HAZARDOUS (CLASSIFIED) LOCATIONS

Hazardous locations are those locations where the risk of a fire or explosion may exist due to the presence of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings.

In reality, flammable gases and vapours and combustible dusts exist almost everywhere. Fortunately they are usually present in quantities far less than what is required for a fire or explosion hazard to occur. Therefore the fact that flammable gases, vapours, or combustible dust may be present of a does not define a hazardous location; materials must be present in sufficient quantities or concentrations that pose a risk that an explosion could occur.

The National Electrical Code (NEC®) defines the "Classified Locations as follows: "Locations shall be classified depending on the properties of the flammable gas, flammable liquid–produced vapor, combustible liquid–produced vapors, combustible dusts, or fibers/flyings that may be present, and the likelihood that a flammable or combustible concentration or quantity is present. Each room, section, or area shall be considered individually in determining its classification. Where pyrophoric materials are the only materials used or handled, these locations are outside the scope of this article."

The NEC does not classify locations where there is an explosion hazard due to the presence of high explosives, such as dynamite, TNT, Ammonium Nitrate/Fuel Oil (ANFO) mixtures, blasting caps, propellants, ammunition, firework, etc. as hazardous locations. There are other standards and Federal regulations covering the handling and use of such materials. Some of these standards require the use of electrical equipment suitable for use in hazardous locations as defined in the NEC as it provides a greater degree of safety than general-purpose equipment; not because it was tested for use in the presence of high explosives. In a similar manner, areas containing or manufacturing pyrophoric materials, such as some phosphorous compounds are not within the scope of the NEC.

UNDERSTANDING HAZARDOUS LOCATIONS

The evolution of hazardous location electrical codes and standards throughout the world has taken two distinct paths. In North America, the "Class, Division" System has been used since the 1930s as the basis for area classification of hazardous (classified) locations. Since the hazards, and the methods of protecting against the those hazards, differ for various materials, the NEC® separates hazardous locations into "Classes" based on the nature of the material or product, i.e. gas or vapor, dusts, or fibers. Each Class is then further divided into "divisions" or "Zones" based on the material being present in sufficient quantities for an explosion to occur. While Canada and the United States have some differences in acceptable wiring methods and product standards, their systems are quite similar.

In other parts of the world, explosive atmospheres are dealt with using the "Zone System" based on the International Electrotechnical Commission (IEC®) standards.

While specific requirements differ, both the United States and Canada have incorporated the IEC Zone System of Area Classification into their electrical codes. The NEC permits the use of either the Class/Division System or the Class/Zone System.

In the United States, NEC Articles 500 through 517 deal with Hazardous (Classified) Locations. NEC Article 500 provides general rules and permits the use of either the Division System or Zone System.

In Canada, the Canadian Electrical Code (CEC) mandates the use of the Zone system for all new construction. It does allow existing facilities, classified using the Division System, to continue using the Class/Division System. In 2015, the CEC removed the term "Class" from the main body of the Code. The rules dealing with the Division System are contained in Annex J18 and J20 of the CEC.

Both systems provide effective solutions for electrical equipment used in hazardous locations and both have excellent safety records.

The Zone System (in the NEC, CEC and IEC) defines hazardous materials as follows:

- **Explosive Atmospheres** — mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, dust, fibers, or flyings which, after ignition, permits self-sustaining propagation
- **Explosive Gas Atmospheres** — a mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapor, or mist in which, after ignition, combustion spreads throughout the unconsumed mixture
- **Explosive Dust Atmosphere** — mixture with air, under atmospheric conditions, of flammable substances in the form of dust, fibers, or flyings which, after ignition, permits self-sustaining propagation

In the Division System, Hazardous (Classified) Locations are divided into three Classes based on the explosive characteristics of the material. The Classes of material are further divided into "Divisions" or "Zones" based on the probability that the material will be present in sufficient quantities for an explosion could occur. The Zone system has three levels of hazard whereas the Division system has two levels.

The table below provides a comparison between the "Class/Division" System and the "Zone" System.

EXPLOSIVE ATMOSPHERE	DIVISION SYSTEM	ZONE SYSTEM
Gases and Vapors①	Class I	Explosive Gas Atmospheres, Zones 0, 1 and 2
Combustible Dusts	Class II	Explosive Dust Atmospheres, Zones 20, 21 and 22
Easily Ignited Fibers & Flyings	Class III	

①The United States and Canada have incorporated the Zone System of Area Classification for all explosive atmospheres into their Electrical Codes

CLASS I LOCATIONS

Class I locations are those in which flammable gases vapors or mists are, or may be, present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Explosive Gas Atmospheres are defined as those in which flammable gases or vapors are, or may be, present in the air in quantities sufficient to produce explosive gas atmosphere. The use of the two similar terms, 'gas' and 'vapor' is intended to differentiate between a gas as being in the gaseous state such as hydrogen or methane, and a vapor that flashes off (rises) from a liquid such as gasoline under normal atmospheric conditions.

General

The subdivision of Class I, locations into Zones or Divisions is based on the probability of an explosive material being present in sufficient quantities for an explosion to occur. If the risk is extremely low, the location may be considered non-hazardous location. A good example of a low risk area is a family residence that uses natural gas or propane furnace for heating or cooking. The gas could, and on extremely rare occasions does, leak into the home and encounter an ignition source which can result in an explosion, often with devastating consequences. However, since the risk is so low, because of the safety systems built into the gas supply and equipment, these areas are not classified as "hazardous locations". If the risk is higher, the area would need to be classified based on the probability that an explosion could occur. Area Classification is essentially a risk assessment that identifies potential sources of release for flammable materials, the nature of those materials and other factors such as ventilation and assigns a level of risk based on the Division or Zone System.

For Explosive Gas Atmospheres, NEC Article 501 contains the Rules for the Class/Division System and Article 505 contains the Rules for the Class/Zone System

Unclassified Locations

According to the American Petroleum Institute (API), there are locations that contain explosive gases or vapors that are not necessarily classified. This would include all-welded closed piping systems or continuous metallic tubing without valves without valves, flanges and containers or vessels used for storage or transport of materials that are Department of Transport (DOT) approved for that purpose.

CLASS I LOCATIONS DIVISION CLASSIFICATION

Class I, Division 1

Class I, Division 1 locations are defined as those in which hazardous concentrations of flammable gases or vapours exist continuously, intermittently, or periodically under normal operating conditions. This is a very broad definition since there is no times associated with intermittently or periodically which are open to many interpretations.

Division 1 also includes area that may exist frequently because of repair or maintenance operation or because of leakage and locations where breakdown or faulty operation of electrical equipment or processes might release ignitable concentrations of flammable gases or vapors, and may also cause simultaneous failure of electrical equipment.

An example of such a location might be an area where a flammable liquid is stored under cryogenic conditions. A leak of the extremely low temperature liquid directly onto electrical equipment could cause failure of the electrical equipment at the same time the vapors of the evaporating liquid could be within the flammable range.

Class I, Division 2

Class I Division 2 areas are defined in the code as; "areas where flammable volatile liquids, flammable gases, or vapors are, processed, handled or used, but in which the liquids, gases, or are normally confined within closed containers or closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or systems or the abnormal operation of the equipment". Or, where hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation, but which may become hazardous as the result of failure or abnormal operation of the ventilating equipment."

Division 2 locations also exist around Division 1 locations where there is no barrier or partition to separate the Division 1 space from a non-hazardous location, or where ventilation failure (an abnormal condition) might extend the area where flammable material is present under normal conditions.

The abnormal conditions of occurrence, or lower risk areas, Division 2 and Zone 2 are basically identical in the Zone and Division system. However, in areas where a hazard is expected to occur during normal operation, Division 1 and Zone 1 and 0, the Zone system deals with highest risk areas Zone 0 separately, and risk associated with the remaining location Zone 1, is considered lower. The Division system tends to be less specific in its consideration of Division 1. The Division system treats all areas where a hazard is expected to occur in normal operation the same.

CLASS I LOCATIONS ZONE CLASSIFICATION

Class I, Zone 0

These are locations in which ignitable concentrations of flammable gases or vapors are present continuously or for long periods of time. Zone 0 represents the most dangerous part of the Division 1 classification.

There are situations where flammable liquids are stored in tanks and the vapor space above the liquid is above the upper flammable limit. If the vapor space is above the upper flammable limit most of the time, the space is not a Zone 0 location because the requirements are for "ignitable concentrations" of flammable gases or vapors (concentrations within the flammable range).

Class I, Zone 1

These locations are very similar to Class I, Division 1 locations except they do not include those locations defined as Class I, Zone 0, where ignitable concentrations are present all or most of the time.

Class I, Zone 2

These locations are effectively the same as Class I, Division 2 locations.

CLASS I LOCATIONS COMPARING THE DIVISION & ZONE SYSTEMS

Unlike the Division System, the Zone System includes guidelines based on hours per year as one of the criteria that determines an area classification. These are by no means intended as absolute numbers.

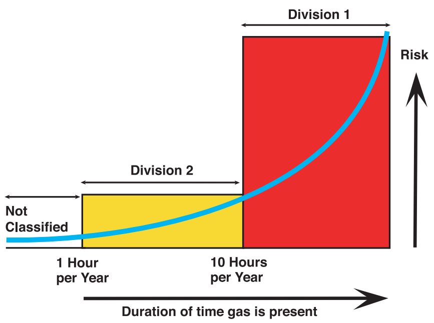
For example, an area which may be in the explosive range in excess of 1000 hours per year should be identified as Zone 0. However, that does not suggest an area that is in the explosive range 999 hours per year, or even 900 hours per year, should automatically become Zone 1. Similarly, if the probability of a gas release in a building was extremely low, it would likely be identified as Zone 2. However if this was a remote, unmanned building, it could take more than ten hours to reach which could put it above the hours per year suggested for Zone 2 locations. In all cases, common sense and sound engineering judgement should be used.

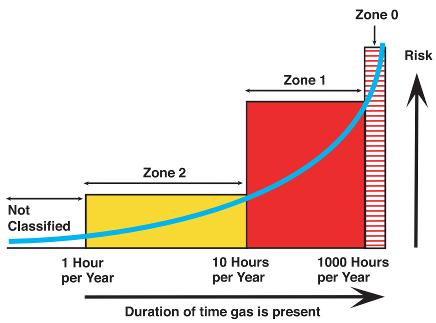
GRADE OF RELEASE	ZONE	FLAMMABLE MIXTURE PRESENT
Continuous	0	1000 hours per year or more (10%)
Primary	1	Between 10 and 1000 hours per year or more (0.1% to 10%)
Secondary	2	Less than 10 hours per year (0.01% to 0.1%)
Unclassified		Less than 1 hour per year (Less than 0.01%)*

This is a combination of Tables 2 and 3 from API RP505

**Some controversy surround the 1 hour per year figure. The IEC does not define hours per year.*

The illustrations below compare the similarities and differences between the Division System and the Zone System. It is accepted that the higher the concentration of explosive atmospheres or greater the time it is present, the higher the risk.





The key difference between the two systems is that the Zone system looks at the highest level of risk (in excess of 1000 hours per year) and identifies it “Zone 0”, with the remainder being defined as “Zone 1”. The Division System identifies the higher risk areas as Division 1 which basically is the combination of Zones 0 and 1. The criteria used to identify the lower risk areas of Zone 2 and Division 2 is virtually identical.

The Table below provides a comparative view of the relationship between Divisions and ZonesThe chart below compares the Class/Division locations to Class/Zone Locations

CLASS I	DIVISION SYSTEM	ZONE SYSTEM	NOTES:
Gases and Vapors	Division 1	Zone 0	Zone 0 locations are a typically less than 1% of hazardous locations in a facility.
		Zone 1	Class I, Division 1 locations encompass both Zones 0 and 1. While the wiring practices and acceptable products differ, Zone 1 represents most of Division 1.
	Division 2	Zone 2	Zone 2 and Division 2 are essentially the same

CLASS I LOCATIONS GAS GROUPS

In terms of physical properties, most gases and vapors are unique. The combinations of how each reacts in air, when they change from a liquid to a gas or what causes them to ignite are infinite. These properties that include ignition temperature, flash point, flammable limits, and minimum ignition energy are explained later in this chapter.

While the area classification of a facility is based on the specific type of material present, electrical equipment can be tested and approved for use in multiple explosive gas atmospheres. Gases or vapors are categorized by two key factors they have in common; how much energy is required to ignite them, and how that explosion moves though the air. Without gas groups, the certification of electrical equipment would be extremely difficult and the cost would be prohibitive.

This allows multiple gasses and vapors to be “grouped” together based on their “Minimum Igniting Current (MIC) Ratio” and the “maximum experimental safe gap (MESG)” between surfaces that will allow an explosion to propagate from a contained atmosphere, such as an enclosure, to an outer atmosphere. These are measured based on the “most easily ignited” or “stoichiometric” gas-air mixture ratio. The ignition energy required increases as the percent air/mixture ratio deviates from the stoichiometric ratio.

Minimum Ignition Current is the smallest amount of current flowing in a circuit that will cause a spark when the current flow is interrupted which cause an explosion in a fuel oxygen mixture. Minimum ignition current can come from multiple sources which include; discharge of a capacitive circuit, interruption of an inductive circuit, intermittent making and breaking of a resistive circuit, or hot wire fusing. If the MIC of a material is known, electrical circuits can be designed so that any sparks created do not have enough energy to cause an explosion. Controlling the spark energy is the basic concept in intrinsically safe and non-inductive equipment.

Minimum Ignition Energy (MIE) is the minimum energy input required to initiate combustion. This is the smallest amount of energy stored in a capacitor that when discharged across a spark gap is capable of igniting a stoichiometric mixture. All hazardous location materials have a minimum ignition energy that is specific to its’ chemical or mixture, the concentration, pressure, and temperature.

Minimum Igniting Current (MIC) Ratio: The ratio of the minimum current required from an inductive spark discharge to ignite the most easily ignitable mixture of a gas or vapor, divided by the minimum current required from an inductive spark discharge to ignite methane under the same test conditions.

The grouping is therefore based on the two key factors; maximum gap an exploding gas can pass through is based on laboratory tests performed in an apparatus, which varies both the width and gap of a joint and the pressure rise caused by an explosion.

Maximum Experimental Safe Gap (MESG) is maximum spacing between flat surfaces of a specified width in experimental test equipment that will prevent the propagation of an explosion from inside the explosion test chamber to a surrounding flammable atmosphere. The MESG is determined using a testing chamber such as the Westerberg Explosion Test Vessel.

While there are slight discrepancies between the North American and IEC® values, the intent is basically the same. The reasons for the differences are the introduction of new test parameters and rounding. When North America adjusted their evaluation methods, the definition for some materials also changed. The committees responsible for those changes decided not to reclassify the materials. This is the primary reason some gases in the division system are not aligned with those in the Zone system.

CLASS I LOCATIONS DIVISION SYSTEM GAS GROUPS A, B, C, & D

Group A

The highest explosion pressures of the materials grouped are generated by acetylene, the only material in Group A. Thus, explosionproof equipment designed for Group A must be very strong to withstand the explosion anticipated, and must have a very small gap between joint surfaces. Explosionproof equipment for Group A is the most difficult to design and there is less explosionproof equipment listed for this group than for any other group.

Group B

Group B materials produce explosion pressures somewhat less than acetylene, and the design of explosionproof enclosures for this group is somewhat less rigorous than for Group A enclosures. However, because of the very high explosion pressures in both Groups A and B, and, in particular, the very small gap between mating surfaces needed to prevent propagation of an explosion, there are no explosionproof motors listed for use in either Group A or B locations.

Group C

The chemical materials in Group C fall within the range between Groups B and D in both the explosion pressures generated and the gap between mating surfaces of explosion proof equipment that will prevent an explosion.

Group D

Group D is the most common group encountered in the field, and there is more equipment available for this group than for any other group.

CLASS I LOCATIONS ZONE SYSTEM GAS GROUPS IIC, IIB, & IIA

Zone Gas Groups General information

The Zone gas groups are based on the IEC and prefixed by “II” which means equipment intended for surface industries. The prefix “I” identifies equipment intended for underground coal mining. Since the NEC does not deal with mining; references to “I” are excluded.

HAZARDOUS LOCATION DATA

Group IIC

(Effectively the combination of the Division system Groups A and B) includes materials such as acetylene, butadiene, propylene oxide, carbon disulphide or hydrogen or other gases or vapours of equivalent hazard.

Group IIB

(basically Division System Group C) includes materials such as cyclopropane, diethyl ether, ethylene, ethylene oxide, hydrogen sulfide, or unsymmetrical dimethyl hydrazine (UDMH), or other gases or vapours of equivalent hazard.

Group IIB +Hydrogen (or IIB+H_2)

The identification of Group IIB +Hydrogen excludes acetylene and actually aligns to the Division System Group B definition. The issue was that an acetylene explosion will propagate through any flat joint. Group IIB+H_2 was introduced to allow for enclosure for hydrogen atmospheres that do not propagate through properly designed flat joints.

Group IIA

(basically Division System Group D) includes materials such as acetaldehyde, acetone, alcohol, ammonia, benzine, butane, gasoline, hexane, isoprene, lacquer solvent vapours, natural gas, propane, propylene, styrene, vinyl chloride, xylenes, or other gases or vapour of equivalent hazard.

CLASS I LOCATIONS COMPARING DIVISION & ZONE GAS GROUPS

The first definitions of flammable gases in North American Standards appeared in 1935 and were based on theoretical calculations. In the 1960s an engineer at UL developed an instrument called the Westerberg Explosion Test Vessel that could vary gap and joint width dimensions of a chamber to perform actual test. In the early 1970s, the IEC® developed a different test vessel that could perform the same test. Although most of the results were similar, they were not identical. Both Systems grouped materials based on the test results.

In the 1997 Edition of NFPA 497 a new method to estimate the group classification of a mixture was introduced. While some materials, mostly Groups C and D, no longer met the new definitions exactly, based on the safety of historical practices, the standard committee decided not to reclassify them.

This results in slight differences in how gases are identified in the Zone system versus the same gas in the Division System. For purposes of equipment selection, area classifications should identify both the Zone and Division gas group of the material(s) present.

GAS GROUPS	
DIVISION	ZONE
A	IIC
B	
B*	(IIB + H_2)
C	IIB
D	IIA

** Added to Accommodate Flat Joints for Hydrogen Atmospheres*

COMPARISON OF DIVISION AND ZONE SYSTEM GAS GROUPS EVALUATION					
DIVISION SYSTEM			ZONE SYSTEM		
GROUP	MESG (MM)	MIC RATIO	GROUP	MESG (MM)	MIC
Not Classified	< 0.076 (e.g. Carbon Disulphide)		IIC	≤ 0.50	≤ 0.45
A	Acetylene (Has same MESG and MIC Ratio as group B, but generates much higher explosive pressures)				
B	> 0.076 ≤ 0.45	≤ 0.40			
C	> 0.45 ≤ 0.75	> 0.40 ≤ 0.80	IIB	> 0.50 ≤ 0.90	> 0.45 ≤ 0.80
D	> 0.75	> 0.80	IIA	> 0.90	> 0.80

CLASS I LOCATIONS TEMPERATURE ISSUES

Ambient Temperature

The ambient temperature is the surrounding temperature of the environment in which a piece of equipment is installed, whether it is indoors or outdoors. Certain heat producing equipment such as lighting fixtures list a Temperature Code or T-Code at a given ambient temperature. (See below)

A heat producing product is considered acceptable for the location, provided the minimum ignition temperature of the hazardous material present and the ambient temperature of the location do not exceed the limits set by the manufacturer. If the ambient temperature is higher than the maximum stated on the name plate, it might still be acceptable to use the product under certain conditions, provided the minimum ignition temperature of the hazardous material has not been exceeded. In all cases, consult the factory for assistance.

Operating Temperature

The rated operating temperature for hazardous (classified) products is determined by conducting laboratory test in an ambient temperature of 40°C. Products certified by the various agencies consider products certified to their standards to be suitable for different temperature ranges. The range for the range for UL is -25°C to +40°C, the range for CSA is -50°C to +40°C, and the range for IEC is -20°C to +40°C.

TEMPERATURE CODE OR T-CODE

The *"Temperature Code"* or *"T-Code"* of an explosive gas material relates to the autoignition temperature of the gas or vapour present. The autoignition temperature is the minimum temperature that will ignite a material without a spark or flame. Heat producing equipment Electrical equipment such as lighting fixtures, motors, electrical trace heating, etc. needs to operate below the auto ignition temperature of the explosive materials it is likely to come into contact with. Use of the Temperature Code marking allows equipment to be designed for a multiple materials with different autoignition temperatures based on specific temperature ranges. In some cases the NEC Requires the T-Code be reduced to 80% of the normal value.

The relationship between ambient temperature and T-Code is somewhat linear in that a product running at 450°C at a 40°C ambient will run at approximately 460°C at a 50°C ambient. This is only a rule of thumb and since it does not consider the effect of a higher ambient on the performance or life of a product should not be used without consulting the manufacturer.

The ignition temperature or autoignition temperature (AIT) is the minimum temperature that will cause an explosive material to ignite without a spark or flame. The lowest published ignition temperature should be the one used to determine the acceptability of equipment. This is of particular concern when selecting heat producing equipment such as lighting fixtures or motors which may generate sufficient heat to ignite the surrounding atmosphere.

The T-Codes used in the Division System vary slightly from those in the Zone System. While the basic values are identical, the Division System has intermediate levels which are not used in the NEC Zone System. Internationally only Canada permits the use of these intermediate levels for Zone locations. The IEC System has no intermediate levels.

TEMPERATURE CODES NEC (DIV.) & CEC	TEMPERATURE CODES (ZONES) NEC/IEC/ATEX	MAXIMUM TEMPERATURE	
		°C	°F
T1	T1	450	842
T2	T2	300	572
T2A	-	280	536
T2B	-	260	500
T2C	-	230	446
T2D	-	215	419
T3	T3	200	392
T3A	-	180	356
T3B	-	165	329
T3C	-	160	320
T4	T4	135	275
T4A	-	120	248
T5	T5	100	212
T6	T6	85	185

CLASS II, LOCATIONS

General

The NEC contains two systems to deal with combustible or explosive dusts. NEC Article 502 contains the rules for areas classified using the Division System and Article 506 contains the rules using the Zone System. Similar to Class I locations, Class II is separated area into Divisions or Zones base on the likelihood combustible dust is normally in suspension in the air in sufficient quantities to produce ignitable mixtures or where a failure or abnormal operation of equipment might produce a hazardous concentration of dust.

Unlike gases and vapors, one of the key determining factors of Class II material is particle size. The definition of a Class II dust is; any finely divided solid material that is 420 microns or smaller in diameter (material passing through a No. 40 Standard Sieve) and presents a fire or explosion hazard when dispersed and ignited in air. An example of the importance of particle size would be wood; a log will burn but not explode, however very fine sawdust particles suspended in air are highly explosive.

Typical Class II Dust Location

There is a major difference between the NEC Class/Division and Class/Zone Systems in that the Class/Zone System combines both Class II and Class III. For this reason the Class/Zone System (Article 506) later in this section.

Division 1

A Class II, Division 1 location is one where combustible dust is normally in suspension in the air in sufficient quantities to produce ignitable mixtures, or where mechanical failure or abnormal operation of equipment or machinery might cause an explosive or ignitable dust-air mixture to be produced, and might also provide a source of ignition through simultaneous failure of electrical equipment.

Division 2

A Class II, Division 2 location is one where combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitable mixtures, and dust accumulations are not normally sufficient to interfere with the normal operation of electrical equipment, such as clogging ventilating openings or causing bearing failure. It includes locations where combustible dust may be in suspension in the air only as a result of infrequent malfunctioning of handling or processing equipment, and those locations where dust accumulation may be on or in the vicinity of the electrical equipment and may be sufficient to interfere with the safe dissipation of heat from the equipment, or may be ignitable by abnormal operation or failure of the electrical equipment.

GUIDE TO CLASSIFICATION OF CLASS II LOCATIONS BY DIVISION*		
THICKNESS OF DUST LAYER ON EQUIPMENT**	DUST GROUP	DIVISION
Greater than 1/8 in.	E, F, G	1
1/8 in or less but surface color not discernible	E	1
1/8 in or less but surface color not discernible	F, G	2
1/8 in or less and surface color discernible under dust layer	E, F, G	non-classified

** From NFPA 497B-1991*

*** Based on build-up of dust level in a 24-hr period on the major portions of the horizontal surfaces.*

CLASS II LOCATIONS DIVISION DUST GROUPS E, F AND G

Class II substances are divided into three groups for similar reasons to those of Class I materials, equipment design and area classification. Class II groups are based on different characteristics than those of Class I, given the requirements for an explosion to occur and the protection methods required for equipment. In Class II locations the ignition temperature, the electrical conductivity, and the thermal blanketing effect the dust are critical when dealing with heat-producing equipment, such as lighting fixtures and motors. It is these factors which are the deciding factors in determining the Class II groups.

Group E

This includes metal dusts, such as aluminums and magnesium. In addition to being highly abrasive, and likely to cause overheating in equipment such as motor bearings should the dust get into the bearing, these (Group E) dusts are electrically conductive. If allowed to enter an enclosure, they are likely to cause electrical failure of the equipment. Since Group E, dusts can potentially be the source of the equipment failure, the source of ignition and fuel for an explosion at the same time, any accumulation is normally considered to be Division 1.

HAZARDOUS LOCATION DATA

Group F

These are carbonaceous, the primary dust in this group being coal dust. These dusts have somewhat lower ignition temperatures than those in Group E and a higher thermal insulating value than a layer of a Group E dust. Therefore Group F dusts require careful control of the temperature on the surface of electrical equipment to prevent an explosion. Such dusts are semi-conductive, which is not usually issue in dealing with equipment rated 600 volts and less.

Group G

This includes plastic dusts, most chemical dusts, and food and grain dusts. These are not electrically conductive. Group G dusts generally have the highest thermal insulating characteristics and the lowest ignition temperatures. Electrical equipment for use in Group G atmospheres must have very low surface temperatures to prevent ignition of a dust layer by the heat generated within the equipment.

While it is common for Class I, products certified for use in Class II locations; it is not always the case. Given the different design requirements, equipment suitable for Class I locations are not necessarily suitable for Class II locations, nor is equipment suitable for Class II locations necessarily suitable for Class I locations. Equipment must be designed, approved and marked for use in specific hazardous locations.

Manufacturers typically develop equipment to suit a wide range of hazardous locations to be more cost effective. The equipment is marked as such and may have different temperature limitations on heat producing devices for different types of hazardous material. As always, care must be taken in selecting equipment for any hazardous location.

Temperature Restrictions

In Class II areas all products must operate at temperatures as shown below based on whether they are heat producing or subject to overloading or not, and based on the Group which they fall under. Class III products in all cases must operate below 165° C.

	EQUIPMENT THAT IS NOT SUBJECT TO OVERLOADING		EQUIPMENT (SUCH AS MOTORS OR POWER TRANSFORMERS			
			NORMAL OPERATION		ABNORMAL OPERATION	
CLASS II GROUPS	°C	°F	°C	°F	°C	°F
E	200	392	200	392	200	392
F	200	392	150	302	200	392
G	165	329	120	248	165	329

CLASS III LOCATIONS

Class II, Division System Dust Groups E, F, and G

Class III locations are those that are hazardous because of the presence of easily ignitable fibers or flyings, but in which the fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Easily ignitable fibers and flyings present a fire but not an explosion hazard. A typical example of this type of material is the cotton lint that accumulates in the lint trap of clothes dryers. Listed clothes dryers are designed so that even if the lint ignites, the fire will be contained within the dryer enclosure.

CLASS III, DIVISIONS 1 AND 2

Division 1

This is a location where the equipment producing the ignitable fibers or flyings is located (near textile mill machinery, for example) or where the material is handled (for example, where the material is stuffed into bags).

Division 2

This is a location where the easily ignitable fibers are stored or handled, except in manufacturing processes (which is Division 1).

Class III Groups

There are no groups in Class III locations.

CLASS II ZONE SYSTEM

The differences between the IEC system for Explosive Dust Atmospheres and the North American Class/Division system are far greater than those for explosive gases. In 2005 the NEC added Article 506 to mirror the IEC system for Explosive dust Atmospheres, making its use optional (as was done with Explosive gas Atmospheres). The CEC adoption of the IEC System for Explosive Dust Atmospheres in 2015 was quite different; Not only is the use of the new system mandatory for new construction, all references to the original “Class” system rules were removed in the main body of the Code and relocated to Annex J. Unlike the NEC, the new CEC rules cannot be ignored and are likely to cause some initial confusion for users.

Similar to the system for Explosive Gas Atmospheres, the IEC Zone system for combustible dusts has three levels of hazard. In the Division system, Division 1 meant the material was present under normal operating conditions, Division 2 meant the material was present under abnormal conditions only. The Zone system introduces Zones 20, 21 and 22 based on the probably of the material being present and suspended in air in sufficient quantities for an explosion to occur.

Zone 20:

A location in which an Explosive Atmosphere in the form of combustible dust in air is present continuously, frequently, or for long periods

Zone 21:

A location in which an Explosive Atmosphere in the form of combustible dust in air is likely to occur under normal operation occasionally

Zone 22:

A location in which an Explosive Atmosphere in the form of combustible dust in air is not likely to occur under normal operation but, if it does occur, it will persist only for a short period of time

Materials are grouped on their physical properties. In the original system Group E was electrically conductive dust, Group F, carbonaceous dust, and Group G, agricultural dust. In the Zone system, Group E becomes Group IIIC, Groups F and G become Group IIIB and Class III becomes Group IIIA. (See Table below)

ZONE DUST GROUPS		
TYPE OF DUST	DIVISION DUST GROUP	ZONE DUST GROUP
Conductive dust	Class II, Group E	IIIC
Non-conductive dust	Class II, Groups F, G	IIIB
Combustible flyings	Class III Locations	IIIA

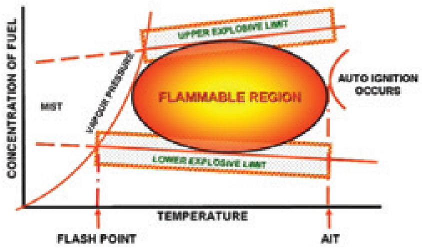
GENERAL PROPERTIES OF HAZARDOUS LOCATION MATERIALS

Simply because hazardous location materials are present does not mean that the conditions necessary for an explosion to occur also exist. With explosive materials several other factors must occur simultaneously to result in an explosion. Larger dust particles are often referred to as fibres or flyings and, if sufficient material is present, elevated temperatures may not cause a fire but may result in a flash fire.

Although there is the risk of an explosion with both Explosive gas and dust materials, the factors required for that to occur are somewhat different. In both cases the material needs to mix with air (to provide the oxygen required), be in specific fuel to air concentrations (flammable limits) and then encounter an ignition source with sufficient energy to start an explosion.

The physical properties of gases and vapours allow them to easily mix with air whereas dusts tend to settle on surfaces. If gas is released into the atmosphere it can rise, settle or linger in the air around it depending on the vapour density and dispersion depends on the air movement in the area. For a dust to form and explosive cloud it needs to be suspended. This can take place in process equipment, leaking equipment or by strong air movement which could be caused by a smaller explosion.

Flammable Limits



With all flammable gases or vapours there is a minimum and maximum concentration in oxygen (air) beyond at which an explosion cannot occur. These minimum and maximum concentrations are called the flammable or explosive limits. If the mixture has too little fuel (a lean mixture) or if there is too much fuel (a rich mixture), it cannot be ignited or cause an explosion. The flammable limits of gases and vapours are usually measured in percentage in air, by volume and referred to as the lower explosive limit (LEL) and upper explosive limit (UEL). Some materials have very broad flammable limits, whereas others have very narrow flammable limits.

While combustible dusts suspended in air have measurable lower flammable limits, there is no finite upper limit; even as the dust approaches the density of the solid material from which it originates. The lower explosive limit for combustible dust suspended in air is usually so dense that visibility beyond one or two meters is impossible. The lower flammable limit of dust air mixtures is usually measured in ounces per cubic foot.

Oxygen

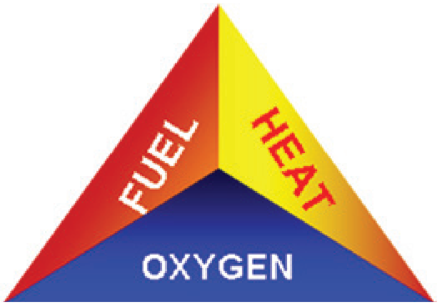
For an explosion to occur oxygen must be present and be mixed within the explosive limits of a fuel. While sufficient oxygen is usually available in the air around us it is not the only source. For example, a mixture of the (now seldom used) aesthetic gases, ethyl ether and nitrous oxide can produce violent explosions because oxygen is provided by the nitrous oxide.

If the oxygen concentration exceeds that normally found in air (21% by volume) flammable limits are normally expanded and the ignition energy needed to cause an explosion decreases. An explosion with increased oxygen is often considerably more violent than if the oxygen concentration had been the same as in air.

The Fire Triangle

For a fire or explosion to occur, three conditions must exist in the correct combination.

- There must be a fuel (flammable gas or vapour) in ignitable quantities
- There must be an ignition source (energy in the form of heat or a spark) of sufficient energy to cause ignition
- There must be oxygen, usually the oxygen in the air

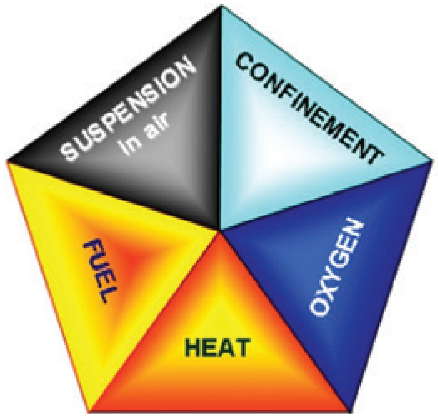


By remove any one or more of these three components, it is impossible for a fire or explosion to occur. This is the basis of the various methods of protection used in the design of electrical equipment permitted for use in hazardous locations.

The Dust Pentagon

The fire triangle indicates the condition required for combustion for gases and vapors. Dust explosions however require two other factors to sustain an explosion; suspension and containment. This is called the Dust Pentagon

- There must be a fuel (Combustible dust) in ignitable quantities
- There must be an ignition source (energy in the form of heat or a spark) of sufficient energy to cause ignition
- There must be oxygen, usually the oxygen in the air
- The Dust must be suspended in air
- The location must be confined



Dust that is not suspended in air may pose fire risk but is not necessarily explosive. Catastrophic dust explosions differ from those involving gases and vapours. A fire or an initial explosion in processing equipment or confined location may damage containment systems or cause other accumulated dust in the area to be dispersed in the atmosphere. This can result in a secondary, far more powerful explosion. These secondary explosions can continue and increase in intensity as more material is dispersed.

As with the Fire Triangle, elimination of one of the components of the Dust Explosion Pentagon can prevent an explosion from happening. In most Class II locations the elimination of oxygen or confinement by buildings or process equipment is difficult to eliminate. However the other components of the Dust Pentagon can be controlled through proper design, operation and maintenance.

BASIC DESIGN OF ELECTRICAL EQUIPMENT FOR HAZARDOUS LOCATIONS

There are a number of ways of protecting electrical equipment so that it cannot cause an ignition of an explosive atmosphere. The approach for explosive gas atmospheres is somewhat different to that of explosive dust atmospheres.

Division Approved Equipment

Electrical equipment must be designed and manufactured in such a way that it cannot become a source of ignition when used in an explosive gas atmosphere. The code addresses this by permitting only certain types of equipment to be installed in hazardous locations (either “explosionproof” or “intrinsically safe”). Equipment that is approved for Class I, Division 1, locations has to be specifically manufactured for the intended use and must carry markings to identify that. In Class I, Division 2 locations, certain "non-hazardous" types of equipment, such as terminals and non-sparking motors, are permitted. Equipment specifically built for Class I locations will be marked to indicate where the equipment can be installed. This is discussed in greater detail below.

Class II, Division 1 areas the primary protection method are dustproof or dust-ignition-proof. In many cases, equipment which is suitable for use in Class I locations is acceptable in Class II locations however, it must be specifically marked as such.

For Class III locations the determining factor is more preventing accumulations inside equipment and temperature control.

Zone Approved Equipment

The Zone system identifies Equipment protection levels (EPL) which assign a code defining the level of protection of equipment that is based on the likelihood of the equipment becoming a source of ignition. The EPL uses "G" for Explosive Gas Atmospheres and "D" for Explosive Dust Atmospheres. This is followed by one of the three levels of protection with "a" being the highest and "c" the lowest which translate into suitability for the various Zones or Divisions. The IEC also identifies Explosive Atmospheres in mines susceptible to firedamp which is not part of the NEC or CEC.

- **EPL Ga —** equipment for Explosive gas Atmospheres, having a "very high" level of protection, which is not a source of ignition in normal operation, during expected malfunctions or during rare malfunctions
- **EPL Gb —** equipment for Explosive gas Atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or during expected malfunctions
- **EPL Gc —** equipment for Explosive gas Atmospheres, having an "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp)
- **EPL Da —** equipment for Explosive dust Atmospheres, having a "very high" level of protection, which is not a source of ignition in normal operation, during expected malfunctions, or during rare malfunctions
- **EPL Db —** equipment for Explosive dust Atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or during expected malfunctions
- **EPL Dc —** equipment for Explosive dust Atmospheres, having an "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp)

EPL G a

Protection Level
a – Highest (Zone 0, 20)
b – High (Zone 1, 21)
c – Enhanced (Zone 2, 22)

Material
G – Explosive Gas Atmosphere
D – Explosive Dust Atmosphere

Equipment Protection level

EQUIPMENT PROTECTION LEVEL		
EPL	ZONE SUITABILITY	DIVISION SUITABILITY
Ga	Zone 0	Class I, Division 1
Gb	Zone 1	Class I, Division 2
Gc	Zone 2	Class I, Division 2
Da	Zone 20	Class II/III, Division 1
Db	Zone 21	Class II/III, Division 2
Dc	Zone 22	Class II/III, Division 2

Both the NEC and CEC refer to newer versions of the IEC 60079 Series of Standards. Many of these have been rewritten to include multiple levels of protection. Originally, with the exception of Intrinsic Safety which had 2 levels of protection ("ia" for Zone 0, and "ib" for Zone 1) all other standards had a single level of protection (later Encapsulation "Ex ma" "Ex mb" were added). All Zone 2 requirements were contained in IEC 60079-15 (UL/ISA/ANSI and CSA adopted these standards).

To address the specific technical requirements of Zone 2, Explosive Dust Atmospheres and to allow for other equipment to be allowed in Zone 0, changes to the IEC standards are underway to add "Levels of Protection" to each "Types of Protection". Many of these are recognized in the NEC and CEC. The Levels of Protection follow the EPL in that "a" is the highest protection and "c" is the lowest.

Original Marking

Ex e

Type of Protection

New Marking

Ex e b

Level of Protection
Type of Protection

BASIC TYPES OF PROTECTION OF EQUIPMENT FOR HAZARDOUS LOCATIONS

EXPLOSION PROOF (TYPE OF PROTECTION "Ex d" FLAMEPROOF) (Also "Ex da" (for gas detection only), "Ex db" and "Ex dc")

The basic protection concept of Explosionproof and Flameproof are the same although certification requirements for flameproof are less severe than those for explosionproof equipment. The intent of both is to contain an internal explosion of gas or vapor and prevent the escape of any hot or burning materials that could ignite the surrounding atmosphere. Because "Flameproof equipment" is not permitted to be used in Zone 0 Locations this type of construction cannot be used permitted in Class I, Division 1 locations (which theoretically includes Zone 0).

Since flammable gases and vapors are expected to be inside the enclosure the equipment design must be capable of withstanding an explosion caused by sparks from contactors or other switching devices, high temperatures, or electrical faults. The enclosure is designed so that hot gases generated during an internal explosion are cooled below the ignition temperature of the surrounding flammable atmosphere as they are transmitted through the joints of the enclosure.

In addition, the external surfaces of enclosures must reach temperatures that could ignite a surrounding atmosphere as a result of heat energy within the enclosure. This heat energy may be the result of normal operation of heat producing equipment such as lighting fixtures, or the result of an electrical arc to the enclosure from an arcing ground fault. Explosionproof and Flameproof use various types of joints to maintain their protection.

- **Threaded Joints** used for conduit entries or enclosure covers.
- **Flat Joints** between mating surfaces that are bolted tightly together,
- **Cylindrical Joints** such as used in push-buttons, toggle switches, and shafts for electric motors
- **Rabbet Joints** commonly used for large diameter cylindrical parts, such as between a motor end bell and the main frame.
- **Labyrinth Joints** is used on both rectangular and cylindrical parts which force expanding hot gases to make several right-angle turns before they can exit an enclosure

Care should be taken when dealing with any joints in an Explosionproof and Flameproof product.

ENCAPSULATION - TYPE OF PROTECTION "Ex m" (Also "Ex ma", "Ex mb" and "Ex mc")

Encapsulation is a type of protection in which the parts than can ignite an explosive atmosphere are enclosed in a resin (plastic). The resin must be sufficiently resistant to environmental influences that the explosive atmosphere cannot be ignited by either sparking or heating, which may occur within the device. This is typically used with small contacts such as used in relays or electronic devices.

HERMETICALLY SEALED

A common type of hermetically sealed equipment is a contact block or reed switch. In this method, the arcing components of the switch are encased in a glass tube. The connecting wires are fused to the glass sealing the unit to prevent any ingress of flammable gases. Hermetically sealed equipment is suitable for Division 2 or Zone 2 only.

INCREASED SAFETY - TYPE OF PROTECTION "Ex e" (Also "Ex eb" and "Ex ec" will eventually replace "Ex nA")

This protection system is for equipment that, under normal operating conditions, does not produce ignition-capable arcs or sparks or high temperatures. It provides special increased spacing between live parts and live parts of opposite polarity or grounded metal parts. Special insulating materials are used to reduce the likelihood of arc tracking along with special terminals to reduce the likelihood of high temperatures caused by loose connections and temperature control on heat producing equipment. It is commonly used for protection of squirrel cage motors, terminal and connection boxes (junction boxes), and terminal boxes of flameproof equipment where the arcing contacts are in a separate enclosure connected to the increased safety enclosure by special factory sealed fittings.

INTRINSICALLY SAFE OR INTRINSIC SAFETY (IS) EQUIPMENT-TYPES OF PROTECTION "i", "Ex ia" and "Ex ib" (Also "Ex ic")

With the adoption of the IEC Standard, North America now identifies three versions of this protection method. Types "i" and "ia" are virtually identical as it was originally based on the IEC Standard. In Zone 0 the only acceptable type of equipment is types "i" and "ia". Type "Ex ib" is acceptable in Zone 1 and the recently introduced "Ex ic" is acceptable for Division/Zone 2 locations.

The intent of IS equipment is to limit the energy within the entire circuit to a level below that which could ignite the surrounding atmosphere. For testing purposes the most easily ignited gas mixture is used. The common protective device used in the circuit is a IS Barrier device (often called a Zener Diode Barrier although other barriers are available). While this type of device controls the energy going to a circuit, it does not prevent products such as capacitors, cables, etc from storing energy which could increase beyond the maximum permitted in the complete system. Therefore Intrinsic Safety is a "system approach" and that no single device provides total protection.

NON-SPARKING - TYPE OF PROTECTION "n X"

The ordinal concept of Type "n" was to deal with equipment suitable for use in Class I, Zone 2 or Division 2 areas only. This is changing an future versions (and North American adopted versions) of IEC 60079-15 will likely include Restricted Breathing ("Ex nR") only.

Symbol Ex n X	Protection
R	Restricted breathing enclosure
L	Energy limitation devices (non-incendive)
P	Enclosure with simplified pressurization

NON-INCENDIVE EQUIPMENT

Non-Incendive is similar to Intrinsic Safety in that it considers spark energy. It is intended for Class I, Division/Zone 2 locations. It also considers contacts for making or breaking an incendive circuit where the contact mechanism is constructed so that the component is incapable of igniting the specified flammable gas or vapour-air mixture. The housing of a non-incendive component is not intended to exclude the flammable atmosphere or contain an explosion.

OIL IMMERSION - TYPE OF PROTECTION "Ex o" (Also "Ex ob" and "Ex oc")

Oil immersion is similar to powder filling in that it excludes the outer atmosphere from coming in contact with the arcing, sparking or heat producing parts of the apparatus. In the past, large transformers or circuit breakers used this technique. Its use today is limited.

PURGED AND PRESSURIZED - TYPE OF PROTECTION "p" (Also "Ex p", "Ex px", "Ex pxb", "Ex py", "Ex pyb", "Ex pz" or "Ex pzc")

This type of protection prevents the surrounding atmosphere from entering an enclosure by maintaining a positive pressure within the unit. Clean air or inert gas is used to maintain a higher pressure than the surrounding atmosphere. In purging, the electrical equipment is interlocked with a system which cycles clean are within the unit to remove explosive gases prior to start up.

The IEC Standard has become quite complicated and has multiple levels of protection identified.

There is also an NFPA Standard used for the Division system and Zone 2.

NFPA 496 Identifies three types of pressurization as follows:

TYPE	EXPLANATION
X	Changes the area within the unit from Class I, Division 1 to non- hazardous
Y	Changes the area within the unit from Class I, Division 1 to Class I, Division 2
Z	Changes the area within the unit from Class I, Division 2 to non- hazardous

SAND FILLED APPARATUS TYPE OF PROTECTION "q" (Also "Ex qb" and "Ex qc")

In this type of protection, the enclosure, or electrical apparatus, is filled with a material in finely granulated quartz (or very small glass beads) to prevent any arc which may occur within the enclosure from igniting the surrounding atmosphere. The equipment can have no moving parts, which are in direct contact with the filling materials, and the enclosure must have a minimum protection of IP 54.

DUST- IGNITION-PROOF EQUIPMENT

This concept is similar to Dust-Tight however enclosures were designed to contain an internal dust explosion. Since the explosive pressures generated a dust explosion are significantly less than those generated by gases, enclosures could be made with much thinner walls. In most equipment used today, dust tight provides a more cost effective option.

DUST-TIGHT EQUIPMENT

The "Dust-Tight" method of protection removes the fuel leg of the fire triangle (by preventing dust from entering the enclosure, and the heat leg of the fire triangle, by restricting its surface temperature. This type of protection makes the equipment safe for use in Class II hazardous locations.

Dust-Tight equipment is designed to prevent combustible dust from entering apparatus and to prevent any hot particles or sparks generated within the unit from passing from to the outside of the enclosure through its joints. The objective is to prevent the ignition of combustible dust suspended in the air or the ignition of layers of dust on the equipment from being ignited by materials escaping the enclosure. This heat can, as in explosion proof apparatus, result from normal or abnormal equipment operation, or arcing ground faults.

Since the combustible materials are kept outside the unit, the enclosure is not expected to withstand an internal explosion and it's physical strength needs only to be sufficient to withstand abuse. The unit must also withstand internal arcing ground faults for enough time for the circuit over-current protection to open the circuit and stop the arcing. The types of joints used in Dust-Tight products are similar to explosion-proof equipment, but the requirements are not as rigid. These joints are needed to prevent dust from entering the enclosure and hot particles from exiting under fault conditions.

Since the ignition temperature of dusts is usually lower than that of gases and vapours, the control of external surface temperatures is more rigorous in dust-tight equipment than in explosion proof equipment. Dust layers on the equipment can prevent dissipation of heat generated within the equipment and increase the surface temperature even under normal operating conditions.

EQUIPMENT DUST IGNITION PROTECTION BY ENCLOSURE "t" (Also "Ex ta", "Ex tb" and "Ex tc")

Much like North American dust tight requirements the objective of the IEC version is to keep dust from entering the enclosure. The testing parameters and material are different.

ENVIRONMENTAL PROTECTION

The following are environmental protection designations, which are specified in addition to electrical or hazardous location requirements. Many people refer to the NEMA (National Electrical Manufacturers Association) when requesting enclosure types, however the NEMA 250 Standard is for reference only. In North America products are tested to the harmonized with UL 50/ CSA C22.2 No. 94 standard and identified as Enclosure Type followed by the appropriate number as indicated below.

Type 1 Enclosures

Intended for indoor use primarily to provide a degree of protection against limited amounts of falling dirt.

Type 2 Enclosures

Intended for indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt.

Type 3 Enclosures

Intended for outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust; and damage from external ice formation

Type 3R Enclosures

Intended for outdoor use primarily to provide a degree of protection against rain, sleet; and damage from external ice formation, and must have a drain hole.

Type 3S Enclosures

Intended for outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust; and to provide for operation of external mechanisms when ice laden.

Type 4 Enclosures

Intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose directed water; and damage from external ice formation.

Type 4X Enclosures

Intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose directed water; and damage from external ice formation.

Type 5 Enclosures

Intended for indoor use primary to provide a degree of protection against settling airborne dust, falling dirt, and dripping non corrosive liquids.

Type 6 Enclosures

Intended for indoor or outdoor use primarily to provide a degree of protection against hose directed water, the entry of water during occasional temporary submersion at a limited depth; and damage from external ice formation.

Type 6P Enclosures

Intended for indoor or outdoor use primarily to provide a degree of protection against hose-directed water, the entry of water during prolonged submersion at a limited depth; and damage from external ice formation.

Type 12 Enclosures

Intended for indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping non-corrosive liquids.

Type 12K Enclosures

Intended knockouts are intended for indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping non corrosive liquids.

Type 13 Enclosures

Intended for indoor use primarily to provide a degree of protection against dust, spraying of water, oil, and non-corrosive coolant.

DEFINITIONS REFERRING TO NEMA REQUIREMENTS FOR HAZARDOUS LOCATIONS

The following NEMA type enclosures occasionally appear on specifications and product literature however, they are not included in the UL 50/CSA C22.2 No. 94 Standard. These NEMA types are specific to the US only.

NEMA 7 Enclosures

Intended for indoor use in locations classified as Class I, Groups A, B, C, or D, as defined in the NEC.

NEMA 8 Enclosures

Intended indoor or outdoor use in locations classified as Class I, Groups A, B, C, or D, as defined in the NEC.

NEMA 9 Enclosures

Intended for indoor use in locations classified as Class II, Groups E, F, and G, as defined in the NEC.

NEMA 10 Enclosures

Are constructed to meet the applicable requirements of the Mine Safety and Health Administration. (MSHA)

COMPARISON OF SPECIFIC APPLICATIONS OF ENCLOSURES FOR INDOOR NONHAZARDOUS LOCATIONS										
PROVIDES A DEGREE OF PROTECTION AGAINST THE FOLLOWING ENVIRONMENTAL CONDITIONS	TYPE OF ENCLOSURE									
	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 and coolant spraying and splashing	—	—	—	—	—	—	—	—	—	X
Corrosive agents	—	—	—	X	—	—	—	—	—	—
Occasional temporary submersion	—	—	—	—	—	X	X	—	—	—
Occasional prolonged submersion	—	—	—	—	—	—	—	—	—	—

These enclosures may be ventilated. However, Type 1 may not provide protection against small particles of falling dirt when ventilation is provided in the enclosure top.

** *These fibers and flyings are nonhazardous materials and are not considered as Class III type ignitable fibers or combustible flyings. For Class III type ignitable fibers or combustible flyings see the National Electrical Code®, Article 500.*

COMPARISON OF SPECIFIC APPLICATIONS OF ENCLOSURES FOR OUTDOOR NONHAZARDOUS LOCATIONS							
PROVIDES A DEGREE OF PROTECTION AGAINST THE FOLLOWING ENVIRONMENTAL CONDITIONS	TYPE OF ENCLOSURE						
	3	3R***	3S	4	4X	6	6P
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X
Rain, snow, sleet*	X	X	X	X	X	X	X
Sleet**	—	—	X	—	—	—	—
Windblown dust	X	—	X	X	X	X	X
Hosedown	—	—	—	X	X	X	X
Corrosive agents	—	—	—	—	X	—	X
Occasional temporary submersion	—	—	—	—	—	X	X
Occasional prolonged submersion	—	—	—	—	—	—	X

* *External operating mechanisms are not required to operate when the enclosure is ice covered.*

** *External operating mechanisms are operable when the enclosure is ice covered.*

*** *These enclosures may be ventilated.*

COMPARISON OF SPECIFIC APPLICATIONS OF ENCLOSURES FOR INDOOR HAZARDOUS (CLASSIFIED) LOCATIONS								
PROVIDES A DEGREE OF PROTECTION AGAINST ATMOSPHERES TYPICALLY CONTAINING HAZARDOUS GASES, VAPORS, AND DUSTS***	TYPE OF ENCLOSURE NEMA 7 & 8, CLASS I GROUPS**				TYPE OF ENCLOSURE NEMA 9 & 10, CLASS II GROUPS**			
	CLASS	A	B	C	D	E	F	G	10
Acetylene	I	X	—	—	—	—	—	—	—
Hydrogen, manufactured gases	I	—	X	—	—	—	—	—	—
Diethyl ether, ethylene, cyclopropane	I	—	—	X	—	—	—	—	—
Gasoline, hexane, butane, naptha, propane, acetone									
Toluene, isoprene	I	—	—	—	X	—	—	—	—
Metal dusts	II	—	—	—	—	X	—	—	—
Carbon black, coal dust, coke dust	II	—	—	—	—	—	X	—	—
Flour, starch, grain dust	II	—	—	—	—	—	—	X	—
Fibers, flyings*	III	—	—	—	—	—	—	X	—
Methane with or without coal dust	MSHA	—	—	—	—	—	—	—	X

* *Due to the characteristics of the gas, vapor, or dust, a product suitable for one Class or Group may not be suitable for another Class or Group unless so marked on the product.*

** *For Class III type ignitable fibers or combustible flyings refer to the National Electrical Code® Article 500.*

*** *For a complete listing of flammable liquids, gases, or vapors refer to NFPA 497 - 1997 (Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas and NFPA 325 - 1994 (Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids). Reference also NFPA 499 – 1997 Classifications of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.*

PROTECTION CLASSES OF ENCLOSURES (IP CODE)

The IEC uses the term "Ingress Protection" to identify the environmental protection of an enclosure.

This is defined in IEC Standard 529 and is referenced by the CEC®. IP Codes are comparable to NEMA Enclosure Types.

The IP classification system designates, by means of a number, the degree of protection provided by an enclosure and the electrical equipment against physical contact, foreign bodies and water ingress.

The protection classes for electrical equipment in respect of:

I. Protection of persons against contact with live or moving parts. (Physical contact protection)

II. Protection against ingress of solid foreign bodies. (Foreign body protection)

III. Protection against ingress of water. (Water protection)

Structure and use of the IP Code:

I. If a code digit does not have to be given it should be replaced with the letter "X".

II. Additional and/or supplementary letters may be omitted without substitute letters.

III. If more than one supplementary letter is required, alphabetical order should be followed.

The numbering system and degree of protection follows:

The additional (optional) letter concerns protection of persons and refers to information about protection against access to dangerous parts by:

I.	Back of the hand	letter A
II.	Finger	letter B
III.	Tool	letter C
IV.	Wire	letter O

The supplemental (optional) letter concerns protection of the equipment and provides supplementary information specially for:

I.	High voltage equipment	letter H
II.	Water-proofing during operation	letter M
III.	Water-proofing during standstill	letter S
IV.	Weather conditions	letter W

IP Code: Numbering System

IP 5 4 C S

- IP — Code letters
- 5 — First Digit 0 to 6 contact and foreign body protection
- 4 — Second Digit 0 to 8 water protection
- C — Additional letters A, B, C, O (optional)
- S — Supplementary letter H, M, S, W (optional)

DIGIT	FIRST DIGIT PHYSICAL PROTECTION	FOREIGN BODY PROTECTION	SECOND DIGIT WATER PROTECTION
0	Non-protected	Non-protected	Non-protected
1	Protection against back of hand contact.	Protected against solid objects greater than 50 mm (1.97 in.).	Protected against water dripping vertically.
2	Protection against finger contact.	Protected against solid objects greater than 12 mm (0.47 in.).	Protected against vertically dripping water when tilted up to 15, degrees.
3	Protection against contact from a wire or tools.	Protected against solid objects greater the 2.5 mm (0.098 in.).	Protected against spraying water at an angle up to 60° degrees from the vertical.
4	Protection against contact with a wire or strip of thickness greater than 1.0 mm (0.039 in.).	Protected against solid objects greater the 1.0 mm (0.039 in.).	Protected from splashing water from any direction.
5	Protection against contact with a wire.	Dust-protected prevents ingress of dust in sufficient quantity to interfere with operation of equipment.	Protected against water jets from any direction.
6	Protected against contact with a wire.	Dust-tight no dust ingress.	Protected against heavy seas or powerful jets of water and prevents ingress sufficient to cause harm.
7			Protected against the effects of immersion between a depth of 150 mm to 1 meter.
8			Protected against submersion, suitable for continuous immersion in water under conditions specified by the manufacture.

Refer to IEC Standards Publication 529 (Classification of Degrees of Protection Provided by Enclosures) for complete descriptions and test requirements.

NEMA ENCLOSURE TYPES VS. IEC CLASSIFICATION DESIGNATION	
NEMA ENCLOSURE TYPE NUMBER	**IEC ENCLOSURE CLASSIFICATION**
1	IP 23
2	IP 30
3	IP 64
3R	IP 32
3S	IP 54
4 and 4X	IP 66
5	IP 52
6 and 6P	IP 67
12 and 12K	IP 55
13	IP 65

Marking

Typical North American marking

Class I,	Divisions 1 & 2	Groups A, B, C, and D, T6
Class I,	Zones 1 & 2	Groups IIC, IIB, IIA, T6
Class II,	Divisions 1 & 2	Groups E, F, and G

Class III

NEMA 3, 4, 4X

United States "AEx" marking requires Class and Zone suitability (Class I, Zone 1, AEx e IIC T5)

EQUIPMENT CERTIFICATION

In most cases, equipment for use in hazardous locations must be certified to an appropriate National Standard and marked as such by an accredited third party testing organization. Follow-up inspection to ensure conformance is usually part of the program. Products may carry multiple markings for multiple countries. The specific requirements for product certification vary from country to country.

United States and Canada

While CSA, FM and UL are similar in there are a number of differences in specific product standards that still exist. Acceptance is up to the “Authority Having Jurisdiction” (AHJ) responsible for electrical installations in a specific location. Product certification can be obtained by a Nationally Recognized Testing Laboratory (NRTL) approved by the Occupational Health and Safety Administration (OSHA) in the US or the Standards Council of Canada (SCC) in Canada. Most NRLTs issue component listing of products which means that selected products may be offered in modular form, which the customer may assemble without affecting the listing.

IECEx Scheme.

The IECEx Scheme is a global conformity assessment program administered by the International Electrotechnical Commission (IEC). The objective of the IECEx System is to facilitate international trade in equipment and services for use in explosive atmospheres, while maintaining the required level of safety. This certification scheme is based upon IEC TC 31 Standards as the basis for participating countries’ certification of electrical equipment for hazardous locations.

The intent of IECEx Scheme is that certificates for product testing issued by one member certification body are transferable to another member a certification body. This reduces testing and certification costs and time to market. An IECEx certificate alone is not acceptable to most countries and other requirements apply. For Example; In North America products must also meet ordinary location product standard requirements however and IECEx certificate can be used to prove compliance of the hazardous location requirements.

Presently the US Coast Guard (USCG), Australia, New Zealand and Singapore permit an IECEx Certificate of Compliance to be used without further investigation..

ATEX

ATEX – comes from the French for “**AT**mosphères **EX**plosibles” it identifies Equipment and Protective systems intended for use in Potentially Explosive Atmospheres and confirms that products meet the Applicable Essential Health and Safety Requirements (EHSR) of the European Economic Area (EEA). The EEA includes the European Union (EU), the European Free Trade Association (EFTA), Switzerland and Turkey.

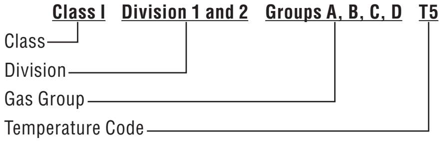
ATEX is not actually a certification system since conformity assessment principles are not consistently applied and it does not require compliance to specific any standards. The primary objective of ATEX is not about safety, it is about removing barriers to trade within the (EEA). In fact, it creates minor trade barriers with the rest of the world. ATEX defines minimum requirements for equipment and avoids safety issues becoming barriers to trade. Much or an ATEX listing is self declared by the manufacturer following certain minimal requirements.

The USCG specifically has banned vessels with equipment certified to ATEX only from operating in US waters.

US (NEC 500) Marking for Division Equipment

The basic marking for Division product is as follows. Abbreviations may be used for example “Div” or “D” instead of the whole word “Division”. Products marked as Class I only are taken to be suitable for both Division 1 and 2.

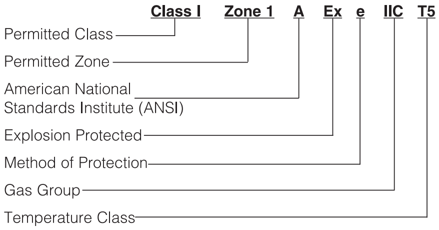
EXPANDED MARKINGS
US. (NEC 500)



US (NEC 500) Marking for Zone Equipment

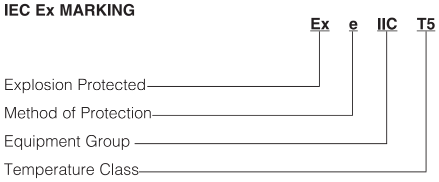
The “Ex” type(s) of protection used in the product must proceeded with the letter “A” or “AEx” to indicate the certification is to US Standards.

U. S. (NEC 505)



IECEx Marking

IEC Ex MARKING



CERTIFICATION MARKINGS

EQUIPMENT CERTIFICATION

Equipment certified by the various test authorities may require additional marking information such as the symbol or name of the test authority, certificate number, year of issue, etc. European countries issue certificates of conformity, and these certificates will include special instructions on the installation, including installation limitations.

With the advent of free trade, the Standards Council of Canada (SCC) and OSHA have accredited a number of nationally recognized testing laboratories (NRTL) to certify equipment to each others' National Standards.

USA

Multiple agencies issue product standards

- OSHA accredits testing agencies (Listing to ANSI Standards)
- Specific, multiple or no marking may be acceptable to, or required by regulatory agencies.
- If approved by the authority having jurisdiction over electrical installations in a specific area agrees, self-certification by a manufacturer is permitted.

Canada

The SCC is responsible for approving standards development organizations (SDO) to write electrical standards. Until recently, only the Canadian Standards Association (CSA) was approved. More recently, the SCC has approved Underwriters Laboratories Inc. (UL) as an SDO for Canadian Standards. In the case of UL no duplication of standard is permitted.

- Standards Council of Canada accredits testing agencies (Listing to CSA Standards)
- Specific marking required for approval by regulatory agencies.

European Union (EU)

CENELEC is the European Committee for Electrotechnical Standardization and is responsible for standardization in the electrotechnical engineering field. CENELEC prepares voluntary standards, which help facilitate trade between member countries, create new markets, cut compliance costs and support the development of a Single European Market. The Standards developed by CENELEC are called Euro Norms (EN) Standards are harmonized with IEC Standards through parallel voting.

Products designed for use in explosive atmospheres must meet the essential health and safety requirements (EHSR) of the applicable EU 94/9/EC "Equipment" Directive. The objective of Directive 94/9/EC is to ensure free movement for the products to which it applies in the EU territory.

For approval purposes equipment intended for use in Category 1 (Zone 0) and Category 2 (Zone 1) locations require the involvement of a Notified Body (NB). For Category 3 equipment, the NB can issue a voluntary certificate. A Notified Body is a "third party" body "notified" to the European Commission by a National Government to perform specific actions in relation to a directive. Currently there is no requirement for them to prove their competency. In a new directive, ATEX 2014/34/EU NBs will need to be properly assessed.

The NB prepares a technical file which allows the manufacturer to issue an ATEC Declaration of Conformity (DoC). This DoC is the responsibility of the manufacturer to maintain. The DoC is commonly referred to as an ATEX Certificate.

ATEX Certificates are used throughout the European Economic Area (EEA) which includes the European Union (EU), the European Free Trade Association (EFTA), Switzerland and Turkey

IECEx

The IECEx Conformity Assessment Scheme allows testing to IEC Standards both electrical and non-electrical that deal with equipment for explosive atmospheres. IECEx identifies Certification Bodies (CB) and Test Laboratories (ExTL) in member countries and closely monitors them. Unlike the NBs of the EU, each CB and ExTL undergoes regular peer assessment to confirm they are competent to perform their function. (CBs can also be a ExTLs). The ExTL issues a Technical Report (TR) which is used by the CB to issue a Certificate of Compliance (CoC) for a product. Self certification by the manufacturer is not permitted under IECEx rules.

Valid TRs can be used as proof of compliance to all other IECEx CBs which can eliminate the need for retesting of the explosion protection compliance in another IECEx member country. For example, North America is an IECEx member and adopts IEC Standards dealing with explosive atmospheres. While they may impose some minor deviations to the IEC Standard in their adoption process, the standards are technically identical. Both the US and Canada require that all electrical products meet the ordinary location standards related to shock and fire safety. Products can be tested to the ordinary location standards and the IECEx CoC and TR can be used to prove compliance with the requirements for explosive atmospheres.

Currently the US Coast Guard, Australia, New Zealand and Singapore are the only jurisdictions that permit IECEx products to be used without further investigation.

UNITED STATES ACCEPTABLE CERTIFICATION MARKS

The following are some of the certification marks permitted by OSHA for certain types of equipment for Hazardous (Classified) Locations. Final acceptance of a certification mark is up to the individual AHJs. With the exception of UL, all these agencies have one level of listing refer to as either "certified" or "approved". These terms mean the same type of approval.

Canadian Standards Association (CSA)

FM Approvals LLC (FM)

Intertek Testing Services NA, Inc. (ITSNA)

MET Laboratories, Inc. (MET)

QPS Evaluation Services Inc.

SGS North America, Inc. (IS & non-incendive only)

Underwriters Laboratories Inc. (UL)

UL is the leading certification body in the US. Unlike the other NRTLS, UL has three levels of certification as follows:

LISTED: Listed means the same as certified or approved. This means a product has been fully investigated to a specific set of construction standards. In hazardous locations, Zone type products must be specifically "Listed" for the location.

CLASSIFIED: Classified products are different than listed products. Products carrying this mark have been evaluated for specific properties. Although UL has a Canadian mark, CSA has no equivalent certification process.

UL's Component Recognition Service covers the testing and evaluation of component products that are incomplete or restricted in performance capabilities. These components will later be used in complete products or systems approved by UL. UL's Component Recognition Service covers components, such as plastics, wire and printed wiring boards that may be used in very specific, or a broad spectrum of end-products, or components such as motors or power supplies. These components are not intended for separate installation in the field, they are intended for use as components of complete equipment submitted for investigation to UL.

CANADA ACCEPTABLE CERTIFICATION MARKS

Standards Council of Canada has accredited multiple NRTLs to approve product for use in Canada

- Canadian Standards Association (CSA)
- ESA Field Evaluation (ESAFE)
- FM Approvals LLC (FM)
- Intertek Testing Services NA, Inc. (ITSNA)
- LabTest Certification Inc.
- MET Laboratories, Inc. (MET)
- QPS Evaluation Services Inc.
- SGS North America, Inc. (IS & non-incendive only)
- Underwriters Laboratories of Canada
- Underwriters Laboratories Inc. (UL)

COMBINATION US AND CANADIAN ACCEPTABLE CERTIFICATION MARKS

The use of dual marking for the US and Canada can be confusing to users. Typically marks contain the letters "US" in the four o'clock position and "C" in the eight o'clock position as identifiers although the positioning of these letters is up to the specific NRTL.

US CERTIFICATION MARKS

CANADIAN CERTIFICATION MARKS

CANADIAN CERTIFICATION MARKS

EUROPEAN ECONOMIC AREA (EEA) REQUIRED CERTIFICATION MARKS

This includes the European Union (EU), the European Free Trade Association (EFTA), Switzerland and Turkey

The CE mark indicates a specific product complies with the applicable European Union (EU) directives that apply to it. Directives for a particular type of product such as electromagnetic compatibility (EMC) or electromagnetic interference (EMI). This mark is self declared by the manufacturer.

The "Hex EX" mark identifies products which are approved to the ATEX Directive. The Ex symbol is accompanied by the name of the testing agency and a report number. All hazardous location products used in the EU must have the Ex mark along with CE and ATEX markings

OTHER COUNTRY SPECIFIC CERTIFICATION REQUIREMENTS

Many other countries have specific requirements for approval to be used in their country. In some cases this is merely an administration procedure, in others additional requirements must be met.

For example,

- Brazil requires Inmetro approval.
- The Russian Federation, Belarus, Kazakhstan, Armenia and Kyrgyzstan recently replaced Gost-R requirement with the need for a Customs Union TR approval.
- India has a combination of the PESO (Petroleum and Explosives Safety Organization) and DGMS (Director General of Mines Safety) approvals to import product

Killark can assist customers in better understanding the global requirements for product certification. Killark offers products that meet most Global requirements

TRADEMARKS

The designs of Killark products are original and proprietary and in many instances are covered by patents.

Killark products are designed to be installed as governed by the National Electric Code. The products are designed to conform with suitable Third Party Certifier standards where such standards exist. Most Killark standard cataloged products are covered by third party certification reports and inspection procedures. These certifications are a matter of record and are indicated by the product identification marking and the certifiers logo. Generally, the marking is required on the product itself, however, under certain circumstances, the marking may be applied to the carton only.

In general, products are Third Party Certified as complete assemblies, however, exceptions do exist. One such exception would be separate shipment of control station cover assemblies and the splice boxes. In some instances, components may be covered (i.e., UL Recognized) for use in other equipment which will be submitted for certification of the complete assembly. The nature of the agreements with Third Party Certifiers requires that product deviations from the originally submitted design be resubmitted for evaluation prior to application of the logo. It is not uncommon for re-submittals to take a substantial length of time.

Generally, Killark's standard cataloged products are covered by one or more of the following Third Party certifiers: Underwriters Laboratories Inc., Factory Mutual Research Corporation, Canadian Standards Association, CENELEC, BASEEFA and PTB. Products covered are indicated by the Third Party Certifiers logo and file number on the individual catalog pages. There may be instances where not all products on a particular page containing a logo are listed. When certification information is required, consult the factory or refer to the appropriate certifier for listings.

HUBBELL®
KILLARK®
Registered Logotype and Trademark of:
Killark
A Division of Hubbell Incorporated (Delaware)
St. Louis, MO USA
Manufacturer of Electrical Products for Hazardous and Non-Hazardous Locations: Fittings, Enclosures, Distribution Equipment, Plugs and Receptacles, Controls and Lighting Fixtures.

K-PAK®
Is a registered trademark identifying Killark Shelf packaging.

CorroSAFE® Electrical Conduit Fittings
CorroSAFE is a trademark identifying a protective coating.

DURALOY® Electrical Conduit Fittings
DURALOY is a trademark identifying a Tri-Coat protective finish used on Iron Electrical Conduit Fittings.

CLENCHER® Cable Connectors
CLENCHER is a registered trademark identifying Killark Cable Connectors.

Z SERIES® Cord Connectors — Cord and Cable Connectors
Z-SERIES is a trademark identifying Killark Cord and Cable Connectors.

SEAL-X® Control Stations
SEAL-X is a registered trademark identifying Killark Factory Sealed Control Stations.

QUANTUM® Enclosures for Hazardous & Hostile Locations
QUANTUM is a registered trademark identifying Killark Electrical Junction Boxes and Enclosures.

PRISM® Enclosures
PRISM is a registered trademark identifying Killark Enclosures, Motor Controls, Disconnect Switches and Panelboards.

ACCEPTOR® Plugs and Receptacles
ACCEPTOR is a registered trademark identifying Killark interchangeable Plug and Receptacle System.

VersaMATE® Plugs & Receptacles
VersaMATE is a registered trademark identifying Killark Pin & Sleeve Plugs and Receptacles.

CERTILITE® Lighting
CERTI*LITE* is a registered trademark identifying Killark Luminaires.

ENVIRORITE® Lighting
ENVIRO*RITE* is a registered trademark identifying Killark Luminaires.

HOSTILELITE® Lighting
HOSTILE*LITE* is a registered trademark identifying Killark Luminaires.

MARIGARD® Lighting
MARI*GARD* is a trademark identifying Killark Stainless Steel Floodlights.

LINEARLITE® * Lighting
* marca registrada MEXICO
LINEAR*LITE* is a trademark identifying Killark Fluorescent Luminaires.

LINEARLITE® * E EMERGENCY
* marca registrada MEXICO
LINEARLITE E is a trademark identifying Killark Emergency Fluorescent Luminaires.

TECHNeTERM® Terminal Enclosures
TECHNeTERM is a registered trademark identifying Killark Increased Safety Terminal Enclosures.

SEAL-XM™ Factory Sealed Control Stations
SEAL-XM is a registered trademark identifying Killark Control Stations.

HAZCON™ Controls
HAZCON is a trademark identifying Killark Factory Sealed Control Stations.

HP20®
HP20 is a trademark identifying RigPower connectors.

MCC-1®
MCC-1 is a trademark identifying RigPower connectors.

RMP® II
RMP is a trademark identifying RigPower connectors.

Secure Mount®
Secure Mount is a trademark identifying RigPower connectors.

StrateLine™
StrateLine is a trademark identifying Vantage connectors.

Vantage® Technology Connectors
Vantage Technology is a trademark identifying Vantage Connectors