



English version

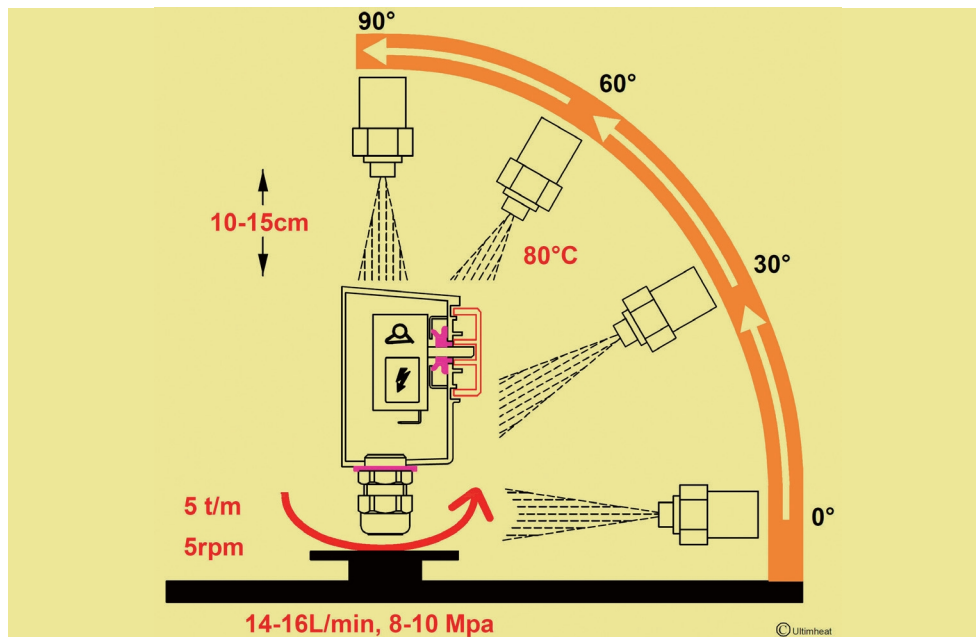


Jacques Jumeau

Technology of components used in heating.

## Chapter 22

# Protection classes of electrical connection boxes



## Protection classes of electrical connection boxes

The housings are designed to protect electrical equipment located inside. This protection must be considered in the electrical and environmental angles.

Sets Y0 to Y5 describe products with protection classes are different and intended for different applications. This introduction allows to understand and define the specifications for an application.

For further information on the specific protection explosive atmospheres, see the resistance of plastics and elastomers to temperature and UV.

### Electrical protection classes




There are two main types of electrical protection, protection against the risk of **direct contact** (functional isolation) and protection against **indirect contact** hazards.

The functional isolation is not sufficient in case of electrical failure and it is necessary to add protection against the risks of indirect contacts, which can be achieved by the following means:

- The earthing of all metal parts
- Double or reinforced insulation
- A low voltage supply via a transformer

The combination of these protections determines the class of electrical protection of the device.

### The 4 electrical safety levels of electrical devices

Class	Symbol	Description
0		Equipment with only functional insulation but not binding to the metal masses. <b>Banned in Europe.</b>
1		Material with a functional isolation and earthing of metal masses. <b>These devices must be connected to earth.</b>
2		Equipment with dual insulation of live parts (functional isolation and physical). No earthing of metal parts. This ensures that no double insulation accessible part may be subject to dangerous voltages even after a first insulation fault. The advantage of this class of appliances is a higher protection to the user regardless of the electrical sockets used (With or without earth terminal). <b>These devices must not be connected to earth.</b>
3		Equipment class 2 transformer with a SELV (Safety Extra Low Voltage). This solution ensures that no accessible part may be subject to dangerous voltages even after a first and a second insulation fault. The electrical insulation of a device by a transformer located apart eliminates the risks of electrical ground return on a user by accidental contact with an electric leakage. On the other hand, the low voltage SELV severely limits the current that can pass through the human body in contact with two elements of the device under different potentials. The advantage of this class of appliances is a higher protection to the user regardless of the electrical sockets used (With or without earth terminal). <b>These devices must not be connected to earth</b>

### IP protection (Ingress protection)

The IP rating defined by the IEC 60529 specifies the degree of protection against ingress of solid bodies (first digit) and against the ingress of water (second digit).

The third and fourth characters are optional and provide information on the level of protection. The classification is done by increasing efficiency. There are 7 levels against solid (0: no protection, 6 fully protected) and 9 levels against water (0: no protection, 8: protected against immersion under pressure).

For example, «IP21» means protected against solid objects greater than 12.5 mm (eg a finger) and resistant to condensation.

### « X » use in the IP Coding

The letter X is used anywhere in the code when the protection it represents is meant to be avoided. There may be various reasons for choosing this coding variant, such as marketing considerations. Thus, e.g. an IPX7 rating for a consumer device specifies that the device has water protection up to limited immersion, but gives deliberately no information as to whether the device has any protection against mechanical ingress or dust. Among other common IP ratings using the

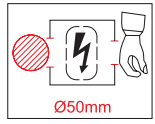
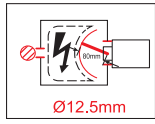
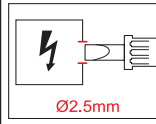
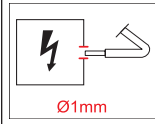
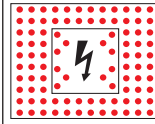
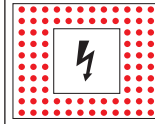
## Protection classes of electrical connection boxes

letter X, is IPX4. IP2X is frequently used on electrical items to specify the item must prevent from finger access to live terminals i.e plug sockets are IP2X.

### First digit (Solid particle protection)

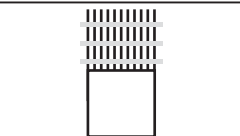
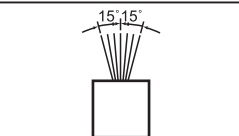
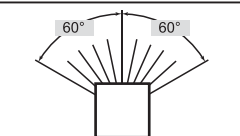
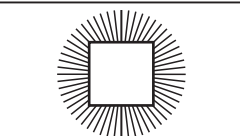
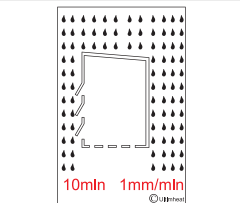
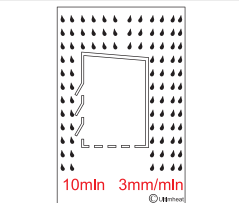
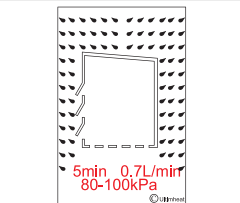
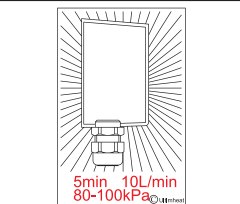
The first digit indicates the level of protection that the enclosure provides against access to hazardous parts (e.g., electrical conductors, moving parts) and the ingress of solid foreign objects.

The first digit of the IP marking is not required by EN 60335-1.

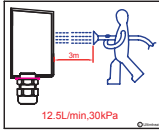
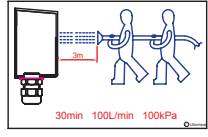
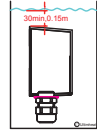
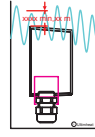
IP1X	IP2X	IP3X	IP4X	IP5X	IP6X
 Ø50mm	 Ø12.5mm	 Ø2.5mm	 Ø1mm		
First digit	Protection type		Effective		
0	No protection		No protection against contact and ingress of objects.		
1	Protected against solid particles >50 mm		Protected against any large surface of the body, such as the back of a hand, but no protection against deliberate contact with a smaller body part.		
2	Protected against solid particles >12.5 mm		Protected against fingers or similar objects		
3	Protected against solid particles >2.5 mm		Protected against tools, thick wires, etc.		
4	Protected against solid particles >1 mm		Protected against most wires, screws, etc.		
5	Dust protected		Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment. Completely protected against contact.		
6	Dust tight		Completely protected against ingress of dust. Completely protected against contact.		

### Second digit (Liquid ingress protection)

The second digit indicates the level of protection that the enclosure provides against harmful ingress of water.

IPX1	IPX2	IPX3	IPX4
			
 10mln 1mm/mln	 10mln 3mm/mln	 5min 0.7L/mir 80-100kPa	 5min 10L/min 80-100kPa
Second digit	Protection type	Effective protection	Test description
0	Not protected		
1	Dripping water	Dripping water (vertically falling drops) shall have no harmful effect.	-Water equivalent to 1 mm rainfall per minute. -Test duration: 10 minutes.
2	Dripping water when tilted up to 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle up to 15° from its normal position.	-Water equivalent to 3 mm rainfall per minute. -Test duration: 10 minutes.

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Second digit	Protection type	Effective protection	Test description
3	Spraying water	Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect.	-Water volume: 0.7 liters per minute -Pressure: 80–100 kPa -Test duration: 5 minutes
4	Splashing water	Water splashing against the enclosure from any direction shall have no harmful effect.	Water volume: 10 liters per minute - Pressure: 80–100 kPa - Test duration: 5 minutes
IPX5	IPX6	IPX7	IPX8
			
Second digit	Protection type	Effective protection	Test description
5	Water jets	Water projected by a 6.3 mm dia. nozzle against enclosure from any direction shall have no harmful effects.	- Water volume: 12.5 liters per minute - Pressure: 30 kPa - Distance: 3 m - Test duration: 3 minutes
6	Powerful water jets	Water projected in powerful jets (12.5 mm nozzle) against the enclosure from any direction shall have no harmful effects.	- Water volume: 100 liters per minute - Pressure: 100 kPa - Distance: 3 m - Test duration: 3 minutes
7	Immersion up to 1 m	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).	- Immersion to a depth of at least 1 m measured at bottom of device, <b>and at least 15 cm measured at top</b> of device. -Test duration: 30 minutes
8	Immersion beyond 1 m	The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a way that it produces no harmful effects.	Test duration: continuous immersion in water. Depth is specified by the manufacturer.

### First additional letter

Additional letters that can be appended to classify only the level of protection against access to hazardous parts by persons.

Letter	Protected against access to hazardous parts with
A	Back of hand
B	Fingers
C	Tools
D	Wires

### Second additional letter

D'autres lettres peuvent être ajoutées pour définir un niveau de protection supplémentaire de l'enveloppe

Letter	Meaning
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## Protection classes of electrical connection boxes

<b>H</b>	High voltage device
<b>M</b>	Device moving during water test
<b>S</b>	Device standing still during water test
<b>W</b>	Weather conditions

### IP69K (DIN 40050-9)

	<b>Description</b>
	<p>Specific ingress protection rating for high-pressure, high-temperature washing applications. Such enclosures must not only be dust tight (IP6X), but also able to withstand high-pressure and steam cleaning.</p>
	<b>Test description</b>
	<ul style="list-style-type: none"> <li>- Water volume: 14-16L liters per minute</li> <li>- Water temperature: 80°C</li> <li>- Pressure: 8-10 Mpa (80-100 bar)</li> <li>- Distance: 10 to 15cm from the tested device at angles of 0°, 30°, 60° and 90° for 30s each. The test device sits on a turntable that rotates once every 12s.</li> </ul>

### Examples of ingress protection ratings requested by standards and applications

An IP protection rating may be required by specific standards such as NF15100 (domestic electrical installation rules), EN60335-xx (design rules for electrical appliances) and machine-specific standards. Hereafter are the main specifications extracted from these standards.

Area	Minimal IP requirements	Electrical protection
<b>0</b>	<p>All electric heaters are prohibited. Other equipments: <u>Bathrooms:</u> IPX7 <u>Pools and similar:</u> IPX8</p>	SELV limited to 12V DC or 30V AC
<b>1</b>	<p>All electric heaters are prohibited. Other equipments: <u>Bathrooms:</u> IPX4, but IPX5 if this volume can be subjected to water jets for cleaning in public baths. <u>Pools and similar:</u> IPX5</p>	SELV limited to 12V DC or 30V AC
<b>2</b>	<p><u>Bathrooms:</u> IP24 mini heaters are authorized Other equipments: IPX3, but IPX5 if this volume can be subjected to water jets for cleaning in public baths. <u>Indoors Pools:</u> IP24 mini heaters authorized Other equipments: IPX2, but IPX5 if this volume can be subjected to water jets for cleaning. <u>Outdoors Pools:</u> IPX5</p>	<ul style="list-style-type: none"> <li>- Class 2 devices</li> <li>- Controls should not be accessible from the shower or bath.</li> <li>- Heaters must not be powered by a wall mounted socket.</li> <li>- Line must be protected by a 30 mA residual current circuit breaker.</li> </ul>
<b>3</b>	<p><u>Bathrooms:</u> IP21 mini heaters are authorized Other equipments: IPX1 <u>Pools:</u> Heaters authorized IP21 mini Other equipments: IPX1, but IPX5 if this volume can be subjected to water jets for cleaning. <u>Outdoors Pools:</u> IPX5</p>	<ul style="list-style-type: none"> <li>- Class 1 or Class 2 devices</li> <li>- Heaters must not be powered by a wall mounted socket.</li> <li>- Line must be protected by a 30 mA residual current circuit breaker.</li> </ul>

<b>Saunas</b>	Electrical equipment must have an IP 24 minimum protection rating
<b>Underfloor heating</b>	The heating elements intended to be embedded in a concrete or other similar material must be IPX7

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<b>Electrical devices that are permanently outdoor</b>	The degree of protection shall be at least IPX4.
<b>Residential, Offices, Schools</b>	Generally clean, dry and free from harmful deposits of dust, but some condensate may be present due to atmospheric conditions. Minimum protection is typically IP2X for dry conditions.
<b>Control rooms/ Sub-Stations</b>	Generally dry and free from harmful deposits of dust, but some condensate may be present due to atmospheric conditions. Where access is restricted to skilled or instructed persons, IP2X is the typical minimum requirement for dry conditions.
<b>Commercial, Light Industrial</b>	These premises may not be clean, but normally dry and free from harmful deposits of dust. Suitable minimum protection: -Where condensate is not present: IP2X -Where condensate may be present: IP21. -Equipment installed within range of fire sprinkler systems: IP22.
<b>Machine control equipment</b>	Where fluids may be present, e.g. lathes, millers etc., minimum protection typically requested is IP54. Consideration should also be given to the corrosive properties of certain fluids
<b>Heavy Industrial, Chemical.</b>	These environments are not usually totally clean, with possible presence of corrosive elements and harmful deposits of dust. Protection to IP54 will be typically required, with special consideration given to the corrosion resisting properties of the enclosure. When explosion risks exist, enclosures and equipment should meet the specifications of these environments.
<b>Food Processing</b>	Will vary depending on the type of food being processed and the possible requirement for washing down. Where fine powders are present, a minimum of IP53 should be used. This should be increased to IP54/65 if the equipment needs to be washed or hosed down. If the equipment should be washed with a jet of hot or cold water under high pressure, it is possible that the IP 65 rating is insufficient and that the IP69K is required.
<b>Dump trucks, cement mixers, food industry, car wash</b>	In these high-pressure, high-temperature wash-down applications, enclosures must not only be dust tight (IP6X), but also able to withstand high-pressure and steam cleaning. The recommended protection rating is IP69K (DIN40050-9).
<b>Weatherproof equipment</b>	If subjected to exposure to any specific weather condition, an agreement between the User and Manufacturer is necessary, with consideration given to specific testing conditions, including the corrosion resisting properties of the enclosure, fittings and cable glands.

### IK : Mechanical impact resistance (EN 62262)

This mechanical impact is identified by the energy needed to qualify a specified resistance level, which is measured in joules (J). Protection class impact resistance was eventually given previously by the third digit of the IP rating. It was dropped during the 3rd edition of IEC60529 (1978), and replaced by an independent marking specified by the EN62262 standard.

Although dropped from the 3rd edition of IEC 60529 onwards, and not present in the current EN versions, older enclosure specifications will sometimes be seen with an optional third IP digit denoting impact resistance. Newer enclosures must be coded with an IK rating. However there is not an exact correspondence of values between the old and new standards.

### Obsolete IP third number for mechanical impact resistance

IP third digit	Impact energy (Joules)	Equivalent drop mass and height
0	Unprotected	No test
1	0.225	150 g dropped from 15 cm
2	0.375	250 g dropped from 15 cm
3	0.5	250 g dropped from 20 cm
5	2	500 g dropped from 40 cm
7	6	1.5 kg dropped from 40 cm
9	20	5.0 kg dropped from 40 cm

### IK mechanical impact resistance values






IK number	Impact energy (Joules)	Equivalent drop mass and height
00	Unprotected	No test
01	0.15	200 g dropped from 7.5 cm
02	0.2	200 g dropped from 10 cm

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IK number	Impact energy (Joules)	Equivalent drop mass and height
03	0.35	200 g dropped from 17.5 cm
04	0.5	200 g dropped from 25 cm
05	0.7	200 g dropped from 35 cm
06	1	500 g dropped from 20 cm
07	2	500 g dropped from 40 cm
08	5	1.7 kg dropped from 29.5 cm
09	10	5 kg dropped from 20 cm
10	20	5 kg dropped from 40 cm

### Other classifications

NFC 15100 standard also refers to a «water drop» marking that household appliances and lightings can wear depending on their protection rating. This marking is different from the IP marking. Double marking, the water drops and the IP code, is not allowed because the tests are different.

Description	Protected against vertical water drops	Protected against rainfall	Protected against splashing water	Protected against water jets	Protected against immersion up to 1 m
IP equivalent	IPX1	IPX3	IPX4	IPX5	IPX7
Standard logo					

### NEMA (USA) rating equivalences with IP

The United States National Electrical Manufacturers Association (NEMA) also publishes protection ratings for enclosures similar to the IP rating system published by the International Electro-technical Commission (IEC). However, it also dictates other product features not addressed by IP codes, such as corrosion resistance, gasket aging, and construction practices. Thus, while it is possible to map IP Codes to NEMA ratings that satisfy or exceed the IP Code criteria, it is not possible to map NEMA ratings to IP codes, as the IP Code does not mandate the additional requirements. The below table indicates the minimum NEMA rating that satisfies a given IP code, but can only be used in that way, not to map IP to NEMA.

North American enclosure rating systems are defined in NEMA 250, UL 50, UL 508, and CSA C22.2 N°. 94.

Equivalent IP Code	Min. NEMA Enclosure rating to satisfy IP Code.
IP20	NEMA-1
IP54	NEMA-3
IP66	NEMA-4, NEMA-4X
IP67	NEMA-6
IP68	NEMA-6P