Enclosure Standards and Protection Concepts

NEMA Enclosure Standards

NEMA (National Electrical Manufacturers' Association) has established standards for enclosures to provide protection from environmental contamination. A description of the more common standards is listed below. Type definitions are from NEMA 250-1997. For more detailed and complete information, NEMA Standards Publication 250-1997, *"Enclosures for Electrical Equipment (1000 Volts Maximum)"* should be consulted. This Standards Publication, as well as all other NEMA publications, is available from IHS at 1-800-854-7179.

Standards for Non-Hazardous Locations

Type 1: Enclosures constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection against falling dirt.

Type 2: Enclosures constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment, to provide a degree of protection against falling dirt, and to provide a degree of protection against dripping and light splashing of liquids.

Type 3: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, and windblown dust; and that will be undamaged by the external formation of ice on the enclosure.

Type 3R: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, and snow; and that will be undamaged by the external formation of ice on the enclosure.

Type 3S: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, and windblown dust; and in which the external mechanism(s) remain operable when ice laden.

Type 4: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water; and that will be undamaged by the external formation of ice on the enclosure.

Type 4X: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, hose-directed water, and corrosion; and that will be undamaged by the external formation of ice on the enclosure

Type 5: Enclosures constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against settling airborne dust, lint, fibers, and flyings; and to provide a degree of protection against dripping and light splashing of liquids.

Type 6: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against hose-directed water and the entry of water during occasional temporary submersion at a limited depth; and that will be undamaged by the external formation of ice on the enclosure.

Type 6P: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against hose-directed water and the entry of water during prolonged submersion at a limited depth; and that will be undamaged by the external formation of ice on the enclosure.

Type 12: Enclosures constructed (without knockouts) for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against circulating dust, lint, fibers, and flyings; and against dripping and light splashing of liquids.

Type 12K: Enclosures constructed (with knockouts) for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against circulating dust, lint, fibers, and flyings; and against dripping and light splashing of liquids.

Type 13: Enclosures constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt; against circulating dust, lint, fibers, and flyings; and against the spraying, splashing, and seepage of water, oil, and non-corrosive coolants.

Standards for Hazardous Locations (replaced by NEC/CEC Hazardous Area Codes)

Type 7: Enclosures constructed for indoor use in hazardous locations classified as Class I, Division 1, Groups A, B, C, or D as defined in NFPA 70.

Type 8: Enclosures constructed for either indoor or outdoor use in hazardous locations classified as Class I, Division 1, Groups A, B, C, and D as defined in NFPA 70.

Type 9: Enclosures constructed for indoor use in hazardous locations classified as Class II, Division 1, Groups E, F, or G as defined in NFPA 70.

Type 10: Enclosures constructed to meet the requirements of the Mine Safety and Health Administration, 30 CFR, Part 18.

Comparison of Specific Applications of Enclosures for Outdoor Nonhazardous Locations							
	Type of Enclosure						
Provides a degree of protection against the following environmental conditions	3	3R*	3S	4	4X	6	6P
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X
Rain, snow, and sleet**	X	X	X	X	X	X	X
Sleet ***	...	...	X	...	...	...	...
Windblown dust, lint, fibers, and flyings	X	...	X	X	X	X	X
Hosedown	...	...	...	X	X	X	X
Corrosive agents	...	...	...	...	X	...	X
Occasional temporary submersion	...	...	...	...	...	X	X
Occasional prolonged submersion	...	...	...	...	...	...	X

* *These enclosures may be ventilated.*
** *External operating mechanisms are not required to be operable when the enclosure is ice covered.*
*** *External operating mechanisms are operable when the enclosure is ice covered.*

IEC Enclosure Standards

The International Electrotechnical Commission has established enclosure standards for protection from environmental contamination as shown below. These standards are used widely in Europe, the Middle East, Africa and parts of Asia.

Example: IP 6 7

Ingress Protection

Protection Against Solid Bodies

Protection Against Liquids

Protection Against Solid Bodies

0: no special protection
1: protected against solid objects greater than of 50mm ø
2: protected against solid objects greater than 12mm ø
3: protected against solid objects greater than 2.5mm ø
4: protected against solid objects greater than 1mm ø
5: dust protected
6: dust-tight

Protection Against Liquids

0: no special protection
1: protected against vertical falling water drops
2: protected against vertical falling water drops when enclosure is tilted at 15°
3: protected against sprayed water
4: protected against splashing water
5: protected against water jets
6: protected against heavy seas
7: protected from the effects of temporary immersion
8: protected from the effects of continuous immersion

Hazardous Area Descriptions

National Electrical Code (NEC) 500

Traditional standards used in North America.

Example: Class I, Div 1, Group B, C, D, T4

- Permitted Class
- Permitted Division
- Permitted Group
- Temperature Class

Permitted Class

Class I: Gas Vapors
Class II: Dusts
Class III: Fibers

Permitted Division

Division 1: Gasses or vapors exist under normal conditions

Division 2: Gasses or vapors are present but are normally contained and can escape only through accident or abnormal operation

Permitted Group

Group A: Acetylene

Group B: Hydrogen or Equivalents

Group C: Ethyl Ether, Ethylene or Cylclopropane

Group D: Gasoline, hexane, naphtha, benzene, butane, propane, alcohol, acetone, benzol, lacquer, and natural gas

Group E: Metal Dust

Group F: Carbon Black

Group G: Flour, starch, grain dusts

Temperature Class*

T1: 450°C (842°F)
T2: 300°C (572°F)
T3: 200°C (392°F)
T4: 135°C (275°F)
T5: 100°C (212°F)
T6: 85°C (185°F)

** Device may be exposed to gases whose ignition temperature is higher than this value.*

National Electrical Code (NEC) 505

North American Standards developed to harmonize with IEC standards.

Example: Class I, Zone 1, AEx d [ia] IIC T4

- Permitted Class
- Permitted Zone
- Method of Protection
- Intrinsically Safe Output
- Gas Group
- Temperature Class

Permitted Class

Class I: Gas Vapors
Class II: Dusts
Class III: Fibers

Permitted Zone

Zone 0: Gas present continuously

Zone 1: Gas present intermittently

Zone 2: Gas present under abnormal operation

Protection Method

e: Increased Safety: no arcs sparks or hot surfaces

d*: Flame proof: contain explosion and quench flame

m: Encapsulation, Zone 1: keep flammable gas out

nA: Nonsparking equipment

nC: Sparking equipment in which the contacts are suitably protected other than by restricted breathing enclosure

nR: Restricted breathing

***[ia]:** Intrinsically safe, Zone 0, 1, and 2

***[ib]:** Intrinsically safe, Zone 1 and 2

Gas Group

IIC: Acetylene

IIB + H2: Hydrogen or equivalents

IIB: Ethyl Ether, Ethylene or Cylclopropane

IIA: Gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer, and natural gas

Temperature Class*

T1: 450°C (842°F)
T2: 300°C (572°F)
T3: 200°C (392°F)
T4: 135°C (275°F)
T5: 100°C (212°F)
T6: 85°C (185°F)

** Device may be exposed to gases whose ignition temperature is higher than this value.*

IEC & EU (European) Standards

The IEC (International Electrotechnical Commission) markings are as follows:

Example: EEx d IIB T3

- EEx — European Standard Explosion Protection
- d — Type of Protection
- IIB — Gas Group Classification
- T3 — Temperature Classification

Type of Protection

- **d:** flameproof enclosure - contain explosion and quench flame
- **p:** pressurized enclosure - fill with inert gas
- **ia:** intrinsically safe for Zone 0 - limit energy
- **ib:** Intrinsically safe for Zone 1 - limit energy
- **o:** oil immersion
- **s:** special protection
- **e:** increased safety - no arcing, sparking or hot surfaces
- **m:** encapsulation - sealed arcing devices or non-arcing
- **q:** sand-filled
- **nL:** nonincendive - limited energy
- **nA:** nonincendive - non sparking
- **me:** encapsulation/increased safety

Gas Group Classification

- **IIC:** Acetylene and hydrogen
- **IIB:** Diethel ether, ethylene, cyclopropane and others
- **IIA:** Gasoline, hexane, butane, naphtha propane, isoprene and many others

Temperature Classification*

- **T1:** 450°C (842°F)
- **T2:** 300°C (572°F)
- **T3:** 200°C (392°F)
- **T4:** 135°C (275°F)
- **T5:** 100°C (212°F)
- **T6:** 85°C (185°F)

* *Device may be exposed to gases whose ignition temperature is higher than this value.*

ATEX Marking (94/9/EC)*

European requirements centered around the safety of hazardous area equipment that became mandatory on July, 1 2003. All equipment exported into European member countries must meet the ATEX hazardous and essential health and safety requirements for acceptance.

Example:  II 1 G

- — European Community Explosion Protection Symbol
- II — Equipment Group
- 1 — Category
- G — Explosive Atmosphere

Equipment Group

- **I:** Mines
- **II:** Other than mines

Category

- **1:** Zone 0
- **2:** Zone 1
- **3:** Zone 2

Explosive Atmosphere

- **G:** Gases/Vapors
- **D:** Dusts

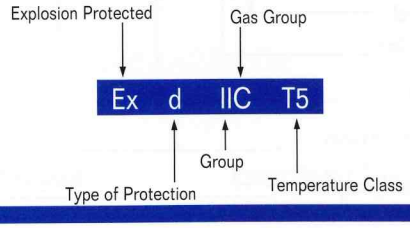
The ATEX markings are in addition to the standard Zone markings and indicate compliance to the new directives.

Expert Guide to Hazardous Locations

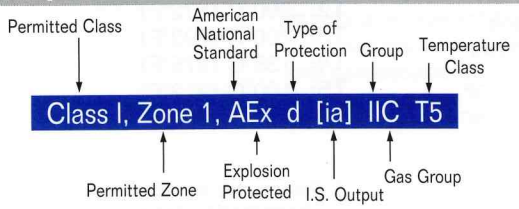
FM Approvals — An FM Global Enterprise

Ex Marking

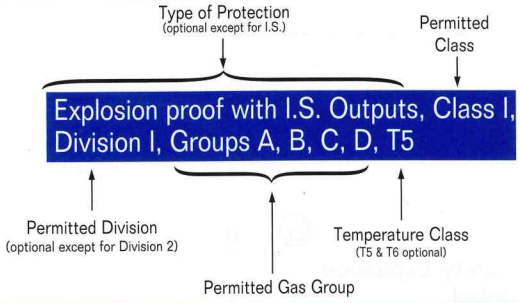
IEC



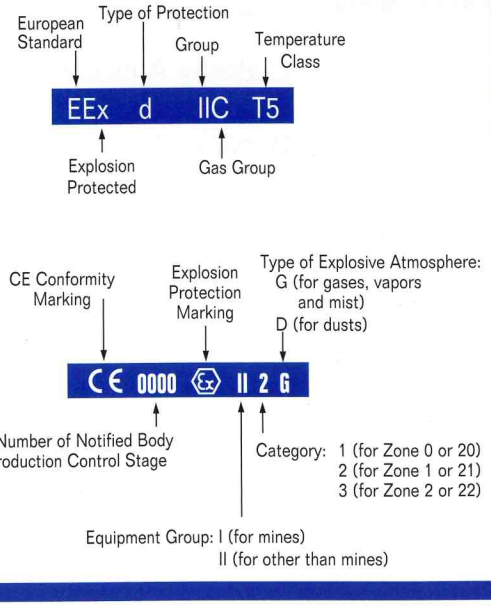
US (NEC® 505)



US (NEC® 500)



EU (Directive 94/9/EC) - ATEX (from July1, 2003)



Acronyms

CENELEC - European Committee for Electrotechnical Standardization
EU - European Union
IEC - International Electrotechnical Commission
I.S. - Intrinsically Safe
MSHA - Mine Safety and Health Administration
NEC® - National Electric Code®

Area Classification

	Flammable Material Present Continuously	Flammable Material Present Intermittently	Flammable Material Present Abnormally
IEC/EU	Zone 0 (Zone 20 - dust)	Zone1 (Zone 21 - dust)	Zone 2 (Zone 22 - dust)
US NEC® 505	Zone 0	Zone1	Zone 2
NEC® 500	Division 1		Division 2

IEC classification per IEC 60079-10.
EU classification per EN 60 079-10.
US classification per ANSI/NFPA 70 National Electric Code® (NEC®) Article 500 or Article 505

Apparatus Grouping

Typical Gas/Dust/Fiber	US (NEC® 505) IEC EU	US (NEC® 505)
Acetylene	Group IIC	Class I/Group A
Hydrogen	(Group IIB + H	Class I/Group B
Ethylene	Group IIB	Class I/Group C
Propane	Group IIA	Class I/Group D
Methane	Group I*	Mining*
Metal Dust	None	Class II/Group E
Coal Dust	None	Class II/Group F
Grain Dust	None	Class II/Group G
Fibers	None	Class III

**Not within scope of NEC®. Under jurisdiction of MSHA.*

Temperature Class

Maximum Surface Temperature	US (NEC® 505) IEC EU	US (NEC® 505)
450° C	T1	T1
300° C	T2	T2
280° C		T2A
260° C		T2B
230° C		T2C
215° C		T2D
200° C	T3	T3
180° C		T3A
165° C		T3B
160° C		T3C
135° C	T4	T4
120° C		T4A
100° C	T5	T5
85° C	T6	T6