Degrees of protection for enclosures of electrical equipment

Standardizing NEMA and IP degrees of protection in one solution

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Degrees of protection provided by enclosures

Enclosures for electrical equipment can be found in countless applications and areas. In either case, they must be protected in such a way that the electrical equipment is not harmed and does not cause any harm as a result of the respective environmental and operating conditions throughout their service life. Two dominating standards exist worldwide for classifying the degrees of protection. This white paper shows the basic differences – and that compliance with both standards in one product is entirely possible. This gives rise to increasingly standardized solutions that can be used globally.

A White Paper from: Siemens.

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IP degrees of protection

What are IP degrees of protection for enclosures?

The IP degrees of protection are based on the requirements of the international standard IEC 60529 and indicate the suitability of electrical equipment with regard to use under various environmental conditions.

The IP degree of protection defines the protection against

- contact with live parts
- ingress of foreign objects
- ingress of water

inside of or into an enclosure. IP stands for "**I**nternational **P**rotection" (often also interpreted as "Ingress Protection").

The IP Code is expressed with one or two characteristic numerals and up to two optional letters.

Structure and meaning of the IP Code

The IP degree if protection is designated as follows:

IP XXXX

Each position stands for a defined protective function:

1st position: Protection against contact / ingress of foreign objects

2nd position: Protection against ingress of water

3rd position: Additional protection against contact (optional)

4th position: Supplementary information (optional)

If the characterization of one of the first two positions is not relevant, it can be replaced with an "X".

Example: IP 2X

The enclosure/component provides protection against access with a finger and protection against ingress of foreign objects with a diameter ≥ 12.5 mm (characteristic numeral "2" in the 1st position, see Table 1.)

The protection against ingress of water is not relevant in this case ("X" in the 2nd position).

The additional letter (3rd position) gives the degree of protection for persons against access to hazardous parts and is only used when:

- the actual protection against access to hazardous parts is higher than the protection indicated by the first characteristic numeral

or

- only the protection against access to hazardous parts is specified and the first characteristic numeral is replaced by an "X".

The supplementary letter can be indicated after the second characteristic numeral or the additional letter (3rd or 4th position). A precondition is compliance with the required safety and product standards.

Note on the second characteristic numeral (protection against ingress of water):

Up to and including characteristic numeral 6, the requirements of all lower characteristic numerals are also met. The same is not true for characteristic numerals 7, 8 and 9.

If an enclosure meets several requirements, this must also be indicated as appropriate.

Example: IP X6 / IP X8

The enclosure/component provides protection against powerful jetting (numeral 6) and protection against continuous and temporary immersion (numeral 8).

Overview of IP degrees of protection according to IEC 60529

Element	Numerals or letters	Meaning for the protection of equipment	Meaning for the protection of persons
Code letters	IP		
First characteristic numeral	0 1 2 3 4 5 6	Against ingress of solid foreign objects **(non-protected)** **≥ 50 mm diameter** **≥ 12.5 mm diameter** **≥ 2.5 mm diameter** **≥ 1.0 mm diameter** **dust-protected** **dust-tight**	Against access to hazardous parts with **(non-protected)** **back of hand** **finger** **tool** **wire** **wire** **wire**
Second characteristic numeral	0 1 2 3 4 5 6 7 8 9	Against ingress of water with harmful effects **(non-protected)** **vertically dripping** **dripping (15° tilted)** **spraying** **splashing** **jetting** **powerful jetting** **temporary immersion** **continuous immersion** **High pressure and temperature water jet**	–
Additional letter (optional)	A B C D	–	Against access to hazardous parts with: **back of hand** **finger** **tool** **wire**
Supplementary letter (optional)	H M S W	Supplementary information specific to: **High voltage apparatus** **Motion during water test** **Stationary during water test** **Weather conditions**	–

Table 1: Structure and meaning of the IP Code (source: IEC 60529).

NEMA Enclosure Types

What are NEMA Enclosure Types?

NEMA is a U.S. trade association that represents the interests of the electrotechnical industry and, among other things, is a publisher of numerous standards. NEMA stands for National Electrical Manufacturers Association.

NEMA Enclosure Types are defined in the standard "NEMA 250 – Enclosures for Electrical Equipment".

NEMA is not a testing organization that tests enclosures for compliance with the standard. This testing must be done in the U.S. by recognized test labs (NRTLs – Nationally Recognized Testing Laboratories) such as UL, CSA or TÜV Süd. The standard "UL 50E – Enclosures for Electrical Equipment, Environmental Considerations" is usually applied for this testing.

A NEMA 250 Enclosure Type Rating indicates numerous protective functions, such as:

- Protection against direct contact
- Suitability for use in indoor and outdoor installations
- Protection against ingress of water, dust, oil or coolants
- Protection against ice formation and falling dirt
- Protection against corrosion

This white paper is limited to the degrees of protection for non-hazardous locations. Degrees of protection for hazardous locations are not covered.

Enclosure Type Ratings relevant for indoor locations are 1, 2, 4, 4X, 5, 6, 6P, 12, 12K and 13.

Enclosure Type Ratings relevant for outdoor locations are 3, 3R, 3S, 3X, 3RX, 4, 4X, 6 and 6P. See Table 2.

Overview of NEMA Enclosure Types according to NEMA 250/UL 50E

Provides a Degree of Protection Against the Following Environmental Conditions	For Outdoor Use									
	Enclosure Type Number									
	3	3R	3S	3X	3RX	3SX	4	4x	6	6P
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Rain, snow, and sleet	X	X	X	X	X	X	X	X	X	X
Sleet*	–	–	X	–	–	X	–	–	–	–
Windblown dust	X	–	X	X	–	X	X	X	X	X
Hosedown	–	–	–	–	–	–	X	X	X	X
Corrosive agents	–	–	–	X	X	X	–	X	–	X
Temporary submersion	–	–	–	–	–	–	–	–	X	X
Prolonged submersion	–	–	–	–	–	–	–	–	–	X
Provides a Degree of Protection Against the Following Environmental Conditions	**For Indoor Use**									
	Enclosure Type Number									
	1	**2**	**4**	**4X**	**5**	**6**	**6P**	**12**	**12K**	**13**
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X	X	X	X
Falling liquids and light splashing	–	X	X	X	X	X	X	X	X	X
Circulating dust, lint, fibers, and flyings	–	–	X	X	–	X	X	X	X	X
Settling airborne dust, lint, fibers, and flyings	–	–	X	X	X	X	X	X	X	X
Hosedown and splashing water	–	–	X	X	–	X	X	–	–	–
Oil and coolant seepage	–	–	–	–	–	–	–	X	X	X
Oil or coolant spraying and splashing	–	–	–	–	–	–	–	–	–	X
Corrosive agents	–	–	–	X	–	–	X	–	–	–
Temporary submersion	–	–	–	–	–	X	X	–	–	–
Prolonged submersion	–	–	–	–	–	–	X	–	–	–

*Mechanism shall be operable when ice covered.

Table 2: Overview of NEMA Enclosure Types and the associated degrees of protection (source: NEC Table 110.28).

Enclosure Types for individual requirements and tasks

From the overview of the Enclosure Types and degrees of protection, it is apparent that a higher number and degree of protection does not necessarily include the lower numbers and their protection properties. Rather, the majority of degrees of protection are assigned individual protective functions.

It holds true here that the degree of protection in "Column 1" can only be maintained if the openings in the enclosure are closed with appropriately designed components from "Column 2".

Example:

Enclosure type (Column 1)	Openings are able to be closed by equipment marked (Column 2)
2[a]	2, 3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 5, 6, 6P, 12, 12K, 13, "Wet Location", or "Raintight"
3	3, 3S, 3SX, 3X, 4, 4X, 6, 6P
3R[b]	3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 6, 6P, "Wet Location", or "Raintight"
3RX	3RX, 3SX, 3X, 4X
3S[c]	3, 3S, 3SX, 3X, 4, 4X, 6, 6P
3SX[C]	3SX, 3X, 4X
3X	3SX, 3X, 4X
4	4, 4X, 6, 6P
4X	4X, 6P
5	3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 5, 6, 6P, 12, 12K, 13, "Wet Location", or "Raintight"
6	6, 6P
6P	6P
12, 12K	12, 12K, 13
13	13

[a] Type 1 components, ventilation openings, or observation windows are able to be installed when their profile outside the enclosure is completely protected by the drip shield from water dripping vertically downward from above.
[b] Components marked "Weatherproof" or "Rainproof" are able to be installed below all other live parts within the enclosure.
[c] Components with external operating mechanisms shall be Type 3S or 3SX for use on a Type 3S enclosure, or Type 3SX for use on a Type 3SX enclosure.

Table 3: Cross-references for closing of openings in enclosures (source: UL 508A – Table 19.2).

This fact means that certain cross-references must be observed when installing devices in openings of an enclosure. An overview of this is provided in the standard "UL 508A – Industrial Control Panels" (see Table 3).

If openings are made in an enclosure with NEMA Enclosure Type **4**, only components that themselves conform to NEMA Enclosure Type **4, 4X, 6 or 6P** may be mounted in these openings. Otherwise, the original NEMA Enclosure Type **4** no longer applies to the enclosure.

If compliance with the specifications in Table 3 is not possible because a component has a different degree of protection than indicated in "Column 2", this results in a different degree of protection for the enclosure as a whole. This is shown in Table 4 below.

Example:

If components with NEMA Enclosure Type **3 or 3S** were to be installed in the door or on the wall of the control panel with NEMA Enclosure Type **4**, this **reduces** the degree of protection of the entire control panel to NEMA Enclosure Type **3**.

Note:

If components are mounted in a tested control panel enclosure and the combination of the NEMA Enclosure Types is not contained in both tables, the entire NEMA Enclosure Type is reduced to **1**.

Enclosure type (including components and fittings that comply with Tables 19.1/19.2) (Column 1)	Component/fittings ratings that do not comply with Tables 19.1/19.2 (Column 2)	Resulting enclosure rating (Column 3)
3, 3RX, 3S, 3SX, 3X, 4, 4X, 6, 6P	3R, "Wet Location", "Raintight", "Weatherproof"[c], "Rainproof"[c]	3R[a, b, c]
4X	3RX, 3SX, 3X	3RX[a, b]
4X	3, 3S	3[b]
4X	3X, 3SX	3X[b]
6, 6P	4, 4X	4
6P	6	6
13	12, 12K	12
12, 12K, 13	3, 3S, 4, 4X, 5, 6, 6P, "Wet Location", "Raintight"	5[b]

[a] When a drain is added.
[b] When provision is made for locking the door (such as loop for padlock, key-locking type handle or latch) or tools are required to open the enclosure.
[c] Components marked "Weatherproof" or "Rainproof" shall be installed below all other live parts within the enclosure.
Openings for conduit or conduit fittings shall comply with note a, b, or c in Table 19.1 for type 3R enclosures.

Table 4: Resulting overall classification for installations with different NEMA Enclosure Types (source: UL 508A – Table 19.3).

IP degrees of protection vs. NEMA Enclosure Types

Are the two protection standards comparable?

The overviews of the two most common protection standards clearly show that IP degrees of protection and NEMA Enclosure Types differ essentially in structure, classification, protective functions and use.

The reason for this is that the test criteria of the two test standards are different. Generally speaking, the requirements of NEMA 250 for Enclosure Types are wider ranging than those of IEC 60529 for IP degrees of protection. Some of the test criteria and protective functions of NEMA 250 are not included at all in IEC 60529.

A comparison of the protection standards is nevertheless possible at any time (see overview below).

A conversion or recoding of IP degrees of protection to NEMA Enclosure Types, and vice versa, is not possible, however.

Table 5: Assignment of IP degrees of protection to NEMA Enclosure Types (source: NFPA 79 – Standard for Industrial Machinery, Table F.5.5).

A														B
	NEMA Enclosure Type													
IP First Character	**1**	**2**	**3**	**3R**	**3S**	**4**	**4X**	**5**	**6**	**6P**	**12**	**12K**	**13**	**IP Second Character**
IP0_	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	IP0_
IP1_	A	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	IP1_
IP2_		B	AB	B	AB	AB	AB	AB	AB	AB	AB	AB	AB	IP2_
IP3_			AB	B	AB	AB	AB	AB	AB	AB	AB	AB	AB	IP3_
IP4_			AB	B	AB	AB	AB	AB	AB	AB	AB	AB	AB	IP4_
IP5_			AB		AB	AB	AB	A	AB	AB	A	A	A	IP5_
IP6_			A		A	AB	AB		AB	AB				IP6_
									B	B				IP7_
										B				IP8_

A: The first IP character designation is the protection against access to hazardous parts and ingress of solid foreign objects. The respective NEMA Enclosure Type meets the requirements for the IEC 60529 IP first character designation.
B: The IP second character designation is the protection against ingress of water. The respective NEMA Enclosure Type meets the requirements for the IEC 60529 IP second character designation.

Notes:
(1) Type-rated enclosures for hazardous locations and potentially explosive areas have been excluded from the table. The additional and supplementary letters for IP ratings have also been excluded from the table. (See NEMA 250, UL 508, and IEC 60529.)
(2) This table should be used only to assign an IP rating to a type-rated enclosure, and not to assign a type rating to an IP-rated enclosure. This table assists in specifying enclosure ratings and should not be used as a definitive guide. For example, if the conditions of installation require IP 55 degree of protection, this table indicates that a Type 3, 3S, 4, 4X, 6, or 6P enclosure can be utilized. However, if the conditions of installation require a NEMA Type 4 enclosure, an enclosure that is only IP-rated cannot be used as a substitute.
(3) Although the corresponding NEMA type ratings meet or exceed the corresponding IP ratings as indicated in the table, IEC does not currently accept these type ratings without further IEC testing.

Implementing and standardizing IP degree of protection and NEMA Enclosure Type in one

In many areas of machine and plant construction, it is necessary to achieve as high a degree of standardization as possible in order to reduce the number of variants and, thus, overall costs.

This is especially true for machines and plants designed for worldwide export. For enclosures to also meet this necessity in terms of their degree of protection, it is recommended that the different technical requirements be considered when installing components.

A classification purely according to IEC 60529 (IP degree of protection), no matter how encompassing, can lead to a recognition not being granted on the North American market. The same holds true in the reverse case. A classification purely according to NEMA 250 (Enclosure Type) is not yet accepted by the IEC without additional testing – even though the NEMA classification fulfills, or even in some cases surpasses, the classification of the corresponding IP Code.

When designing and equipping enclosures for electrotechnical components that are intended for worldwide use, both the IP degrees of protection and the NEMA Enclosure Types should therefore be taken into account.

The SIRIUS ACT pushbuttons and indicator lights from Siemens put machine and plant builders on the safe side in this regard.

IP degrees of protection and NEMA Enclosure Types for command and signaling devices

SIRIUS ACT pushbuttons and indicator lights from Siemens

Pushbuttons and indicator lights of the SIRIUS ACT portfolio are designed for a host of applications in different industries and can be used around the world with their wide-ranging certifications. The portfolio, which encompasses four product lines, combines:

- a modern design
- comprehensive communication capabilities via AS-i and Profinet
- easy handling, which also allows mounting with one hand

as well as

- a high degree of ruggedness and reliability in use – versions with IP degree of protection IP69K and NEMA Enclosure Types 1, 2, 3, 3R, 4, 4X, 12, 13 for the North American market.

Overview of IP degrees of protection and NEMA Enclosure Type Ratings for the SIRIUS ACT pushbuttons and indicator lights portfolio

Protection standard	Standard	Codes / Ratings
IP degree of protection	IEC 60529	IP66, IP67, IP69 (IP69K)
NEMA Enclosure Type Rating	NEMA 250/UL 50	1, 2, 3, 3R, 4, 4X, 12, 13

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