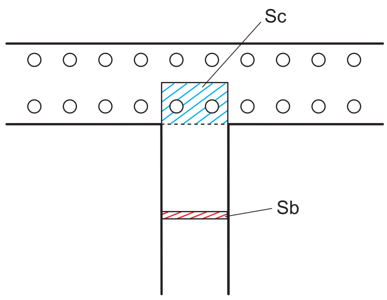


For main busbar continuity links, it is advisable to establish contacts along the entire length of the bar in order to ensure optimum heat transfer.

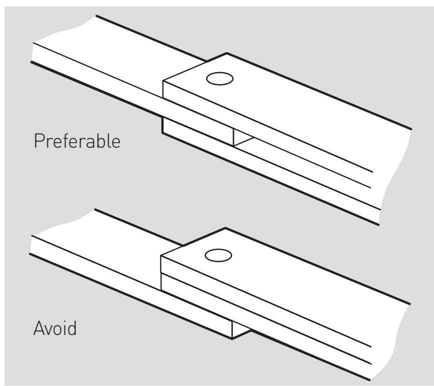


Edgewise positioning of the bars is preferable to flat, as this promotes heat dissipation by natural convection. Otherwise, the current-carrying capacity in the bars must be reduced.

For branch busbars off the main busbar, the contact area can be smaller, complying with the condition Sc > 5 x Sb.



For equipment connection plates, contact must be made over the entire surface of the plate for use at nominal current.



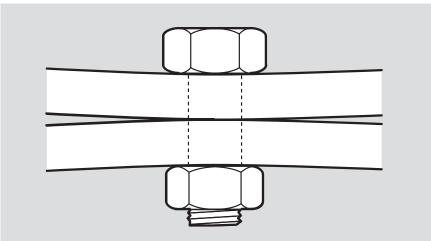
Connection on extension rod, adaptor or spreader

CONTACT PRESSURE

The contact pressure between bars is provided using screws whose size, quality, number and tightening torque are selected according to the current and dimensions of the bars to be connected.
If the contact pressure is too high, the limit of elasticity of the bar will be exceeded. The temperature rise could cause some creep leading to a reduction of this pressure on cooling.
It is therefore advisable to distribute the pressure by increasing the number of screw points and using wide washers or back plates.

TELL-TALE

Applying a mark such as paint or a brittle lacquer will indicate any loosening and can also be used to check that tightening has been carried out correctly.



Too high a tightening torque or not enough screws can lead to deformation which reduces the contact area.

Connection on 120 x 10 bars (4000 A)

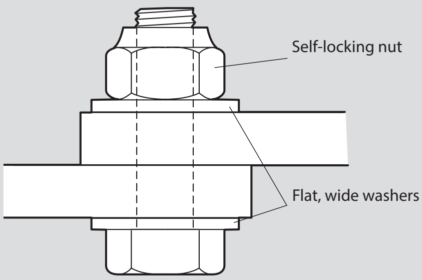
Double connection: 100 x 10 bars (3200 A) and 80 x 10 bars (2500 A) on 120 x 10 common bars

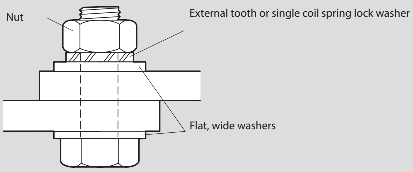
GUIDE VALUES FOR THE CHARACTERISTICS OF THE SCREWS AND RECOMMENDED TIGHTENING TORQUES

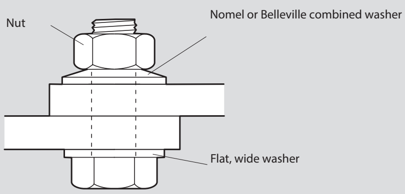
Thickness of bar	I (A) 1 bar	I (A) 2 or more bars	Width of bar (mm)	Min. number of screws	Screw Ø (mm)	Quality class	Torque (Nm)
5 mm	1.5	-	< 25	1	M8	8-8	15/20
	< 400	-	< 32	1	M10	6-8	30/35
				2	M6	8-8	10/15
	< 630	-	< 50	1	M12	6-8	50/65
				2	M10	6-8	30/35
				2	M8	8-8	15/20
	800	1250	< 80	4	M8	8-8	15/20
				4	M10	6-8	30/35
	1000	1650	< 100	4	M10	8-8	40/50
				2	M12	6-8	50/60
	1600	2000	< 125	3	M12	6-8	50/60
10 mm	-	2500	< 80	3	M12	8-8	70/85
	-	3200	< 100	4	M12	8-8	70/85
	-	4000	< 125	6	M12	8-8	70/85

If the tightening torques are too high, the limit of elasticity of the bolts will be exceeded and there will be creeping of the copper.

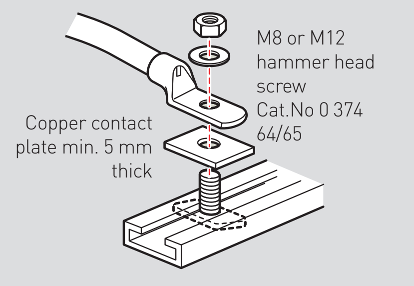
PRECAUTIONS TO AVOID LOOSENING





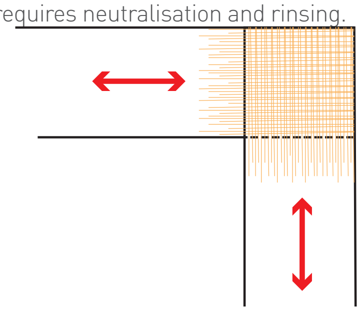


When it is necessary to connect conductors with lugs on C-section busbars, a copper contact plate must be used. When connecting flexible bars, it is advisable to check that the contact between the flexible bar and the C-section bar is correct. If this contact is not satisfactory, it will also be necessary to use a base plate.



CONDITION OF THE SURFACES IN CONTACT

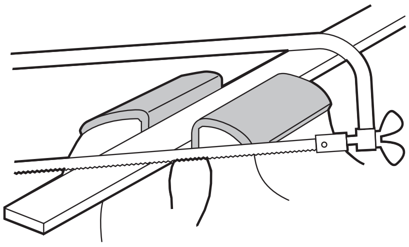
Unless there is pronounced oxidation (significant blackening or presence of copper carbonate or "verdigris"), copper bars do not require any special preparation. Cleaning with acidulated water is prohibited, as, apart from the risks, it requires neutralisation and rinsing.



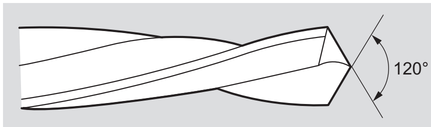
Surface sanding (240/400 grain) can be carried out, complying with the sanding direction indicated above so that the scratches on bars that are in contact are perpendicular.

CUTTING AND DRILLING BARS

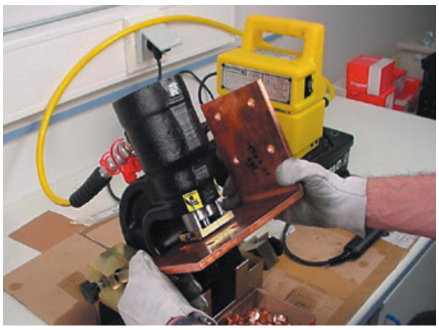
Copper is generally shaped dry, but lubrication is necessary for high-speed cutting or drilling operations.



Cutting using a saw (8D medium tooth) in a vice with jaw covers.



It is possible to make holes using drills designed for use on steel, but it is preferable to use special drills (with elongated flutes for easy detachment of chips).

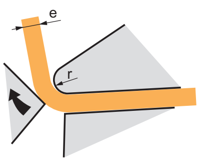


A hydraulic punch can be used to make precision holes easily and with no chips.

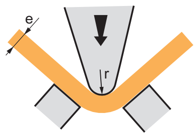
BENDING BARS

It is strongly recommended that a full-scale drawing is made of the bars, in particular where bars are bent and stacked.
The bars are separated by their thickness "e". The total centre line length before bending is the sum of the straight parts that are not subject to any deformation (L1 + L2) and the length l of the curved elements on the neutral line (in theory at the centre of the thickness of the metal) i.e. L1 + L2 + l.

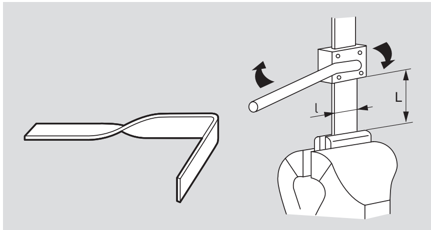
The calculation must be carried out based on the tool used and its actual bend radius r.



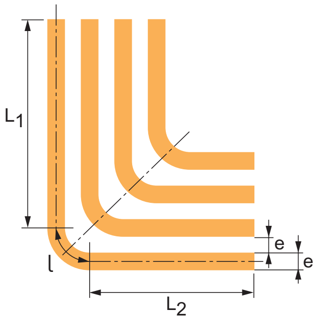
Bending on bending machine:
r = 1 to 2e



Bending on V-block:
r min. = e



CREATING A TWIST:
The length L of the twist is at least twice the width l of the bar

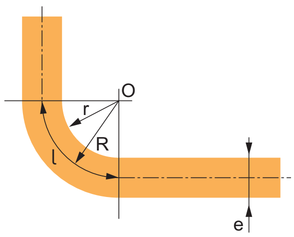


Calculation of the length l

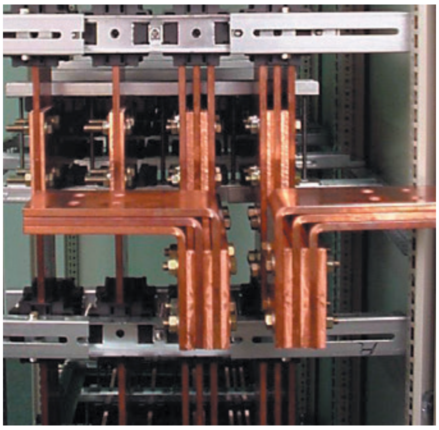
90° bend:

$$l = \frac{2\pi R}{4} = \frac{\pi}{4}(2r+e)$$

Useful formula:
l = R x 1.57



Bending a 10 mm thick copper bar on a portable hydraulic tool



Example of bending three bars one on top of the other to create power sockets

The prefabricated connection kits for DMX³, comprising cut, bent and drilled copper bars, greatly simplify the construction of distribution assemblies conforming to the rules.

Using flexible bars

With flexible bars it is easy to make connections to devices or to create links that can be adapted to virtually any requirement. Flexible bars are generally used for currents over one hundred amps. Like rigid bars, they can be used for direct connection to the connection plates of devices. Guaranteeing safety and a high quality finish, they also provide an attractive touch.

Flexible bars have higher current-carrying capacities than cables or rigid bars with the same cross-section, due to their lamellar structure (limitation of eddy currents), their shape (better heat dissipation) and their permissible temperature (105°C high-temperature PVC insulation).

CONDITION OF THE SURFACES IN CONTACT

As with any conductor, the current-carrying capacities of flexible bars differ according to the conditions of use and installation:
- Ambient temperature (actual in enclosure)
- Period of use (continuous or cyclic load)
- Bars on their own or grouped together (side by side in contact or with spacers)
- Ventilation: natural (IP < 30), forced (fan) or none (IP > 30)
- Vertical or horizontal routing

The considerable variability of all these conditions leads to very different current-carrying capacities (in a ratio of 1 to 2, or even more).

CURRENT-CARRYING CAPACITIES OF LEGRAND FLEXIBLE BARS

Cat.No	Cross-section (mm)	Ie (A) IP < 30	Ithe (A) IP > 30
0 374 10	13 x 3	200	160
0 374 16	20 x 4	320	200
0 374 11	24 x 4	400	250
0 374 67	20 x 5	400	250
0 374 17	24 x 5	470	520
0 374 12	32 x 5	630	400
0 374 44	40 x 5	700	500
0 374 57	50 x 5	850	630
0 374 58	50 x 10	1250	800

Incorrect use can result in temperature rises that are incompatible with the insulation and can cause disturbance or even damage to connected or surrounding equipment.

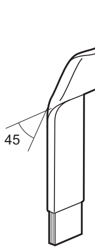
Ie (A) AND Ithe (A) CURRENTS OF FLEXIBLE BARS

- Ie (IP < 30): maximum permanent current-carrying capacity in open or ventilated enclosures. The positions of the bars and the relative distance between them ensure correct cooling. The temperature in the enclosure must be similar to the ambient temperature.
- Ithe (IP > 30): maximum permanent current-carrying capacity in sealed enclosures. The bars can be installed close to one another, but must not be in contact. The temperature in the enclosure can reach 50°C.

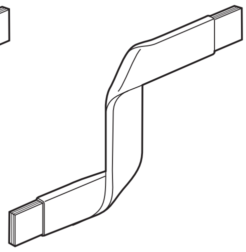
BENDING AND DRILLING

Flexible bars are shaped manually without the need for any special tools, although some dexterity is required to achieve a perfect finish.
When several connections (depending on the number of poles) have to be made, start with the longest bar. There will be no risk of the following connections, which will be made in the same way as the first, being too short.
If possible, compensate for a bend in one direction with one in the opposite direction to limit the relative displacement of the copper laminates.
The ends must not be stripped and drilled until the shaping has been completed.
Holes should preferably be punched (little deformation and no chips). Use guide backing plates when making holes using drills.

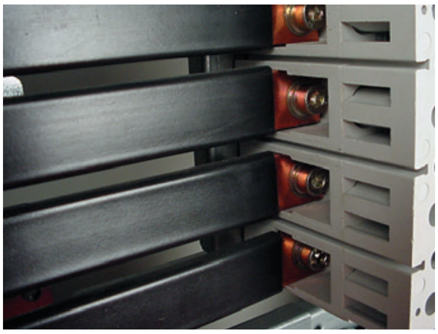
Examples of bends



90° bend
(parallel planes)



Bayonet
(parallel planes)

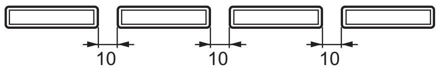


Connection to DPX³ 250 using 24 x 5 bars

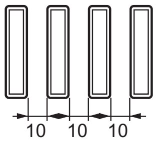
CONDITIONS FOR INSTALLATION AND ROUTING

The way flexible bars are installed can have a considerable effect on their cooling capacity and their ability to withstand electrodynamic forces if there is a short-circuit.
In view of the wide variety of configurations, it is very difficult to give universal rules for how bars should be held in place with regard to short-circuits.
Three standard configurations are shown, from the most to the least favourable:

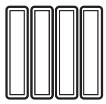
A: bars flat, 10 mm apart



B: bars edgewise, 10 mm apart



C: bars edgewise and in contact

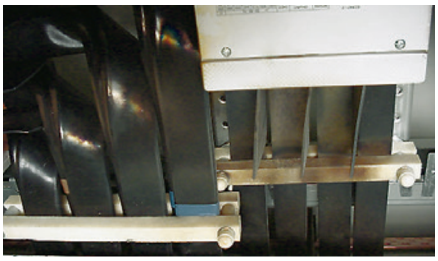


The guide distances given in the table below do not predict the mechanical withstand of the supports used, which may be subjected to significant forces. In general, the following should be used:
- Customised devices (machined washers + screws) in mode A
- Spacing washers in mode B (caution, some washers only act as a spacer for heat dissipation, and additional clamps will then be necessary to provide the mechanical strength)
- Clamps for mode C, which should be limited to prospective short-circuits which do not exceed 15 kA

GUIDE VALUES FOR THE MINIMUM DISTANCES D (in mm) BETWEEN DEVICES FOR HOLDING FLEXIBLE BARS IN PLACE

Bar cross-sections (mm)		13 x 3			20 x 4 - 20 x 5 24 x 4			24 x 5			32 x 5 - 40 x 5			50 x 5			50 x 10		
Configuration[1]		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Ipk (kÂ)	10	350	150	100		250	150		500	400		500	400			500			
	15	250	100	70	500	150	100		400	250		300	250		500	350			
	20	200	80	50	350	100	100	500	300	200		250	200		300	250			500
	25	150	60		300	100	80	400	200	150		200	150		250	200		500	400
	30	100			250			350	150	100	500	150	150		200	150		400	350
	40				200			250	100		400	100	100		150	100		300	250
	50				150			200			300			500	100			250	200
	60							150			250			450				200	150
	70							100			200			400			500	150	100
	80										150			350			450	100	
	90										100			300			400		
	100													250			350		

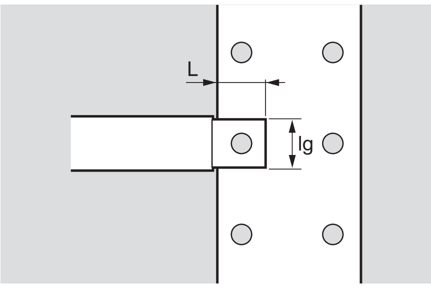
(1) A: bars flat, 10 mm apart - B: bars edgewise, 10 mm apart - C: bars edgewise and in contact


Clamping flexible bars

When there is a high short-circuit (> 25 kA), flexible bars may become deformed.
At this level, the presence of the insulation limits the risk of contact with an exposed conductive part.
For very high short-circuits (around 50 kA), the main risk becomes tearing out of the connections: connection using screws which pass through the bars is therefore recommended.

CONNECTION

Flexible bars have the advantage of being able to be connected directly to rigid busbars or to the connection plates of devices without the use of lugs. The connection plates of flexible bars must be sized according to their cross-sections.



The length of overlap L must be at least equal to the width of the bar lg or to 5 times its thickness, whichever is greater.
For 10 mm thick bars, a minimum overlap of 75 mm and tightening using 2 screws are recommended.

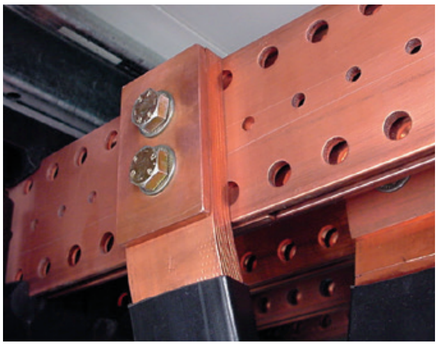
RECOMMENDED SCREW DIAMETERS	
Width of bar	Screw Ø
13 mm	M6
20 mm	M6/M8
25 mm	M8
32 mm	M10
50 mm(1)	M12

(1) For 10 mm thick bars, provide two M12 screws

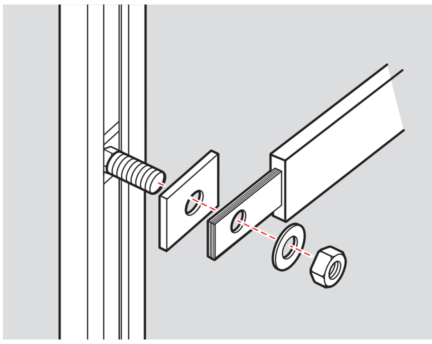
The flexible bar must be clamped so that the copper laminates are held tightly in place. The use of wide washers or a back plate is recommended.

Connection of a 50 x 10 bar using two M12 screws Cat.No 0 374 65 with integrated wide washers

Direct clamping of 5 mm thick flexible bars between two rigid bars with the same spacing



Clamping a 50 x 10 bar with back plate



Flexible bars must be connected to C-section bars using hammer head screws Cat.Nos 4 044 91/92 (M8/M12). It may be necessary to use a base plate if the contact is not satisfactory.

Cables and conductors

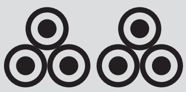
The wide variety of installations, ranges of power ratings, and even local work practices or regulations mean there is no standard model for wiring panels.
There are numerous types of conductor. The choice depends on what they are to be used for, which is clearly defined for installations. However this is not always the case for distribution assemblies. In addition to the current-carrying capacity, this choice is dependent on the requirements relating to the panel, the rated voltage, the installation method, the type of insulation, the types of application, etc.

CROSS-SECTIONS OF THE WIRING CONDUCTORS INSIDE ASSEMBLIES

The choice of conductors to be used inside the assembly and their cross-sections are the responsibility of the original manufacturer. The conductors must have a minimum cross-section conforming to IEC 60364-5-52.
Examples of how to adapt this standard for the conditions inside an assembly are given in the following table which is taken from Annex H of IEC 61439-1 (provided for information purposes only).
There are two types of conductor:
- PVC for conductors with PVC or rubber insulation, generally used for wiring conductors up to 35 mm²
- PR for conductors with polyethylene or elastomer insulation. In practice these are usually reserved for cross-sections greater than 35 mm²

The installation and ambient temperature conditions have been named empirically:
- IP < 30 for conductors installed with good cooling conditions (enclosure open or naturally ventilated, low to medium wiring density, enclosure internal temperature similar to the ambient temperature up to 35°C)
- IP > 30 for conductors installed in poor cooling conditions (sealed enclosure, high wiring density, multicore cables, enclosure internal temperature that may reach 50°C)

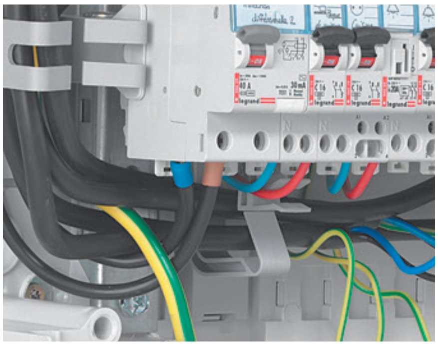
GUIDE VALUES FOR MINIMUM CROSS-SECTIONS (in mm²)

			Space at least 1x the diameter of the cable 	
Manufacturer's specification	Single-core cables exposed in the open air or placed in a perforated cable tray. 6 cables (2 three-phase circuits) continuously loaded.		Single-core cables placed horizontally and separated in the open air	
	35°C	55°C	35°C	55°C
Conductor cross-section mm²	Maximum current-carrying capacity Imax[c] A		Maximum current-carrying capacity Imax[b] A	
1.5	14	9	23	15
2.5	20	13	32	21
4	28	18	43	28
6	35	23	55	36
10	49	32	77	50
16	68	44	103	67
25	91	59	137	89
35	113	74	170	110
50	138	90	206	134
70	179	116	264	171
95	218	-	321	208
120	255	-	372	242

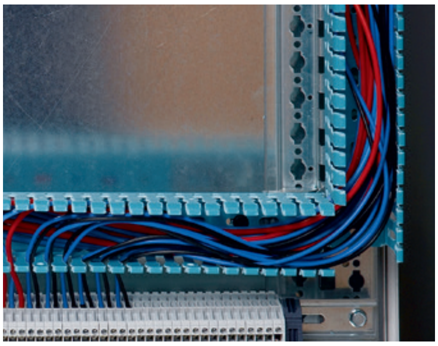
[c] Current-carrying capacity I_{30} for a three-phase circuit from IEC 60364-5-52:2009, table B.52.10, column 5 (installation method: point F in table B.52.1). Values for cross-sections less than 25 mm² calculated according to IEC 60364-5-52 Annex D. k_2 = 0.88 (point 4 in table B.52.17, two circuits)
[d] Current-carrying capacity I_{30} for a three-phase circuit from IEC 60364-5-52:2009, table B.52.10, column 7 (installation method: point G in table B.52.1). Values for cross-sections less than 25 mm² calculated according to IEC 60364-5-52 Annex D. (k_2 = 1)

Column 1 applies when conductors from different circuits are installed touching one another and grouped together (for example, installation in trunking or in strands). Column 2 applies when the conductors or cables are separated in the open air (see photo opposite). The usual cross-sections of protective conductors (PE) in assemblies are given on page 30.

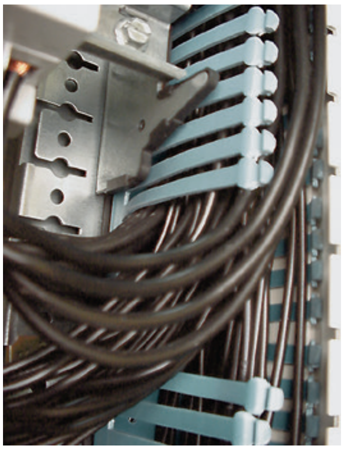
The cross-sections of the conductors to be used for wiring inside assemblies are not covered in a single standard document.
• Standard IEC 60364 recommends that the cross-sections are determined according to installation methods 31 and 32.
In fact, the method is difficult to apply as it requires, for the application of the correction factors, information that will only be known after the installation has been carried out: parts which run vertically, parts which run horizontally, groups, number of layers, separate conductors or cables, as well as knowledge of the ambient temperature in the enclosure, which is always difficult.
• Standard IEC 61439-1 does not recommend cross-sections but stipulates a "current range" for the temperature rise tests. The conductors taken into consideration have PVC insulation and the ambient temperature is not specified. These conditions do not therefore cover all applications.



Conductors not touching, held in place with guide rings: column 2 installation



Several circuits in the same trunking and all wiring in vertical and horizontal trunking: column 1 installation

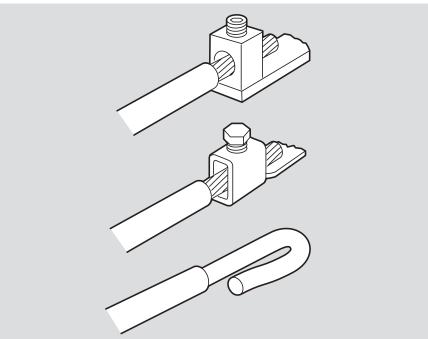


Horizontal circulation "in the open air", only the vertical conductors are grouped in trunking: column 2 installation as here. If the packing ratio of the vertical trunking is high: column 1 installation

CONNECTING CONDUCTORS (LEGRAND RECOMMENDATIONS)

CONDUCTORS WITH RIGID COPPER CORE

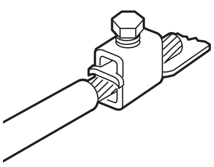
This type of conductor, which is by far the most widely used in fixed installations, does not require any particular precautions since the terminal to which it is connected is sized for the required cross-section and current.
The quality and durability of the connections are assured by the use of an appropriate tool and compliance with the recommended tightening torques.

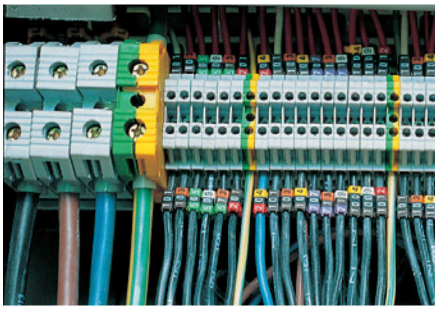


Connecting small conductors in direct pressure screw terminals requires some precautions to be taken.

- Do not tin the core where it is stripped as this could cause subsequent breaking of the conductor
- Do not over-tighten, to limit shear
- The end of the conductor can be folded back to provide better contact

DX³ modular devices and Viking 3 terminal blocks have indirect pressure screw terminals with plates: the conductor is clamped by a plate which distributes the force and enables tightening to 0.

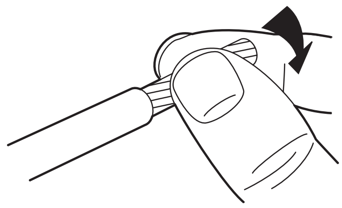




Viking 3 terminal blocks: a reliable solution for connecting flexible conductors

CONDUCTORS WITH FLEXIBLE COPPER CORE

Due to the relative fragility of the strands which make up the core, connecting flexible conductors requires some precautions to be taken.
Excessive tightening may shear the strands. An incorrect cross-section causes dispersion of the strands and poor contact.
To avoid loosening and the risk of dispersion of the strands, it is recommended that the core is bent back on itself in the initial direction, often to the left.
Do not tin flexible conductors before



connection: if tin is applied it may undergo a disintegration phenomenon over time known as "fretting corrosion". The risk of dielectric breakdown makes the use of conductive contact grease inadvisable in damp or conductive atmospheres. It is preferable to fit cable ends, sleeves or lugs if the operating conditions are difficult.

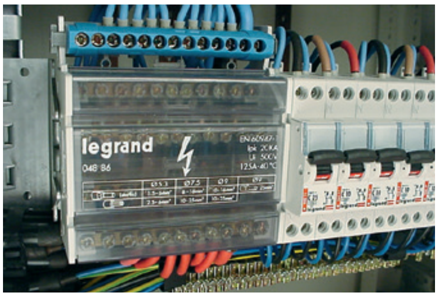
The risks of shear and dispersion of the strands, especially inherent in direct screw terminals, can be avoided by using Starfix™ ferrules.
The products in the Starfix™ range (standard, ratchet and S multi-purpose tools, and 0.5 to 25 mm² ferrules) ensure totally reliable connection of flexible conductors.
The Starfix S tool cuts, strips and crimps using a single tool.

BRANCHING CONDUCTORS

The simultaneous connection of two rigid conductors with the same cross-section is not generally possible upstream. That of two conductors with different types of core or cross-section is highly inadvisable. Downstream branching is possible. In this case the capacities, types of conductor and combinations are indicated on the products themselves or in their accompanying documentation.

PE CONDUCTORS
Branching or connection in the same terminal is not permitted on protective circuits. Nor is it permitted on the terminals of operating devices (except for socket outlets, luminaires, lighting units, etc. as long as appropriate terminals are provided).

The branching required due to the large number of circuits must be carried out using appropriate, safe devices.



Additional terminal block for neutral conductor on distribution block Cat.No 0 048 86

Tap-off on Viking 3 blocks using separable equipotential bridging combs Cat.Nos 0 375 00/01/03/04

CONDUCTORS WITH ALUMINIUM CORE

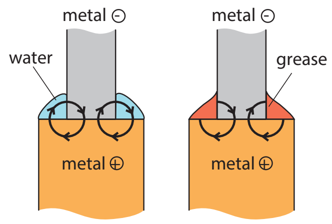
Aluminium is an excellent conductor and offers a favourable weight/conductance ratio for large cross-sections. Very widely used in power systems, its use is now being extended to include power distribution.

A good understanding of the specific difficulties associated with connecting this metal is required in order to avoid subsequent problems which will certainly occur:

- In the open air aluminium quickly becomes coated with a thin, very hard insulating layer, alumina. It must therefore be connected immediately after stripping and if necessary after abrasive surface finishing.
- Aluminium expands a great deal more than other commonly used metals (iron, copper, brass, etc.) and this leads to inevitable loosening of the connections. The connection terminals for aluminium must therefore also be made of aluminium or an alloy, or have elastic devices (washers, strips) to compensate for these expansion differences.
- Aluminium has a very negative electrochemical potential (- 1.67 V) and will therefore tend to corrode when it comes into contact with many other metals. This "sacrificial anode" behaviour increases in damp or conductive environments. It is essential to avoid direct contact between aluminium and stainless steel, silver or copper. However, metals such as zinc, steel and tin are compatible with aluminium.

In all cases, it is recommended that connections are re-tightened to the correct torque after a few days.

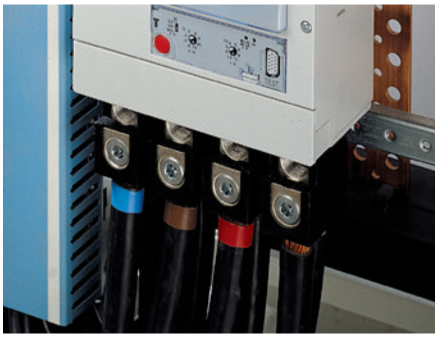
When the metals used are chosen correctly and the atmosphere is dry, the risk of electrolytic corrosion is low.
This risk increases in damp environments (water acts as an electrolyte in the battery that is formed). The use of a neutral grease (generally silicone-based) limits this phenomenon.



The circuit closes: the metal has corroded

The circuit does not close: there is no corrosion

All DPX³, DPX-IS and Vistop devices allow connection using copper/aluminium bi-metal lugs which provide a very high level of reliability. The recommended capacities (cross-section and drilling) are specified in the technical data sheets and guides.
It is also possible to connect aluminium conductors directly using the connection terminals available as accessories.
Distribution boxes Cat.Nos 0 374 80/81 can be used for connection and tap-offs on power circuits using aluminium cables.



Connection of two aluminium conductors (185 mm² per pole) to a DPX³ 630 with terminals Cat.No 0 261 51

Direct connection of a DPX³ 630 using cage terminals Cat.No 0 262 50

EQUIVALENT CROSS-SECTIONS OF ALUMINIUM/COPPER CONDUCTORS

Copper cross-section (mm²)	Aluminium cross-section (mm²)	
	At same temp. rise	At same voltage drop
6	10	10
10	16	16
16	25	25
25	35	35
35	50	50
50	70	70
70	95	95
95	150	150
120	185	185
150	240	240
185	300	400

WIRING PRECAUTIONS

The wiring components must not suffer any damage due to mechanical or thermal forces.
This damage can be caused by:
- Electrodynamic effects caused by short-circuits
- Expansions and contractions caused by temperature rises
- Magnetic effects caused by the current flowing through them
- Movement of the moving parts of the panel, etc.

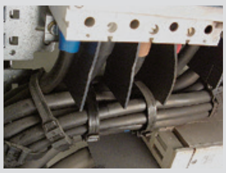
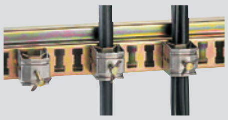
It is also important to ensure compliance with the following points:
- Avoid the cables coming into contact with sharp edges and the moving parts of the panel
- Comply with the bend radii of the cables (values provided by the cable manufacturers)
- Check that the cables are not subjected to any pulling or twisting
- Check that the connections of the devices mounted on removable parts of the assembly (doors, pivoting faceplates, etc.) are made using flexible cables and that these conductors are held in place by attachments other than the electrical connections.

PROTECTION AGAINST THE EFFECTS OF SHORT-CIRCUITS

Two destructive effects can affect conductors if there is a short-circuit:
- Thermal stress, against which protection is normally provided by the protective devices (fuses, circuit breakers)
- Electrodynamic stresses, including forces between conductors

When there is a short-circuit between two live conductors (most probable situation), the conductors through which the short-circuit current passes will tend to repel each other with a force that is proportional to the square of the current. If they are incorrectly attached, they will start to whip around with the risk of pulling out of their connections and touching another conductor or an exposed conductive part causing another short-circuit with a very destructive arcing effect.
Multicore cables are designed to withstand the forces that may be exerted between conductors. However, the use of single-core cables requires particular precautions to be taken.
The information provided in the table below, intended to draw attention to the importance of attaching conductors correctly, does not on its own guarantee withstand to short-circuit conditions, which can only be simulated by tests.

While the installation conditions of busbars are systematically precisely determined with regard to short-circuits (distances between supports), this is not generally the case for the conductors inside panels. They are often the source of damage, and this risk should be clearly taken into account.

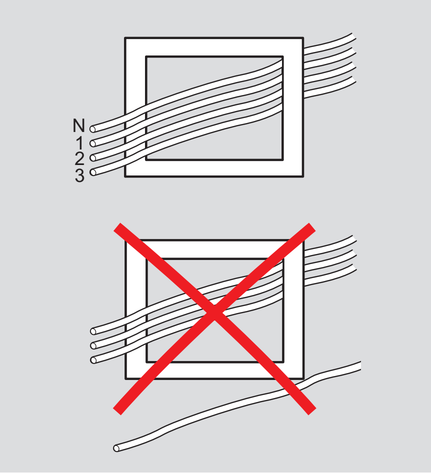
WIRING PRECAUTIONS		
Prospective short-circuit value (I_k)	Attachment of conductors	
I_k < 10 kA	No specific precautions (standard IEC 61439-1 does not stipulate any tests).	
10 kA < I_k < 25 kA	The conductors must be attached using clamps. They can be grouped together in stranded cables for the same circuit.	
25 kA < I_k < 35 kA	Conductors in the same circuit must be kept separate and attached individually. If they are grouped together in stranded cables, the number of clamps must be increased (one every 50 mm).	
35 < I_k < 50 kA	Conductors in the same circuit must be attached individually on a rigid support (crosspiece, profile) with no sharp edges. They must be physically separated. Each attachment must consist of two crossed clamps.	
I_k > 50 kA	At these short-circuit values, the forces become such that the attachment devices must be specially designed: for example, machined crosspieces and threaded rods. Legrand stainless steel profiles and flanges can be used in some extreme cases.	 

PROTECTION AGAINST MAGNETIC EFFECTS

High currents passing though conductors cause magnetic effects in the surrounding metal conductive parts. These effects can cause an unacceptable temperature rise of the materials.

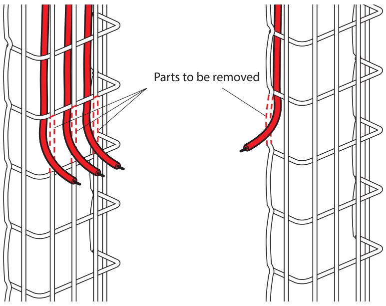
It is therefore essential to take some wiring precautions. "Hysteresis" loss associated with the saturation of the magnetic materials occurs in the frames created by the structural components (enclosure structures, chassis, support frames) located around the conductors. To reduce the induction created, the conductors must be arranged so that the field is as weak as possible.

To minimise the induction created in magnetic loops, it is always advisable to have all the live conductors in the same circuit (phases and neutral) in the same metal (steel) frames. As the vectorial sum of the currents is zero, that of the fields created is also zero.



When it is not possible for all the conductors in the same circuit to pass through together without the insertion of ferromagnetic components (this could be the case with device supports, cable entry plates, dividers), they must be placed in supports made of non-magnetic material (aluminium, copper, stainless steel or plastic).

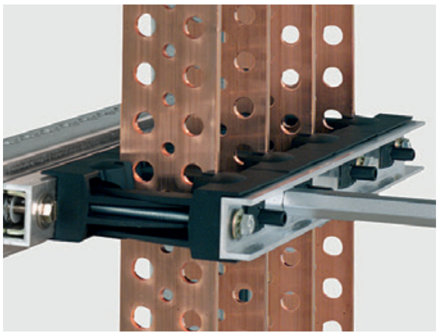
This is recommended from 400 A per conductor upwards, and is essential above 630 A. As far as possible, conductors should be in a trefoil arrangement to reduce the induced fields.



The insertion and attachment of separate conductors on cable ladders also requires some precautions to be taken. To avoid significant temperature rises of the components of the cable ladder, it is advisable to remove the parts which create frames around a conductor.

It is also possible to break the magnetic frame by removing components.

In all cases, check that the mechanical strength of the support remains acceptable.



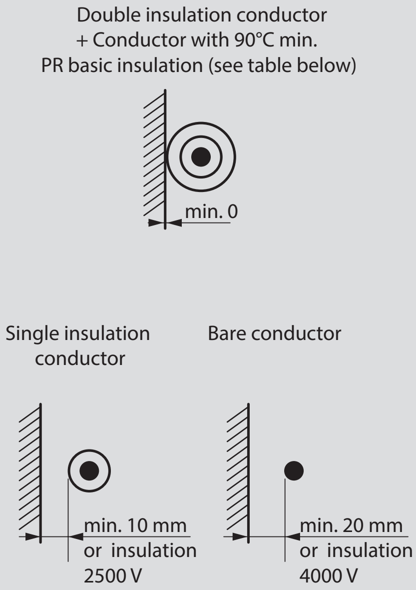
Inserting aluminium crosspieces on Legrand busbar supports prevents the creation of magnetic frames

The corner pieces of XL³ 4000/6300 enclosures are designed to avoid the formation of magnetic frames on their structure. These enclosures can therefore be used for very high powers with no uncontrolled magnetic induction effects.

WIRING UPSTREAM OF PROTECTIVE DEVICES

Upstream of overcurrent protection devices (TN and IT neutral earthing systems) or residual current devices (TT system), protection against the consequences of a possible fault (between phases and metal conductive part) is not assured.
It is essential to avoid the risk of indirect contact using another means: in practice, the only measure that can be used to compensate for this is double insulation. This can be obtained directly using devices or by supplementary insulation on the installation.
The implementation of class II upstream of the protective devices is based on four basic rules:
- The use of conductors or cables which have double insulation as a result of their composition (page 32)
- The provision of supplementary insulation around conductors that do not have this double insulation (installation in insulated ducting, insulated conduits or insulated enclosures)
- The use of insulating components which hold the bare conductive components in place (busbars) with an clearance double the conventional value
- Clamping the conductors so that there can be no contact with a nearby exposed conductive part if they accidentally become detached or disconnected

LOCATION OF CONDUCTIVE COMPONENTS IN RELATION TO THE METAL CONDUCTIVE PARTS EXAMPLE OF 500 V INSULATION VOLTAGE



These provisions assume that the minimum distances are permanently maintained, including when there are faults (electrodynamic forces), using appropriate clamping.
The clearances can be replaced by thinner insulating components (screens, supports, separators), which have sufficient mechanical strength and a minimum dielectric strength of 2500 V or 4000 V.

CABLES CONSIDERED AS BEING DOUBLE INSULATION

U_0: 500 V	U_0: 250 V
U-1000 R12N	H05 RN-F
U-1000 R2V	H05 RR-F
U-1000 RVFV[1]	H05 VV-F
H07 RN-F	H05 VVH2-F
A07 RN-F	FR-N05 VV5-F
FR-N1 X1 X2	A05 VVH2-F[1]
FR-N1 X1 G1	
H07 VVH2-F	

[1] According to conditions of use.

Flexible bars have an insulation voltage of 1000 V. They can be classed as double insulation conductors by limiting the operating voltage to U_0: 500 V (the insulation is then considered to be reinforced insulation) or, preferably, by holding the insulation of the bars in place mechanically (clamping, supports, their own rigidity) at an adequate distance from the metal parts (10 mm).

SELECTION OF CONDUCTORS AND INSTALLATION REQUIREMENTS (IEC 61439-1 SECTION 8.6.4)

Type of conductor	Requirements
Bare conductors or single-core conductors with basic insulation, for example, cables conforming to IEC 60227-3	Mutual contact or contact with conductive parts must be avoided, for example by using separators
Single-core conductors with basic insulation and a maximum permitted usage temperature of at least 90°C, for example, cables conforming to IEC 60245-3, or thermoplastic cables with PVC insulation, with heat-resistance conforming to IEC 60227-3	Mutual contact or contact with conductive parts is permitted if no external pressure is applied. Contact with sharp edges must be avoided. These conductors must be loaded such that the operating temperature is no greater than 80% of the maximum permitted temperature for the use of the conductor
Conductors with basic insulation, for example cables conforming to IEC 60227-3, with supplementary secondary insulation, for example, cables covered individually with retractable sleeves or laid individually in plastic conduits	No additional requirements
Conductors insulated using a material with very high mechanical strength, for example, ethylene tetrafluoroethylene (ETFE) insulation, or conductors with double insulation with reinforced external sheath for use up to 3 kV, for example cables conforming to IEC 60502	
Single-core or multicore cables in sheaths, for example cables conforming to IEC 60245-4 or to IEC 60227-4	

PERMANENTLY ENERGISED WIRING CIRCUITS

Some measurement, signalling or detection circuits have to be connected upstream of the assembly's main protective device.

In addition to their protection against indirect contact, special precautions must be taken with these circuits:

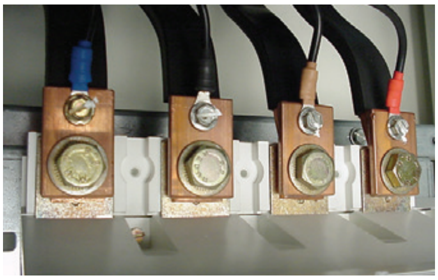
- Against the risks of short-circuits
- Against the risks associated with the fact they that remain energised after breaking of the main protective device

The double insulation specification must be applied to limit the risk of contact with the exposed conductive parts and measures must be taken so that any risk of short-circuit is unlikely. The conductors of these unprotected circuits must be connected as securely as possible. The mechanical strength of the conductors must be taken into consideration when creating unprotected circuits:

- Conductors with single insulation (H07 V-U/R or H07 V-K) must be protected using an additional sheath (for example sleeving Cat.No 366 38) or laid in ducting if there are risks of contact with parts which may cause injury
- Conductors with a high degree of mechanical strength (with PTFE insulation) can be used directly
- Single-core and multicore cables can be used without any additional sheath unless there are risks of hazards such as the presence of sharp edges

In practice, the cross-sections of the conductors of unprotected circuits, normally chosen according to the power of the circuits to be supplied, must not be too small, in order to provide sufficient mechanical strength. A minimum value of 4 mm² is generally applied.

The protective devices for permanent circuits must, of course, be chosen according to the current of the circuit to be protected and also the prospective short-circuit current at the supply end of the assembly. Very high values often lead to the use of cartridge fuse type circuit breakers.



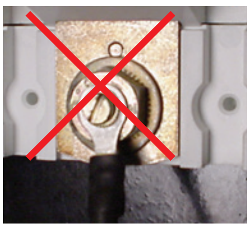
Example of connection to separate copper plate on the connection. The screws have washers to prevent loosening

DO NOT

• Connect to the heads of screws: drilling the thread can weaken even the largest diameter screw

• Connect the wires between the lugs and the connection plate on the device: the wire may be cut and the area of the surfaces is compromised

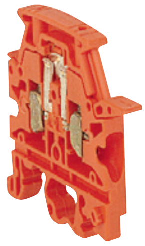
• Connect the large cross-section power supply cable directly in the terminals on the device: the hold is uncertain



Permanently energised unprotected circuits have no specific marking (IEC 60364).

It is however advisable to identify them clearly using the following type of wording: "Caution, permanent circuits not broken by the main device", with possible additional identification of the circuits concerned (for example: "voltage present", "enclosure lighting", "group detection", etc.).

Standard IEC 60204-1 (safety of machinery) recommends that these circuits are physically separated from the other circuits and/or identified by orange insulation on the conductors. Orange Viking 3 terminal blocks are specially designed for these circuits.



Neutral conductors and protective conductors

TREATMENT OF THE NEUTRAL CONDUCTOR

BASIC RULES

As a matter of principle the neutral conductor is considered to be a live conductor. It must therefore be sized in the same way as a phase conductor, protected against overcurrents and capable of being isolated.

There are exemptions to each of these requirements, whose limits must be known.

SIZING

In three-phase circuits with a cross-section "S" greater than 16 mm² (or 25 mm² for aluminium), the cross-section of the neutral conductor can be reduced to S/2.

If the loads supplied are not more or less balanced and the current in the neutral is greater than 30% of the current in the phases, or the loads generate harmonics, reducing the cross-section of the neutral is not recommended.

If the total 3rd order harmonic distortion is greater than 33%, the neutral conductor must be oversized. The cross-section of the neutral must then be calculated for a current of 1.45 times the rated current in the phases.

ISOLATION

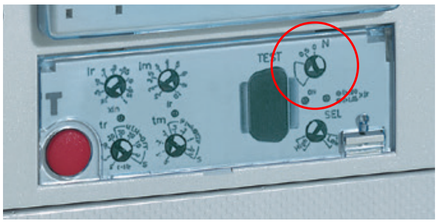
It must be possible to isolate all live conductors, including the neutral, at the origin of the installation and at the origin of the each of the main circuits, unless the neutral is performing the function of PEN conductor (see page 33).

OVERCURRENT PROTECTION

When the cross-section of the neutral conductor (TT or TN system) is identical to that of the phase conductors, the neutral pole cannot have overcurrent detection (unprotected pole).

CIRCUIT BREAKERS WITH INDEPENDENT NEUTRAL SETTING

Before start-up, check the setting position of the neutral protection.



TREATMENT OF THE PROTECTIVE CONDUCTORS

The cross-sections of the protective conductors in an assembly to which external conductors have to be connected can be determined using two methods: with or without calculation.

DETERMINATION WITHOUT CALCULATION

The cross-sections of the conductors are selected so as to limit any risk, irrespective of the short-circuit conditions. It is the simplest and safest method, although it tends to oversize the cross-sections of the protective conductors. The values to be used are given in the table below.

BASIC RULES FOR DETERMINING THE CROSS-SECTION (IEC 61439-1)

Phase conductor cross-section S_{ph} (in mm²)	Minimum cross-section of corresponding protective conductor S_{PE} (in mm²)
$S_{ph} < 16$	S_{ph}
$16 < S_{ph} < 35$	16
$35 < S_{ph} < 400$	$S_{ph}/2$
$400 < S_{ph} < 800$	200
$S_{ph} < 800$	$S_{ph}/4$

The minimum cross-section of single PE conductors is 2.5 mm² if the PE conductor is mechanically protected (for example inside a conduit), and 4 mm² if the PE conductor is not mechanically protected.

These cross-sections are given for copper conductors. The following equivalence rule can be applied for using other metals:

- Aluminium: 1.5 x S_{PE}
- Brass: 2 x S_{PE}
- Steel: 2.8 x S_{PE}
- Lead: 5.2 x S_{PE}

In TN-C systems, the minimum cross-section of the PEN conductor is 10 mm² for copper or 16 mm² for aluminium.

DETERMINATION BY CALCULATION

The cross-sections are determined by a calculation proving that the conductors and their terminals are capable of withstanding the maximum short-circuit stress. This method enables the cross-sections used to be optimised, but requires precise knowledge of the prospective short-circuit value and the characteristics of the protective devices.

The cross-section is then calculated for breaking times less than 5 s using the following formula:

$$S_{PE} = \frac{\sqrt{I^2 t}}{K}$$

S_{PE}: cross-section of the protective conductor (in mm²)
I: rms value of the fault current (If in A)
t: operating time of the breaking device (in s)
K: coefficient dependent on the permissible temperatures, the metal used and the insulation, the values of which are given in the table below.

CONTINUITY AND DURABILITY OF PROTECTIVE CONDUCTORS

Protective conductors must be protected against mechanical and chemical damage and against electrodynamic forces.
Apart from connections that can only be dismantled using tools, no device must be inserted in the protective conductors, including the windings of any continuity checking devices.
Unless they are used as protective conductors, the exposed conductive parts must not be connected in series.
Disconnecting one circuit must not result in other circuits being disconnected, which means that the protective conductors must be single and separate.
These connections must remain accessible for checking and measurement.
When protection against indirect contact is provided by overcurrent protection devices (IT and TN systems), the protective conductors must be incorporated in the same wiring system or in close proximity to the live conductors.

K VALUE FOR LIVE CONDUCTORS AND PROTECTIVE CONDUCTORS

Insulation	PVC			PR/EPR			Rubber 60°C			Rubber 85°C			Silicone rubber			No insulation		
θ° max (°C)	160/140[2]			250			200			220			350			200/150[1]		
Type of core	Cu	Al	Steel	Cu	Al	Steel	Cu	Al	Steel	Cu	Al	Steel	Cu	Al	Steel	Cu	Al	Steel
Protective conductor not incorporated in a cable or conductors not grouped together	143 133[2]	95 88[2]	52 49[2]	176	116	64	159	105	58	166	110	60	201	133	73	159 138[1]	105 91[1]	58 50[1]
Live conductor or protective conductor part of a multicore cable or grouped conductors	115 103[2]	76 68[2]		143	94		141	93		134	89		132	87		138	91	50

(1) If there is a particular fire risk
(2) Cross-section greater than 300 mm² or conductors grouped together

The table below gives the cross-sections generally used for the PE conductor (for information purposes only). These values may differ in the installation according to the conditions.

USUAL CROSS-SECTIONS OF PROTECTIVE CONDUCTORS IN ASSEMBLIES ACCORDING TO THE CURRENT	
I (A)	S_{PE} (mm²)
10	1.5
16	2.5
20	4
25	4
32	6
40	10
63	16
80	16
100	16
125	25
160	35
200	50
250	70
315	95
400	120
500	150
630	185
800	240
1000	185[1] or 2 x 150[2]
1250	240[1] or 2 x 165[2]
1600	240[1] or 2 x 240[2]
> 1600	S_{PE}/4

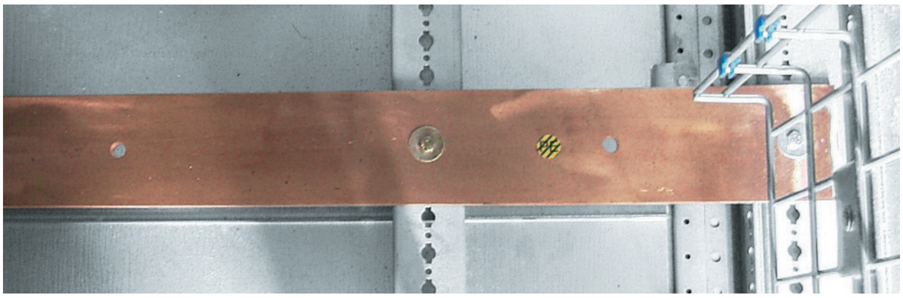
(1) SPh/4 values according to IEC 61439-1 table 11
(2) SPh/2 values according to IEC 60364

MAIN PROTECTIVE CONDUCTOR TERMINAL

This terminal can be in the form of a terminal block, a terminal bar, a rail with terminal blocks or a copper bar, depending on the power of the installation. It is often called the protective conductor collector.
The following are connected to this terminal:
- The main protective conductor
- Optionally, the protective conductor of the transformer
- The protective conductors of the load circuits
- The equipotential links

As for protective conductors, the characteristics of this terminal must be determined with care.

When a large number of protective circuits is connected, it may be necessary to use two (or more) basic collector bars. It is advisable to connect these bars to one another using a conductive component that cannot be inadvertently removed, rather than using a green/yellow conductor.



Main terminal consisting of a copper bar at the bottom of the enclosure

PRACTICAL CONNECTION SOLUTIONS

➔ See Workshop specifications

<table>
<tr><th colspan="10">SOLUTIONS FOR ALL POWERS, FOR ALL PANELS</th></tr>
<tr><th colspan="4" rowspan="2">Enclosure type</th><th>Maximum current of the assembly</th><th>Protective conductor terminal or collector</th><th>Catalogue Number</th><th>Thermal stress I^2t [1]</th><th>Cross-section of copper main protective conductor S_{PE} [2]</th></tr>
<tr><th>(A)</th><th colspan="2"></th><th>(A^2s)</th><th>(mm^2)</th></tr>
<tr><td rowspan="16">XL³ 4000</td><td rowspan="13">XL³ 800</td><td rowspan="10">XL³ 400</td><td rowspan="6">XL³ 160 [3]</td><td rowspan="2">80</td><td>Distribution terminal blocks on 12 x 2 flat bar [4]</td><td>0 048 19
0 048 01/03/04/30/32/34</td><td>0.9 x 10^7</td><td>16</td></tr>
<tr><td>Viking terminal blocks on rail [4]</td><td>0 200 00/02
0 371 72/74</td><td>0.9 x 10</td><td>16</td></tr>
<tr><td>100</td><td>Distribution terminal blocks on 12 x 2 flat bar [4]</td><td>0 048 19
0 048 01/03/05/06/07
0 048 01/03/05/06/06</td><td>1.2 x 10^7</td><td>16</td></tr>
<tr><td>160</td><td>Brass bar [4]</td><td>0 373 01</td><td>2 x 10^7</td><td>25</td></tr>
<tr><td rowspan="2">160</td><td>Perforated 12 x 4 copper bar + connectors [4]</td><td>0 373 89
0 373 65</td><td>4.7 x 10^7</td><td>35</td></tr>
<tr><td>Viking terminal blocks on rail [4]</td><td>0 200 00/02
0 371 72/73/74/75/79</td><td>3.2 x 10^7</td><td>35</td></tr>
<tr><td rowspan="4"></td><td>200</td><td>12 x 4 copper bar + clamps [4]</td><td>0 373 49/373 02
0 373 60/61/62</td><td>5.8 x 10^7</td><td>50</td></tr>
<tr><td>250</td><td>15 x 4 copper bar</td><td>0 374 33</td><td>9.1 x 10^7</td><td>70</td></tr>
<tr><td>315</td><td>18 x 4 copper bar</td><td>0 374 34</td><td>1.3 x 10^8</td><td>95</td></tr>
<tr><td>400</td><td>24 x 4 copper bar</td><td>0 374 38</td><td>2.5 x 10^8</td><td>120</td></tr>
<tr><td colspan="2" rowspan="3"></td><td>500</td><td>25 x 5 copper bar</td><td>0 374 18</td><td>3.9 x 10^8</td><td>150</td></tr>
<tr><td>630</td><td>32 x 5 copper bar</td><td>0 374 19</td><td>6.5 x 10^8</td><td>185</td></tr>
<tr><td>800</td><td>50 x 5 copper bar</td><td>0 374 40</td><td>2.5 x 10^9</td><td>240</td></tr>
<tr><td colspan="3" rowspan="3"></td><td>1000</td><td>63 x 5 copper bar [5]</td><td>0 374 41</td><td>2.5 x 10^9</td><td>2 x 150 or 300</td></tr>
<tr><td>1250</td><td>80 x 5 copper bar [5]</td><td>0 374 43</td><td>4.1 x 10^9</td><td>2 x 185</td></tr>
<tr><td>1600</td><td>100 x 5 copper bar [5]</td><td>0 374 46</td><td>6.9 x 10^9</td><td>2 x 240</td></tr>
</table>

(1) The protective conductor terminals or collectors are sized for the same short-circuit thermal stress withstand as that of the main protective conductor.
(2) In TT systems, the cross-section of the main protective conductor can be limited to 25 mm² if the earth connections of the neutral and the exposed conductive parts are separate.
(3) XL³ 160 cabinets are supplied with a brass bar.
(4) Can be used in double or reinforced insulation assemblies.
(5) In accordance with standard IEC 60439-1, the cross-section of the bar can be limited to 50 x 5 (S/4).

USING THE EXPOSED CONDUCTIVE PARTS AS PROTECTIVE CONDUCTORS

CHASSIS

The exposed conductive parts consisting of the chassis of XL³ cabinets and enclosures can be used as protective conductors in that the attachments of the various components automatically provide an equipotential interconnection conforming to the provisions of standard IEC 61439-1 section 7.4.3.1 and standard IEC 60364-5-54 section 542.2.

However, it is advisable to limit the protective conductor function to the uprights of the chassis only and to pay particular attention to the risk of breaking the protective circuit by mechanical dismantling.

When using uprights as protective conductors, the cross-section of the equivalent protective conductor is:

- 50 mm² for XL³ 160, XL³ 400 and XL³ 800
- 70 mm² for XL³ 4000 enclosures

Permissible thermal stress for equipment uprights:

- Cabinets and enclosures: XL³ 160, XL³ 400 and XL³ 800: 1.1 x 108 A²s

- XL³ 4000 enclosures: 1.4 x 108 A²s

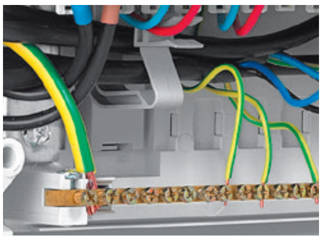
FIXING RAILS

The fixing rails of type 2 devices can also be used as protective circuit collectors, provided that the connections are made using Legrand terminal blocks specifically designed for this purpose: Cat.Nos 0 371 72/73/74/75/79.

The equivalent electrical cross-section of the exposed conductive parts consisting of the XL³ cabinets and enclosures enables them to be used for the equipotential link and for connecting the earths of surge protective devices. To avoid any ambiguity, do not use the exposed conductive parts for both protection purposes (PE conductor) and for functional purposes (surge protective devices). The use of the exposed conductive parts as PEN is prohibited.

ASSEMBLY PROTECTED BY TOTAL INSULATION

In an assembly conforming to IEC 61439-1 section 8.4.4, protection by total insulation, the protective conductors are considered to be live parts and the metal parts must not be connected to these protective conductors. The main protective conductor terminal must therefore be insulated. Appropriate measures for mounting in XL³ enclosures have therefore been provided.



XL³ 160 insulated contacts take brass bars or flat bars for terminal blocks

WIRING A DOUBLE OR REINFORCED INSULATION ASSEMBLY

➔ See page 20

TREATMENT OF THE PEN CONDUCTOR

Using the same conductor for both the neutral function (N) and the protective conductor function (PE) can provide economical optimisation of the installation, in particular by using 3-pole devices.

STANDARD REQUIREMENTS

The use of a PEN conductor is subject to specific standard requirements.

• The protection function is crucial, and the PEN conductor must be marked with dual green/yellow colouring (or failing that, using coiled wiring markers). It is advisable to mark it "PEN".

• The PEN conductor must not be isolated or cut, and no device must be inserted in the protective circuit.

• The minimum cross-section of the PEN conductor is 10 mm² for copper or 16 mm² for aluminium.

Using the PEN conductor requires specific precautions to be taken:

- All risks of breaking the PEN conductor must be avoided. It is therefore advisable not to reduce its cross-section in relation to the phase conductors
- The PEN conductor must be insulated for the nominal voltage in relation to earth. This insulation is not compulsory inside assemblies, and the PEN collector bar can be mounted directly on the structure, but the metal conductive parts (structures, cable trays, etc.) must not be used as PEN conductors
- The PEN bar can be installed near the phase bars without inserting ferromagnetic components (structures, crosspieces, etc.)
- Separate connection devices must be provided for the neutral conductor and the protective conductor

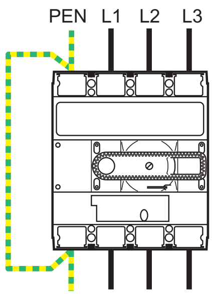
4-pole busbar supports can generally be used for distribution using a TN-C system inside an assembly. The absence of the neutral bar(s) does not change the characteristics of these supports.
They can be used in 4-pole assemblies and the PEN bar is insulated and installed properly close to the phase bars. It is then possible to reduce its cross-section to S/2 using for example one bar instead of two, provided that the minimum cross-section conditions required for the neutral function and the protective conductor function are complied with.

It is advisable to position the bar (PE, N or PEN) near the accessible side of the assemblies to:

- **Decrease the risk of electric shocks**
- **Identify the neutral earthing system**
- **Decrease the magnetic field radiated towards the measuring devices**

INSULATION MEASUREMENT AND PEN CONDUCTOR

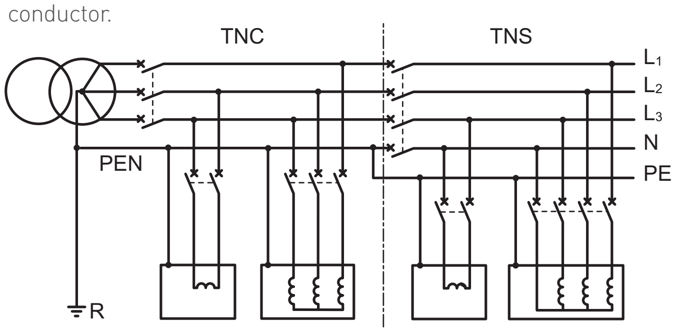
The rule concerning the non-isolation of the PEN conductor can be inconvenient when measuring the insulation, in particular that of an HV/LV transformer. In fact breaking the earth conductor does not totally isolate the windings, which are still connected to the PEN conductor, which is itself earthed via the protective conductors or the equipotential links of the installation. It is therefore necessary to isolate the PEN conductor very briefly.
There are two possibilities, the second of which is preferable.
1 - Place a disconnecting strip or a disconnectable terminal on the PEN conductor in close proximity to the main disconnecting switch. It should only be possible to remove this using a tool, and a warning notice should be fitted, stating: "Caution, TN-C system. Breaking of the PEN is prohibited unless taking measurements while de-energised".
2 - Install a 4-pole isolating device (or better still, 3P + offset N). The pole of the PEN conductor will be short-circuited by a green/yellow conductor with the same cross-section. This conductor is disconnected to carry out measurements after isolation. The advantage of this solution is that the continuity of the PEN is physically linked to the re-energisation.



COEXISTENCE OF TN-C AND TN-S

If these two systems coexist in the same installation, the TN-C system must be used upstream of the TN-S system. Residual current devices must not be used in TN-C systems.
If RCDs are used to protect the outgoing lines supplying secondary distribution boards, the PEN conductor must not be used downstream of these devices and the PE conductor of these circuits must be connected upstream of these devices.
The neutral conductor and the protective conductor must not be connected downstream of their separation point. At this separation point, each conductor must be connected separately (lug, terminal, etc.).

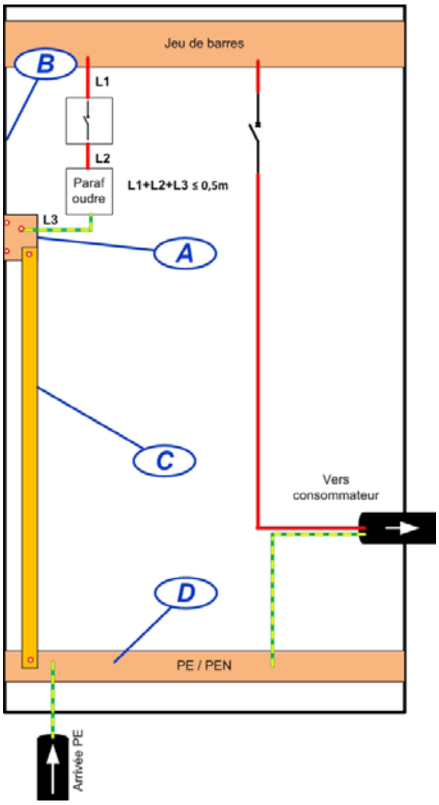
As a general rule, final circuits are created using the TN-S system (separate neutral conductor and PE). If they are created using the TN-C system (complying with the required cable cross-sections) and there are separate connection terminals for the neutral and the protective conductor, they must be connected together to the PEN conductor.



INSTALLING A SURGE PROTECTIVE DEVICE IN AN ENCLOSURE OR CABINET WITH A METAL STRUCTURE (LEGRAND RECOMMENDATIONS)

Connections L1, L2 and L3 must be as short as possible (preferably no more than 0.5 m in total; see the standards below).

- An additional conductive plate Ⓐ must be fixed to the metal structure Ⓑ of the XL³ enclosure, as close as possible to the surge protective device.
- The electrical connection point between connection L3 and the conductive plate Ⓐ must not be the same as the mechanical fixing point of the plate Ⓐ on the metal structure Ⓑ of the XL³.
- An additional connection Ⓒ can be added between the conductive plate Ⓐ and the main earth bar Ⓓ. This additional connection is recommended to comply with certain local installation practices. In this case, the cross-section of the connection Ⓒ must be at least the same as that of connection L3. It can be created using a copper bar (recommended) or a cable.

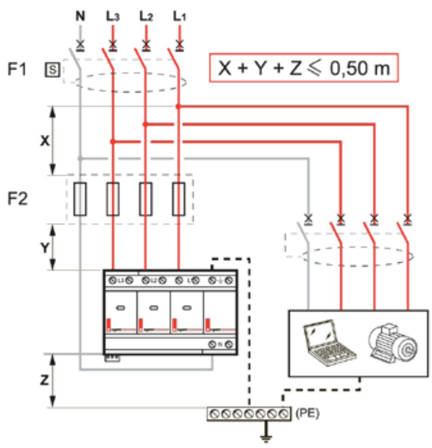


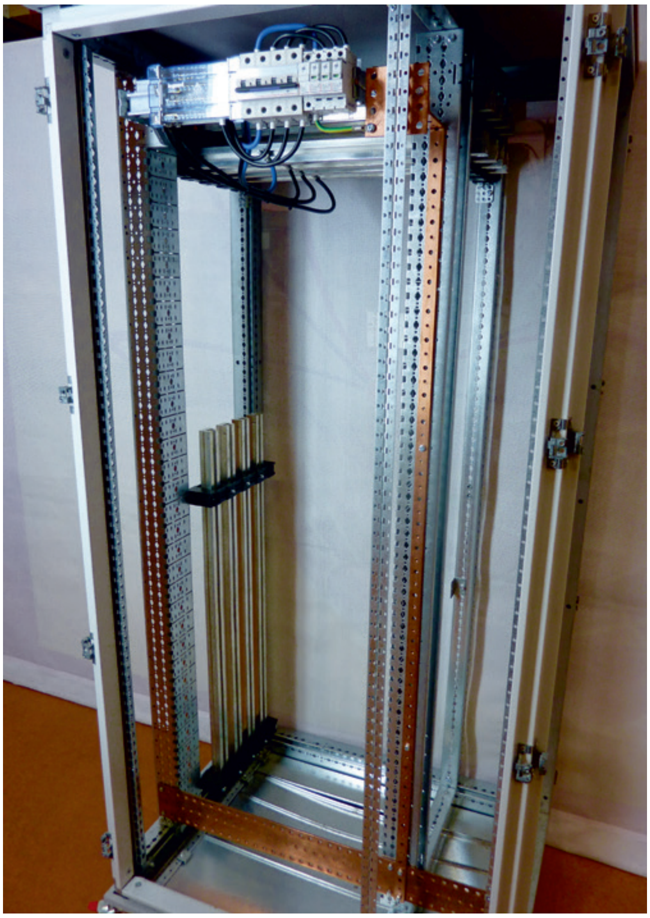
HOW LEGRAND APPLIES THE STANDARDS

IEC 60364

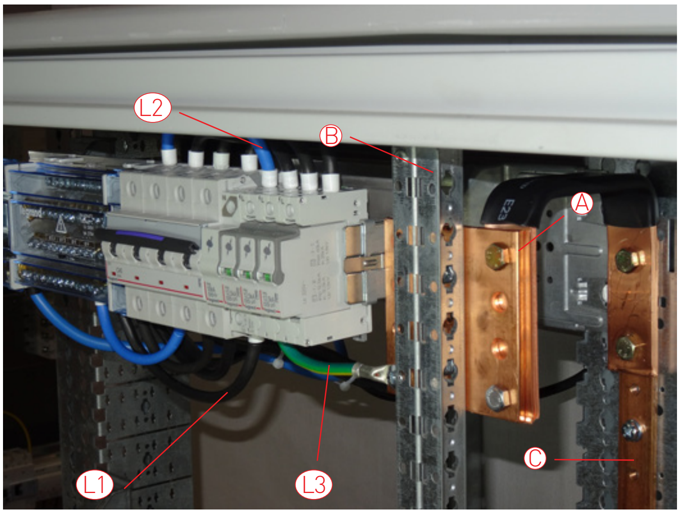
Section 534.1.3.4: To provide optimum overvoltage protection, the conductors connecting the surge protective device must be as short as possible.

The mounting recommendations for Legrand surge protective devices define a total length X+Y+Z ≤ 0.5 m. These recommendations are available in the installation manuals.

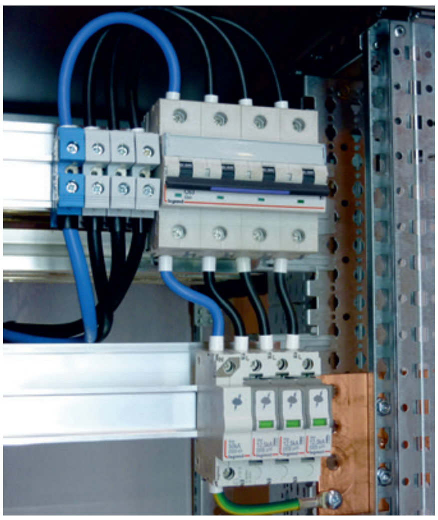




Example of building an XL³ enclosure with the power supply via the bottom for the protection associated with the surge protective device.



Earth connection with an additional conductive plate (A), fixed to the metal structure of the XL³ enclosure.



Another example of creating connections L1, L2 and L3.

It is advisable to affix additional information, identifying the power supply on the product and on the faceplate (see page 36).

Wiring devices

CONDUCTOR ENTRIES

For practical reasons of routing conductors, it is becoming increasingly common for incoming cables to be connected either on the top or the bottom terminals of the devices, as required.
This requires two precautions to be taken:
- The device to be connected must be chosen accordingly (reversible power supply)
- The power supply terminals must be identified, in particular if the cables are connected to the bottom terminals

DPX³ devices can be supplied via either the top terminals or the bottom terminals, including when they are equipped with earth leakage modules. They can operate in a vertical or horizontal position.

There may be a preferred direction for supplying devices according to the market or national practices. If that used for the installation is different, it is advisable to affix additional information identifying the power supply on the product and on the faceplate.

Examples of information:

CAUTION: power supply via bottom terminals

or markings such as:

↑↑↑↑	↓↓↓↓
Outgoing terminals	Incoming terminals

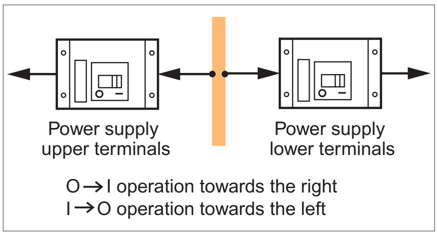
POSITIONS OF THE DEVICES

To avoid accidents, common sense dictates that the direction of opening and closing of the devices should be identical for the whole installation and in particular for the same assembly (e.g. left to right, bottom to top) according to the positions of the devices. Particular care must therefore be taken with devices installed horizontally.

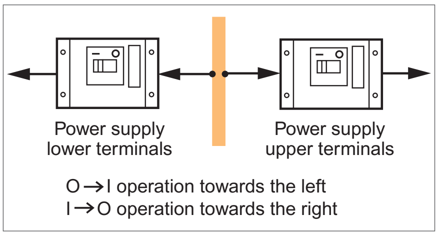
Standard IEC 60447, referred to in IEC 61439-1, indicates that any "mirror effect" (e.g. direction of opening of two devices reversed) must be prohibited.

All DPX³ devices installed horizontally can be positioned either way: O —> I to the right or to the left. Symmetry is achieved by simply reversing the device.

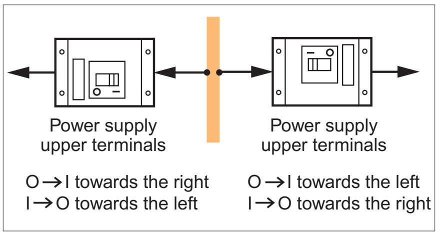
Different power supply configurations with devices installed horizontally



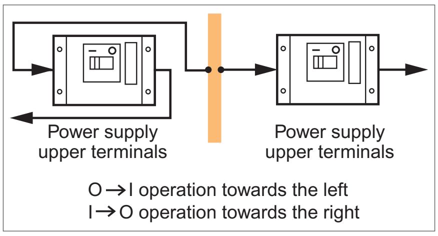
Recommended configuration if the power supply terminals are marked



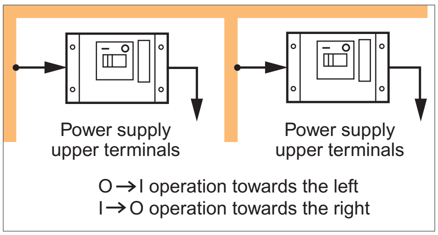
Configuration permitted if the power supply terminals are marked



Configuration not recommended: devices supplied via upper terminals, but directions of operation reversed



Recommended configuration if there is a requirement concerning the direction of the power supply



Recommended configuration for ease of routing bars and cables (bar sleeve on the left, cable sleeve on the right)

MARKING THE NEUTRAL POLE

There is no standard position for the neutral pole. It can differ according to local practices. The neutral conductor must be marked using light blue. When conductors of this colour are not available (industrial cables), it is advisable to place coloured sleeves at the ends close to the terminals.

DPX³ are supplied with neutral marked on left-hand pole

WIRING COILS

The wiring of the coils for residual current devices requires specific precautions to be taken:

- Limit the length of the connection cables between the coil and the relay as much as possible
- Place the cables at the centre of the coil and the neutral conductor preferably at the centre of the phase conductors
- Comply with an angle of 90° between cables and coils
- If necessary, use shielded cable
- For very high currents, the measure should preferably be taken on the connection between the transformer neutral and earth rather than on the phases
- If necessary, add a non-magnetic sleeve with a height of at least twice the Ø of the coil
- Check that the information marked on the coils is still visible after installation.

When the coils are placed on a busbar, in addition to the above recommendations, it is advisable to:

- Place the coils in staggered rows to avoid having to reduce the clearances
- Place spacers between the bars in the same phase, when the busbar has several bars per phase

Separations inside an assembly

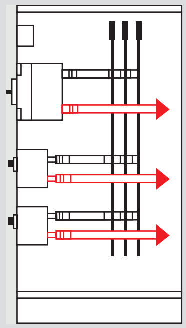
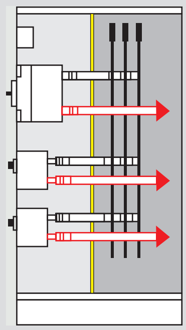
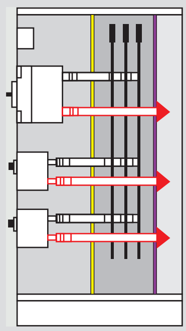
Standard IEC 61439-2 defines the separations inside an assembly according to 4 types of form, each form being divided into two groups, "a" and "b". These internal separations are created using barriers or screens made of metal or insulating material.
Their purpose is to divide the panel into closed protected areas to provide:
- Protection against direct contact with dangerous parts of neighbouring functional units. The degree of protection must be at least IP XXB.
- Protection against the entry of solid objects. The degree of protection must be at least IP 2X (which covers IP XXB).

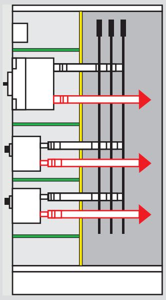
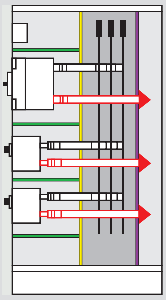
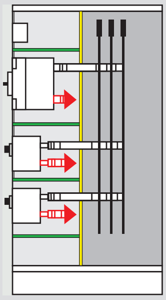
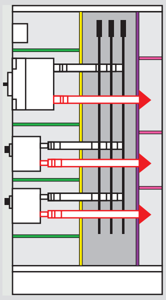
The main purpose is to maintain the availability of the power supply in the event of a fault or if work is being carried out on the panel.
Separations also limit the propagation of an electric arc and the risk of sparkover.
However, they limit the natural ventilation of the panel and can thus cause temperature rises. It is therefore advisable to check the thermal equilibrium. Separations will inevitably increase the size of the panel and its cost, both in terms of labour and components.

With the XL³ 4000/6300 system all types of forms can be created using components available in the catalogue.

FORMS

➜ See Forms Workshop specifications

SPECIFICATIONS OF THE DIFFERENT TYPES OF FORM		
Form 1		No separation
Form 2a		Separation of busbars from functional units. Terminals for external conductors do not need to be separated from busbars.
Form 2b		Separation of busbars from functional units. Terminals for external conductors are separated from busbars.

SPECIFICATIONS OF THE DIFFERENT TYPES OF FORM (CONTINUED)		
Form 3a		Separation of busbars from functional units and separation of all functional units from each other. Terminals for external conductors do not need to be separated from busbars.
Form 3b		Separation of busbars from functional units and separation of all functional units from each other. Separation of terminals for external conductors from functional units but no separation between terminals.
Form 4a		Separation of busbars from functional units and separation of all functional units from each other, including the terminals for external conductors which are an integral part of the functional unit. Terminals for external conductors are in the same compartment as the functional unit.
Form 4b		Separation of busbars from functional units and separation of all the functional units from each other including terminals for external conductors. Terminals for external conductors are not in the same compartment as the functional unit but in separate individual compartments.

FUNCTIONAL UNIT

This term refers to part of an assembly comprising all the mechanical and electrical components used to perform a single function.
In the case of distribution panels, a functional unit almost exclusively comprises the protective device and its auxiliaries, apart from "draw-out unit" systems.

IS (INCREASED SAFETY) DISTRIBUTION

If the ability to carry out maintenance work or upgrades on the panel without switching off all power to the assembly is required, the HX³/VX³ IS distribution system is particularly suitable and can be a good replacement for separation forms.

Draw-out bases
+
protection of the bars
+
terminal covers
=
safety of work

Empty draw-out bases
=
safe upgrades

It is not necessary to add partitions between the functional units for forms 3a, 3b, 4a and 4b.
The IP 2X degree of protection of DPX³ devices covers IP XXB. Separation can be obtained by insulating the live parts or by placing the device concerned inside an integrated unit, for example a moulded-case circuit breaker conforming to IEC 61439-2 section 8.101.

Pushbuttons and indicators

Colours and flashing are effective visible methods of attracting attention. They must be used for clearly determined applications and there must be no ambiguity.
Standard IEC 60073 defines the colours to be used for pushbuttons and indicators.
It is advisable to limit the number of colours used to what is strictly necessary.
The main colours used are red, yellow, green, blue, white, grey and black.
The meanings of the colours must be assigned in order of priority with regard to the following criteria:
- Safety of people or property
- Situation of a process
- Status of equipment

MEANINGS OF THE COLOURS

Red = danger
Yellow = caution, warning or abnormal condition
Green = safe or normal operation
Blue = obligation
White, grey or black = indication, information

Osmoz range: a wide variety of pushbuttons and indicators

INDICATORS AND PUSHBUTTONS	SAFETY	PROCESS	STATUS
Red	Danger	Emergency	Fault
Yellow	Caution	Abnormal condition	Abnormal
Green	Safe	Normal	Normal
Blue	Compulsory action		
White, grey, black	Indication, information		

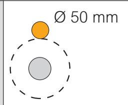
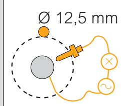
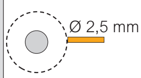
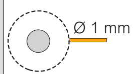
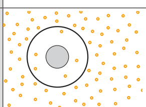
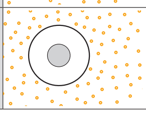
IP degrees of protection

The protection index (IP) defines the ability to protect people and to prevent entry of solid objects and direct contact (first number) and entry of liquids (second number). The additional letter indicates the protection against access to hazardous parts. With its XL³ range, Legrand provides an ideal response, suitable for all environments.

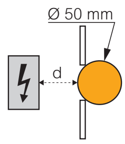
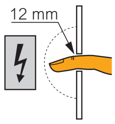
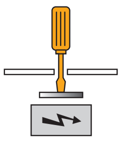
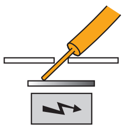
From the XL³ 160 IP 30 cabinet to the XL³ 4000/6300 industrial distribution enclosure, all levels of protection are possible. These IP levels are maintained for enclosures used with Legrand accessories.

IP DEGREES OF PROTECTION IN ACCORDANCE WITH STANDARDS IEC 60529 AND EN 60529

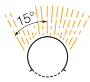
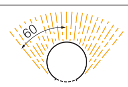
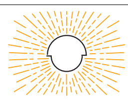
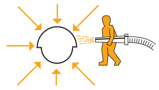
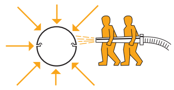
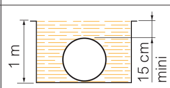
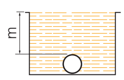
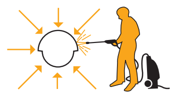
1st number: protection against the penetration of solid objects

IP	tests	
0		No protection
1		Protected against solid objects larger than 50 mm
2		Protected against solid objects larger than 12.5 mm
3		Protected against solid objects larger than 2.5 mm
4		Protected against solid objects larger than 1 mm
5		Protected against dust (no harmful deposits)
6		Totally protected against dust

Additional letter IP XX (ABCD): protection against direct contact by access to hazardous live parts

IP	tests	protection
A		The back of the hand is kept away from hazardous parts
B		If a finger is inserted it cannot touch hazardous parts
C		If a tool is inserted (for example, a screwdriver) it cannot touch hazardous parts
D		If a wire is inserted it cannot touch hazardous parts

2nd number: protection against liquids

IP	tests	
0		No protection
1		Protected against vertically falling drops of water (condensation)
2		Protected against dripping water up to 15° from the vertical
3		Protected against rainwater up to 60° from the vertical
4		Protected against water sprayed from all directions
5		Protected against water jets from all directions
6		Totally protected against powerful water jets similar to heavy seas
7		Protected against the effects of immersion
8		Protected against the effects of prolonged immersion under specified conditions
9		Protected against high-pressure and high-temperature water jets

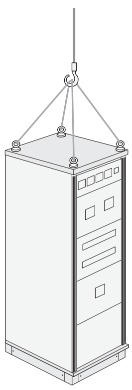
Handling assemblies

LIFTING ASSEMBLIES

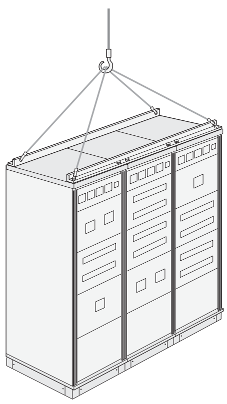
The recommendations and safety precautions for lifting assemblies using slings are given for information purposes only, as they are dependent on the competence of the slinger, the travelling crane operator or the jib crane operator.

LIFTING ACCESSORIES

XL³ lifting rings can be used to handle units less than 2 m wide.
When the assembly is more than 2 m wide or the load is particularly heavy, bolted brackets must be used. This method applies to XL³ 4000/6300 and XL³ 800 IP 55 enclosures, but not XL³ 800 IP 43 enclosures.



Lifting with rings

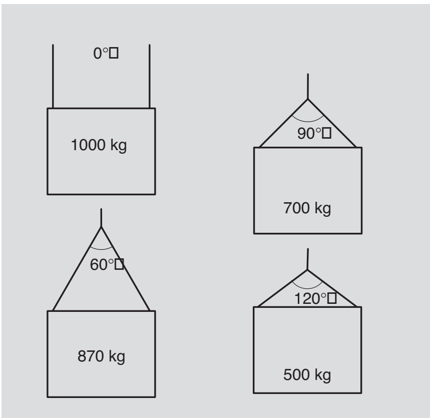


Lifting with bolted brackets

Endless slings or straps are never recommended for hooking onto rings.

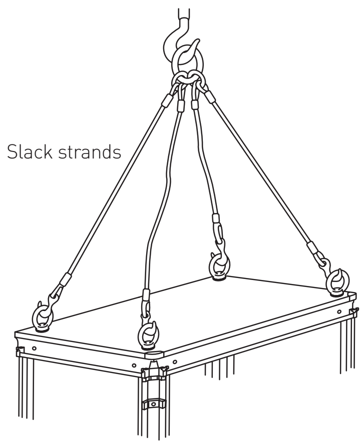
CHOOSING THE SLINGS

It is the responsibility of the slinger to choose the appropriate sling according to the weight to be handled and the lifting equipment available.
- Make a generous estimation of the weight to be handled. If there is no precise data, the values of the permitted loads can be used as a basis.
- Determine the necessary sling capacity. The safe working load (SWL, which has to be marked on the sling) must be suitable for the lifting to be performed.
The minimum SWL of the slings is indicated on the lifting diagrams in the manuals of the enclosures (value for a single sling or for one strand of a multiple sling).
- Check the liftable load taking into account the slinging mode factor M, which is dependent on the angle and the number of strands.



Angle between the strands on the liftable load

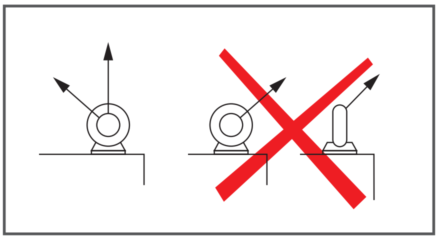
The load to be lifted is often not balanced. The strands are not uniformly loaded and their lengths are not identical. This results in a reduction of the liftable load.



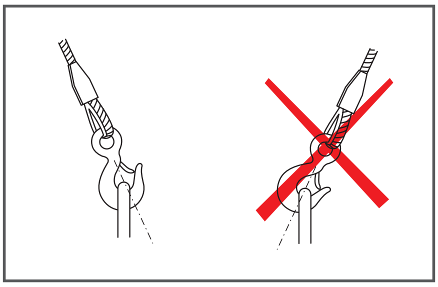
It is recommended that the angle between the strands is limited to 90° and never exceeds 120° because at these angles the attachment points are subjected to significant lateral forces and the load which can be lifted is considerably reduced.

LAYOUT OF RINGS, SLINGS AND HOOKS

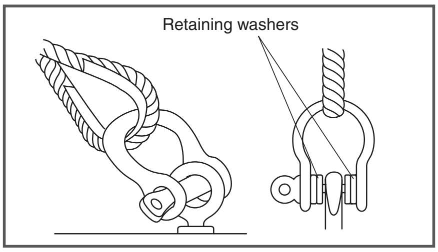
Screw in the devices, complying with the max. recommended tightening torques



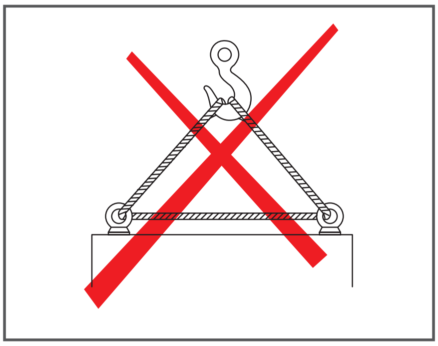
Turn the rings so that they are in line with the slings. If necessary, adjust them by loosening them. The lateral forces on incorrectly positioned rings can cause them to break.



Position the hooks with their jaws facing upwards.



- Use devices to prevent accidental unhooking: hooks with safety clips or shackles (inserting washers keeps shackles centred).



- Inserting an endless sling through two rings must be strictly forbidden. The forces applied on the rings and the sling may exceed their capacities.

LIFTING LONG LOADS

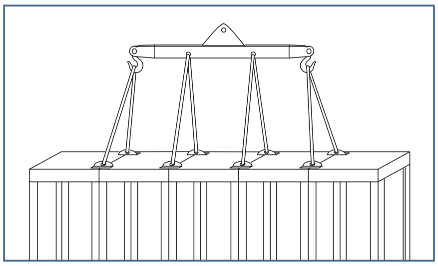
Very long assemblies may require specific precautions to be taken to balance the load and limit swinging.

• Use of a balancing sling

This type of practice requires a good knowledge of the distribution of the load. If in doubt use a lifting beam.

• Use a lifting beam

Sling in a "trapeze" arrangement to limit swinging. Do not use flat slings.



HANDLING WITH TROLLEY AND FORKLIFT TRUCK

Assemblies attached to pallets can be handled using a pallet truck, a trolley or a forklift truck with no risk of damage.

XL³ enclosures can still be handled when the pallets have been removed.

The bases of the enclosures are strong enough to take the forks of a forklift truck, even when they are equipped with wiring accessories. The removable traps must be removed from the plinths before lifting them.

WHEELING ENCLOSURES

All XL³ enclosures can be wheeled around on the ground, whether or not they are fitted with plinths. The outer edges of the base are reinforced to create a continuous running surface.

This point must be detailed in the technical folder to ensure that the finished assembly is handled correctly before final installation.

CERTIFICATION
OF ASSEMBLIES

Standard IEC 61439-1 & 2

The certification of low voltage distribution assemblies is defined by international standards IEC 61439-1, IEC 61439-2 and IEC 61439-3

WHAT HAS CHANGED IN RELATION TO THE IEC 60439 STANDARDS

The IEC 61439 series of standards was issued as a complete replacement of the IEC 60439 series of standards.
The following technical changes have been made:
- The dual role of IEC 60439-1 as both a product standard in its own right and a standard providing general rules for assemblies covered by a subsidiary product part of the IEC 60439 series has been abandoned. As a result, IEC 61439-1 is purely a "general rules" standard that should be referred to by the subsidiary product parts of the IEC 61439 series.
- The product standard replacing IEC 60439-1 is IEC 61439-2.
- The distinction between standard assemblies (SA) and assemblies derived from the standard (ADS) has been replaced by the verification approach.
- Three different but equivalent types of verification of requirements have been introduced: verification by testing, verification by calculation/measurement or verification by satisfying design rules.
- The requirements concerning temperature rise have been clarified.
- The rated diversity factor (RDF) is covered in greater detail.
- Requirements for empty enclosures for assemblies (IEC 62208) have been incorporated.
- The entire structure of the standard has been aligned with its new function as a "general rules" standard.

Unlike IEC 60439-1, conformity cannot be established simply on the basis of the general rules (IEC 61439-1). Assemblies must comply with the specific standards which apply to them; in this case, standards IEC 61439-2, IEC 61439-3, etc.
This document only covers the certification of power cabinets and enclosures designed to be used by authorised persons, i.e. parts 1 and 2 of the new standard.

IEC 60439 I OLD 1992 SERIES

IEC 60439-1 Standard assemblies and assemblies derived from the standard		IEC 60439-3 Distribution boards	IEC 60439-4 Assemblies for construction sites	IEC 60439-5 Assemblies for power distribution	IEC 60439-2 Busbar trunking systems	
↓	↓	↓	↓	↓	↓	
IEC 61439-1 General rules	IEC 61439-2 Power switchgear and controlgear assemblies	IEC 61439-3 Distribution boards	IEC 61439-4 Assemblies for construction sites	IEC 61439-5 Assemblies for power distribution	IEC 61439-6 Busbar trunking systems	IEC 61439-7 Electric vehicles

IEC 61439 I NEW 2011 SERIES

DEFINITIONS

- **Power switchgear and controlgear assembly (PSC):**

Complete system of electrical and mechanical components (enclosures, busbars, functional units, etc.) as defined by the Original Manufacturer and intended to be assembled in accordance with the Original Manufacturer's instructions.
Example: pre-equipped distribution enclosure.

- **Assembly Manufacturer:**

Entity which carries out assembly and wiring and is responsible for the finished assembly.
Example: panel builder.

- **Original Manufacturer**

Entity responsible for the original design and associated verification of an assembly in accordance with standard IEC 61439.
Example: Legrand.

The Assembly Manufacturer and the Original Manufacturer can be the same entity.
Example: panels assembled and wired by Legrand.

ROLES AND RESPONSIBILITIES OF EACH ENTITY

The original manufacturer manufactures or specifies the various components which make up the distribution panel: protective devices, enclosures, distribution system, etc. All these components have product certificates of conformity. Representative configurations created based on these products undergo a series of tests: these are the type tests.

The assembly manufacturer assembles the electrical enclosure, installs the equipment and carries out the wiring in line with the rules for the selection and installation of the products according to the methods defined by the original manufacturer, the standards, the regulations and good practice. The assembly manufacturer is responsible for certifying the finished assembly and providing the technical documentation. The individual tests (insulation, continuity of the exposed conductive parts) and the final inspection are all recorded in a simplified individual report (see example in the appendix).
Full compliance with this process can then be certified by a declaration of conformity (see example on page 62) and the assembly can be marked accordingly. Compliance with standard IEC 61439-2 also enables the CE mark to be affixed, if required.

Tests to be performed by the original manufacturer

Standard IEC 61439-2 requires verification of 13 characteristic points for certification of power switchgear and controlgear assemblies (PSC).
These verifications concern the finished assembly and do not replace the compliance tests for the component parts specified by the product standards.

Verification can be carried out using three different methods, depending on the characteristic:
- Testing carried out on a sample of an assembly or on parts of assemblies
- Structured comparison of a design proposal for an assembly, or parts of an assembly, with a reference design that has been verified by testing
- Verificati on of compliance with the design rules or strict calculations applied to a sample of an assembly or to parts of assemblies, including the use of appropriate safety margins

When there are several methods for the same verification, these methods are considered to be equivalent and the choice of the appropriate method is the responsibility of the original manufacturer.

As an original manufacturer, Legrand has had most of these verifications carried out on representative samples by a recognised laboratory.
If all the requirements and instructions given by Legrand are complied with in full, the assembly manufacturer does not have to repeat these verifications on the finished assembly.
When the assembly manufacturer incorporates its own measures, which are not included in the original manufacturer's verification, it is considered to be the original manufacturer with respect to these measures and must therefore repeat these verifications.

DESIGN VERIFICATIONS					
No.	**Characteristic to be checked**	**Article or section**	**Available verification options**		
			Tests	**Comparison**	**Evaluation**
1	Strength of materials and parts:	10.2			
	Resistance to corrosion	10.2.2	YES	NO	NO
	Properties of insulating materials:	10.2.3	YES	NO	NO
	Thermal stability	10.2.3.1	YES	NO	NO
	Resistance of insulating materials to abnormal heat and fire due to internal electrical effects	10.2.3.2			
	Resistance to ultra-violet (UV) radiation	10.2.4	YES	NO	YES
	Lifting	10.2.5	YES	NO	NO
	Mechanical impact	10.2.6	YES	NO	NO
	Marking	10.2.7	YES	NO	NO
2	Degree of protection provided by enclosures	10.3	YES	NO	YES
3	Clearance	10.4	YES	NO	NO
4	Creepage distance	10.4	YES	NO	NO
5	Protection against electric shock and integrity of protective circuits:	10.5			
	Effective continuity between the exposed conductive parts of the assembly and the protective circuit	10.5.2	YES	NO	NO
	Short-circuit withstand strength of the protective circuit	10.5.3	YES	YES	NO
6	Incorporation of connection devices and components	10.6	NO	NO	YES
7	Internal electrical circuits and connections	10.7	NO	NO	YES
8	Terminals for external conductors	10.8	NO	NO	YES
9	Dielectric properties:	10.9			
	Power frequency withstand voltage	10.9.2	YES	NO	NO
	Impulse withstand voltage	10.9.3	YES	NO	YES
10	Temperature rise limits	10.10	YES	YES	YES
11	Short-circuit withstand strength	10.11	YES	YES	NO
12	Electromagnetic compatibility (EMC)	10.12	YES	NO	YES
13	Mechanical operation	10.13	YES	NO	NO

The 13 design verifications in detail

TEST 1

STRENGTH OF MATERIALS AND PARTS:

The mechanical, electrical and thermal capacities of the construction materials and parts of the assemblies must be deemed to be proved by verification of the construction and performance characteristics. Tests are therefore carried out to check resistance to: heat, ultra-violet radiation, lifting and mechanical impact.

TEST 2

VERIFICATION OF THE DEGREE OF PROTECTION (IP)

The IP defines the ability to protect people from dangerous parts and to prevent entry of solid objects (first numbers) and liquids (second number). The additional letter indicates protection against access to dangerous parts only.

TEST 3

CLEARANCES AND CREEPAGE DISTANCES:

The measurement methods for the clearances and creepage distances are covered in detail in Annex F of standard IEC 61439-1 which is based on standard IEC 60664-1. The clearances and distances are measured between live parts with different polarities, and also between live parts and exposed conductive parts (example in the appendix).

TEST 4

ASSEMBLING DEVICES AND EQUIPMENT

Legrand guarantees compliance with the clearances and distances for the insulation voltages of these devices when they are installed in accordance with the specified conditions. Experience has shown that the greatest risk is in the wiring. Connections, bundles of conductors and busbars must be meticulously checked. Unsuitable connectors, bolted connections, joints and metal supports can reduce the insulation values initially envisaged.

TEST 5

EFFECTIVENESS OF THE PROTECTIVE CIRCUIT

The continuity of the protective circuit is a decisive factor for safety. It is checked: in accordance with standard IEC 61439-1 at a test current of 25 A between the terminal connecting the protective conductors and all the exposed conductive parts, and also in accordance with an additional Legrand test, at a high fault current that could occur following accidental detachment of a conductor.

TEST 6

INCORPORATION OF CONNECTION DEVICES AND COMPONENTS

These are rules concerning the installation of devices included in the assembly, whether they are fixed or removable parts, and compliance with the customer's wiring requirements. This also includes accessibility to adjustment and reset devices; and all types of indication (LEDs, dials, etc.).

TEST 7

■ INTERNAL ELECTRICAL CIRCUITS AND CONNECTIONS

This test consists of checking conformity of the power and control circuits with the design requirements. It includes correct sizing of the busbar and cables, earthing the control circuits, etc. It also includes identification of the various circuits using different colours.

TEST 8

■ TERMINALS FOR EXTERNAL CONDUCTORS

This rule requires the terminal capacity and whether the terminals are suitable for aluminium or copper conductors to be specified to the end user. It also includes checking all the types of terminal that can be used for the cable entries and outlets (neutral, PEN, symbolic PE, etc.).

TEST 9

■ DIELECTRIC PROPERTIES

The dielectric tests check the insulation performance levels for the maximum operating voltage. They are carried out at the power frequency of 50 Hz and in the form of voltage waves simulating a lightning strike.

TEST 10

■ TEMPERATURE RISE LIMITS

Temperature rise test on assemblies

This test checks that assemblies operate correctly under maximum operating conditions (current, number of devices, volume of enclosure). It is used to define the heat balance data for an average temperature rise of the air in assemblies of less than 30°C and a temperature rise in the terminals of less than 70°C.

See the estimation of the heat balance for XL³ enclosures on page 70.

TEST 11

■ SHORT-CIRCUIT WITHSTAND STRENGTH

The tests carried out guarantee the withstand strength of the busbars and their supports, the breaking devices (Vistop/ DPX-IS), the protective devices (DMX³/ DPX³/DX³) and the enclosures in relation to the thermal and electrodynamic stresses.

TEST 12

■ ELECTROMAGNETIC COMPATIBILITY

This test consists of checking the electromagnetic interference caused by the assembly when operating in its environment, the aim being for it to cause no interference.

TEST 13

■ VERIFICATION OF THE MECHANICAL OPERATION

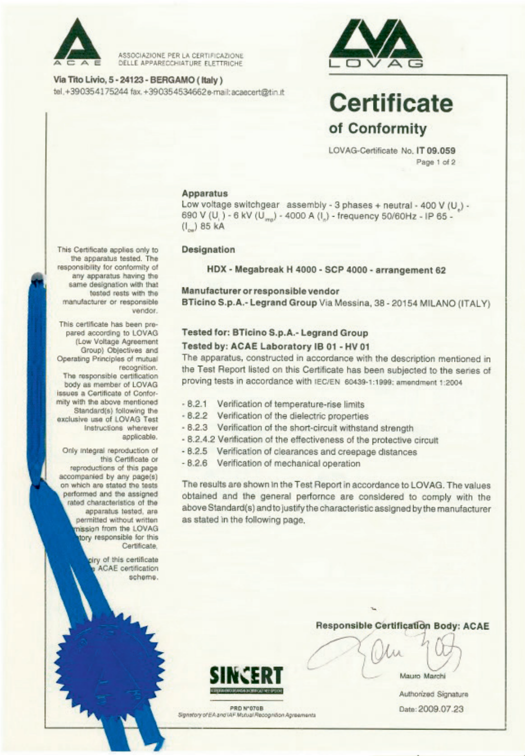
In accordance with the provisions of the standard, tests are carried out on parts and devices that are not subject to any specific requirements.

Correct mechanical operation is checked by carrying out 200 operating cycles on draw-out racks and faceplate fixings.

Response to the tests

Design verifications are carried out on a sample of an assembly or on parts of assemblies to demonstrate that the design satisfies the requirements of the applicable assembly standard.

These verifications are carried out officially by neutral organisations on assemblies representative of the usual wiring configurations and device layouts (see opposite).



ACAE ASSOCIAZIONE PER LA CERTIFICAZIONE DELLE APPARECCHIATURE ELETTRICHE
Via Tito Livio, 5 - 24123 - BERGAMO (Italy)
tel.+390354175244 fax.+390354534662 e-mail: acaecert@tin.it

LOVAG

Certificate
of Conformity

LOVAG-Certificate No. **IT 09.059**
Page 1 of 2

This Certificate applies only to the apparatus tested. The responsibility for conformity of any apparatus having the same designation with that tested rests with the manufacturer or responsible vendor.

This certificate has been prepared according to LOVAG (Low Voltage Agreement Group) Objectives and Operating Principles of mutual recognition. The responsible certification body as member of LOVAG issues a Certificate of Conformity with the above mentioned Standard(s) following the exclusive use of LOVAG Test Instructions wherever applicable.

Only integral reproduction of this Certificate or reproductions of this page accompanied by any page(s) on which are stated the tests performed and the assigned rated characteristics of the apparatus tested, are permitted without written ...mission from the LOVAG ...tory responsible for this Certificate.

...piry of this certificate ... ACAE certification scheme.

Apparatus
Low voltage switchgear assembly - 3 phases + neutral - 400 V (U_e) - 690 V (U_i) - 6 kV (U_{imp}) - 4000 A (I_n) - frequency 50/60Hz - IP 65 - (I_{cw}) 85 kA

Designation
HDX - Megabreak H 4000 - SCP 4000 - arrangement 62

Manufacturer or responsible vendor
BTicino S.p.A.- Legrand Group Via Messina, 38 - 20154 MILANO (ITALY)

Tested for: BTicino S.p.A.- Legrand Group
Tested by: ACAE Laboratory IB 01 - HV 01
The apparatus, constructed in accordance with the description mentioned in the Test Report listed on this Certificate has been subjected to the series of proving tests in accordance with IEC/EN 60439-1:1999; amendment 1:2004

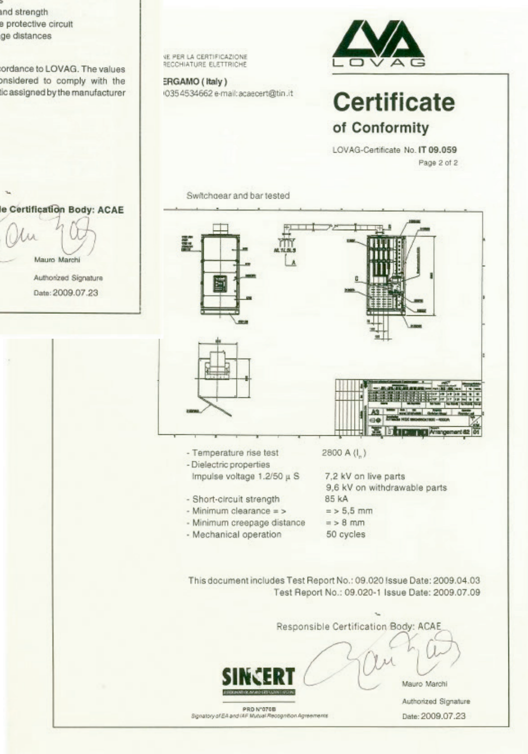
- 8.2.1 Verification of temperature-rise limits
- 8.2.2 Verification of the dielectric properties
- 8.2.3 Verification of the short-circuit withstand strength
- 8.2.4.2 Verification of the effectiveness of the protective circuit
- 8.2.5 Verification of clearances and creepage distances
- 8.2.6 Verification of mechanical operation

The results are shown in the Test Report in accordance to LOVAG. The values obtained and the general perfornce are considered to comply with the above Standard(s) and to justify the characteristic assigned by the manufacturer as stated in the following page.

Responsible Certification Body: ACAE

SINCERT
PRD N°070B
Signatory of EA and IAF Mutual Recognition Agreements

Mauro Marchi
Authorized Signature
Date: 2009.07.23



LOVAG

Certificate
of Conformity

LOVAG-Certificate No. **IT 09.059**
Page 2 of 2

Switchgear and bar tested

- Temperature rise test	2800 A (I_n)
- Dielectric properties	
Impulse voltage 1.2/50 µ S	7,2 kV on live parts
	9,6 kV on withdrawable parts
- Short-circuit strength	85 kA
- Minimum clearance = >	= > 5,5 mm
- Minimum creepage distance	= > 8 mm
- Mechanical operation	50 cycles

This document includes Test Report No.: 09.020 Issue Date: 2009.04.03
Test Report No.: 09.020-1 Issue Date: 2009.07.09

Responsible Certification Body: ACAE

SINCERT
PRD N°070B
Signatory of EA and IAF Mutual Recognition Agreements

Mauro Marchi
Authorized Signature
Date: 2009.07.23

LEGRAND UNDERTAKES TO CARRY OUT DESIGN VERIFICATIONS ON THESE XL³ ENCLOSURES

CHARACTERISTICS TO BE CHECKED	ORIGINAL MANUFACTURER (LEGRAND)
Strength of materials and parts	LOVAG 10.2 certificate
Degree of protection (IP)	LOVAG 10.3 certificate
Clearance	LOVAG 10.4 certificate
Creepage distance	LOVAG 10.4 certificate
Protection against electric shock and integrity of protective circuits	LOVAG 10.5 certificate
Integration of connection devices and components	Verified on tested configurations Legrand 10.6
Internal electrical circuits and connections	Verified on tested configurations Legrand 10.7
Terminals for external conductors	Verified on tested configurations Legrand 10.8
Dielectric properties	LOVAG 10.9 certificate (time 5 s)
Temperature rise	LOVAG 10.10 certificate
Short-circuit withstand strength	LOVAG 10.11 certificate
Electromagnetic compatibility	LOVAG 10.12 certificate
Mechanical operation	LOVAG 10.13 certificate

Tests to be performed by the assembly manufacturer

The individual routine tests, sometimes referred to as assembly tests, specified and defined by standard IEC 61439-1, must be carried out on the assembly by the assembly manufacturer, after assembly and wiring.
The individual routine tests include certain visual inspections and the only actual instrumental test is the dielectric test (power frequency withstand voltage at 50 Hz and impulse withstand voltage).
These verifications are designed to detect material and quality defects in components and to check that the manufactured assembly operates correctly.

The individual routine tests are not necessary on specific devices and separate components incorporated in the assembly when they are installed in accordance with the assembly instructions. In this case Legrand enclosures, circuit breakers and distribution system must be used

THE 10 INDIVIDUAL ROUTINE VERIFICATIONS

CHARACTERISTICS TO BE CHECKED	ASSEMBLY MANUFACTURER (Panel builder)
Degree of protection (IP)	Visual check 11.2
Clearance	Visual check 11.3
Creepage distance	Visual check 11.3
Protection against electric shock and integrity of protective circuits	Spot check 11.6
Integration of connection devices and components	Visual check 11.5
Internal electrical circuits and connections	Spot check 11.6
Terminals for external conductors	Visual check 11.7
Dielectric properties	Test to be performed 11.9 (time 1 s)
Mechanical operation	Visual check 11.8
Wiring, operational performance and function	Function test or visual check 11.10

DEGREE OF PROTECTION (IP) (ARTICLE 11.2)

The degree of protection of an assembly defines its capacity to protect people from direct contact with live parts and to prevent the entry of solid objects or liquids. It is specified by the IP code in accordance with the tests described in standard IEC 60529 (see below). The IP code required for an assembly in an enclosure depends on its installation conditions and the external influences to which it is subjected. In all cases it must be at least IP 2X.
The degree of protection of an open assembly must be at least IP XXB

Compliance with the assembly rules ensures that the IP of XL^3 enclosures is as stated

■ What the assembly manufacturer has to do

The assembly manufacturer must carry out a visual inspection, once all the components have been assembled, to check that the enclosure and its components comply with the stated degree of protection.

For example, if control and signalling auxiliaries are installed on doors or panels, their own IP and their installation must comply with the stated IP value.
In this case, no additional testing is required.

IP CODE ACCORDING TO STANDARD IEC 60529

1st number: protection against the penetration of solid objects

IP	tests	
0		No protection
1	Ø 50 mm	Protected against solid objects larger than 50 mm
2	Ø 12,5 mm	Protected against solid objects larger than 12.5 mm
3	Ø 2,5 mm	Protected against solid objects larger than 2.5 mm
4	Ø 1 mm	Protected against solid objects larger than 1 mm
5		Protected against dust (no harmful deposits)
6		Totally protected against dust

Additional letter IP XX (ABCD): protection against direct contact by access to hazardous live parts

IP	tests	protection
A	Ø 50 mm, d	The back of the hand is kept away from hazardous parts
B	12 mm	If a finger is inserted it cannot touch hazardous parts
C		If a tool is inserted (for example, a screwdriver) it cannot touch hazardous parts
D		If a wire is inserted it cannot touch hazardous parts

2nd number: protection against liquids

IP	tests	
0		No protection
1		Protected against vertically falling drops of water (condensation)
2	15°	Protected against dripping water up to 15° from the vertical
3	60	Protected against rainwater up to 60° from the vertical
4		Protected against water sprayed from all directions
5		Protected against water jets from all directions
6		Totally protected against powerful water jets similar to heavy seas
7	1 m, 15 cm mini	Protected against the effects of immersion
8	m	Protected against the effects of prolonged immersion under specified conditions
9		Protected against high-pressure and high-temperature water jets

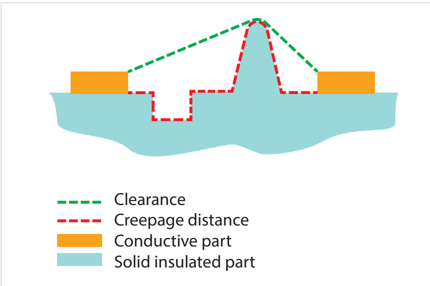
DEGREE OF PROTECTION OF LEGRAND ENCLOSURES

Type of enclosure	Without door	With door
XL^3 160	IP 30	IP 40
XL^3 400	IP 30	IP 40 [1]
XL^3 400 IP 55	-	IP 55
XL^3 800	IP 30	IP 40 [1]
XL^3 800 IP 55	-	IP 55
XL^3 4000	IP 30	IP 55
XL^3 6300	IP 30	IP 55

1: IP 43 with seals

CLEARANCES AND CREEPAGE DISTANCES (ARTICLE 11.3)

- Clearances represent the shortest distance between two conductive parts with different voltages. If there is a breakdown that disrupts the air, the electric arc will follow this path. The minimum clearances are determined according to the impulse withstand voltage Uimp of the assembly.
- Creepage distances represent the shortest distance along the surface of the insulating materials. The minimum creepage distances are determined according to the stated insulation voltage Ui for the assembly and the degree of pollution of its installation environment. As a general rule, degree of pollution 2 can be applied for residential or commercial applications and degree of pollution 3 for industrial applications.



MINIMUM CLEARANCES IN AIR ACCORDING TO IEC 61439-1

Rated impulse withstand current Uimp (kV)	Minimum clearance (mm)
≤ 2.5	1.5
4	3
6	5.5
8	8
12	14

MINIMUM CREEPAGE DISTANCES ACCORDING TO IEC 614391

Rated insulation voltage Ui (V) [1] (Ui ≥ Ue)	Degree of pollution							
	1	2			3			
	All material groups [2]	Material group [2]			Material group [2]			
		I	II	IIIa IIIb	I	II	IIIa	IIIb
250	1.5	1.5	1.8	2.5	3.2	3.6	4	4
320	1.5	1.6	2.2	3.2	4	4.5	5	5
400	1.5	2	2.8	4	5	5.6	6.3	6.3
500	1.5	2.5	3.6	5	6.3	7.1	8.0	8.0
630	1.8	3.2	4.5	6.3	8	9	10	10
800	2.4	4	5.6	8	10	11	12.5	
1000	3.2	5	7.1	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	

1: For lower insulation voltage values, refer to table 2 in standard IEC 61439-1

2: The material groups are classified as follows, according to the range of values of the comparative tracking index (CTI)

– Material group I	600 ≤ CTI
– Material group II	400 ≤ CTI < 600
– Material group IIIa	175 ≤ CTI < 400
– Material group IIIb	100 ≤ CTI < 175

The correspondence between the nominal voltage of the power supply and the rated impulse withstand voltage (Uimp) of the equipment is given in table G1 in IEC 61439-1.

■ What the assembly manufacturer has to do

Compliance with the clearances and creepage distances depends largely on compliance with the specifications and the care taken with mounting the components of the assembly. It is therefore the responsibility of the assembly manufacturer to check the finished assembly by means of a visual inspection or a physical measurement if visual inspection is not adequate.

The clearances and distances are measured between the live parts with different polarities, and also between the live parts and the exposed conductive parts. The measurement methods are described in standard IEC 61439-1 Annex F.

Experience has shown that the greatest risk is in the wiring (see page 24). Unsuitable connectors, bolted connections, joints and metal supports can reduce the clearances.

Particular attention must be paid to:

- The distances between the connections of devices (lugs, terminals for cable lugs, etc.) and nearby exposed conductive parts (chassis, plates, etc.)
- The distances between connections
- Bolted connections and connections on bars (distances from other bars and the exposed conductive part)

If necessary, partitions or insulated screens can be used to increase the distances in air.

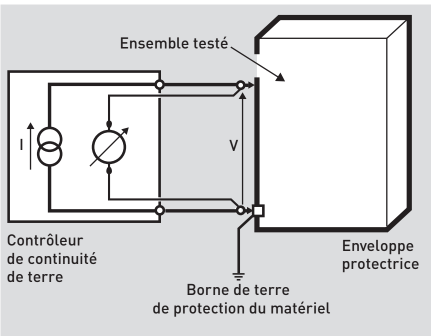
If the clearances are below the values in the table opposite, an impulse withstand test must be carried out (see page 60).

HX³/VX³ OPTIMISED DISTRIBUTION

When HX³/VX³ devices and equipment are mounted and connected in accordance with the specified conditions, compliance with the minimum clearances and distances for the insulation voltages of these devices is assured.

PROTECTION AGAINST ELECTRIC SHOCK AND INTEGRITY OF PROTECTIVE CIRCUITS (ARTICLE 11.4)

The main protection of enclosed distribution assemblies against electric shocks is provided by a metal or insulated casing (cabinets or enclosures).
In addition, each assembly must have a protective conductor for easy automatic cut-off off the power supply if a fault occurs inside the assembly or on the external circuits supplied via the assembly. This protective conductor must be able to withstand the short-circuit stresses which may occur where the assembly is installed.
The applicable wiring rules and precautions are given on page 4.
All the metal conductive parts of the assembly must be connected together and to the protective conductor.
The building of "totally insulated" assemblies is subject to specific precautions (see page 6).



PRINCIPLE OF THE CONTINUITY TEST
The measurement is carried out at 10 A, and the resistance must not exceed 0.1 Ω.

The assembly of XL³ enclosures provides continuity of the exposed conductive parts

- **What the assembly manufacturer has to do**

A check must be carried out to ensure that the various exposed conductive parts of the assembly are connected to the terminal of the incoming external protective conductor.
The check must be carried out using a resistance measurement instrument which is capable of carrying a current of at least 10 A (AC or DC). This current is injected between each exposed conductive part and the terminal for the external protective conductor. The resistance is measured and must not exceed 0.1 Ω.
Random spot checks of the tightening of screwed and bolted assemblies must be carried out. Details of the tightening torques are available in our technical data sheets and guides.

It is recommended that the duration of the test is limited when low power equipment may be affected by the test.

INCORPORATION OF CONNECTION DEVICES AND COMPONENTS (ARTICLE 11.5)

All the components incorporated in an assembly must be suitable for their use and must comply with the corresponding IEC standards. The values of the electrical characteristics of the devices (voltage, current, rated frequencies, breaking and making capacity, short-circuit resistance, insulation voltage, rated impulse withstand voltage, etc.) must comply with the specifications and installation conditions of the assembly.

For example for a main LV distribution board specified for an operating voltage Ue of 400 V, and therefore suitable for use on a 400 V system, no product in this assembly must have an insulation voltage Ui of less than 400 V. Likewise, its main switch must, amongst other requirements, be sized for the short-circuit current.

All information on any protection to be associated with it must be detailed on the nameplate and in the technical documentation. The adjustment and reset devices and also the terminals for connecting devices must be easily accessible.

The busbars must be designed and sized to withstand the short-circuit stresses. The conductors must be sized according to the rules in IEC 60364-5-5, suitable for the conditions inside the assemblies (see page 20).

All products must be used in accordance with manufacturer's instructions.

The first part of this guide gives essential recommendations and precautions for constructing assemblies. Recommendations specific to Legrand XL³ enclosures, distribution systems and products are given in the workshop specifications and in the product guides.

- **What the assembly manufacturer has to do**

The assembly manufacturer must check that the products and their identification comply with the specifications of the assembly and that their installation complies with the original manufacturer's instructions. This check is carried out by means of a visual inspection.

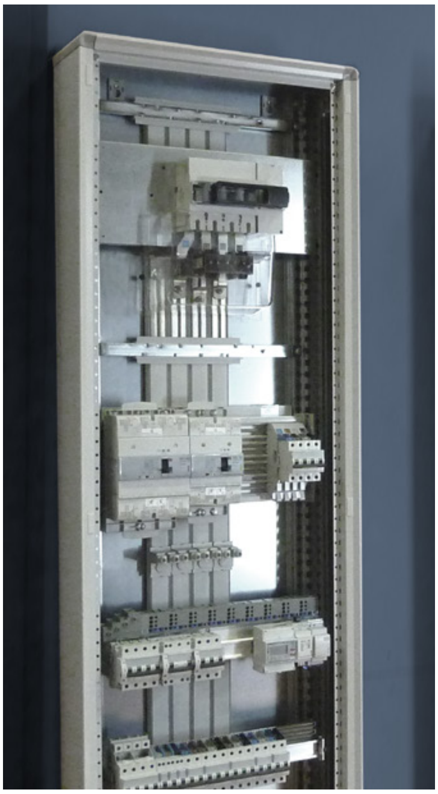
The assembly manufacturer must ensure that the technical documentation is compiled with the manuals and other instructions provided by the original manufacturer.

Download Legrand workshop specifications from the e-catalogue.

The XL³ workshop specifications include the assembly instructions and provide additional information for selecting and installing equipment, accessories and distribution systems.
The workshop specifications can be downloaded from :
http://www.export.legrand.com/EN
The list is available in the appendices p.106.

INTERNAL ELECTRICAL CIRCUITS AND CONNECTIONS (ARTICLE 11.6)

Busbars and power circuit conductors must be sized and installed according to the prospective short-circuit current which could occur at the assembly installation point.
For the selection and sizing of busbars, refer to the XL³ workshop specifications or the XLPRO³ software. The choice of conductors must comply with the requirements of standard IEC 60364-5-52 (see page 12).
In certain conditions, the cross-sections of the neutral conductors can be reduced (see page 28).
It must be possible to identify the neutral conductors by their colour.
The auxiliary circuits must be protected against the effects of short-circuits or must be set up in such a way that there is no chance of a short-circuit.



- **What the assembly manufacturer has to do**

The tightening of connections must be checked by random spot checks.
The finished assembly must be checked by means of a visual inspection. Compliance with the conductor identification diagram is the responsibility of the assembly manufacturer.

Example: checking the tightening torque.

THE use of Legrand HX³/VX³ optimised distribution systems (busbars, power supply and connection kits, row distribution blocks) simplifies wiring and checking compliance with the standard.

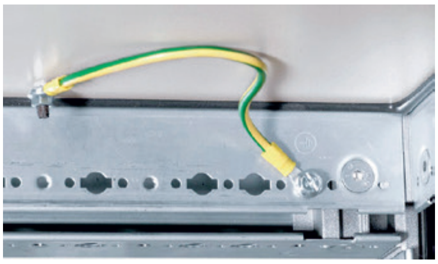
TERMINALS FOR EXTERNAL CONDUCTORS (ARTICLE 11.7)

The number, type and identification of the terminals must be checked in accordance with the manufacturing instructions for the assembly.

The conductors must not be subjected to stresses which could reduce their normal life expectancy.
The assembly manufacturer must indicate whether the terminals are suitable for copper or aluminium conductors, or for both.

The terminals must be such that the external conductors can be connected by a means (screws, connectors, etc.) which provides the necessary contact pressure corresponding to the rated current value and the short-circuit resistance of the device and that the circuit is maintained.

The terminals of the external conductors must be marked in accordance with IEC 60445.

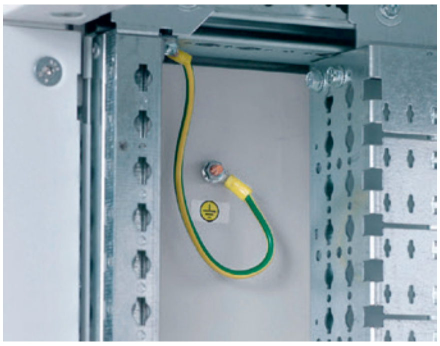


Example: the connection points of the equipotential links provided are marked with the (earth) symbol.

Example: the phases must at least be marked N, L1, L2, L 3, at the ends and at the connection points.

- **What the assembly manufacturer has to do**

The assembly manufacturer must check all the types of terminal which can be used for the cable entries and outlets (neutral, PEN, etc.) and check that they are suitable for copper or aluminium conductors, or both.
The terminals for the external conductors must be identified.
The finished assembly must be checked by means of a visual inspection.



MECHANICAL OPERATION (ARTICLE 11.8)

The correct operation of the mechanical control devices, interlocks and locking devices, including those associated with removable parts, must be checked.

This verification test does not have to be carried out on the devices (for example draw-out circuit breaker) of an ASSEMBLY that has previously undergone type tests in accordance with their applicable product standard unless their mechanical operation has been modified by their mounting.

For devices which require verification by a test, the satisfactory mechanical operation must be checked after installation in the ASSEMBLY. 200 operating cycles must be carried out. The operation of the mechanical interlocks associated with these movements must be checked at the same time.

Example: operating test on doors, faceplates, interlocks, etc.

- **What the assembly manufacturer has to do**

The correct mechanical operation of the doors and faceplates mounted on hinges must be checked, as well as the mechanical control components, interlocks and locking devices, including those associated with removable parts. 200 operating cycles must be carried out.

The test is considered to be satisfactory if the devices and interlocks remain in good working order, if the specified degree of protection is unaffected and if the effort required for operation is virtually the same as before the test.

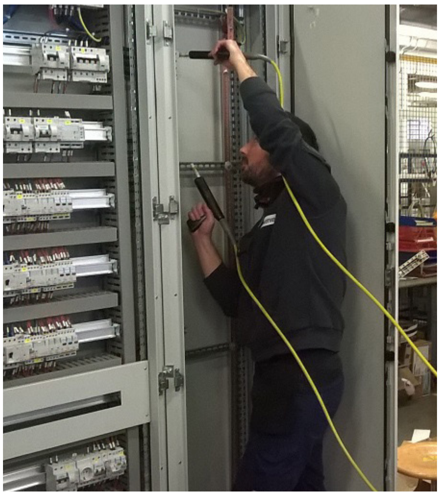
DIELECTRIC PROPERTIES (ARTICLE 11.9)

The dielectric tests check the insulation performance levels for the maximum operating voltage. They are carried out at the power frequency of 50 Hz and in the form of voltage waves simulating a lightning strike.

■ **What the assembly manufacturer has to do**

The dielectric test must be carried out in accordance with the instructions or specifications for the assembly.
- Test at power frequency for a given insulation value Ui
- Impulse voltage test (1.2/50 µs wave) for a given Uimp value

The assembly being tested must be de-energised and there must be no receiver devices connected.



Example: dielectric test at power frequency.

All the breaking devices must be in position I (ON).

The test voltage must be applied according to the following sequence:
- Between each pole of each circuit (power, control, auxiliaries) and the exposed conductive part of the assembly,
- Between each pole of the main circuit and the other poles (between each phase and between each phase and neutral),
- Between each circuit if they are not electrically connected (for example, SELV or separate control circuit and main circuit),
- Between the protective circuit and exposed conductive part for class II assemblies,
- Between drawn-out or separate parts for the isolation function.

All components with electronics must be disconnected to avoid any damage or destruction.
Earth leakage modules, DPX³ with e.l.c.b.s and MP6 protection units have a dielectric test selector switch which enables the on-board electronics to be protected.

As an alternative, for assemblies with rated incoming current protection of 250 A or less, the insulation resistance can be measured using an insulation measurement device at a voltage of at least 500 DC.
In this case, the test is satisfactory if the insulation resistance between the circuits and the exposed conductive parts is at least 1000 Ω/V referring to the supply voltage of these circuits in relation to earth.

TABLE 8 - POWER-FREQUENCY WITHSTAND VOLTAGE FOR THE MAIN CIRCUITS (10.9.2)

Rated insulation voltage U_i (AC or DC between phases) V	AC rms insulation test voltage V	AC insulation test voltage[b] V
U1 ≤ 60	1000	1415
60 < U_i ≤ 300	1500	2120
300 < U_i ≤ 690	1890	2670
690 < U_i ≤ 800	2000	2830
800 < U_i ≤ 1000	2200	3110
1000 < U_i ≤ 1500[a]	-	3820

[a] For DC only
[b] Test voltages in IEC 60664-1, 6.1.3.4.1, 5th paragraph

TABLE 9 - POWER-FREQUENCY WITHSTAND VOLTAGE FOR AUXILIARY AND CONTROL CIRCUITS (10.9.2)

Rated insulation voltage U_i (between phases) V	AC rms insulation test voltage[b] V
U1 ≤ 12	250
12 < U_i ≤ 60	500
60 < U_i	See table 8

TABLE 10 - IMPULSE WITHSTAND VOLTAGE (10.9.3)

Rated impulse withstand voltage U_{imn}	Test voltages and corresponding altitudes during the test									
	$U_{i\,2/50}$, AC, peak value and DC kV					AC rms kV				
kV	Sea level	200 m	500 m	1000 m	2000 m	Sea level	200 m	500 m	1000 m	2000 m
2.5	2.95	2.8	2.8	2.7	2.5	2.1	2.0	2.0	1.9	1.8
4.0	4.8	4.8	4.7	4.4	4.0	3.4	3.4	3.3	3.1	2.8
6.0	7.3	7.2	7.0	6.7	6.0	5.1	5.1	5.0	4.7	4.2
8.0	9.8	9.6	9.3	9.0	8.0	6.9	6.8	6.6	6.4	5.7
12.0	14.8	14.5	14.0	13.3	12.0	10.5	10.3	9.9	9.4	8.5

WIRING, ELECTRICAL PERFORMANCE AND FUNCTION (ARTICLE 11.10)

A check must be carried out to establish that the specified information and marking are complete.

The ASSEMBLY manufacturer must provide every ASSEMBLY with a nameplate, with durable marking and placed in a location where it is visible and legible when the ASSEMBLY is installed and operating.

Depending on the complexity of the ASSEMBLY, it may be necessary to examine the wiring and carry out an electrical operating test. The test procedure and the number of tests depend on whether or not there are interlocks, complicated control sequences, etc. in the ASSEMBLY.

In certain cases, it may be necessary to carry out this test, or repeat it, on site before commissioning the installation.

All the technical information listed opposite must, where appropriate, be compiled in the assembly manufacturer's documentation or technical specifications and supplied with the assembly. The assembly manufacturer must also specify any conditions for handling, installation, operation and maintenance of the assembly and the equipment it contains. For this, examples of a letter of conformity, a test certificate and a test report are provided on the following pages (pages 62 to 65), to assist with compiling the technical specifications.

Example of a nameplate

■ **What the assembly manufacturer has to do**

The information and markings must be verified. A functional test is also necessary before the assembly is commissioned.
The following information must be marked on the nameplate:
Name or trademark of the assembly manufacturer (responsible for the finished assembly), e.g. Company Name of the panel builder.
Type designation or an identification number, e.g. TD01-RDC or g18732.
Means of identifying the date of manufacture,e.g. 2015 or 2015-03 or 12W09
IEC 61439-X (the specific part X must be identified), e.g. IEC 61439-2.
The following additional information must be included in the technical documentation supplied with the assembly (documentation or technical specifications):

■ Rated voltage of the assembly (Un), e.g. Un = 400 V

■ Rated operating voltage of a circuit (Ue), e.g. Ue = 230 V (if different from Un)

■ Rated impulse withstand voltage (Uimp), e.g. Uimp = 6 kV

■ Rated insulation voltage (Ui), e.g. Ui = 800 V

■ Rated current of the assembly (Ina), e.g. Ina = 3100 A

■ Rated current of a circuit (Inc), e.g. Inc = 250 A

■ Permissible rated peak current (Ipk), e.g. Ipk = 140 kA

■ Permissible rated short-time withstand current (Icw), e.g. Icw = 50 kA 1 s

■ Conditional rated short-circuit current (Isc), e.g. Isc = 70 kA

■ Rated frequency (fn), e.g. fn = 50 Hz

■ Rated diversity factor (RDF), e.g. RDF = 0.7

Example of letter of conformity

DECLARATION OF CONFORMITY

Company name:
Address:

Addressee:
Document no: Date:
Assembly no: Date:

Standard IEC 61439-2

The assembly manufacturer hereby certifies that the power switchgear and controlgear assembly designated above has been built in conformity with the requirements of standard IEC 61439-2/IEC 61439-1.
The components used have been installed in accordance with the instructions of the original manufacturer with regard to the design verifications performed in accordance with IEC 61439-2:

- Verification of the strength of the materials and parts
- Verification of the degree of protection
- Verification of the clearances and creepage distances
- Verification of the effectiveness of the protective circuit
- Verification of the integration of the components
- Verification of the electrical circuit and the connections
- Verification of the terminals for external conductors
- Verification of the dielectric properties
- Verification of the temperature rise limits
- Verification of the short-circuit withstand strength
- Verification of the electromagnetic compatibility
- Verification of the mechanical operation

The individual routine tests form the subject of the individual inspection report, comprising, in accordance with the standard:

- Visual check of the degree of protection
- Visual check of the clearances
- Visual check of the creepage distances
- Verification of the protective circuits
- Visual check of the integrated components
- Spot check of the connections
- Visual check of the terminals for external conductors
- Verification of the mechanical operation
- Power frequency withstand voltage test (time 1s)
- Visual check of information and marking + operating test

Declarant:

Signature:

Test certificate

Name of the assembly: ______ **Order no:** ______

List of operations to be performed by the assembly manufacturer in accordance with standard IEC 61439-2

Individual tests	Completed	Not applicable
1 - Inspection of the equipment		
1.1. Correspondence between the wiring diagram and the installation in the enclosure	❑	❑
1.2. Equivalence of the equipment installed and the list of equivalence of the components	❑	❑
1.3. Visual check of the degree of protection of the enclosure (art. 11.2)	❑	❑
1.4. Verification of the clearances in the air with voltage test at 50 Hz (art. 11.3)	❑	❑
1.5. Verification of the surface clearances (creepage distance) by physical or visual measurement (art. 11.3)	❑	❑
1.6. Verification of the correct installation of devices (art. 11.5)	❑	❑
1.7. Verification of the electrical connections by sampling (art. 11.6)	❑	❑
1.8. Verification per terminal for external conductors (art. 11.7)	❑	❑
1.9. Verification of correct mechanical operation (art. 11.8)	❑	❑
2 - Verification of continuity of the protective circuits (art. 11.4)		
2.1. Visual verification of the interconnections	❑	❑
2.2. Verification using an audible indicator	❑	❑
2.2. Verification using an optical indicator	❑	❑
3 - Dielectric test and insulation test (art. 11.9)		
3.1. 1890 Vrms 50 Hz test voltage with 1 s application time	❑	❑
3.2. 500 V test voltage with resistance greater than 1000 Ω/V (applied to the supply voltage)	❑	❑
4 - Wiring and operational performance (art. 11.10)		
4.1. Main circuit with complete insertion of circuits	❑	❑
4.2. Phase sequence	❑	❑
4.3. Auxiliary circuits with complete insertion of equipment	❑	❑
4.4. Operation of the control devices	❑	❑
4.5. Tripping of residual current devices by testing	❑	❑
4.6. Reading and control of instrumentation	❑	❑
5 - Final inspection		
5.1. Verification of the correspondence of the affixed labels	❑	❑
5.2. Retrieval and addition of the documentation to be attached	❑	❑

Date:

Name of inspector: ______ Person present at the inspection: ______

Signature: ______ Person present at the inspection: ______

Inspection report (example)

No...................

GENERAL INFORMATION

Company name of the manufacturer (panel builder):
Address:

Type of distribution panel:
Identification of the distribution panel:
Year of construction:

Project name:
Project number:

Dimensions of the distribution panel: ... x ... x ... mm
Weight:

TECHNICAL DATA

Un:	VAC	Frequency:	Hz
Ue:	VAC	Type of earthing:	TT/TN-C/S/IT*
Ui (insulation voltage):	V	Degree of pollution: 1/2/3/4*	
Uimp (impulse withstand voltage):	V	Installation: indoor/outdoor/fixed/mobile*	
Un (control voltage)	230 VAC	Divergent control voltage: .... VAC	
	24 VAC	Protection index: IP	
Ina:	A	Impact resistance: IK	
Inc:	A	EMC classification: A/B*	
Isc/cw* (rms short-circuit current):	kA	Format: 1/2/3/4 - A/B*	
Isc with upstream protection device:	kA	Rated Diversity Factor (RDF):	
Ipk (peak short-circuit current):	kA	Service index:	
Cross-section of the main rail system:	3P/3P+N	.... x .... x .... mm	
Cross-section of the secondary rail system:	3P/3P+N	.... x .... x .... mm	
Cross-section of the earthing rail:..............		.... x .... x .... mm	
Cross-section of the PEN link: mm²			

INSPECTION PROCEDURE

Inspection according to IEC 61439-1/2 & Legrand directives

Inspection point	Item	Accepted	N/A	Refused	Corrected	Comment
2	**Visual check**					
2.01	DB[1] assembled according to the drawing					
2.02	No damage/damaged paint/scratches, no foreign bodies, etc.					
2.03	DP[1] clean internally and externally					
2.04	Appropriate type of cable glands and a sufficient number fitted					
3	**Main/secondary rail system (IEC 61439-1 section 11.6)**					
3.01	Application of appropriate tightening torques					
3.02	Rms protection					
3.03	Codes affixed to the rail supports					
3.04	Distances between rail supports					
3.05	Application of appropriate rail supports					
3.06	Application of the appropriate CU cross-section					
3.07	Presence of routing/sharing					
3.08	Presence of earthing rail					
3.09	Presence of PEN link					
3.10	Presence of distributors with adequate kA value					
3.11	Clearance and creepage distance conform to Legrand specifications and IEC 61439-1					
4	**Wiring**					
4.01	Wiring cross-section					
4.02	Wiring mounted with some clearance in relation to the rail systems					
4.03	Cable colours					
4.04	Coding of cables					
4.05	Wiring connected correctly and at a sufficient distance from sharp edges					
4.06	No damaged wiring					
4.07	Wiring installed neatly					
4.08	Wiring connected in accordance with the installation diagram					
4.09	Application of 90° wiring					
4.10	Warning labels for upstream tap-offs					
5	**Components**					
5.01	Installation according to the supplier's drawing and specifications					
5.02	Mechanical inspection					

Inspection point	Item	Accepted	N/A	Refused	Corrected	Comment
5.03	Short-circuit withstand of the components					
5.04	Correct orientation of the components					
5.05	Adjustment of power PLCs					
5.06	Adjustment of motor protection switches					
5.07	All components are delivered in "off" position					
5.08	Installation suitable for the electrical specifications					
5.09	The colours of the pushbuttons and illuminated indicators are appropriate					
5.10	Correct operation of interlocks					
5.11	The interlocks are created in accordance with the specifications					
5.12	Screw connection terminal blocks present					
5.13	Application of appropriate tightening torques					
6	**Mounting frame**					
6.01	If class 1, enclosure fully connected to protective conductor					
6.02	If there are components in the door with U ≥ 50 V, door earthed					
6.03	All DIN rails are correctly screwed in					
6.04	Mounting plates correctly fitted					
7	Tests	Insulation resistance > 0.5 MΩ Umin. = 500 V Only authorised on distribution blocks < 250 A				
7.01	Insulation test					
7.01a	Insulation resistance L1-L2					
7.01b	Insulation resistance L2-L3					
7.01c	Insulation resistance L3-L1					
7.01d	Insulation resistance L1-N					
7.01e	Insulation resistance L2-N					
7.01f	Insulation resistance L3-N					
7.01g	Insulation resistance L1-PE(N)					
7.01h	Insulation resistance L2-PE(N)					
7.01i	Insulation resistance L3-PE(N)					
7.02	High voltage test (test at AC voltage)	(Minimum 1 s)/(..<Ui<60 V) test voltage 1 kV/(60<U<300 V) test voltage (300<Ui<690 V) test voltage 1890 V				
7.02a	High voltage test L1-L2					
7.02b	High voltage test L2-L3					
7.02c	High voltage test L3-L1					
7.02d	High voltage test L1-N					
7.02e	High voltage test L2-N					
7.02f	High voltage test L3-N					
7.02g	High voltage test L1-PE(N)					
7.02h	High voltage test L2-PE(N)					
7.02i	High voltage test L3-PE(N)					
7.03	Earth continuity test	Resistance < 100 mΩ U = 6-24 V (only applicable for 7.03a)				
7.03a	Earth continuity test with current ≥10 A					
7.03b	Earth continuity test with signal tester + visual check					
7.04	Tests of residual current devices (fault current)					
7.05	Electrical operation in accordance with installation diagram					
8	**Enclosure**					
8.01	Lifting eyes fitted correctly					
8.02	Doors and front panels close correctly					
8.03	The required keys are present					
8.04	Appropriate index of protection					
8.05	Partitioning conforms to the format					
8.06	Protective conductors and equipotential link conductors installed in accordance with the documentation					
8.07	Weight of the distribution panel					
9	**Finish**					
9.01	Nameplate fitted					
9.02	Self-adhesive CE mark in place					
9.03	Front panels mounted and fixed					
9.04	Coding of components and screw terminal blocks					
9.05	Presence of a document-holder					
9.06	Presence of the installation diagrams					
9.07	Presence of the terminal block diagram					
9.08	Addition of manuals for components					
9.09	Overall photos of the distribution panel and detailed photos taken					
* Delete as appropriate. (1) DP = distribution panel						

SIGNED AND AGREED

Name of **installer**:
Signature:
Date:

Name **of inspector**:
Signature:
Date:

Company stamp:

TEMPERATURE RISE LIMITS FOR ASSEMBLIES

Assembly temperature rise test in accordance with standard IEC 61439-1

The assembly temperature rise test checks that assemblies operate correctly under the most unfavourable conditions (current, number of devices, volume of the enclosure). It enables the heat balance data to be defined at an ambient temperature which must not exceed +40°C.

As the original manufacturer, Legrand has had this check performed on a representative configuration by a recognised laboratory.

These configurations are available in our LOVAG certificates (see page 51).

CERTIFICAT LOVAG

The assembly manufacturer does not have to repeat these verifications on the finished assembly if all the requirements and instructions given by Legrand are complied with in full.
When the assembly manufacturer incorporates its own configurations, it then becomes the original manufacturer and must therefore repeat these verifications.

Test methods

The temperature rise verification defined in standard IEC 61439-1 can be carried out using three different methods:

BY TESTING (SECTION 10.10.2)

The complete assembly is loaded at a rated current defined in IEC 61439-1 or by the original manufacturer. Once the temperature rise is maintained in service conditions, it is measured at predefined points inside the enclosure. The measured values are then compared with the permissible values (extract from the standard on page 68).
The assembly complies with the test if the measured values are less than or equal to the permissible values.

Measurement of the temperature rise limits in an XL³ enclosure.

BY COMPARISON (SECTION 10.10.3)

Assemblies verified by comparison with a similar assembly that has been verified by testing must satisfy the following conditions:
- The functional units must be comparable with a similar thermal behaviour (identical wiring diagrams, devices of the same size, identical layouts and fixings, identical assembly structure, identical cables and wiring),
- Must have the same type of construction,
- The overall dimensions must be the same or larger,
- The cooling conditions must be at least as good as those in the test (forced or natural convection, identical or wider ventilation apertures),
- The internal compartmentalisation must be identical or less restrictive,
- The power dissipated in one column must not be higher.

REPLACEMENT OF A DEVICE

A device can be replaced by a similar device from a range other than that used in the original verification, as long as the power it dissipates and the temperature rise of its terminals when it is subjected to the test in accordance with the product standard are the same or less. In addition, the internal physical layout of the functional unit and its rated characteristic must remain unchanged.

TEMPERATURE RISE LIMITS FOR ASSEMBLIES

BY CALCULATION (SECTION 10.10.4)

This method can only be used for assemblies with rated currents of up to 1600 A.
There are two calculation methods, depending on the rated current of the assembly. Both methods determine the capacity of the enclosure to dissipate heat, and compare this value with the losses dissipated from the integrated equipment and conductors.

- **Assembly up to 630 A**

The first method is applicable to assemblies with a rated current of up to 630 A.
An enclosure's capacity to dissipate heat is determined using heating resistors which produce heat equivalent to the enclosure's stated heat dissipation capacity. After stabilisation, the temperature rise of the air is measured at the top of the enclosure.

The dissipated powers of XL³, DMX³ and DPX³ enclosures are available in the appendices.

The temperature of the enclosure must not exceed the value given in the table opposite. This target value is compared with the total dissipated losses from the integrated components and conductors, with certain conditions indicated in standard IEC 61439- 1:
- Availability of the dissipated losses of the components from the manufacturer,
- Uniform distribution of the internal losses,
- The rated current of the circuits must not exceed 80% of the free air thermal current (Ith),
- The equipment installed must be laid out so that the air circulation is not significantly affected,
- Conductors carrying currents of more than 200 A must be laid out so that the eddy current losses are negligible,
- The minimum cross-section of all conductors is based on 125% of the rated current The losses dissipated by the conductors and bars are determined by calculation (see table on page 74).

TEMPERATURE RISE LIMIT VALUES (EXTRACT FROM STANDARD IEC 61439-1)	
Parts of the assembly	**Permissible temperature rises[1] (K)**
Components, devices, subassemblies, power supplies	Conforming to their own particular specifications (product standards) taking account of the ambient temperature of the assembly[2]
Terminals for external conductors	70[3]
Busbars, contacts on busbars, distribution	Depending on the materials in contact or close by. The nominal currents of Legrand busbars are given for the various usage options[4]
Control devices	Metal: 15[5] Insulated material: 25
Enclosures and accessible external panels	Metal: 30[5] Insulated material: 40

(1) Temperature rise refers to the increase above ambient temperature. The temperature limit is therefore equal to the sum of the ambient temperature values plus the temperature rise.
(2) As a general rule, a maximum temperature of 40°C is advisable. That is, an average temperature rise of 25 to 30 K to be taken into consideration for determining the power that can be dissipated. Above this level, it may be necessary to derate the currents permitted by the devices, to cool the assembly using an appropriate system, or more simply to select a larger enclosure.
(3) The temperature rise of Legrand connection terminals and terminal blocks does not exceed 65 K.
(4) The currents of Legrand busbar and distribution systems are given for a maximum temperature rise of 65 K.
(5) These values can be increased (+ 10 K) if the parts are not frequently touched during normal operation.

■ **Assembly up to 1600 A**

The second method is applicable to assemblies with a rated current of up to 1600 A.

XLPRO³ includes calculation algorithms for this. The method is based on standard IEC 60890 and also includes data from numerous tests carried out in our laboratories.
Legrand's heat balance principle is explained in detail on the next page.

The temperature rise of the assembly can be determined based on the total losses, using the calculation method in IEC 60890.
This method can be used if the conditions for the first method on page 68 are met, with the following additions:
- For enclosures with ventilation apertures: the cross-sections of the air outlet apertures must be at least 1.1 times the cross-section of the air inlet apertures,
- There must be no more than three horizontal separations for each section of the assembly,
- If enclosures with external ventilation apertures have to be divided into compartments, the areas of the ventilation apertures in each internal horizontal separation must be equal to at least 50% of the horizontal cross-section of the compartment.

RESULTS TO BE OBTAINED

The ASSEMBLY is verified if the calculated temperature of the air at the mounting height of each device does not exceed the permissible ambient air temperature given by its manufacturer.

For the connection devices or the electrical components of the main circuits this means that the steady-state load does not exceed either its permissible load at the punctual calculated air temperature or 80% of its rated current.

Assemblies over 1600 A.
It is not possible to check the conformity of the temperature rise limits of assemblies over 1600 A using the calculation methods in IEC 61439-2.

Heat balance

The XLPRO³ software includes a thermal management module. With this module it is easy to check the temperature rise limits inside an assembly in accordance with standard IEC 61439-1, and the most suitable Legrand thermal management solutions for the dimensions of the enclosures, the volumes and specified conditions can be directly defined.

Legrand's calculation algorithms (described on pages 72 to 78) are based on the method for calculating the temperature rise of the air inside an assembly given in standard IEC 60890 and checked with the results of numerous tests carried out in our laboratories.

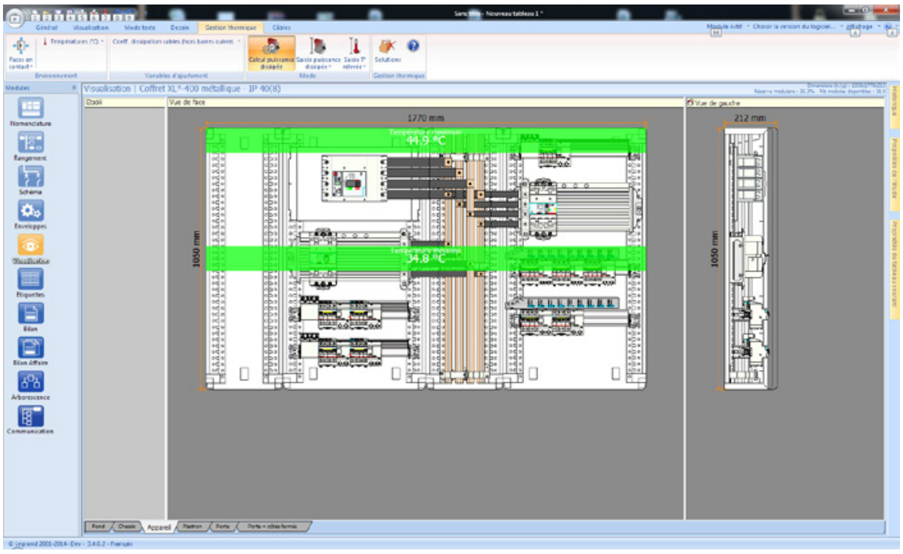
The software incorporates all the dissipated powers of Legrand DMX³, DPX³, etc. devices(see page 101 in the appendices) and the powers that can be dissipated in Legrand enclosures (see page 86 in the appendices) according to the different positions in relation to the surrounding partitions and walls.

The following parameters can be managed and adapted:
- Management of the sides in contact
- External temperature
- Dissipation coefficient of the cables
- Manual entry of a dissipated power
- Entry of the average internal temperature

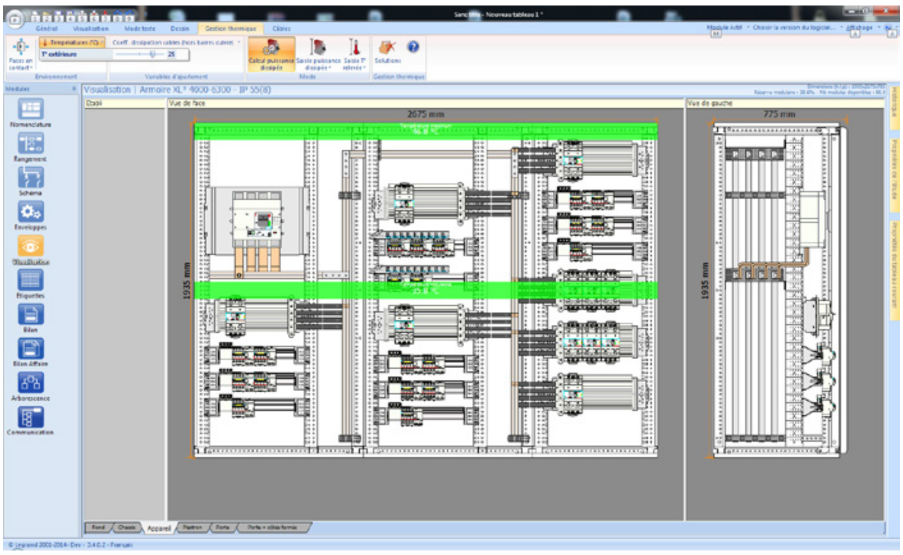
The average temperature is displayed at the centre and the top of the enclosure using a colour code (see examples opposite). This colour code displays the various acceptable and unacceptable temperatures according to preset parameters.

The thermal management module is used to adjust and suggest Legrand solutions (air circulation kits, air conditioning unit, see page 79) according to the inappropriate temperature.

This tool, which is available in XLPRO³ free of charge, helps assembly manufacturers validate their finished assemblies.



Example of design with an XL³400 enclosure.



Example of design with an XL³4000 enclosure.

DETERMINATION OF THE DISSIPATED POWER

An accurate estimation of the actual dissipated power can be obtained using the method given below.
The power actually dissipated (in W) can be defined using the following formula:
P = (PA + PC) · U · M · S · C · E where:
Pa: total of the individual powers dissipated by each of the devices at its nominal current
Pc: power dissipated by the wiring
U: load factor
M: duty factor
S: coincidence factor
C: switching factor
E: expected extension factor

- **Total of the individual powers dissipated by each of the devices at its nominal current (P_A)**

The power generated in distribution enclosures is above all associated with the circuit breakers and the wiring. In control and automation system enclosures the items that generate the most heat are speed drives, power supplies and contactors. The power dissipated by the wiring is generally low.

It is useful to refer to the tables and documents written by the manufacturers of the devices, which give guideline dissipated power values to be taken into account (see appendices).

- **Power dissipated by the wiring (P_c)**

This can be determined using standard IEC 60890-A1, or more simply by considering the nominal current carried by each conductor, together with its length and cross-section, and applying the following formula for each one: $P = RI^2_{av.}$

TYPICAL LINEAR RESISTANCE OF CONDUCTORS ACCORDING TO THEIR CROSS-SECTION

Flexible copper core class 5		Rigid stranded core class 2		
Cross-section (mm²)	Resistance (Ω/km²)	Cross-section (mm²)	Resistance (Ω/km) copper	Resistance (Ω/km) aluminium
0.5	36.1	50	0.36	0.59
0.75	24	70	0.25	0.44
1	18	95	0.18	0.3
1.5	12.3	120	0.14	0.23
2.5	7.4	150	0.11	0.19
4	4.58	185	0.09	0.15
6	3.05	240	0.07	0.115
10	1.77	300	0.055	0.092
16	1.12	400	0.043	0.072
25	0.72	500	0.033	0.056
35	0.51	630	0.026	0.043

NB: For simplification purposes, the linear resistance values of the conductors have been intentionally limited to the most commonly used types of conductor.
The resistance value has been given for a core temperature of 40°C.
The intensity factor (I2) is predominant in the calculations. Reference can be made to the tables giving the dissipated powers of the various conductors at their nominal operating currents.

EMPIRICAL RULE FOR DETERMINING THE DISSIPATED POWER:
The power dissipated in an enclosure by the devices and their wiring is more or less proportional to the incoming current entering the panel. If there is no accurate data available, or to obtain an initial estimate, the following calculation can be performed:
- Enclosures with incoming current ≤ 400 A, use 1.25 W/A (for example for a 63 A cabinet, 63 × 1.25 = 78 W)
- Enclosures with incoming current > 400 A and ≤ 1000 A, use 1 W/A
- Enclosures with incoming current > 1000 A, use 0.8 W/A

■ **Load factor (U)**

Ratio of the actual power consumption to the nominal power at the supply end of the installation.
Use a value of 0.8 (which corresponds to 0.9 In) for panels with ≤ 400 A incoming current and 0.65 (which corresponds to 0.8 In) for panels with higher currents.
NB: The coefficients are applied to the power. They correspond to the square of the coefficients that would be applied to the current value.

■ **Duty factor (M)**

Ratio of the operating time of the equipment to the stoppage time. This varies from 0.3 to 1 in industry.
Use 1 if the operating time is greater than 30 min and for all heating and lighting applications.

■ **Coincidence factor (S)**

Ratio of the load of the outgoing (secondary) circuits, during simultaneous operation, to the maximum load of all the outgoing circuits. It describes what is commonly known as "simultaneity factor".

Use:
S = 1 for 1 circuit (i.e. 100% current)
S = 0.8 for 2 to 3 circuits (i.e. 90% current)
S = 0.7 for 4 to 5 circuits (i.e. 83% current)
S = 0.55 for 6 to 9 circuits (i.e. 75% current)
S = 0.4 for 10 or more circuits (i.e. 63% current)

This coefficient takes account of both the number of circuits in operation and their actual loads.

The coincidence factor must not be confused with the rated diversity factor (RDF) defined by standard IEC 60439-1 which refers to the ratio of the sum of the actual currents of the main circuits to the maximum theoretical current. It is defined for carrying out tests and is applied to current values (see opposite).

It must be determined and modulated if necessary for each main group of circuits (group of lighting circuits, group of socket circuits, motor starters, air conditioning, etc.).

■ **Switching factor (C)**

Coefficient that takes account of the number of cycles or switching operations (inrush currents of high-speed automation systems).

Use:
C = 1.2 for fast cycles
C = 1 in other cases (distribution)

■ **Expected extension factor (E)**

This must be considered for each case individually. A value of 1.2 can be used if no precise information is available.

■ **Rated diversity factor (RDF)**

The new standard IEC 61439-1 now incorporates a rated diversity factor which enables better determination of the thermal effects which may occur inside an assembly.

This new factor, in the form of a ratio associated with the currents passing through each outgoing circuit, defines the amount of current that each circuit can withstand, taking into account the mutual influences of the other circuits and the surrounding environment. This approach thus enables the definition of a simultaneous continuous operating current of each circuit with no adverse effect on the assembly and with no thermal runaway.

This is closer to actual usage than can be achieved with the consumers in an installation, using the periodicity of operation and the load factor of each circuit.

Rules for calculating this factor are given in Annex E of standard IEC 61439-1.

They show that some circuits may have no current during the normal operation of an assembly although these circuits have been quantified for a given power.

This factor can be determined for the whole assembly or for groups of circuits. It takes into account characteristics specific to the component parts of the assembly which are supplied by the original manufacturer.

It is the responsibility of the assembly manufacturer to provide this diversity factor, which is written RDF.

TEMPERATURE RISE LIMITS FOR ASSEMBLIES

POWER DISSIPATED BY CONDUCTORS AT THEIR USUAL OPERATING CURRENTS

Copper conductors

S (mm²)	0.5	0.75	1	1.5	2.5		4	6	10	16	25	
I (A)	2	4	6	10	16	20	25	32	40	63	80	100
P (W/m)	0.15	0.4	0.6	1.2	1.9	3	2.9	3.1	2.8	4.4	4.6	7.2
S (W/m²)	35		50	70		95	120	150	185	240	2 x 185	2 x 240
I (A)	100	125	125	160	160	200	250	250	315	400	630	800
P (W/m)	5.1	8	5.6	6.4	4.6	7.2	8.7	6.9	8.9	11.2	17.8	22.4

Aluminium conductors

S (mm²)	35		50	70		95	120	150	185	240		300
I (A)	63	80	80	100	125	160	160	200	250	250	315	400
P (W/m)	3.2	5.1	3.6	5.9	6.8	7.7	5.9	7.6	9.3	7.2	11.4	14.7

Copper busbars and links

Dimensions		12 x 2	12 x 4	15 x 4	18 x 4	25 x 4	25 x 5	32 x 5	50 x 5	63 x 5	75 x 5	80 x 5	100 x 5	2 x 50 x 5	2 x 63 x 5	2 x 75 x 5	2 x 80 x 5	2 x 100 x 5
IP > 30	I (A)	80	125	160	200	250	270	400	600	700	850	900	1050	1000	1150	1300	1450	1600
	(W/m)	8.1	7.4	9.6	12.5	14.4	13.1	22.8	33	35.7	45.3	47	53.5	47.4	50.6	57.7	65.7	66.3
IP ⩽ 30	I (A)	110	185	205	245	280	330	450	700	800	950	1000	1200	1150	1350	1500	1650	1900
	(W/m)	11.3	12.8	15.8	18.8	17.7	19.6	28.9	45	46.7	54.8	59	70	62.7	69.8	74.4	85	93.4

Flexible bars

Dimensions		13 x 2	20 x 4	24 x 4	24 x 5	32 x 5	40 x 5	50 x 5	50 x 10
IP > 30	I (A)	160	250	250	320	400	500	630	800
	(W/m)	14.4	14.2	14.2	18.4	23	28.5	36.8	40.2
IP ⩽ 30	I (A)	200	350	400	470	630	700	850	1200
	(W/m)	22.5	35	36	40	43	56	67	77

Definitions of the currents according to standard IEC 60947-1 applied to standard usage conditions for temperature rises of the bars not exceeding 65 K.
Ie: rated operating current to be taken into consideration in enclosures with natural ventilation or open panels with protection index IP ⩽ 30.
Ithe: conventional thermal current in enclosures corresponding to the most unfavourable installation conditions. The enclosure does not allow natural air change (IP > 30).
Powers in W/m are given for one pole. They must be multiplied by 3 for three-phase.
As a guide, the following empirical formula can be applied for three-phase busbars:
Dissipated power = 0.15 W/A for a 1 m length.

DETERMINATION OF THE POWER THAT CAN BE DISSIPATED BY ENCLOSURES

The natural power dissipation P (in W) of an enclosure is defined by the following formula: **$P = \Delta t_{av} \cdot K \cdot S_e$**
Δt_{av}: average temperature rise of the air in the enclosure (°C)
K: coefficient of heat transmission through the walls (W/°C m^2)
Se: equivalent dissipation area (m^2)
Each of the terms in the above formula enables simplification of the overall calculation of the power that can be dissipated. The concept of average temperature rise enables different values to be incorporated in a single value temperature rise of the air in the enclosure (thermal gradient). Coefficient K is calculated for the heat exchange of a horizontal reference wall with a heat flow from the bottom to the top. The various walls of the enclosure are represented by the equivalent dissipation area, which is itself applied to a horizontal surface for which the heat exchange conditions are those of coefficient K with a Δt between the inner and outer surface equal to Δt_{av}.

- **Concept of average temperature rise (Δt_{av})**

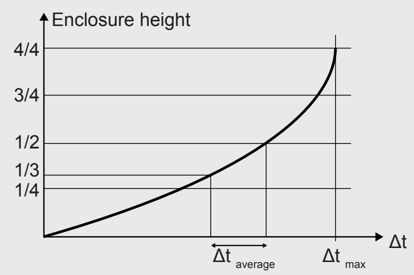
The heat source constituted by the devices and equipment in an enclosure causes a non-homogeneous rise in the temperature of the internal air.

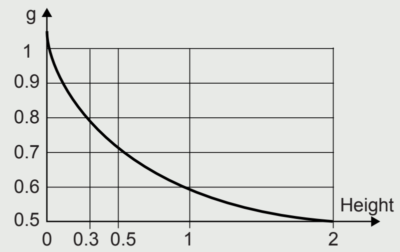
The average temperature rise is considered to be the arithmetic mean of the various temperature rises observed at different heights inside the enclosure.

Experience has shown that this value is always located at between one third and half the height of the enclosure. Although the average temperature rise is used to calculate the power that can be dissipated, it is important to know the maximum temperature rise at the top of the enclosure for installing equipment.

The relationship between the maximum temperature rise of the air (top of the enclosure) and the average temperature rise is governed by the thermal gradient coefficient g: $\Delta t_{av} = g \cdot \Delta t_{max}$.

THERMAL GRADIENT





< The temperature is divided into isothermal strata for which the thermal gradient 1/g increases with the height of the enclosure

PRACTICAL DETERMINATION OF THE DISSIPATED POWER ON AN EXISTING INSTALLATION

1) Measure the ambient temperature θ_{amb} at least 1 m away from the enclosure and 1.50 m above the ground
2) Measure the temperature inside the enclosure θ_{max} approximately 10 cm below the top surface
3) Measure the temperature inside the enclosure θ_{av} at mid-height
4) Calculate the temperature rise values $\Delta tmax = \theta_{max} - \theta_{amb}$ and $\Delta t_{av} = \theta_{av} - \theta_{amb}$
5) Check the thermal gradient value using the equation $\Delta t_{av} = g \cdot \Delta t_{max}$
6) Calculate the equivalent dissipation area S_e by applying various weighting factors (see the table opposite)
7) Determine the value of the overall transmission coefficient K according to Δt_{av}
8) Calculate the power P (W) using the formula $P = \Delta t_{av} \times K \times S_e$

Coefficient of transmission of the heat flux through the walls (K in W/°C m²)

This coefficient characterises the heat exchanges via the enclosure wall. It includes three methods of heat transfer: conduction, convection and radiation.
The latter two methods are most dominant (in more or less equal proportions) while conduction only has a limited effect (a few %).
In heat exchanges through thin walls, as is the case with electrical enclosures, the temperatures of the two surfaces are identical (or isothermal) and the nature of the material has little influence. The result is that the dissipation capacities of metal enclosures and plastic enclosures are very similar.

Equivalent dissipation area (S_e)

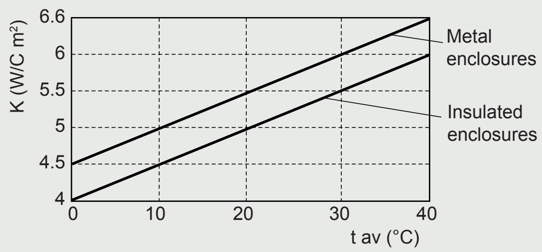
Each heat exchange surface (external surface) is given a coefficient which depends on its relative position in space (vertical or horizontal) and its contact with the walls or the floor (insulated if it is in contact or free if it is not in contact).
The equivalent area is determined by the sum of the various areas:

Se = S1 + S2 + S3 + S4 + S5 + S6 + S7 + S8 + S9 + S10.

CORRECTED DISSIPATION AREA Sc

**In order to directly obtain the value of Δt_{max} the concept of corrected area Sc is used, where Sc = Se x g.
The tables of Sc data for each enclosure can then be used to carry out a simplified calculation.**

VALUES OF THE OVERALL TRANSMISSION COEFFICIENT K ACCORDING TO THE AVERAGE TEMPERATURE RISE



COEFFICIENTS TO BE APPLIED TO THE ACTUAL SURFACES FOR CALCULATING THE EQUIVALENT DISSIPATION AREA SE ACCORDING TO THE IP INDEX OF THE ENCLOSURE

Surface	IP ≤ 30	IP > 30
S1: free upper horizontal surface	1	1
S2: insulated upper horizontal surface	0.7	0.5
S3: free rear vertical surface	0.9	0.8
S4: insulated rear vertical surface	0.4	0.3
S5: free side surface	0.9	0.8
S6: insulated side surface	0.4	0.3
S7: free horizontal lower surface	0.6	0.6
S8: insulated horizontal lower surface	0.3	0.2
S9: front surface with faceplates	0.9	0.8
S10: front surface with faceplates and door	0.6	0.6

CORRECTION COEFFICIENTS TO BE APPLIED FOR CERTAIN CONFIGURATIONS

- **Installation of cabinets with cable trunking**

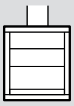
The power that can be dissipated P (W) which has been determined is increased by multiplication coefficient M.

- **Installation with combination of two cabinets**

The power that can be dissipated by the two cabinets is equal to the sum of the powers of each cabinet modified by a reducing coefficient associated with the common wall.

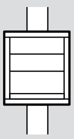
CORRECTION COEFFICIENTS M FOR INSTALLATION WITH CABLE TRUNKING

Trunking on the top of the cabinet



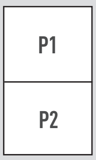
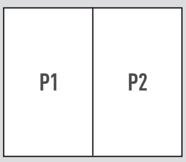
Hauteur (mm)	Largeur (mm)	Nombre de goulottes		
		1	2	3
50/65	160	1,4	1,6	1,8
65	250	1,5	1,7	-

Trunking on the top and bottom of the cabinet



Hauteur (mm)	Largeur (mm)	Nombre de goulottes	
		1	2
50/65	160	2	2,2
65	250	2,4	2,4

CORRECTION COEFFICIENTS FOR COMBINING TWO CABINETS

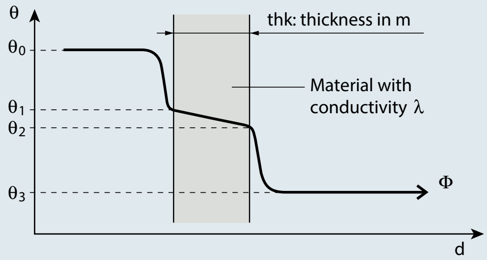
Cabinets on top of one another	Cabinets side by side
	
P = P1 + 0.8 × P2	P = 0.9 × (P1 + P2)

The following calculations demonstrate two essential aspects of the concepts of heat transfer in enclosures:

1 - The convection and radiation methods of heat exchange play an equal role in heat dissipation at normal operating temperatures.

2) The walls of the enclosure have very little effect on the heat transfer flow: their internal and external surface temperatures are virtually identical (isothermal walls) and the type of material of which they are made has almost no influence. Therefore the same size enclosure, whether it is made of plastic or aluminium, has virtually the same heat dissipation capabilities.

Values θ0, θ1, θ2 and θ3 indicate the temperatures of each of the steps in the transfer: internal air, internal surface, external surface, external air (ambient air).



Heat transfer through a wall can be broken down into three stages:

1 - Flow between the internal fluid (internal air of the enclosure) and the wall:

$$\Phi = h_1 (\theta_0 - \theta_1)\, S \quad \Rightarrow \quad \theta_0 - \theta_1 = \frac{\Phi}{S}\,\frac{1}{h_1}$$

2. Flow through the wall:

$$\Phi = \frac{\lambda S}{thk} (\theta_1 - \theta_2) \quad \Rightarrow \quad \theta_1 - \theta_2 = \frac{\Phi}{S}$$

3. Flow between the wall and the external fluid (ambient air):

$$\Phi = h_2 (\theta_2 - \theta_3)\, S \quad \Rightarrow \quad \theta_2 - \theta_3 = \frac{\Phi}{S}$$

Adding the three equations term by term gives the global transfer flow:

$$\theta_0 - \theta_3 = \frac{\Phi}{S}\left(\frac{1}{h_1} + \frac{thk}{\lambda} + \frac{1}{h_2}\right)$$

HEAT EXCHANGE THROUGH A WALL

Giving the simplified formula:

$$\Phi = K\,S\,(\theta_0 - \theta_3) \quad \text{where} \quad \frac{1}{K} = \frac{1}{h_1} + \frac{thk}{\lambda} + \frac{1}{h_2}$$

Coefficients h1 (internal exchange) and h2 (external exchange) incorporate both convection (c) and radiation (r). This then gives:

$$h_1 = h_{1c} + h_{1r} \quad \text{and } h_2 = h_{2c} + h_{2r}$$

The following two formulae are used for calculating h1:

$$h_{1c} = h\,S\,(\theta_0 - \theta_1) \quad \text{(Newton's law)}$$

The value of h depends on a number of factors: flow, type of fluid, temperature, shape of the surfaces. Its calculation, which is complex, is not given here.

$$h_{1r} = F\,S\,\tau\,\frac{\theta_0'^4 - \theta_1^4}{\theta_0' - \theta_1}$$

F: mutual absorption coefficient associated with the interaction between the emissive surfaces of the devices in the enclosure and the walls of the enclosure (internal radiation)

$$F = \frac{1}{a_1} + \frac{1}{a_2} - 1$$

a1 and a2: absorption coefficient of the surfaces facing one another (equipment and material of the enclosure)
S: surfaces facing one another, to be adjusted if necessary to take account of the angle of incidence of the surfaces.
τ: Stephan-Boltzmann constant = $5.7.10^{-8}$ W/m2 K^4.
θ_0': temperature of the emitting bodies (internal equipment) if different from θ0 (the surface temperature of the devices, which is generally higher than that of the internal air of the enclosure)
h2 is calculated in the same way as h1, reducing the radiation calculation to the emission part.
The radiation received by the walls of the building in which the enclosure is installed is ignored:

$$h_{2c} = h\,S\,(\theta_2 - \theta_3)$$
$$h_{2r} = S\,\varepsilon\,\tau\,(\theta_2^4 - \theta_3^4)$$

ε: emissivity coefficient (0.85 for RAL 7035)
accurate calculation of h2r requires knowledge of the space in which the enclosure is installed, so that the same calculation can be applied as for h1r.

Note: Numerous factors relating to heat exchanges do not have absolute values. Thus the overall transmission coefficient through the wall K is dependent on the temperature. The greater the difference between the internal and external surfaces (average temperature rise) the more favourable this is to heat exchange: K increases.
Convection heat exchanges depend to a great extent on the temperature of the air, that of the wall, the height of this wall and its position in space. The convection flow (Newton's law) is therefore also difficult to calculate. The concept of equivalent dissipation area Se enables a calculation to be carried out which incorporates these concepts (see page 115).

• Calculation of the thermal conduction resistance for a painted steel enclosure (for example, Atlantic)

Sheet steel, thickness	thk= 1.5 mm	$\lambda_1 = 52$
2 coats of polyester paint	2 x 60 µ	$\lambda_2 = 0.2$

λ: coefficient of thermal conductivity in W/m°C

$$R_{cond} = \frac{thk}{\lambda} = \frac{1.5\ 10^{-3}}{52} + \frac{120\ 10^{-6}}{0.2} = 6.3\ 10^{-4}$$

This value must be compared with the total resistance:

$$R_{tot} = 1/K$$

using $K_{av} = 5.5$ W/°C m² gives $R_{tot} = 0.18$

the conduction resistance of the wall is 0.35% of the total resistance. It is in fact negligible in the heat exchange.

• Calculation of the thermal conduction resistance for an enclosure made of insulating material

Reinforced polyester, thickness thk = 4 mm

$$R_{cond} = \frac{thk}{\lambda} = \frac{4\ 10^{-3}}{0.2} = 1.6\ 10^{-2} \quad \text{[°C m}^2\text{/W]}$$

In this case, the conduction resistance is 9% of the total resistance. It remains negligible in the heat exchange.
The type of material of which the enclosure is made has very little influence on the heat exchange coefficient and is not therefore a selection criterion with regard to heat dissipation.

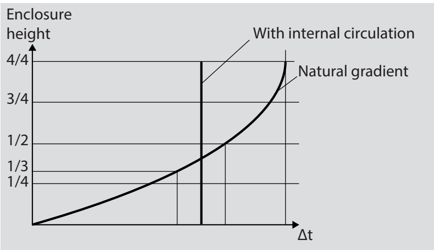
Cooling devices

CIRCULATION OF THE AIR INSIDE THE ENCLOSURE

THERMAL GRADIENT

If the air inside a sealed enclosure is circulated by one or more fans, the concept of thermal gradient is removed. The temperature of the air becomes homogenous throughout the enclosure.

$$\Delta t_{av} = \Delta t_{max} \text{ and } g = 1$$



K VALUE

As the heat exchange at the walls remains laminar, the same K values can be used.

POWER THAT CAN BE DISSIPATED

$$P = \Delta t \cdot K \cdot S$$

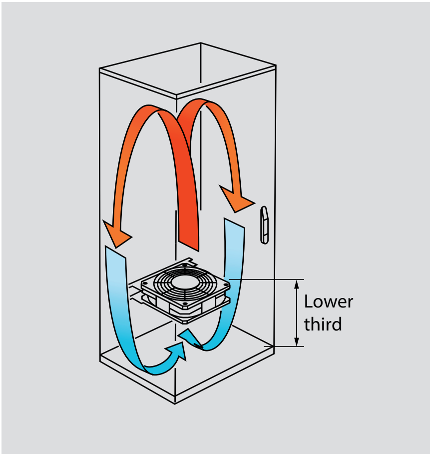
For the same max. permissible temperature rise, the power can therefore be multiplied by 1/g.

1/g being between 1.4 and 2 with no internal circulation. $\Delta t_{av} = \Delta t_{max}$ and g = 1

SELECTION AND LOCATION OF FANS

For an enclosure in which the layout and density of the components are such that the average horizontal air flow area is at least half the area of the base, the min. flow rate of the fan (or fans) per second must be 0.1 times the volume of the enclosure.

For example, for a 0.5 m^3 enclosure, a fan with a minimum flow rate of 0.05 m3/s (50 l/s or 180 m^3/h) will be used.



Experience has shown that the best results are obtained when the fan is placed is the lower third of the enclosure.

HEAT TRANSFER BY AIR FLOW (VENTILATION)

POWER TRANSFERRED (IN W)

$$P = C \cdot \rho \cdot D \cdot \Delta t.$$

C: specific heat of the air in J/kg°C (C = 1000 J/kg°C)

ρ: density of the air in kg/m3 at the temperature in question

D: flow rate in m^3/s

Δt: temperature rise of the air in °C

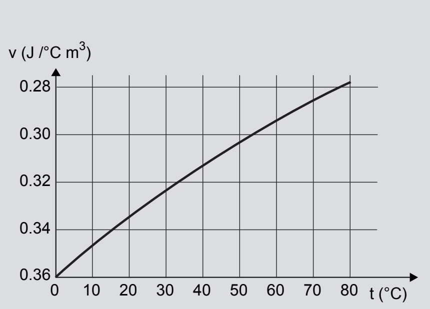
The product C.ρ is comparable to the volumetric heat of the air in (J/m^3 °C), a coefficient which is easier to use, which we will call v, giving P = v · D · Δt

The volumetric heat of the air v is calculated for different temperatures from 0 to 80°C at an atmospheric pressure of 105 Pa.

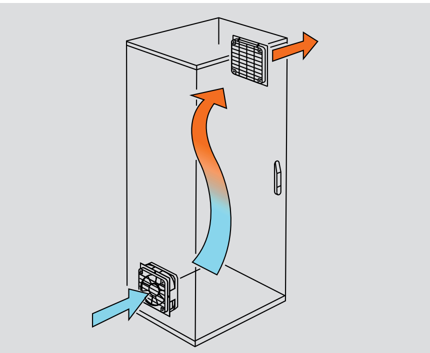
Variations in density ρ are calculated using the formula:

$$\rho = \rho_0 \frac{t_0}{t} \quad \text{where} \quad \rho_0 = 1.293 \quad \text{and} \quad t_0 = 273$$

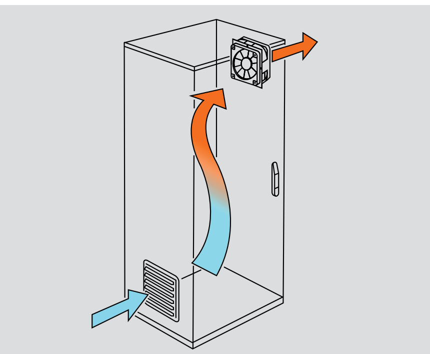
VOLUMETRIC HEAT OF THE AIR ACCORDING TO THE TEMPERATURE



In the formula P = v · D . Δt, v is given according to the temperature while Δt represents the temperature rise: $\Delta t = t - t_{ambient}$
It can be seen that in the usual range of enclosure temperatures, 20 to 60°C, coefficient v only varies by 10%, which could lead to the use of an average coefficient.



Pressurised enclosure

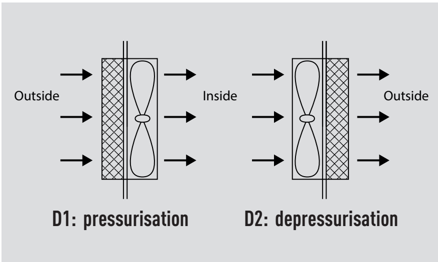


Depressurised enclosure

POSITION OF THE FAN

To avoid impeding the natural rising flow of the hot air, the flow from the fan must be in the same direction.

In theory and considering that the flow rate/pressurisation and flow rate/depressurisation curves of the fan are identical, the position of the fan only affects the power that can be dissipated by varying the volumetric heat υ, while the flow rate D remains constant. The power that can be dissipated will therefore be slightly less when the enclosure is depressurised.



In practice, and in the case of axial flow fans installed with filters, the reverse is observed:

D2 > D1.

From a practical viewpoint:

- Pressurisation encourages the seal-tightness of the enclosure, the fan works at ambient temperature and there is less noise, but the flow rate may be reduced (see above) and the heat produced by the fan motor affects the heat balance.

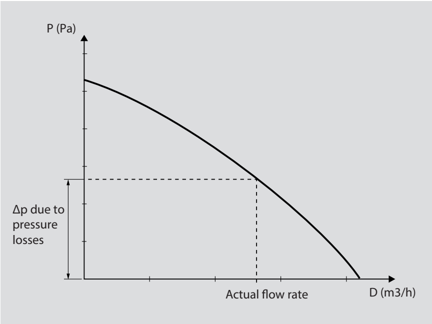
- If the enclosure is depressurised, it may be easier for dust to penetrate, the fan works at a higher temperature (shorter lifetime), there is more noise and the flow rate may be higher.

Fan manufacturers generally advise using the first solution.

INTERPRETATION OF THE CHARACTERISTIC CURVES

The flow rate/pressure curves must refer to the equipment used. The characteristic curve of a fan equipped with filters and fitted on an enclosure may be very different to that of an "isolated" fan.

The actual flow rate will therefore be given by the curve, subtracting the various load losses (grilles, filters and their possible clogging, deflectors, etc.).



USING SEVERAL FANS

When the power to be dissipated or the pressure losses are too great, it may be necessary to install several fans.

In the first case, the fans will be arranged in parallel (side by side). The flow rate will be multiplied by the number of fans, while the available pressure will remain the same.

In the second case, the fans will be arranged in series (one behind the other). The flow rate will be the same, while the pressure increases.

The pressure drops connected with pressure losses vary with the square of the flow rate. Therefore doubling the flow rate requires a quadruple variation in pressure and pressure losses to be taken into account.

TOTAL POWER THAT CAN BE DISSIPATED

This is the sum of the power dissipated through the walls of the enclosure and that transferred by the flow of air, i.e.:

$$P = \Delta t1 \cdot K \cdot S + \Delta t2 \cdot v \cdot D$$

Δt1: average Δt in the enclosure = g·Δtmax

Δt2: Δt between air intake and outlet

v at tambient will be used for pressured enclosures and v at tambient + Δt2 will be used for depressurised enclosures.

For better efficiency, the air outlets are generally placed at the top of the enclosure, and the following can be permitted Δt2 = Δtmax

This then gives: $P = \Delta tmax\,(g \cdot K \cdot S + v \cdot D)$

Fan Cat. No. 0 348 54 supplied with a pair of louvres and a washable filter.

INFLUENCE ON THE THERMAL GRADIENT

The evacuation of the hot air tends to reduce its accumulation at the top of the enclosure, therefore when Δtmax does not exceed 25°C and the ventilation flow rate is at least 0.1 times/s the volume of the enclosure, coefficient g can be raised by 0.1 in relation to the values of the curve and by 0.2 if the flow rate reaches 0.2 times/s the volume of the enclosure (rules drawn from experience).

VENTILATION BY NATURAL DRAUGHT WITH LOUVRES PLACED IN A VERTICAL PLANE

Although this reduces the degree of protection of the enclosure, the use of louvres avoids condensation phenomena and cools the equipment to a certain extent.

The heat transfer is limited.

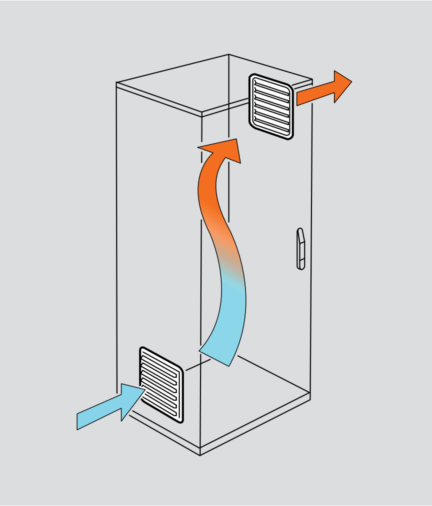
Tests have shown that the air flow rate depends on a number of parameters:
- The difference between the heights of the louvres,
- The difference between the air intake and outlet temperatures: convection effect and specific heat,
- The free air flow area of the louvre.

An empirical formula can be used to estimate the air flow rate in m^3/h:
D = 0.5 · 10-4 · log h · S2 · Δt0.6
h: difference in height between the centres of the intake and outlet louvres in cm
S: air flow area in cm^2
Δt: max. temperature rise of the air

The dissipated power can be calculated in the same way as for fans, using the formula:

P = v · D · Δt

v will be the air outlet temperature if the intake and outlet louvres have the same flow area.



INFLUENCE ON THE THERMAL GRADIENT

When the intake and outlet louvres have the same flow area, they allow the same volume flow rate, but their mass flow rates are different – coefficient g tends to decrease (~ 0.05) and the thermal gradient tends to become more pronounced.

To avoid this phenomenon, the outlet louvres must have a larger flow area than the intake louvres.

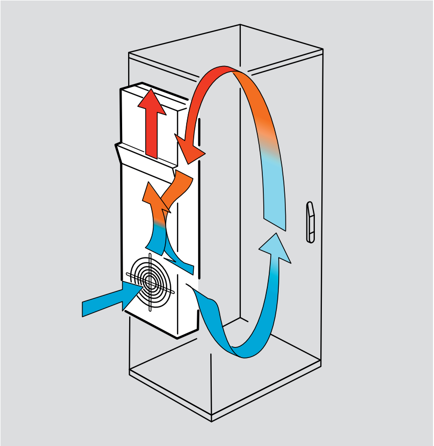
To calculate the flow rate D and the power P, take the flow area S of the intake louvre and the volumetric heat v at ambient temperature.

Cooling via louvres is limited. The natural draught of air can easily be impeded, and there may be hot spots in the enclosure. The most sensitive components must therefore be placed close to the intakes, while those dissipating the most must be near the outlets.

COOLING BY HEAT EXCHANGER

In heat exchangers, the internal air is not in contact with the external air and no pollution is carried into the enclosure, unlike louvres and fans.

Heat exchangers can be based on various technologies (plate, tubular, heat pipe, etc.) and their efficiency can differ according to the technology used. The coolant for enclosures is generally air or water. The amount of heat exchanged is proportional to the difference in temperature between the air inside the enclosure and the air in the cooling circuit, in this case the ambient air.



POWER EVACUATED

This is expressed in the form:

P = Δt · Q

Δt (°C): temperature rise of the internal air

Q (W/°C): specific capacity of the heat exchanger

INFLUENCE ON THE THERMAL GRADIENT

The internal circulation of the air created by the heat exchanger equalises the temperatures in the enclosure in the same way as internal circulation, and g = 1 is therefore used

The total power dissipated will therefore be:

Pt = Δtmax · K · S · Q

Under no circumstances can the internal temperature of the enclosure be lower than the ambient temperature. It will always be higher, due to the efficiency of the heat exchanger, which is between 0.5 and 0.8.
The heat capacity Q of the heat exchanger can vary according to various parameters:
- The temperature rise, on which the volumetric heat and the exchange coefficient in the heat exchanger depend,
- The air flow rates, on which the pressure losses and the exchange coefficient depend,
For precise calculations, it is therefore advisable to refer to the characteristic curves of the heat exchanger.

COOLING BY AIR CONDITIONING UNIT

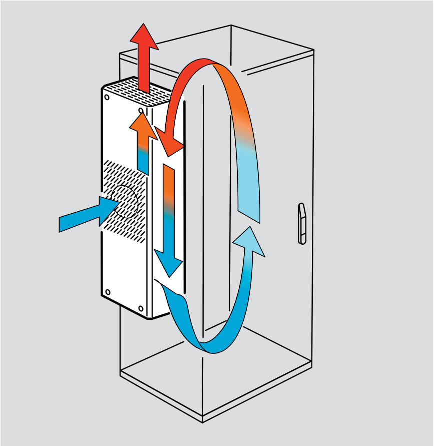
As with the heat exchanger, the internal air in the enclosure is not in contact with the ambient air.

POWER THAT CAN BE DISSIPATED

Air conditioning units are given for a cooling capacity in W or in frig/h. 1 W = 1.16 frig/h

They can therefore maintain a temperature rise close to zero for a dissipated power in the enclosure equal to their cooling capacity.

In this case there is no natural dissipation from the enclosure: Δt = 0 in the formula P = Δt · K · S



Legrand heat exchanger

Cooling efficiency is at its optimum in an ambient temperature range (for example from 15 to 35°C). It decreases as the ambient temperature increases. It is generally given for 35 and 50°C.

INFLUENCE ON THE THERMAL GRADIENT

The internal circulation of the air created by the air conditioning unit equalises the temperatures as with internal circulation.

If a certain temperature rise is permitted for the internal air (within the limits of the correct operation of the air conditioning unit), the power dissipated by the enclosure can be calculated using g = 1 (see page 118), i.e.:

$Pe = \Delta tmax \cdot K \cdot S$

The total power that can be dissipated will be:

$P = Pe + Pf$

Pf: cooling capacity at Δt in question

REDUCING THE INTERNAL TEMPERATURE OF THE ENCLOSURE IN RELATION TO THE AMBIENT TEMPERATURE

Within the operating limits of the air conditioning unit (power and min. setting), the temperature of the enclosure can be reduced to below the ambient temperature.

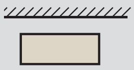
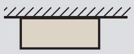
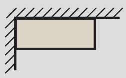
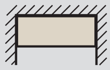
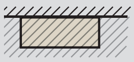
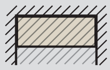
THe choice of the temperature setting of an air conditioning unit is extremely important.
Apart from increased energy expenditure, reducing the temperature to below the ambient temperature reduces the power that can be dissipated (the "captured" power must then be subtracted from the ambient temperature) and increases the risk of condensation (cold wall effect).

Legrand air conditioning units

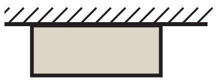
APPENDICES

Dissipated powers of XL^3 enclosures

The tables on the following pages give the power dissipated in the various enclosures in the XL^3 range, according to their configuration (with or without door, with seal, etc.) and their installation specifications.

INSTALLATION SPECIFICATIONS	
	The enclosure is placed on the ground, with no contact with any surface (for example, freestanding enclosures).
	The back of the enclosure is against a vertical surface (enclosure against a wall, or wall-mounting enclosure). All the other sides are free. The back of the enclosure is classed as being in contact if the distance between the enclosure and the vertical surface is less than 10 cm. Enclosures fixed to the wall must be installed at least 10 cm above the ground.
	The back and one of the sides of the enclosure are in contact with a vertical surface (for example, in a corner). The enclosure is classed as being in contact if the distance between the back or the side and the vertical surfaces is less than 10 cm.
	The back and both sides of the enclosure are in contact with a vertical surface (for example, in a conduit or a technical space). The enclosure is classed as being in contact if the distances between the back or the sides and the vertical surfaces are less than 10 cm.
	The back and the top of the enclosure are in contact with a surface (for example, against a wall or under the ceiling). The enclosure is classed as being in contact if the distance between the top of the enclosure and the ceiling is less than 20 cm. CAUTION: The installation of an air conditioning unit on the roof requires a clearance of at least 1 metre above the enclosure.
	The back, sides and top of the enclosure are in contact with a surface (can be compared to flush-mounting). The above distance rules apply: at least 10 cm for vertical surfaces and at least 20 cm above the enclosure.

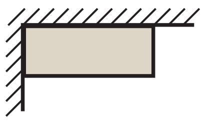
XL³ 160 INSULATED



Dimensions (mm) w x h x d without door (with door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
575 x 450 x 145 (170)		41	57	71	86	110	132	34	47	58	71	90	108	31	43	53	65	83	99
575 x 600 x 145 (170)		45	62	78	99	120	141	37	51	64	81	98	116	34	47	59	74	90	106
575 x 750 x 145 (170)		49	68	90	110	136	161	40	56	74	90	112	132	37	51	68	83	102	121
575 x 900 x 145 (170)		54	75	103	126	155	180	44	62	84	103	127	148	41	56	77	95	116	135
575 x 1050 x 145 (170)		59	86	116	145	171	201	48	71	95	119	140	165	44	65	87	109	128	151

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

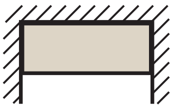
XL³ 160 INSULATED



Dimensions (mm) w x h x d without door (with door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
575 x 450 x 145 (170)		40	55	69	84	109	130	33	45	57	69	89	107	30	41	52	63	82	98
575 x 600 x 145 (170)		43	59	77	94	118	140	35	48	63	77	97	115	32	44	58	71	89	105
575 x 750 x 145 (170)		47	67	87	108	133	158	39	55	71	89	109	130	35	50	65	81	100	119
575 x 900 x 145 (170)		53	74	100	124	150	176	43	61	82	102	123	144	40	56	75	93	113	132
575 x 1050 x 145 (170)		58	85	114	141	167	198	48	70	93	116	137	162	44	64	86	106	125	149

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

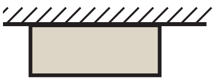
XL^3 160 INSULATED



Dimensions (mm) w x h x d without door (with door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
575 x 450 x 145 (170)		33	48	61	76	98	113	27	39	50	62	80	93	25	36	46	57	74	85
575 x 600 x 145 (170)		36	52	70	84	110	128	30	43	57	69	90	105	27	39	53	63	83	96
575 x 750 x 145 (170)		39	60	81	103	129	146	32	49	66	84	106	120	29	45	61	77	97	110
575 x 900 x 145 (170)		46	67	93	113	147	163	38	55	76	93	121	134	35	50	70	85	110	122
575 x 1050 x 145 (170)		51	77	107	126	165	188	42	63	88	103	135	154	38	58	80	95	124	141

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

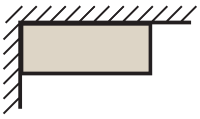
XL^3 160 METAL



Dimensions (mm) w x h x d without door (with door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
575 x 450 x 145 (170)		46	62	78	94	119	145	38	51	64	77	98	119	35	47	59	71	89	109
575 x 600 x 145 (170)		49	68	85	108	133	161	40	56	70	89	109	132	37	51	64	81	100	121
575 x 750 x 145 (170)		53	74	96	122	150	178	43	61	79	100	123	146	40	56	72	92	113	134
575 x 900 x 145 (170)		60	82	109	138	167	197	49	67	89	113	137	162	45	62	82	104	125	148
575 x 1050 x 145 (170)		65	94	125	158	189	220	53	77	103	130	155	180	49	71	94	119	142	165

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

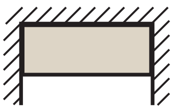
XL³ 160 METAL



Dimensions (mm) w x h x d without door (with door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
575 x 450 x 145 (170)		44	58	73	89	117	139	36	48	60	73	96	114	33	44	55	67	88	104
575 x 600 x 145 (170)		46	62	82	101	128	155	38	51	67	83	105	127	35	47	62	76	96	116
575 x 750 x 145 (170)		49	70	93	119	147	174	40	57	76	98	121	143	37	53	70	89	110	131
575 x 900 x 145 (170)		55	79	107	136	167	193	45	65	88	112	137	158	41	59	80	102	125	145
575 x 1050 x 145 (170)		62	92	123	154	186	218	51	75	101	126	153	179	47	69	92	116	140	164

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

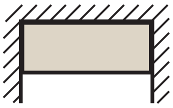
XL³ 160 METAL



Dimensions (mm) w x h x d without door (with door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
575 x 450 x 145 (170)		36	52	67	83	107	124	30	43	55	68	88	102	27	39	50	62	80	93
575 x 600 x 145 (170)		39	57	77	92	121	140	32	47	63	75	99	115	29	43	58	69	91	105
575 x 750 x 145 (170)		43	66	89	113	141	160	35	54	73	93	116	131	32	50	67	85	106	120
575 x 900 x 145 (170)		50	74	102	124	161	180	41	61	84	102	132	148	38	56	77	93	121	135
575 x 1050 x 145 (170)		56	84	117	138	181	206	46	69	96	113	148	169	42	63	88	104	136	155

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

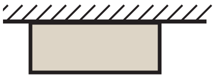
XL³ 160 FLUSH-MOUNTING



Dimensions (mm) w x h x d without door	Δθ (K)	IP 30						IP 40					
		15	20	25	30	35	40	15	20	25	30	35	40
575 x 600 x 110		37	52	69	88	106	125	30	43	57	72	87	103
575 x 750 x 110		41	60	80	103	123	146	34	49	66	84	101	120
575 x 900 x 110		47	71	94	118	138	167	39	58	77	97	113	137
575 x 1050 x 110		54	81	105	136	160	188	44	66	86	112	131	154

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

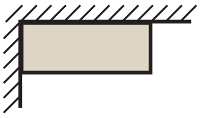
XL³ 400 METAL



Dimensions (mm) w x h x d without door	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
660 x 650 x 175		60	81	112	138	169	198	52	73	90	110	138	165	47	65	85	93	129	158
660 x 850 x 175		72	96	122	148	180	220	59	79	95	119	147	175	57	77	89	115	144	164
660 x 1050 x 175		89	119	142	163	218	255	66	89	111	138	165	192	63	86	104	131	161	183
660 x 1250 x 175		110	142	165	185	250	288	86	116	130	153	189	222	81	110	123	148	183	213
660 x 1450 x 175		131	164	189	213	286	328	110	129	146	176	213	254	106	123	132	163	198	236
660 x 1650 x 175		149	187	212	246	319	370	123	141	158	198	243	289	120	136	147	178	235	268
660 x 1850 x 175		174	209	236	279	358	413	141	153	168	212	263	306	134	148	161	193	253	296
660 x 2050 x 175		198	234	258	301	392	457	159	166	186	236	286	323	146	158	174	226	277	318
910 x 1050 x 175		149	178	193	256	296	365	126	140	153	198	248	293	121	132	147	189	237	287
910 x 1250 x 175		156	190	235	296	346	415	142	157	174	230	288	337	138	151	168	227	280	329
910 x 1450 x 175		166	201	260	333	390	468	155	170	198	259	326	387	150	167	190	251	317	380
910 x 1650 x 175		180	214	295	373	448	538	170	190	228	280	359	422	165	186	223	277	352	418
910 x 1850 x 175		196	225	325	410	487	579	182	209	245	300	376	448	177	201	240	292	371	438
910 x 2050 x 175		207	237	339	431	515	618	194	220	258	327	394	462	187	213	254	321	390	456
410 x 1450 x 175		84	109	156	192	235	279	62	84	119	156	187	224	57	80	113	150	181	219
410 x 1650 x 175		96	129	176	220	262	314	87	117	130	172	200	249	82	109	127	169	195	243
410 x 1850 x 175		105	151	198	249	300	358	99	132	149	189	230	271	91	127	140	182	221	262
410 x 2050 x 175		119	179	219	276	336	398	111	154	165	207	256	300	106	148	161	196	249	292

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

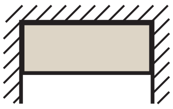
XL³ 400 METAL



Dimensions (w x h x d without door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
660 x 650 x 175		56	78	106	130	167	192	50	71	88	108	136	163	45	62	83	91	126	155
660 x 850 x 175		68	94	119	145	176	216	63	75	92	113	142	165	53	75	96	113	143	162
660 x 1050 x 175		87	117	140	159	215	250	65	88	110	136	161	190	61	85	102	130	158	181
660 x 1250 x 175		107	140	163	181	248	281	84	114	126	150	186	219	79	108	121	147	182	211
660 x 1450 x 175		128	160	177	210	283	324	107	125	141	173	212	252	102	121	131	162	197	234
660 x 1650 x 175		145	178	199	242	310	367	120	139	153	190	241	287	117	134	145	175	235	267
660 x 1850 x 175		162	194	227	276	351	410	139	151	167	210	261	304	132	146	160	198	250	294
660 x 2050 x 175		195	231	244	298	374	450	151	161	180	234	283	320	144	156	170	224	275	315
910 x 1050 x 175		147	176	191	246	288	363	124	138	151	197	245	290	119	130	145	187	235	285
910 x 1250 x 175		154	187	221	290	336	440	138	155	170	227	286	335	135	150	167	223	279	327
910 x 1450 x 175		162	198	256	329	386	464	151	168	196	256	325	386	149	165	189	250	315	379
910 x 1650 x 175		176	210	291	370	440	511	164	187	224	275	357	420	163	184	220	275	351	416
910 x 1850 x 175		190	221	320	400	481	575	180	206	240	297	374	445	176	200	239	290	369	436
910 x 2050 x 175		204	232	337	427	510	615	189	218	256	324	390	460	185	210	253	319	388	454
410 x 1450 x 175		83	107	155	190	233	277	61	83	117	155	184	223	55	79	110	149	179	217
410 x 1650 x 175		94	127	177	217	260	311	86	116	127	170	199	247	80	106	126	166	194	240
410 x 1850 x 175		102	149	196	247	297	356	97	130	146	185	228	270	90	125	138	180	220	260
410 x 2050 x 175		117	176	216	275	335	394	110	153	164	204	254	297	104	145	160	190	246	290

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

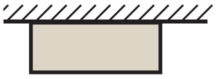
XL³ 400 METAL



Dimensions (w x h x d without door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
660 x 650 x 175		55	77	104	128	161	190	48	70	87	106	134	161	43	60	81	91	124	153
660 x 850 x 175		65	91	115	142	174	204	62	74	90	111	140	163	52	72	91	109	138	160
660 x 1050 x 175		86	116	131	155	200	245	64	87	109	135	159	189	60	84	101	128	156	179
660 x 1250 x 175		103	138	161	177	246	280	82	112	124	148	184	218	77	106	120	145	181	210
660 x 1450 x 175		125	156	175	208	281	340	105	123	139	171	210	250	100	120	130	160	195	233
660 x 1650 x 175		143	173	197	240	308	364	118	137	150	192	238	286	114	133	144	173	233	265
660 x 1850 x 175		160	193	225	273	348	408	137	150	165	208	260	302	130	144	158	197	248	292
660 x 2050 x 175		193	230	243	296	373	448	150	160	178	233	281	318	142	155	168	221	273	313
910 x 1050 x 175		145	174	189	245	286	360	123	137	150	198	244	287	115	128	143	186	234	283
910 x 1250 x 175		153	184	218	285	334	438	135	154	169	225	284	332	134	147	165	220	277	326
910 x 1450 x 175		160	195	254	327	384	462	150	165	190	253	320	383	147	160	185	245	310	375
910 x 1650 x 175		172	208	289	369	438	509	162	185	223	293	352	415	160	181	218	272	348	413
910 x 1850 x 175		189	219	318	395	479	574	176	203	238	294	371	442	173	197	236	287	367	434
910 x 2050 x 175		201	230	335	425	509	610	185	215	253	321	387	456	183	207	251	315	385	451
410 x 1450 x 175		81	105	153	187	231	275	60	82	115	153	182	220	53	75	107	145	176	215
410 x 1650 x 175		93	125	175	216	258	310	85	114	125	168	197	245	79	105	125	164	193	238
410 x 1850 x 175		101	147	194	245	295	354	96	128	144	183	225	267	89	123	135	177	217	257
410 x 2050 x 175		115	175	214	274	334	392	108	151	161	198	251	295	103	143	157	187	244	287

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

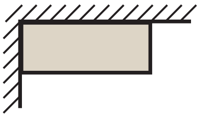
XL³ 400 INSULATED



Dimensions (w x h x d without door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
660 x 650 x 175		50	71	99	125	156	180	47	65	79	98	122	148	43	59	75	82	117	142
660 x 850 x 175		64	82	110	134	161	201	53	72	86	108	131	157	50	70	80	104	127	147
660 x 1050 x 175		78	105	125	147	197	231	60	82	98	125	149	173	57	77	92	117	145	165
660 x 1250 x 175		99	130	150	167	225	260	78	105	117	138	171	205	73	99	111	134	165	198

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

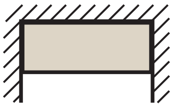
XL³ 400 INSULATED



Dimensions (w x h x d without door)	Δθ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
660 x 650 x 175		48	69	96	117	151	178	45	62	77	95	120	145	41	56	73	80	114	140
660 x 850 x 175		61	80	108	131	160	199	51	68	84	105	127	154	48	68	78	102	125	145
660 x 1050 x 175		77	103	124	145	196	229	58	79	97	123	147	171	55	75	90	115	143	163
660 x 1250 x 175		97	129	147	165	224	258	76	103	114	136	168	203	72	98	109	133	164	195

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

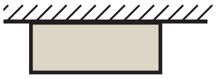
XL³ 400 INSULATED



		IP 30						IP 40						IP 43					
Dimensions (w x h x d without door)	Δθ (K)	15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
660 x 650 x 175		47	68	94	116	148	175	43	59	76	94	118	143	39	54	71	78	112	138
660 x 850 x 175		58	79	104	129	158	197	50	66	81	100	125	150	46	65	76	99	122	143
660 x 1050 x 175		75	101	122	142	190	226	56	77	96	122	144	170	53	73	87	113	141	160
660 x 1250 x 175		95	126	145	161	222	255	74	101	112	134	166	200	70	96	107	131	163	192

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

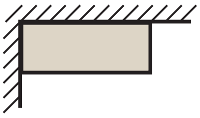
XL³ 800 METAL



		IP 30						IP 40						IP 43					
Dimensions (w x h x d without door)	Δθ (K)	15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
660 x 1050 x 225		91	123	145	188	228	260	70	95	116	144	189	205	68	92	112	139	183	199
660 x 1250 x 225		118	147	168	210	255	294	100	134	144	175	204	248	97	130	139	170	198	241
660 x 1450 x 225		138	168	194	228	294	337	124	141	156	186	228	272	120	137	151	180	221	264
660 x 1650 x 225		155	192	221	253	324	380	141	150	165	200	259	310	137	146	160	194	251	301
660 x 1850 x 225		185	220	243	296	368	423	150	163	179	227	282	329	146	158	174	220	273	320
660 x 2050 x 225		209	242	267	311	410	472	163	175	188	253	305	345	158	170	182	245	295	334
910 x 1050 x 225		154	182	201	262	310	372	134	150	163	215	265	312	130	146	158	208	257	303
910 x 1250 x 225		161	200	243	309	354	427	159	167	175	253	308	361	154	162	170	245	299	350
910 x 1450 x 225		176	208	271	340	403	488	170	179	207	285	348	416	164	174	201	277	337	403
910 x 1650 x 225		187	219	301	382	456	549	189	213	245	319	381	450	183	206	238	309	370	437
910 x 1850 x 225		206	231	336	422	502	592	192	220	266	330	402	478	186	214	258	320	390	464
910 x 2050 x 225		213	247	349	443	527	630	202	234	274	348	418	495	196	227	266	337	405	480
410 x1450 x 225		93	119	164	201	245	290	66	90	126	167	198	239	64	87	123	162	192	232
410 x 1650 x 225		104	139	186	229	273	324	93	125	143	183	215	267	90	122	138	177	208	259
410 x1850 x 225		116	162	208	259	310	376	106	140	158	199	244	289	103	136	153	193	237	281
410 x 2050 x 225		129	189	230	287	345	409	118	165	176	210	273	321	114	160	171	203	265	311

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

XL³ 800 METAL

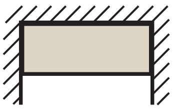


Dimensions (w x h x d without door)	$\Delta\theta$ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
660 x 1050 x 225		89	122	144	187	226	258	65	91	110	137	182	196	63	89	107	132	176	190
660 x 1250 x 225		116	146	166	209	251	292	95	127	137	168	196	237	92	123	132	163	190	230
660 x 1450 x 225		137	161	182	227	292	334	118	137	149	179	221	263	114	132	145	173	214	255
660 x 1650 x 225		148	180	205	252	313	379	137	144	158	191	250	299	132	140	153	185	242	290
660 x 1850 x 225		166	201	234	294	366	421	143	158	173	218	273	318	139	153	168	212	265	309
660 x 2050 x 225		201	239	253	309	389	462	158	168	182	286	294	333	153	163	176	277	285	323
910 x 1050 x 225		151	179	194	255	302	369	128	144	158	207	255	301	124	140	153	201	247	292
910 x 1250 x 225		159	199	240	290	351	420	147	161	168	244	296	348	143	156	163	236	287	337
910 x 1450 x 225		175	204	268	338	397	478	163	173	200	275	336	402	158	168	194	267	326	390
910 x 1650 x 225		185	218	294	377	452	539	182	205	236	308	368	436	176	199	229	298	356	423
910 x 1850 x 225		198	227	335	418	497	590	186	211	256	318	389	462	180	205	249	308	377	448
910 x 2050 x 225		209	234	347	440	524	627	194	226	264	336	404	479	188	219	256	326	392	464
410 x1450 x 225		83	108	159	194	239	286	63	86	121	160	190	231	61	84	117	155	184	224
410 x 1650 x 225		97	130	182	224	266	322	88	121	137	175	207	257	86	117	132	170	201	250
410 x1850 x 225		105	153	200	252	307	366	100	133	150	190	236	278	97	129	146	184	229	270
410 x 2050 x 225		120	182	218	281	343	406	110	158	168	201	265	311	107	153	163	195	257	301

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)

XL³ 800 METAL

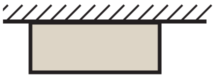


Dimensions (w x h x d without door)	$\Delta\theta$ (K)	IP 30						IP 40						IP 43					
		15	20	25	30	35	40	15	20	25	30	35	40	15	20	25	30	35	40
660 x 1050 x 225		87	118	140	185	224	255	62	88	107	133	177	193	61	86	104	129	171	188
660 x 1250 x 225		113	142	163	206	251	289	90	125	133	165	193	234	88	121	129	160	188	227
660 x 1450 x 225		134	158	178	226	288	335	114	133	146	174	216	257	111	129	141	168	210	249
660 x 1650 x 225		144	175	201	250	309	376	132	140	154	187	244	294	128	136	149	182	237	285
660 x 1850 x 225		162	196	229	291	363	419	140	155	171	215	270	315	135	151	166	209	262	306
660 x 2050 x 225		196	235	247	304	383	455	154	167	179	284	291	331	150	162	173	275	282	321
910 x 1050 x 225		146	175	191	250	252	368	125	143	153	203	250	296	121	139	148	197	242	288
910 x 1250 x 225		155	196	240	255	301	418	142	156	163	239	291	342	138	151	158	232	282	332
910 x 1450 x 225		172	201	263	335	399	484	159	170	194	270	330	395	154	164	189	262	320	383
910 x 1650 x 225		182	213	288	376	460	530	177	200	230	302	361	430	171	194	223	293	350	417
910 x 1850 x 225		193	221	332	405	502	599	181	208	252	315	382	457	176	202	244	306	370	443
910 x 2050 x 225		204	231	341	434	522	625	189	222	260	330	398	471	184	215	252	320	386	457
410 x1450 x 225		80	106	155	191	235	281	59	83	116	156	187	226	58	81	113	151	182	219
410 x 1650 x 225		93	126	177	218	262	316	85	116	132	172	203	252	83	113	128	166	197	244
410 x1850 x 225		103	149	196	247	301	361	97	130	147	187	231	274	94	126	142	182	224	265
410 x 2050 x 225		115	178	213	276	339	399	106	153	164	198	260	307	103	148	159	192	252	298

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)

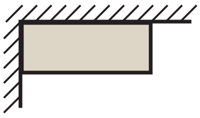
XL³ 400 IP 55



Dimensions (w x h x d with door)	Δθ (K)	IP 65					
		15	20	25	30	35	40
700 x 695 x 205		33	49	68	83	106	120
700 x 895 x 205		51	62	75	92	115	135
700 x 1095 x 205		63	82	94	115	142	170
700 x 1295 x 205		81	93	102	127	156	184

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

XL³ 400 IP 55

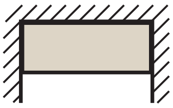


Dimensions (w x h x d with door)	Δθ (K)	IP 65					
		15	20	25	30	35	40
700 x 695 x 205		32	47	67	82	105	118
700 x 895 x 205		50	60	73	88	107	125
700 x 1095 x 205		60	78	88	110	132	158
700 x 1295 x 205		80	89	95	120	144	173

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

APPENDICES

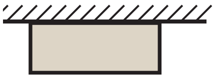
XL³ 400 IP 55



Dimensions (w x h x d with door)	Δθ (K)	IP 65					
		15	20	25	30	35	40
700 x 695 x 205		30	45	65	81	99	115
700 x 895 x 205		48	58	68	85	105	122
700 x 1095 x 205		58	76	85	107	130	154
700 x 1295 x 205		79	87	93	117	140	168

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

XL³ 800 IP 55

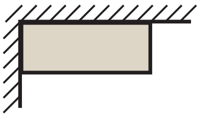


Dimensions (w x h x d without door)	Δθ (K)	IP 30						IP 65					
		15	20	25	30	35	40	15	20	25	30	35	40
700 x 1095 x 250		-	-	-	-	-	-	58	78	99	123	152	181
700 x 1295 x 250		-	-	-	-	-	-	70	85	109	136	166	198
700 x 1495 x 250		109	136	180	230	277	326	80	107	145	181	220	260
700 x 1695 x 250		122	162	201	252	305	362	99	119	159	201	242	289
700 x 1895 x 250		133	171	223	274	334	397	120	137	173	220	265	318
700 x 2095 x 250		142	182	246	298	364	427	137	156	188	245	288	337
950 x 1095 x 250		-	-	-	-	-	-	109	126	152	184	222	267
950 x 1295 x 250		-	-	-	-	-	-	125	137	167	210	247	297
950 x 1495 x 250		147	172	249	317	383	451	138	170	200	248	309	359
950 x 1695 x 250		178	194	258	325	393	463	169	186	208	257	318	371
950 x 1895 x 250		194	205	266	334	402	478	190	203	216	266	328	384
950 x 2095 x 250		203	217	276	348	421	493	200	212	227	277	339	401
500 x 1495 x 250		106	132	163	198	233	286	73	97	142	177	207	251
500 x 1695 x 250		119	148	174	231	253	319	90	109	149	193	237	280
500 x 1895 x 250		131	158	192	253	311	331	111	127	169	217	259	315
500 x 2095 x 250		139	170	221	276	334	383	134	152	180	235	283	328

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)

XL³ 800 IP 55

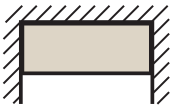


Dimensions (w x h x d without door)	Δθ (K)	IP 30						IP 65					
		15	20	25	30	35	40	15	20	25	30	35	40
700 x 1095 x 250		-	-	-	-	-	-	56	72	97	120	147	177
700 x 1295 x 250		-	-	-	-	-	-	67	82	106	134	163	193
700 x 1495 x 250		104	133	176	223	270	320	77	102	143	180	217	256
700 x 1695 x 250		117	147	192	241	291	345	93	112	156	196	257	282
700 x 1895 x 250		128	157	209	258	312	371	110	132	170	213	258	307
700 x 2095 x 250		137	166	226	275	334	396	132	152	184	232	284	332
950 x 1095 x 250		-	-	-	-	-	-	107	122	140	180	218	260
950 x 1295 x 250		-	-	-	-	-	-	122	132	164	206	243	293
950 x 1495 x 250		144	169	235	294	360	427	135	163	192	245	295	353
950 x 1695 x 250		175	191	248	310	381	452	165	179	202	254	306	364
950 x 1895 x 250		192	200	262	326	400	476	186	198	212	262	320	381
950 x 2095 x 250		200	207	269	344	419	490	191	204	225	272	333	398
500 x 1495 x 250		103	130	158	192	231	283	70	93	138	166	201	247
500 x 1695 x 250		116	140	169	228	249	310	87	101	145	188	230	273
500 x 1895 x 250		128	150	187	249	307	326	108	119	165	210	252	306
500 x 2095 x 250		137	165	217	270	328	375	124	147	171	229	279	325

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)

XL³ 800 IP 55

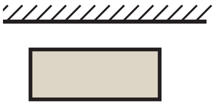


Dimensions (w x h x d without door)	Δθ (K)	IP 30						IP 65					
		15	20	25	30	35	40	15	20	25	30	35	40
700 x 1095 x 250		-	-	-	-	-	-	50	65	95	118	145	173
700 x 1295 x 250		-	-	-	-	-	-	65	84	102	131	159	187
700 x 1495 x 250		101	130	161	203	243	289	93	119	133	166	214	244
700 x 1695 x 250		114	143	179	228	275	325	110	139	149	187	232	269
700 x 1895 x 250		125	152	199	252	307	358	117	149	165	209	250	295
700 x 2095 x 250		133	163	219	273	330	393	128	159	199	230	273	320
950 x 1095 x 250		-	-	-	-	-	-	101	120	136	173	215	255
950 x 1295 x 250		-	-	-	-	-	-	119	129	161	201	239	291
950 x 1495 x 250		141	164	230	291	355	419	130	152	188	240	291	348
950 x 1695 x 250		172	189	245	306	376	446	155	169	199	250	303	362
950 x 1895 x 250		190	195	259	321	397	473	173	189	209	260	315	377
950 x 2095 x 250		197	204	267	336	416	486	185	199	221	269	327	392
500 x 1495 x 250		99	128	154	189	229	279	67	89	133	163	195	241
500 x 1695 x 250		113	137	165	223	245	307	83	97	141	185	227	270
500 x 1895 x 250		120	147	183	244	301	321	103	115	160	205	246	302
500 x 2095 x 250		131	160	213	264	323	372	120	143	168	221	272	320

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)

XL³ 4000

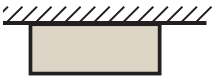


Dimensions (w x h x d) - internal usable dimensions	Δθ (K)	IP 30						IP 55					
		15	20	25	30	35	40	15	20	25	30	35	40
600 x 2000 x 350		167	249	353	456	548	646	156	215	325	386	467	547
600 x 2000 x 600		276	359	438	557	659	788	263	340	419	528	639	759
600 x 2000 x 850		352	428	512	641	788	909	348	419	501	627	755	891
850 x 2000 x 350		283	356	441	552	672	791	172	246	386	481	583	691
850 x 2000 x 600		302	413	512	641	773	916	286	398	465	579	701	813
850 x 2000 x 850		366	441	582	722	861	1019	352	428	546	683	829	973
350 x 2000 x 350		97	163	272	389	488	589	84	158	258	365	472	571
350 x 2000 x 600		170	236	341	442	531	640	159	224	338	429	519	621
350 x 2000 x 850		278	337	428	539	662	781	265	329	415	526	649	768
600 x 2200 x 350		179	261	366	461	561	660	181	229	341	398	471	559
600 x 2200 x 600		281	372	462	581	702	832	286	392	431	540	651	772
600 x 2200 x 850		368	442	528	668	793	943	362	431	519	641	767	909
850 x 2200 x 350		297	361	471	591	712	849	186	259	397	492	599	709
850 x 2200 x 600		311	426	532	663	806	946	298	412	477	588	715	823
850 x 2200 x 850		376	459	620	779	944	1102	369	442	558	697	842	986
350 x 2200 x 350		105	171	282	396	496	595	92	163	269	384	481	585
350 x 2200 x 600		182	245	360	452	551	649	170	234	351	442	530	637
350 x 2200 x 850		288	348	461	578	702	833	276	337	448	559	687	795

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)
In max = 1600 A box B (calculation)

XL³ 4000

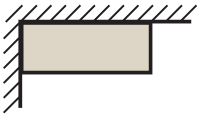


Dimensions (w x h x d) - internal usable dimensions	Δθ (K)	IP 30						IP 65					
		15	20	25	30	35	40	15	20	25	30	35	40
600 x 2000 x 350		159	237	335	433	521	614	148	204	309	367	444	520
600 x 2000 x 600		262	341	416	529	626	749	250	323	398	502	607	721
600 x 2000 x 850		334	407	486	609	749	864	331	398	476	596	717	846
850 x 2000 x 350		269	338	419	524	638	751	163	234	367	457	554	656
850 x 2000 x 600		287	392	486	609	734	870	272	378	442	550	666	772
850 x 2000 x 850		348	419	553	686	818	968	334	407	519	649	788	924
350 x 2000 x 350		92	155	258	370	464	560	80	150	245	347	448	542
350 x 2000 x 600		162	224	324	420	504	608	151	213	321	408	493	590
350 x 2000 x 850		264	320	407	512	629	742	252	313	394	500	617	730
600 x 2200 x 350		170	248	348	438	533	627	172	218	324	378	447	531
600 x 2200 x 600		267	353	439	552	667	790	272	372	409	513	618	733
600 x 2200 x 850		350	420	502	635	753	896	344	409	493	609	729	864
850 x 2200 x 350		282	343	447	561	676	807	177	246	377	467	569	674
850 x 2200 x 600		295	405	505	630	766	899	283	391	453	559	679	782
850 x 2200 x 850		357	436	589	740	897	1047	351	420	530	662	800	937
350 x 2200 x 350		100	162	268	376	471	565	87	155	256	365	457	556
350 x 2200 x 600		173	233	342	429	523	617	162	222	333	420	504	605
350 x 2200 x 850		274	331	438	549	667	791	262	320	426	531	653	755

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)
In max = 1600 A box B (calculation)

XL³ 4000

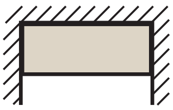


Dimensions (w x h x d) - internal usable dimensions	Δθ (K)	IP 30						IP 65					
		15	20	25	30	35	40	15	20	25	30	35	40
600 x 2000 x 350		151	225	319	412	495	583	141	194	293	348	421	494
600 x 2000 x 600		249	324	395	503	595	711	237	307	378	477	577	685
600 x 2000 x 850		318	386	462	579	711	820	314	378	452	566	681	804
850 x 2000 x 350		255	321	398	498	606	714	155	222	348	434	526	624
850 x 2000 x 600		273	373	462	579	698	827	258	359	420	523	633	734
850 x 2000 x 850		330	398	525	652	777	920	318	386	493	616	748	878
350 x 2000 x 350		88	147	245	351	440	532	76	143	233	329	426	515
350 x 2000 x 600		153	213	308	399	479	578	143	202	305	387	468	560
350 x 2000 x 850		251	304	386	486	597	705	239	297	375	475	586	693
600 x 2200 x 350		162	236	330	416	506	596	163	207	308	359	425	504
600 x 2200 x 600		254	336	417	524	634	751	258	354	389	487	588	697
600 x 2200 x 850		332	399	477	603	716	851	327	389	468	579	692	820
850 x 2200 x 350		268	326	425	533	643	766	168	234	358	444	541	640
850 x 2200 x 600		281	384	480	598	727	854	269	372	430	531	645	743
850 x 2200 x 850		339	414	560	703	852	995	333	399	504	629	760	890
350 x 2200 x 350		95	154	255	357	448	537	83	147	243	347	434	528
350 x 2200 x 600		164	221	325	408	497	586	153	211	317	399	478	575
350 x 2200 x 850		260	314	416	522	634	752	249	304	404	504	620	717

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)
In max = 1600 A box B (calculation)

XL³ 4000

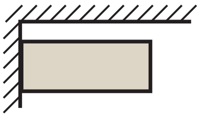


Dimensions (w x h x d) - internal usable dimensions	Δθ (K)	IP 30						IP 65					
		15	20	25	30	35	40	15	20	25	30	35	40
600 x 2000 x 350		143	213	303	391	470	554	134	184	279	331	400	469
600 x 2000 x 600		237	308	376	478	565	676	225	292	359	453	548	651
600 x 2000 x 850		302	367	439	550	676	779	298	359	430	538	647	764
850 x 2000 x 350		243	305	378	473	576	678	147	211	331	412	500	592
850 x 2000 x 600		259	354	439	550	663	785	245	341	399	496	601	697
850 x 2000 x 850		314	378	499	619	738	874	302	367	468	586	711	834
350 x 2000 x 350		83	140	233	334	418	505	72	135	221	313	405	490
350 x 2000 x 600		146	202	292	379	455	549	136	192	290	368	445	532
350 x 2000 x 850		238	289	367	462	568	670	227	282	356	451	556	658
600 x 2200 x 350		153	224	314	395	481	566	155	196	292	341	404	479
600 x 2200 x 600		241	319	396	498	602	713	245	336	370	463	558	662
600 x 2200 x 850		316	379	453	573	680	809	310	370	445	550	658	779
850 x 2200 x 350		255	310	404	507	610	728	159	222	340	422	514	608
850 x 2200 x 600		267	365	456	568	691	811	255	353	409	504	613	706
850 x 2200 x 850		322	394	532	668	809	945	316	379	478	598	722	845
350 x 2200 x 350		90	147	242	340	425	510	79	140	231	329	412	502
350 x 2200 x 600		156	210	309	388	472	556	146	201	301	379	454	546
350 x 2200 x 850		247	298	395	496	602	714	237	289	384	479	589	682

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)
In max = 1600 A box B (calculation)

XL³ 4000

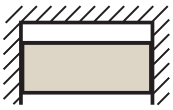


Dimensions (w x h x d) - internal usable dimensions	Δθ (K)	IP 30						IP 55					
		15	20	25	30	35	40	15	20	25	30	35	40
600 x 2000 x 350		155	231	328	424	509	601	145	200	302	359	434	508
600 x 2000 x 600		257	334	407	518	613	733	244	316	389	491	594	706
600 x 2000 x 850		327	398	476	596	733	845	323	389	466	583	702	828
850 x 2000 x 350		263	331	410	513	625	735	160	229	359	447	542	642
850 x 2000 x 600		281	384	476	596	719	851	266	370	432	538	652	756
850 x 2000 x 850		340	410	541	671	800	947	327	398	508	635	771	904
350 x 2000 x 350		90	152	253	362	454	548	78	147	240	339	439	531
350 x 2000 x 600		158	219	317	411	494	595	148	208	314	399	482	577
350 x 2000 x 850		258	313	398	501	615	726	246	306	386	489	603	714
600 x 2200 x 350		166	243	340	429	521	614	168	213	317	370	438	520
600 x 2200 x 600		261	346	429	540	653	773	266	364	401	502	605	718
600 x 2200 x 850		342	411	491	621	737	877	337	401	482	596	713	845
850 x 2200 x 350		276	336	438	549	662	789	173	241	369	457	557	659
850 x 2200 x 600		289	396	495	616	749	879	277	383	443	547	665	765
850 x 2200 x 850		350	427	576	724	878	1024	343	411	519	648	783	917
350 x 2200 x 350		98	159	262	368	461	553	86	152	250	357	447	544
350 x 2200 x 600		169	228	335	420	512	603	158	218	326	411	493	592
350 x 2200 x 850		268	323	429	537	653	774	257	313	416	520	639	739

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)
In max = 1600 A box B (calculation)

XL³ 4000



Dimensions (w x h x d) - internal usable dimensions	Δθ (K)	IP 30						IP 65					
		15	20	25	30	35	40	15	20	25	30	35	40
600 x 2000 x 350		147	220	312	403	484	570	138	190	287	341	412	483
600 x 2000 x 600		244	317	387	492	582	696	232	300	370	466	564	670
600 x 2000 x 850		311	378	452	566	696	803	307	370	442	554	667	787
850 x 2000 x 350		250	314	389	487	593	699	152	217	341	425	515	610
850 x 2000 x 600		267	365	452	566	683	809	253	351	411	511	619	718
850 x 2000 x 850		323	389	514	638	760	900	311	378	482	603	732	859
350 x 2000 x 350		86	144	240	344	431	520	74	140	228	322	417	504
350 x 2000 x 600		150	208	301	390	469	565	140	198	298	379	458	548
350 x 2000 x 850		246	298	378	476	585	690	234	291	366	465	573	678
600 x 2200 x 350		158	230	323	407	495	583	160	202	301	351	416	494
600 x 2200 x 600		248	329	408	513	620	735	253	346	381	477	575	682
600 x 2200 x 850		325	390	466	590	700	833	320	381	458	566	677	803
850 x 2200 x 350		262	319	416	522	629	750	164	229	351	434	529	626
850 x 2200 x 600		275	376	470	585	712	835	263	364	421	519	631	727
850 x 2200 x 850		332	405	548	688	834	973	326	390	493	616	744	871
350 x 2200 x 350		93	151	249	350	438	525	81	144	238	339	425	517
350 x 2200 x 600		161	216	318	399	487	573	150	207	310	390	468	563
350 x 2200 x 850		254	307	407	510	620	736	244	298	396	494	607	702

= Can only be used if T° < 35°C, up to Tmax = 55°C inside the enclosure

In max = 630 A box C (design rule)
In max = 1600 A box B (calculation)

DMX³ dissipated power (W)

FIXED VERSION

Size		1		2	3
Legrand		DMX³ 1600	DMX³ 2500	DMX³ 4000	DMX³ 6300
Number of poles		3-4		3-4	3-4
Type of relay		Electronic		Electronic	Electronic
Nominal current	(A)				
	630	19	13	10	-
	800	31	20	16	-
	1000	48	32	25	-
	1250	75	50	39	-
	1600	123	82	64	-
	2000		128	100	-
	2500		200	156	-
	3200			256	-
	4000			400	208
	5000				325
	6300				516

DRAW-OUT VERSION

Size		1		2	3
Legrand		DMX³ 1600	DMX³ 2500	DMX³ 4000	DMX³ 6300
Number of poles		3-4		3-4	3-4
Type of relay		Electronic		Electronic	Electronic
Nominal current	(A)				
	630	42	32	19	-
	800	67	51	31	-
	1000	105	80	48	-
	1250	164	125	75	-
	1600	269	205	123	-
	2000		128	192	-
	2500		320	300	-
	3200			492	-
	4000			768	400
	5000				625
	6300				992

DPX^3 160 dissipated power (W)

Size		1							
Legrand		DPX³ 160							
Number of poles		3-4							
Type of relay		thermal-magnetic							
Nominal current	(A)	16	25	40	63	80	100	125	160
Connection terminals		2.8	5.0	5.1	6.7	7.0	11.0	12.5	15.4
Lugs		2.8	5.0	5.1	6.7	7.0	11.0	12.5	24.3
Front terminals		2.8	5.0	5.1	6.7	7.0	11.0	12.5	15.4
Spreaders		2.8	5.0	5.1	6.7	7.0	11.0	12.5	20.5
Rear terminals		2.8	5.0	5.1	6.7	7.0	11.0	12.5	25.1
Plug-in version		2.8	5.1	5.4	7.5	8.3	13.0	15.6	20.5

DPX^3 250 dissipated power (W)

Size		3				3			
Legrand		DPX³ 250				DPX³ 250 with earth leakage module			
Number of poles		3-4				4			
Type of relay		thermal-magnetic				thermal-magnetic			
Nominal current	(A)	100	160	200	250	100	160	200	250
Lugs		8.1	15.1	22.8	29.4	9.2	17.4	25.6	37.5
Connection terminals		8.1	15.1	22.8	29.4	9.2	17.4	25.6	37.5
Front terminals		8.1	15.1	22.8	29.4	9.2	17.4	25.6	37.5
Spreaders		8.1	15.1	22.8	29.4	9.2	17.4	25.6	37.5
Rear terminals		8.1	15.1	22.8	29.4	9.2	17.4	25.6	37.5
Plug-in version		10.0	20.5	30.8	41.9	11.2	22.5	33.6	50.0

								1	1			
DPX^3 160 with earth leakage module								DPX^3-I 160	DPX^3 160 MS			
4								4	3			
thermal-magnetic								N/A	magnetic only			
16	25	40	63	80	100	125	160	160	16	25	50	63
2.8	5.0	5.1	6.7	7.0	11.0	12.5	15.4	9.2	0.1	0.2	0.9	1.4
2.8	5.0	5.1	6.7	7.0	11.0	12.5	24.3	9.2	0.1	0.2	0.9	1.4
2.8	5.0	5.1	6.7	7.0	11.0	12.5	15.4	9.2	0.1	0.2	0.9	1.4
2.8	5.0	5.1	6.7	7.0	11.0	12.5	20.5	9.2	0.1	0.2	0.9	1.4
2.8	5.0	5.1	6.7	7.0	11.0	12.5	25.1	9.2	0.1	0.2	0.9	1.4
2.9	5.1	5.4	7.5	8.3	13.0	15.6	20.5	14.3	0.1	0.4	1.4	2.2

3				3				3				3				3-4				3			
DPX^3 250				DPX^3 250 with earth leakage module				DPX^3 -I 250				DPX^3 250 MS				DPX^3 250 AB				DPX^3 250 AB with earth leakage module			
3-4				4				4				3				3-4				4			
electronic				electronic				N/A				magnetic				electronic				electronic			
40	100	160	250	40	100	160	250	-	-	-	250	100	160	200	250	90	130	170	240	90	130	170	240
0.3	2.0	5.1	12.5	0.5	3.0	7.7	18.8	-	-	-	18.8	3.0	7.7	12.0	18.8	1.6	3.4	5.8	11.5	2.4	5.1	8.7	17.3
0.3	2.0	5.1	12.5	0.5	3.0	7.7	18.8	-	-	-	18.8	3.0	7.7	12.0	18.8	1.6	3.4	5.8	11.5	2.4	5.1	8.7	17.3
0.3	2.0	5.1	12.5	0.5	3.0	7.7	18.8	-	-	-	18.8	3.0	7.7	12.0	18.8	1.6	3.4	5.8	11.5	2.4	5.1	8.7	17.3
0.3	2.0	5.1	12.5	0.5	3.0	7.7	18.8	-	-	-	18.8	3.0	7.7	12.0	18.8	1.6	3.4	5.8	11.5	2.4	5.1	8.7	17.3
0.3	2.0	5.1	12.5	0.5	3.0	7.7	18.8	-	-	-	18.8	3.0	7.7	12.0	18.8	1.6	3.4	5.8	11.5	2.4	5.1	8.7	17.3
0.6	4.0	10.2	25.0	0.8	5.0	12.8	31.3	-	-	-	31.3	3.0	7.7	12.0	18.8	3.2	11.6	11.6	23.0	4.1	8.5	14.5	28.8

DPX^3 630 dissipated power (W)

Size		4									
Legrand		DPX³ 630									
Number of poles		3-4									
Type of relay		thermal-magnetic									
Nominal current	(A)	250		320		400		550		630	
Pole		Phase	Neutral	Phase	Neutral	Phase	Neutral	Phase	Neutral	Phase	Neutral
Nominal current of the neutral	(A)				160		250		320		400
Connection terminals		19.2	19.2	16.4	16.5	25.6	18.9	23.6	28.7	37.3	21.2

DPX^3 1600 dissipated power (W)

Size		4				
Legrand		DPX³ 1600				
Number of poles		3-4				
Type of relay		thermal-magnetic				
Nominal current	(A)	500	630	800	1000	1250
Front terminals		30.7	47.7	40.3	53.7	83.9

DPX 630 to 1600 dissipated power (W)

Size		5				
Legrand		DPX 630/800/1000/1250				
Number of poles		3-4				
Type of relay		thermal-magnetic				
Nominal current	(A)	500	630	800	1000	1250
Fixed version: Front terminals		30.7	47.7	40.3	53.7	83.9

4										4				4		
DPX^3 630										DPX^3-I 400/630				DPX^3 630 MS		
3-4										3-4				3		
electronic										no protection				electronic		
250		320		400		550		630		400		630		320	400	630
Phase	Neutral	Phase	Neutral	Phase	Neutral	Phase	Neutral	Phase	Neutral	Phase	Neutral	Phase	Neutral	Phase	Phase	Phase
7.5	7.5	12.3	12.3	19.2	19.2	22.1	22.1	N/A	N/A	25.6	25.6	37.3	37.3	12.3	19.2	35.0

4					4					
DPX^3 1600					DPX^3-I 1600					
3-4					3-4					
electronic					no protection					
500	630	800	1000	1250	500	630	800	1000	1250	1600
30.7	47.7	40.3	53.7	83.9	32.0	50.8	29.8	47.6	74.4	65.3

5			5			5			5		5
DPX 630/800			DPX 1250/1600			DPX-I 630/800			DPX-I 1250		DPX-I 1600
3-4			3-4			3-4			3-4		3-4
electronic			electronic			no protection			no protection		no protection
500	630	800	1000	1250	1600	500	630	800	1000	1250	1600
11.6	18.5	29.8	47.6	74.4	65.3	32.0	50.8	29.8	47.6	74.4	65.3

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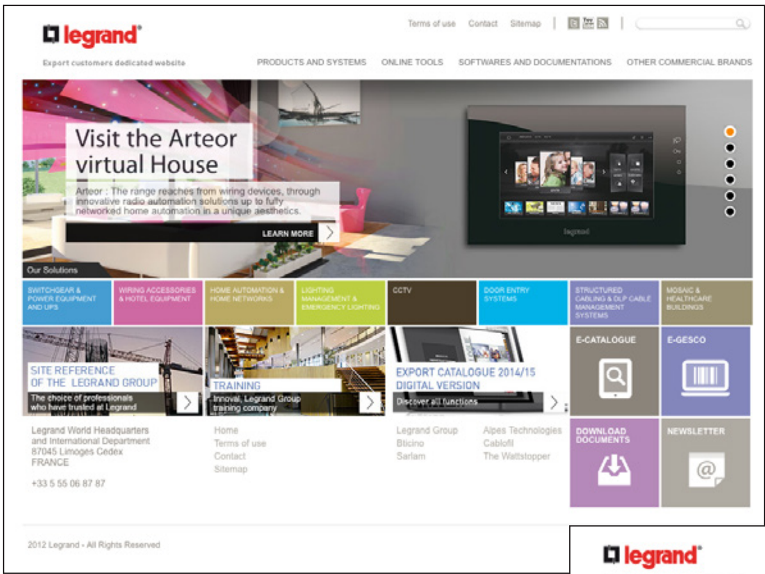

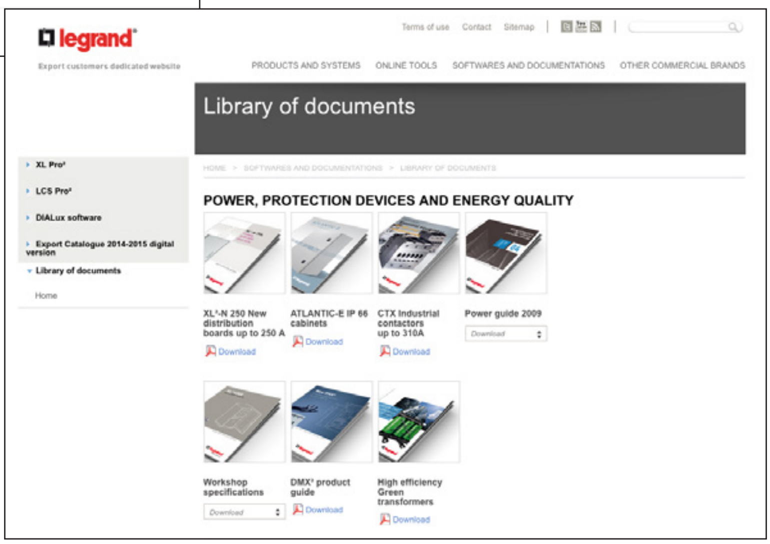

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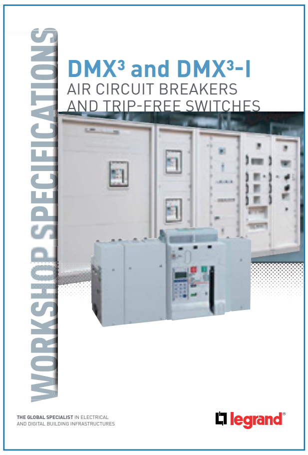

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