

2020 Code Digest

Article 500-516 of the National Electrical Code with product recommendations for use in hazardous (classified) areas



Powering Business Worldwide

2020 Code Digest

Article 500 Hazardous
(Classified) Locations

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Introduction

Foreword

Eaton's Crouse-Hinds has revised its Code Digest for 2020 to meet the needs of design personnel for a ready reference to equipment and installation ideas in hazardous locations. Selected Articles from the *National Electrical Code*® have been explained with diagrams and photographs of electrical hardware taken from our Eaton's Crouse-Hinds Division Product Catalog. Exhaustive laboratory testing and extensive research, development and field experience have proven that these items meet or exceed the requirements set forth by the *National Electrical Code* and UL LLC.®

This latest revision to the series of Eaton's Crouse-Hinds Division service-oriented bulletins reflects the most recent changes in the *National Electrical Code* in Articles 500 through 516. Reproduction of these Articles has been made with the permission of the National Fire Protection Association.

Diagrams of recommended power and lighting installations have been included in Appendices V, VI, VII, VIII, IX and X to assist engineers involved in the design of these systems for hazardous locations. A "Quick-Selector" Guide for electrical equipment used for Class I, Class II and Class III installations is included in Appendix XI. Tables included are those of most frequent applicability and usage. Photographs of actual application of Eaton's Crouse-Hinds series products for a variety of environments have been added for clarity and specific reference.

We sincerely hope that this Digest will be of value to you. Feel free to call on your Eaton's Crouse-Hinds Division representative for personal assistance in your installation planning at any time.

A. The *National Electrical Code* and UL LLC.

The *NEC* is a product of the National Fire Protection Association. It is considered the definitive classification tool and contains explanatory data about flammable gases and combustible dusts as it may apply to storage areas, garages, gasoline stations and other facilities where flammable or combustible materials are found. Specific installation practices have been set up for heavier-than-air vapors. In the case of hydrogen or other gas which has a low vapor density and is used indoors, the most hazardous concentrations are likely to be in the upper portion of the room.

Many states, municipalities and public service companies use the *NEC* as a requirement for their inspectors.

UL LLC. (UL), Canadian Standards Association (CSA), FM Global (FM), and Intertek (ETL), are independent organizations that test for public safety. Their function is to determine whether or not devices and equipment submitted to them are safe and can be used in the *NEC* category for which they were designed. To do this, these agencies maintain extensive laboratory and testing facilities.

It is not the function of these agencies to perform actual enforcement of the National Electric Code. However, as previously indicated, inspection authorities use the certifications and listings from these agencies in carrying out their inspections of hazardous areas.

B. Combustion Principles.

Three basic conditions must be satisfied for a fire or explosion to occur:

1. A flammable liquid, vapor or combustible dust must be present in sufficient quantity.
2. The flammable liquid, vapor or combustible dust must be mixed with air or oxygen in the proportions required to produce an explosive mixture.
3. A source of energy must be applied to the explosive mixture.

In applying these principles, the quantity of the flammable liquid or vapor that may be liberated and its physical characteristics must be recognized.

Vapors from flammable liquids also have a natural tendency to disperse into the atmosphere, and rapidly become diluted to concentrations below the lower flammable limit, particularly when there is natural or mechanical ventilation.

The possibility that the gas concentration may be above the upper flammable limit does not afford any degree of safety, as the concentration must first pass through the flammable range to reach the upper flammable limit.

C. Sources of Ignition.

A source of energy is all that is needed to touch off an explosion when flammable gases or combustible dusts are mixed in the proper proportion with air.

One prime source of energy is electricity. Equipment such as switches, circuit breakers, motor starters, pushbutton stations, or plugs and receptacles, can produce arcs or sparks in normal operation when contacts are opened and closed. This could easily cause ignition.

Other hazards are devices that produce heat, such as luminaires and motors. Here surface temperatures may exceed the safe limits of many flammable atmospheres.

Finally, many parts of the electrical system can become potential sources of ignition in the event of insulation failure. This group would include wiring (particularly splices in the wiring), transformers, impedance coils, solenoids, and other low-temperature devices without make-or-break contacts.

Non-electrical hazards such as sparking metal can also easily cause ignition. A hammer, file or other tool that is dropped on masonry or on a ferrous surface is thus a hazard unless the tool is made of non-sparking material. For this reason, portable electrical equipment is usually made from aluminum or other material that will not produce sparks if the equipment is dropped.

Electrical safety, therefore, is of crucial importance. The electrical installation must prevent accidental ignition of flammable liquids, vapors and dusts released to the atmosphere. In addition, since much of this equipment is used outdoors or in corrosive atmospheres, the material and finish must be such that maintenance costs and shutdowns are minimized.

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I. Classification of Hazardous Atmospheres

A. The National Electrical Code

The *National Electrical Code*, widely used for classification purposes, divides atmospheric explosion hazards into three broad classes that are summarized below. However, it must be understood that considerable skill and judgment must be applied when deciding to what degree an area contains hazardous concentrations of vapors, combustible dusts or easily ignitable fibers and flyings. Many factors, such as temperature, barometric pressure, quantity of release, humidity, ventilation, distance from the vapor source, etc., must be considered. When information on all factors concerned is properly evaluated, a consistent classification for the selection and location of electrical equipment can be developed. For further information on classification of areas see NFPA 497 *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 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

Appendices I and II list flammable gases and combustible dusts which have been classified by NFPA along with their ignition temperatures and other data.

B. Class I Atmospheric Hazards.

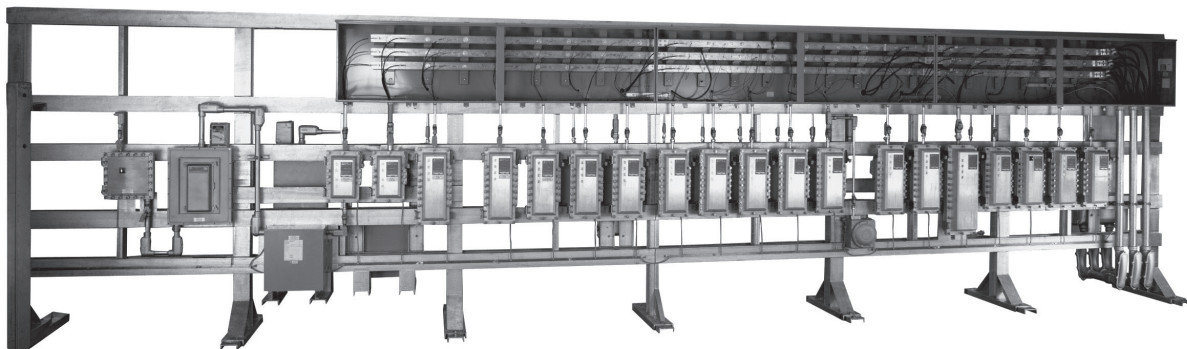
Class I atmospheric hazards are divided not only into the four groups, A, B, C, and D shown in Appendix I, but also into two divisions. Division 1 covers locations where flammable gases or vapors may exist under normal operating conditions, under frequent repair or maintenance operations, or where breakdown or faulty operation of process equipment might also cause simultaneous failure of electrical equipment.

Division 2 covers locations where flammable gases, vapors or volatile liquids are handled either in a closed system, or confined within suitable enclosures, or where hazardous concentrations are normally prevented by positive mechanical ventilation. Areas adjacent to Division 1 locations, into which gases might occasionally flow, would also be Division 2.

The *National Electrical Code* contains an alternate “zone classification” system. For additional information refer to Article 505, beginning on page 51.



TMCX II cable fittings for hazardous locations



Class I, Division 2 switchrack

C. Class II Atmospheric Hazards.

Class II atmospheric hazards cover three groups of combustible dusts, summarized in Appendix II. The groups are based on the type of material: Group E metallic, Group F carbonaceous, or Group G organic. Whether an area is Division 1 or 2 depends on the quantity of dust present, except that for Group E there is only Division 1.

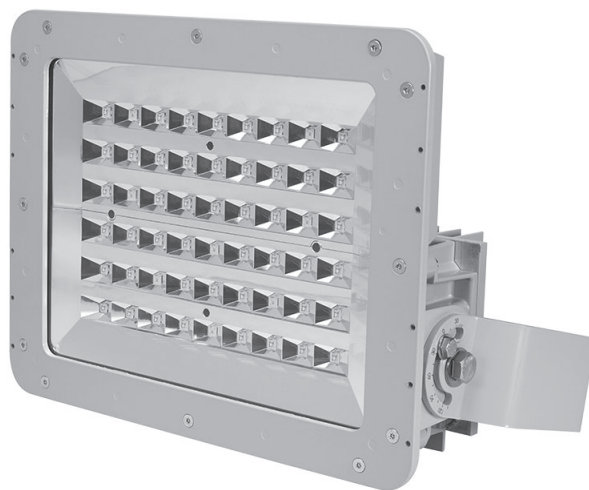
D. Class III Atmospheric Hazards.

Class III atmospheric hazards cover locations where combustible fibers/flyings are present but not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures. Division 1 is where they are manufactured and Division 2 is where they are stored.

E. Evaluation of Hazardous Areas.

Each area that contains gases or dusts that are considered hazardous must be carefully evaluated to make certain the correct electrical equipment is selected. Many hazardous atmospheres are Class I, Group D, or Class II, Group G. However, certain areas may involve other groups, particularly Class I, Groups B and C. Conformity with the *National Electrical Code* requires the use of fittings and enclosures approved for the specific hazardous gas or dust involved.

For Class I and Class II equipment consult the Eaton's Crouse-Hinds Catalog or your Eaton's Crouse-Hinds field representative.



Champ® FMVA floodlights provide full-spectrum, crisp white light for industrial or hazardous locations

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II. Prevention of External Ignition and Explosion

A. Enclosures.

In Class I, Division 1 and 2 locations, conventional relays, contactors and switches which have arcing contacts must be enclosed in explosionproof housings, except for those few cases where general-purpose enclosures are permitted by the *NEC*.

The *NEC* defines “**Explosionproof Apparatus**. Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor that may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and that operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.”

These enclosures must prevent the ignition of an explosive gas or vapor that may surround it. In other words, an explosion inside the enclosure must be prevented from starting a larger explosion on the outside.

Adequate strength is one requirement for such an enclosure. For explosionproof equipment, a test safety factor of 4 is used; i.e., the enclosure must withstand a hydrostatic pressure test of four times the maximum pressure from an explosion within the enclosure.

In addition to being strong, the enclosure must be “flame-tight.” This term does not imply that the enclosure is hermetically sealed but rather that the joints or flanges are held within narrow tolerances. These carefully machined joints cool the hot gases resulting from an internal explosion so that by the time they reach the outside hazardous atmosphere, they are not hot enough to cause ignition.

The strains and stresses caused by internal explosive pressures are illustrated in Figure 1. Dotted lines indicate the shape that a rectangular enclosure strives to attain under these conditions. Openings in an enclosure for these applications can be threaded-joint type (Figure 2) or flat-joint type (Figure 3).

In Class II locations the enclosure must keep the dust out of the interior and operate at a safe surface temperature. Since there will be no internal explosions, the enclosure may have thinner wall sections. The construction of these enclosures is known as dust-ignitionproof.

The *NEC* defines “**Dust-ignitionproof**. Equipment enclosed in a manner that excludes dusts and does not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.”

B. Purged and Pressurized Systems.

The *NEC* defines “**Purged and Pressurized**. The process of (1) purging, supplying an enclosure with a protective gas at a sufficient flow and positive pressure to reduce the concentration of any flammable gas or vapor initially present to an acceptable level; and (2) pressurization, supplying an enclosure with a protective gas with or without continuous flow at sufficient pressure to prevent the entrance of a flammable gas or vapor, a combustible dust, or an ignitable fiber.”

Purged and Pressurized Systems permit the safe operation of electrical equipment under conditions of hazard for which approved equipment may not be commercially available.

For instance, most switchgear units and many large-size motors do not come in designs listed for Class I, Groups A and B.

Whether cast metal enclosures for hazardous locations or sheet metal enclosures with pressurization should be used is mainly a question of economics, if both types are available. As a typical example, if an installation had many electronic instruments that could be enclosed in a single sheet metal enclosure, the installation would lend itself to the Purged and Pressurized System. However, if the instruments, due to their nature, had to be installed in separate enclosures, then the cast metal, hazardous location housing would almost invariably prove more economical.

Pressurized enclosures require:

- A source of clean air or inert gas.
- A compressor to maintain the required pressure on the system.
- Pressure control valves, to prevent the power from being applied before the enclosures have been purged, and to de-energize the system should pressure fall below a safe value.

In addition, door-interlock switches are required to prevent access to the equipment while the circuits are energized. It can readily be seen that all of these accessories can add up to a considerable expenditure.

C. Intrinsically Safe Equipment.

The use of intrinsically safe equipment is primarily limited to process control instrumentation since these electrical systems lend themselves to low energy requirements. ANSI/UL 913-2015 provides information on the design, testing and evaluation of this equipment. Installation requirements are covered in Article 504 of the *NEC*. Intrinsically safe equipment and wiring are incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration.

Intrinsically safe energy levels are sufficient for most instruments. This operating energy is supplied from the safe area to the protected instrument. Output from the instrument is returned to a processor back in an unclassified location. Preventing increased energy levels such as faults or spikes from the hazardous area, an energy-bleeding interface is used in the circuitry. These devices safely bleed excess energy to an electrical ground.

UL LLC, Canadian Standards Association and FM Global list various devices in this category. The equipment and its associated wiring must be installed so they are positively separated from the non-intrinsically safe circuits. Induced voltages could defeat the concept of intrinsically safe circuits.

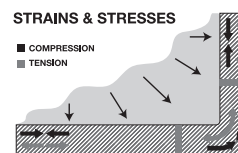
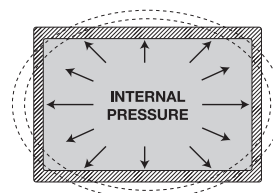


Figure 1. Explosive forces

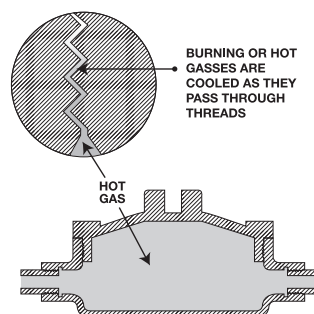


Figure 2. Threaded-joint opening

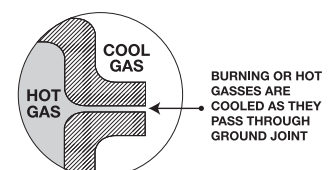


Figure 3. Flat-joint opening

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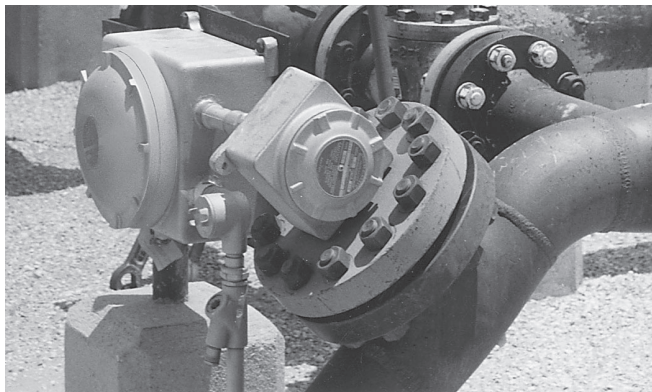
III. Equipment for Hazardous Areas

A. Switchgear and Industrial Controls.

A wide variety of explosionproof or dust-ignitionproof electrical control equipment is available for Class I or II areas, respectively. There are also many dual-rated pushbutton stations, motor controls and branch circuit breakers that are suitable for use in both these locations.

In exposed, but unclassified areas, industrial controls are frequently installed in cast-metal enclosures selected for maximum protection against corrosion and the weather. Additional coatings and vapor-phase inhibitors enhance this protection.

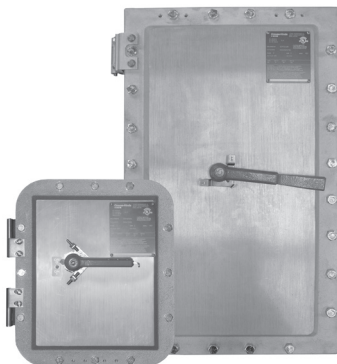
Typical Explosionproof Electrical Controls.



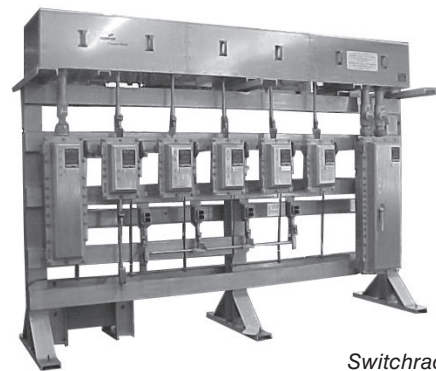
Junction boxes and seals on test manifold



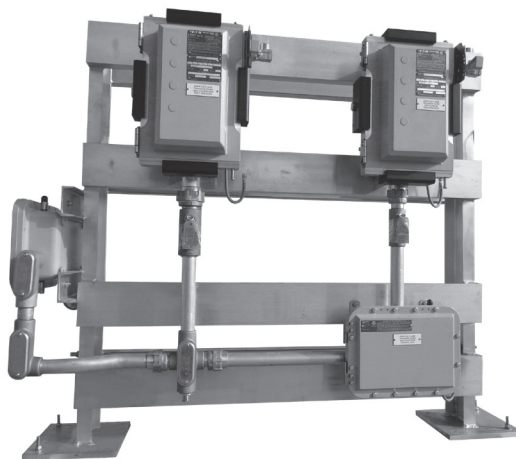
EBMXC series combination starter and breaker



EID/EIDC disconnect assembly



Switchrack assembly



Switchrack assembly with EBMX clamped enclosures



EGL static grounding indicator



EGL clamp

B. Luminaires (Lighting Fixtures).

The *National Electrical Code* uses the term “luminaire” in place of “lighting fixture” and its variations. It is a more internationally accepted term and is also widely used in the lighting industry in North America. This publication will also use that term.

Hazardous area lighting is primarily concerned with functional illumination without regard to the symmetry of installation. The present trend is to classify many lighting areas as Division 2.

While incandescent lighting is still used, the more efficient LED, high intensity discharge and fluorescent type luminaires are being specified for most new installations.

Local lighting is required in many areas. If these areas are Class I, Division 1, luminaires suitable for use in these locations must be used. In Class I, Division 2 areas a luminaire specifically designed and tested for this location is frequently used. It is also permitted to use a luminaire suitable for Class I, Division 1.

Since luminaires are heat-producing devices, operating temperatures are very important to consider when designing a hazardous location lighting system.

Table 500.8(C) of the *NEC* requires the temperature of the luminaire to not exceed the ignition temperature of the specific gas or vapor to be encountered. The limits are based on a 40°C (104°F) ambient temperature while the device is operating continuously at full rated load, voltage and frequency. See Appendix I for additional information.

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III. Equipment for Hazardous Areas

Eaton's Crouse-Hinds luminaires for Class I, Division 1 locations are approved with an explosionproof chamber for the wiring that is separated or sealed from the lamp compartment. This is called "factory-sealed" and, as a result, no separate seal is required adjacent to the luminaires.

When luminaires are used in Class I, Division 2 locations, the *NEC* permits them to operate up to the ignition temperature of the gas or vapor involved if they have been tested and found incapable of igniting the gas or vapor.

Standard fluorescent luminaires are generally used for control room lighting, while strategically located floodlights have found wide usage in general area lighting for outdoor areas.

In Class II, Division 1 a dust-ignitionproof luminaire must be used. The maximum surface temperature of the luminaire must be in accordance with Table 500.8(C) when covered with a layer of dust.

In locations where a flammable gas and a combustible dust are simultaneously present, heat-producing equipment such as luminaires must operate safely in the presence of the gas and with a dust blanket.



This rating is quite different from being approved for Class I or II locations only.

To make sure the safe operating temperatures of the luminaire will not be exceeded, maintenance personnel should always be sure to use the proper lamp specified by the manufacturer on the luminaire nameplate.



HAZARD•GARD® EVM series integrally ballasted H.I.D. luminaires for Class I and Class II areas



EVLED series luminaires for Class I areas – LED

C. Motors and Generators.

Since electric motors are needed to drive pumps, compressors, fans, blowers, and conveyors, their presence in hazardous atmospheres is frequently unavoidable.

The selection of the proper type of motor is important, since this has a considerable effect on the initial cost. The types of hazardous atmospheres and corrosive conditions are both major factors in this selection, as they dictate the degree of protection needed to avoid excessive maintenance and expensive shutdowns.

Corrosive and environmental conditions vary between areas in plants; consequently, no single type of motor construction will suffice for all applications. The types available vary all the way from "drip-proof" to "totally enclosed and fan cooled" motors. In Class I, Division 1 locations, only the explosionproof, totally enclosed and pressurized with clean air, totally enclosed inert gas filled and special submerged type motors may be used.

It should not be assumed that motors and controls designed for one Gas Group are suited for use in a hazardous location of a different Group.

Motors for use in Class I, Division 2 locations in which sliding contacts, switching mechanisms, or integral resistance devices are employed, must also be explosionproof or pressurized. Open type motors such as squirrel-cage induction motors without any arcing devices may be used in Class I, Division 2.

UL has issued a procedure for the repair of listed explosionproof motors. The manufacturer of the motor should be consulted as to which repair shops have been authorized to make the necessary repairs. Unauthorized maintenance of an explosionproof motor may result in voiding the manufacturer's warranty.

Vaporgard™ and CHAMP® series luminaires for Class I, Division 2 and Class II areas

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III. Equipment for Hazardous Areas

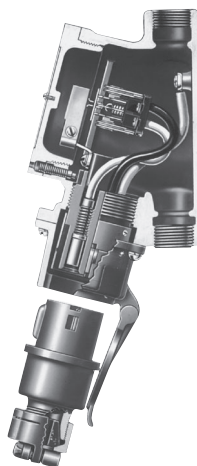
D. Plugs and Receptacles.

In the majority of explosionproof devices, all of the current-carrying parts are inside the enclosure. However, in plugs and receptacles, contact must be made outside of the enclosure. The problem is to make such a device safe for use in explosive atmospheres. Two different methods can be used:

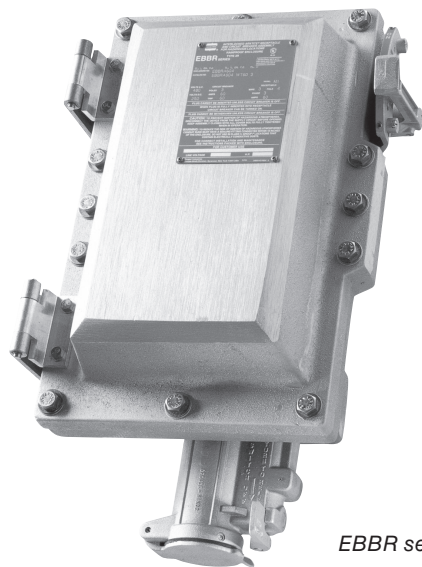
1. **INTERLOCKED, DEAD FRONT**– Receptacle contacts are interlocked with a switch located in an explosionproof enclosure. Receptacle contacts will not be live when the plug is inserted or withdrawn.
2. **DELAYED ACTION** – The plug and receptacle are so constructed that any electrical arcs that may occur at the contacts will be confined inside explosionproof chambers. This design also prevents the rapid withdrawal of the plug from the receptacle, thereby giving any heated metal parts or particles time to cool before they come in contact with the surrounding explosive atmosphere.

Both designs are practical and widely used, although the interlocked dead front type is prevalent.

There is also a wide variety of plugs and receptacles suitable for Class II locations.



Receptacle constructed with an interlocked switch. Rotating the plug after insertion actuates this switch. This is also referred to as “dead front.”



EBBR series

E. Portable Devices.

The design of portable units for use in hazardous locations must permit ready replacement of approved types of flexible cord when the cord becomes damaged. Hence, it is usual to have a separate compartment or connector for the cord connections outside the explosionproof compartment.

In many plants, the use of portable equipment is restricted as much as possible. When it is used, explosionproof construction is specified.

The *National Electrical Code* (250.114(1), 501.145, 502.145, and 503.145) requires that all portable equipment operated in hazardous locations be grounded by means of a separate grounding conductor in cord listed for extra-hard usage.

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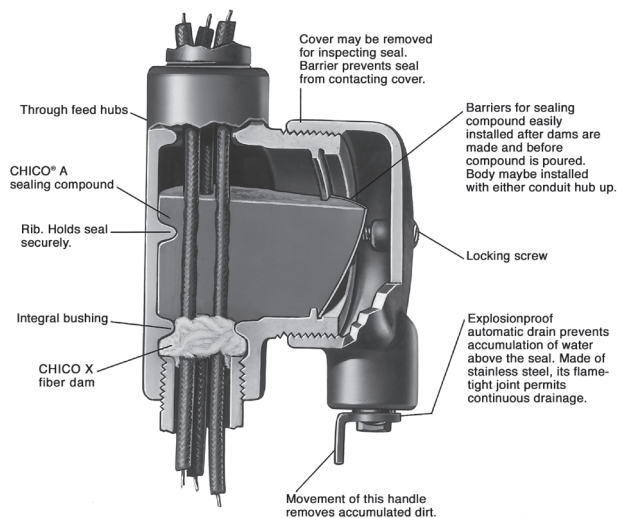
IV. Wiring Methods and Materials

A. Conduit.

In Class I, Division 1, locations, all conduit must be rigid metal or steel IMC with at least five full tapered threads tightly engaged in the enclosure. (An exception to 500.8(E) allows 4-1/2 for factory threaded NPT entries.) All factory-drilled and tapped Crouse-Hinds enclosures satisfy this requirement. When field drilling and tapping is performed it may be required to drill and tap deeper than standard NPT to insure engagement of five full threads. For further information contact your Crouse-Hinds field representative.

A common method of wiring employs thick-walled conduit with a corrosion-resistant finish. In addition to the protective finish on the conduit, various types of paints or special finishes are used extensively to give extra protection from corrosive atmospheres.

Alternate changes in temperature and barometric pressure cause “breathing” — the entry and circulation of air throughout the conduit. As joints in a conduit system and its components are seldom tight enough to prevent this breathing, moisture in the air condenses and collects at the base of vertical conduit runs and equipment enclosures. This could cause equipment shorts or grounds. To eliminate this condition, inspection fittings should be installed and equipped with explosionproof drains to automatically drain off the water.



EZD drain seal

B. Seals for Conduit System.

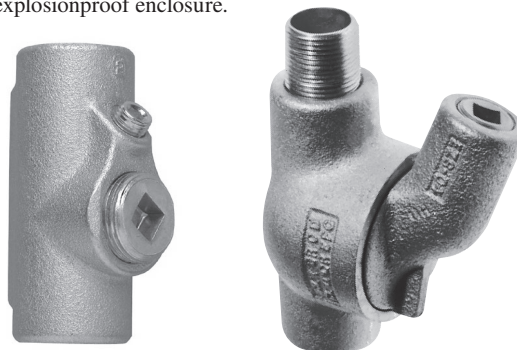
NEC 501.15 requires that sealing fittings filled with approved compound be installed in conduits entering explosionproof enclosures. Seals are necessary to limit volume, to prevent an explosion from traveling throughout the conduit system, to minimize gases or vapors from moving from a hazardous to a nonhazardous area through connecting raceways or from enclosure to enclosure, and to stop pressure piling — the buildup of pressure inside conduit lines caused by precompression as the explosion travels through the conduit. (See Appendix III — Selection of Seals and Drains.)

The standard type seals are not intended to prevent the passage of liquids, gases or vapors at pressures continuously above atmospheric. Temperature extremes and highly corrosive liquids and vapors may affect the ability of seals to perform their intended function.

In hazardous locations, seals are needed in the following instances:

- Where the conduit enters an enclosure that houses arcing or high-temperature equipment. (A seal must be within 18 inches or closer if the manufacturer's instructions so specify of the enclosure it isolates.)
- Where the conduit enters enclosures that house terminals, splices or taps, if the conduit is 2-inch trade size or larger.
- Where the conduit leaves a Division 1 area or passes from a Division 2 hazardous area to a nonhazardous location.

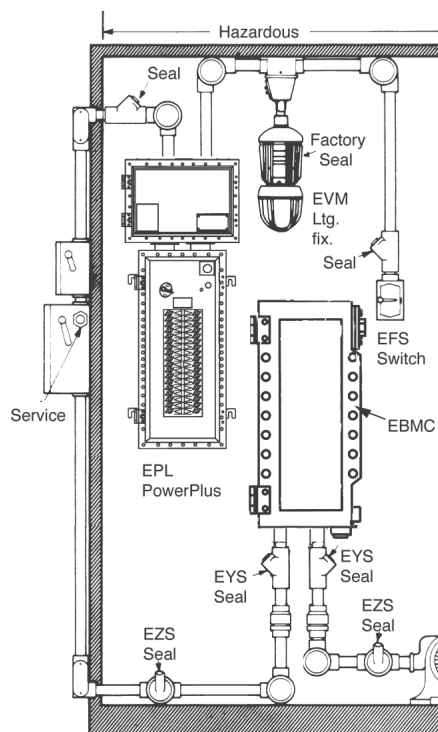
NEC 501.15(A)(1) permits explosionproof unions, couplings, reducers, elbows, and capped elbows to be placed between the seal and the explosionproof enclosure.



EYSX series –
For sealing in vertical or horizontal conduit runs. Class I, Groups A, B, C, D, and Class II, Groups E, F, and G.

EZS series –
For conduits running at any angle between vertical and horizontal. Class I, Groups C, D, and Class II, Groups E, F, and G.

Typical sealing in Class I, Division 1 location



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IV. Wiring Methods and Materials

C. Mineral-Insulated Cable.

Another type of wiring system suitable for Division 1 is mineral-insulated (MI) cable. Mineral-insulated wiring consists of copper conductors properly spaced and encased in tightly compressed magnesium oxide, clad in an overall copper sheath.

Below the melting temperature of the copper sheath, MI cable is impervious to fire. Because of limitations on end connections, its operating range is generally considered to be -40 to 80°C with standard terminals, and up to 250°C with special terminals.

When properly installed, MI cable is suitable for all Class I and Class II locations.

MI cable is available with one to 17 conductors, making it most suitable for wiring of control boards, control components and instrumentation circuits where crowded conditions make conduit installations difficult and expensive.

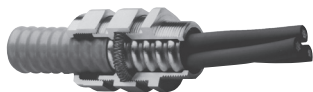
MI cable is hygroscopic; therefore, moisture can be a problem when the ends are left exposed. Care must be taken to install and seal the end fittings as soon as possible to prevent moisture accumulation. If moisture enters, the end must be cut off or dried out with a torch.

D. Metal-Clad Cable.

Metal-clad cable (Type MC) is permitted by the *National Electrical Code* for application in Class I, Division 2 locations.

Use of this type of cable is not limited to any voltage class. The armor itself is available in various metals. When further protection from chemical attack is needed, a supplemental protective jacket may be used.

The *NEC* also permits, under certain restrictions, a particular kind of metal-clad cable (MC-HL) to be used in Class I, Division 1 locations. This is detailed in 501.10(A)(1)(c). Similarly, 501.10(A)(1)(d) permits a certain type of Instrumentation Tray Cable (ITC-HL)



TMC Terminator™ cable fittings for use with Type MC jacketed metal-clad cables with interlocked or corrugated armor in unclassified locations and certain Class I, Division 2 applications.



TMCX II Terminator cable fittings are suitable for use with Type MC jacketed metal-clad cables with interlocked or corrugated armor and Type TC tray cable in Class I, Division 2, Groups A, B, C, and D locations. TMCX fittings are suitable for use with Type MC-HL and Type ITC-HL cable listed for use in Class I, Division 1.

E. Tray Cable.

Power and control tray cable (Types PLTC, PLTC-ER, ITC, ITC-ER, TC and TC-ER) are permitted in Class I, Division 2 locations. It is a factory assembly of two or more insulated conductors with the grounding conductor under a nonmetallic sheath.



CGB cable fitting



ADE-1F2 cable fitting

The *NEC* also permits, under certain restrictions, particular types of Instrumentation Tray Cable (ITC-HL) and Tray Cable Exposed Run (TC-ER-HL) to be installed in Class I, Division 1 locations. These uses are detailed in 501.10(A)(1)d and 501.10(A)(2)(3) respectively.



ADE-1FC cable fitting



TMCX II Terminator cable fitting

F. Other Permitted Cables.

In Class I, Division 2 locations, the *NEC* also recognizes the use of Type PLTC, similar to TC, also Type MV, a single or multiconductor solid dielectric insulated cable rated 2001 volts or higher. The *NEC* also permits Type ITC cable, as covered by Article 727, Instrumentation Tray Cable, which details its construction and use. The *NEC* also permits Type P and Type PLTC-ER cable and elevator cable EO, ETP, and ETT.

G. Cable Sealing.

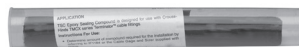
In Class I, Division 1 locations the use of cable, except types MI, MC-HL, ITC-HL, TC-ER-HL and Type P, is limited to installation in conduit. Multiconductor cables that cannot transmit gases through the cores are sealed as single conductors; this type of cable, however, is not readily available. If a cable can transmit gases through its core, the outer jacket must be removed so that the sealing compound surrounds each individual insulated conductor and the jacket, or it can be sealed as a single conductor if the cable end in the enclosure is sealed by an approved means. Crouse-Hinds TSC epoxy is such a means.

In Class I, Division 2 locations cables must be sealed where they enter enclosures required to be explosionproof. As mentioned previously, TMCX fittings are recommended where Type MC, ITC, ITC-ER, ITC-HL, TC, TC-ER, TC-ER-HL, PLTC and PLTC-ER cables are used.

If attached to equipment that may cause a pressure at a cable end, a sheathed cable that can transmit gases through its core must be sealed to prevent migration of gases into an unclassified area.



TMCX II Terminator cable fitting



TSC sealing compound



LSC liquid sealing compound



H. Nonmetallic Conduit.

Under certain restrictions, in Class I, Division 2 locations, reinforced thermosetting resin conduit (RTRC) and Schedule 80 PVC conduit and associated fittings may be used.

I. Other Types.

Under certain restrictions, in Class I, Division 2 locations, optical fiber cable (OFNP, OFCP, OFNR, OFCR, OFNG, OFN, and OFC) are allowed as is cablebus.

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V. Maintenance Principles

Chapter 5 of the *NEC* requires equipment to be constructed and installed in such a way as to insure safe performance under conditions of proper use and maintenance.

It is important that the following points be checked carefully:

A. Electrical Circuits.

Electrical equipment should be serviced or disassembled only after first de-energizing the electrical supply circuits. This also applies when luminaires or units are partially disassembled for relamping. All electrical enclosures should be tightly reassembled before the supply circuits are re-energized.

B. Assembly or Disassembly of Enclosures.

Hammers or prying tools must not be allowed to damage the flat-joint surfaces. Do not handle covers roughly, or place them on surfaces that might damage or scratch the flat-joint surfaces. Protect all surfaces that form a part of the flame path from damage. In storing equipment, always make sure that covers are assembled to their mating bodies.

C. Cover Attachment Screws.

All cover screws and bolts intended to hold explosionproof joints firmly together must always be tight while circuits are live. Leaving screws or bolts loose may make the equipment unsafe. Care should be taken to use only bolts or screws provided by the equipment manufacturer, as the substitution of other types of material may weaken the assembly and make it unsafe.

D. Cleaning and Lubrication.

Particles of foreign material should not be allowed to accumulate on flat or threaded joints as these materials tend to prevent a close fit and may permit dangerous arcs, sparks or flames to propagate through them.

When assembling, remove all old grease, dirt, paint or other foreign material from the surfaces, using a brush and kerosene or a similar solvent with a flash point higher than 38°C (100°F). A film of light oil or lubricant of a type recommended by the equipment manufacturer should be applied to both body and cover joint.

Any lubricated joints exposed for long periods of time may attract small particles of dirt or other foreign material. To avoid this, body and cover joints should be reassembled immediately.

Threaded joints should be tightened sufficiently to prevent accidental loosening due to vibration, but they should not be forced. If the threads are kept clean and lubricated, safe operation can be assured with a minimum of maintenance.

E. Shaft and Bearing Surfaces.

Because a rotating shaft must turn freely, the clearance between shaft and bearing is carefully established within close tolerances by the equipment manufacturer. This clearance should be maintained to prevent flames or sparks from escaping to the external hazardous atmosphere. Always follow the manufacturer's recommendations with respect to lubrication and other servicing.

F. Corrosive Locations.

Threaded covers, flat joints, surfaces, rotating shafts, bearings and operating shafts should be well lubricated. If corrosion products have accumulated on explosionproof joints or surfaces and cannot readily be removed with solvents, the parts should be discarded and replaced. Never use an abrasive material or a file to remove the corrosion products from threaded or flat-joint surfaces. In extremely corrosive locations, equipment should be periodically inspected to guard against unusual deterioration and possible porosity, since this may weaken the enclosure structurally.

G. Portable Equipment.

The extra-hard-usage flexible cord that must be used with this equipment should be examined frequently and replaced at the first indication of mechanical damage or deterioration. Terminal connections to the cord must be properly maintained. In general, where portable equipment is necessary, avoid rough handling and inspect the assembly frequently.

H. Overall Safety.

Safety in hazardous locations may be compromised if additional openings or other alterations are made in assemblies specifically designed for use in these locations.

In painting the exterior of housings for hazardous locations, care should be taken not to obscure the nameplate, which may contain cautionary or other information of importance to maintenance personnel.

I. Plug-in Replacement Units.

One technique that speeds and eases the work of the maintenance department is the use of plug-in type electrical equipment that allows the substitution of a replacement unit while the original unit is being repaired outside the hazardous area.

J. Maintenance.

Eaton's Crouse-Hinds Division recommends an Electrical Preventive Maintenance Program as described in the National Fire Protection Association Bulletin NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance* (www.nfpa.org).

Code Digest Preface:

The following pages contain, in red print and a type font known as Helvetica, Articles 500 through 516 from the 2020 *National Electrical Code*. Diagrams that are part of the *NEC* have a red border around them.

Changes in the 2020 edition of the National Electrical Code are indicated by gray shading.

A **Δ** before a section number indicates that words within that section were deleted and a **Δ** to the left of a table or figure number indicates a revision to an existing table or figure. When a chapter was heavily revised, the entire chapter is marked throughout with the **Δ** symbol.

New sections, figures, tables or articles in the 2020 edition of the *National Electrical Code* are indicated by a shaded "**N**".

Bullets in the margin identify the location where material in the 2020 *National Electrical Code* was deleted.

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Eaton's Crouse-Hinds Division explanatory text and diagrams are in black and Times New Roman font to differentiate them from *NEC* material. Photographs and Appendices are not part of the *NEC*.

The National Fire Protection Association did not produce, review or approve this digest and assumes no responsibility for the application or use of any NEC related material or product set out herein.

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VI. Selected Articles from the National Electrical Code® – 2020

ARTICLE 500 Hazardous (Classified) Locations, Classes I, II, and III, Divisions 1 and 2

Article 500

500.1 Scope — Articles 500 Through 504.

Articles 500 through 504 cover the requirements for electrical and electronic equipment and wiring for all voltages in Class I, Divisions 1 and 2; Class II, Divisions 1 and 2; and Class III, Divisions 1 and 2 locations where fire or explosion hazards may exist due to flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, combustible dusts, or ignitable fibers/flyings.

Informational Note No. 1: The unique hazards associated with explosives, pyrotechnics, and blasting agents are not addressed in this article.

Informational Note No. 2: For the requirements for electrical and electronic equipment and wiring for all voltages in Zone 0, Zone 1, and Zone 2 hazardous (classified) locations where fire or explosion hazards may exist due to flammable gases or vapors or flammable liquids, refer to Article 505.

Informational Note No. 3: For the requirements for electrical and electronic equipment and wiring for all voltages in Zone 20, Zone 21, and Zone 22 hazardous (classified) locations where fire or explosion hazards may exist due to combustible dusts or ignitable fibers/flyings, refer to Article 506.

Informational Note No. 4: Text that is followed by a reference in brackets has been extracted from NFPA 497-2017, *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 499-2017, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installation in Chemical Process Areas*. Only editorial changes were made to the extracted text to make it consistent with this Code.

500.3 Other Articles.

Except as modified in Articles 500 through 504, all other applicable rules contained in this Code shall apply to electrical equipment and wiring installed in hazardous (classified) locations.

500.4 Documentation.

All areas designated as hazardous (classified) locations shall be properly documented. This documentation shall be available to those authorized to design, install, inspect, maintain, or operate electrical equipment at the location.

Informational Note No. 1: For further information on the classification of locations, see NFPA 30-2018, *Flammable and Combustible Liquids Code*; NFPA 32-2016, *Standard for Drycleaning Facilities*; NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*; NFPA 34-2018, *Standard for Dipping, Coating and Printing Processes Using Flammable or Combustible Liquids*; NFPA 35-2016, *Standard for the Manufacture of Organic Coatings*; NFPA 36-2017, *Standard for Solvent Extraction Plants*; NFPA 45-2019, *Standard on Fire Protection for Laboratories Using Chemicals*; NFPA 55-2016, *Compressed Gases and Cryogenic Fluids Code*; NFPA 58-2017, *Liquefied Petroleum Gas Code*; NFPA 59-2018,

Utility LP-Gas Plant Code; NFPA 497-2017, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*; NFPA 499-2017, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*; NFPA 820-2016, *Standard for Fire Protection in Wastewater Treatment and Collection Facilities*; ANSI/API RP 500-2012, *Recommended Practice for Classification of Locations of Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*; and ISA-12.10-1988, *Area Classification in Hazardous (Classified) Dust Locations*.

Informational Note No. 2: For further information on protection against static electricity and lightning hazards in hazardous (classified) locations, see NFPA 77-2019, *Recommended Practice on Static Electricity*; NFPA 780-2017, *Standard for the Installation of Lightning Protection Systems*; and API RP 2003-2015, *Protection Against Ignitions Arising Out of Static Lightning and Stray Currents*.

Informational Note No. 3: For further information on ventilation, see NFPA 30-2018, *Flammable and Combustible Liquids Code*; and ANSI/API RP 500-2012, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*.

Informational Note No. 4: For further information on electrical systems for hazardous (classified) locations on offshore oil- and gas-producing platforms, drilling rigs, and workover rigs, see ANSI/API RP 14F-2018, *Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Division 1 and Division 2 Locations*.

Informational Note No. 5: Portable or transportable equipment having self-contained power supplies, such as battery-operated equipment, could potentially become an ignition source in hazardous (classified) locations. See ANSI/UL 121203-2011, *Standard for Portable Electronic Products Suitable for Use in Class I and II, Division 2, Class I Zone 2 and Class III, Division 1 and 2 Hazardous (Classified) Locations*.

Informational Note No. 6: For information on electrical resistance trace heating for hazardous (classified) locations, see ANSI/UL 60079-30-1-2017, *Explosive Atmospheres — Electrical Resistance Trace Heating — General and Testing Requirements*, and ANSI/IEEE 60079-30-2-2015, *IEEE/IEC International Standard for Explosive atmospheres — Part 30-2: Electrical resistance trace heating — Application guide for design, installation, and maintenance*.

Informational Note No. 7: For information on electric skin effect trace heating for hazardous (classified) locations, see IEEE 844.1-2017/CSA C22.2 No. 293.1-17, *IEEE/CSA Standard for Skin Effect Trace Heating of Pipelines, Vessels, Equipment, and Structures — General, Testing, Marking, and Documentation Requirements*, and IEEE 844.2-2017/CSA C293.2-17, *IEEE/CSA Standard for Skin Effect Trace Heating of Pipelines, Vessels, Equipment, and Structures — Application Guide for Design, Installation, Testing, Commissioning, and Maintenance*.

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Article 500 Hazardous (Classified) Locations

• 500.5 Classifications of Locations.

▲ (A) General. 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 could 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.

Informational Note: Through the exercise of ingenuity in the layout of electrical installations for hazardous (classified) locations, it is frequently possible to locate much of the equipment in a reduced level of classification or in an unclassified location and, thus, to reduce the amount of special equipment required.

Refrigerant machinery rooms that contain ammonia refrigeration systems and are equipped with adequate mechanical ventilation that operates continuously or is initiated by a detection system at a concentration not exceeding 150 ppm shall be permitted to be classified as “unclassified” locations.

Informational Note: For further information regarding classification and ventilation of areas involving closed-circuit ammonia refrigeration systems, see ANSI/IIAR 2-2014, Standard for Safe Design of Closed-Circuit Ammonia Refrigeration Systems.

(B) Class I Locations. Class I locations are those in which flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations shall include those specified in 500.5(B)(1) and (B)(2).

(1) Class I, Division 1. A Class I, Division 1 location is a location:

- (1) In which ignitable concentrations of flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors can exist under normal operating conditions, or
- (2) In which ignitable concentrations of such flammable gases, flammable liquid–produced vapors, or combustible liquids above their flash points may exist frequently because of repair or maintenance operations or because of leakage, or
- (3) In which breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition

Informational Note No. 1: This classification usually includes the following locations:

- (1) Where volatile flammable liquids or liquefied flammable gases are transferred from one container to another
- (2) Interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used
- (3) Locations containing open tanks or vats of volatile flammable liquids
- (4) Drying rooms or compartments for the evaporation of flammable solvents
- (5) Locations containing fat- and oil-extraction equipment using volatile flammable solvents
- (6) Portions of cleaning and dyeing plants where flammable liquids are used

- (7) Gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape
- (8) Inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids
- (9) The interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers
- (10) All other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations

Informational Note No. 2: In some Division 1 locations, ignitable concentrations of flammable gases or vapors may be present continuously or for long periods of time. Examples include the following:

- (1) The inside of inadequately vented enclosures containing instruments normally venting flammable gases or vapors to the interior of the enclosure
- (2) The inside of vented tanks containing volatile flammable liquids
- (3) The area between the inner and outer roof sections of a floating roof tank containing volatile flammable fluids
- (4) Inadequately ventilated areas within spraying or coating operations using volatile flammable fluids
- (5) The interior of an exhaust duct that is used to vent ignitable concentrations of gases or vapors

Experience has demonstrated the prudence of avoiding the installation of instrumentation or other electrical equipment in these particular areas altogether or where it cannot be avoided because it is essential to the process and other locations are not feasible [see 500.5(A), Informational Note] using electrical equipment or instrumentation approved for the specific application or consisting of intrinsically safe systems as described in Article 504.

▲ (2) Class I, Division 2. A Class I, Division 2 location is a location:

- (1) In which volatile flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems or in case of abnormal operation of equipment, or
- (2) In which ignitable concentrations of flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors are normally prevented by positive mechanical ventilation and which might become hazardous through failure or abnormal operation of the ventilating equipment, or
- (3) That is adjacent to a Class I, Division 1 location, and to which ignitable concentrations of flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors above their flash points might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

Informational Note No. 1: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but that, in the judgment of the authority having jurisdiction, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

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Informational Note No. 2: Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Depending on factors such as the quantity and size of the containers and ventilation, locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers may be considered either hazardous (classified) or unclassified locations. See NFPA 30-2018, *Flammable and Combustible Liquids Code*, and NFPA 58-2017, *Liquefied Petroleum Gas Code*.

(C) Class II Locations. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations shall include those specified in 500.5(C)(1) and (C)(2).

Class II, Division 1. A Class II, Division 1 location is a location:

- (1) In which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitable mixtures, or
- (2) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electrical equipment, through operation of protection devices, or from other causes, or
- (3) In which Group E combustible dusts may be present in quantities sufficient to be hazardous **in normal or abnormal operating conditions**.

Informational Note: Dusts containing magnesium or aluminum are particularly hazardous, and the use of extreme precaution is necessary to avoid ignition and explosion.

(2) Class II, Division 2. A Class II, Division 2 location is a location:

- (1) In which combustible dust due to abnormal operations may be present in the air in quantities sufficient to produce explosive or ignitable mixtures; or
- (2) Where combustible dust accumulations are present but are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but could as a result of infrequent malfunctioning of handling or processing equipment become suspended in the air; or
- (3) In which combustible dust accumulations on, in, or in the vicinity of the electrical equipment could be sufficient to interfere with the safe dissipation of heat from electrical equipment, or could be ignitable by abnormal operation or failure of electrical equipment.

Informational Note No.1: The quantity of combustible dust that may be present and the adequacy of dust removal systems are factors that merit consideration in determining the classification and may result in an unclassified area.

Informational Note No.2: Where products such as seed are handled in a manner that produces low quantities of dust, the amount of dust deposited may not warrant classification.

(D) Class III Locations. Class III locations are those that are hazardous because of the presence of easily ignitable fibers or where materials producing combustible flyings are handled, manufactured, or used, but in which such fibers/flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Class III locations shall include those specified in 500.5(D)(1) and (D)(2).

(1) Class III, Division 1. A Class III, Division 1 location is a location in which easily ignitable fibers/flyings are handled, manufactured, or used.

Informational Note No. 1: Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fibers/flyings manufacturing and processing plants; cotton gins and cotton-seed mills; flax-processing plants; clothing manufacturing plants; woodworking plants; and establishments and industries involving similar hazardous processes or conditions.

Informational Note No. 2: Easily ignitable fibers/flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature.

(2) Class III, Division 2. A Class III, Division 2 location is a location in which easily ignitable fibers/flyings are stored or handled other than in the process of manufacture.

500.6 Material Groups.

For purposes of testing, approval, and area classification, various air mixtures (not oxygen-enriched) shall be grouped in accordance with 500.6(A) and (B).

Exception: Equipment identified for a specific gas, vapor, dust, or fiber/flying.

Informational Note: This grouping is based on the characteristics of the materials. Facilities are available for testing and identifying equipment for use in the various atmospheric groups

(A) Class I Group Classifications. Class I groups shall be according to 500.6(A)(1) through (A)(4).

Informational Note No. 1: Informational Note Nos. 2 and 3 apply to 500.6(A).

Informational Note No. 2: The explosion characteristics of air mixtures of gases or vapors vary with the specific material involved. For Class I locations, Groups A, B, C, and D, the classification involves determinations of maximum explosion pressure and maximum safe clearance between parts of a clamped joint in an enclosure. It is necessary, therefore, that equipment be identified not only for class but also for the specific group of the gas or vapor that will be present.

Informational Note No. 3: Certain chemical atmospheres may have characteristics that require safeguards beyond those required for any of the Class I groups. Carbon disulfide is one of these chemicals because of its low autoignition temperature (90°C) and the small joint clearance permitted to arrest its flame.

(1) Group A. Acetylene. [497:3.3.5.1.1]

(2) Group B. Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value less than or equal to 0.45 mm or a minimum igniting current ratio (MIC ratio) less than or equal to 0.40. [497:3.3.5.1.2]

Informational Note: A typical Class I, Group B material is hydrogen.

Exception No. 1: Group D equipment shall be permitted to be used for atmospheres containing butadiene, provided all conduit runs into explosionproof equipment are provided with explosionproof seals installed within 450 mm (18 in.) of the enclosure.

Exception No. 2: Group C equipment shall be permitted to be used for atmospheres containing allyl glycidyl ether, n-butyl glycidyl ether, ethylene oxide, propylene oxide, and acrolein, provided all conduit runs into explosionproof equipment are provided with explosionproof seals installed within 450 mm (18 in.) of the enclosure.

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- ▲ **(3) Group C.** Flammable gas, flammable liquid–produced vapor, or combustible liquid–produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value greater than 0.45 mm and less than or equal to 0.75 mm, or a minimum igniting current (MIC) ratio greater than 0.40 and less than or equal to 0.80. [497:3.3.5.1.3]

Informational Note: A typical Class I, Group C material is ethylene.

- ▲ **(4) Group D.** Flammable gas, flammable liquid–produced vapor, or combustible liquid–produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value greater than 0.75 mm or a minimum igniting current (MIC) ratio greater than 0.80. [497:3.3.5.1.4]

Informational Note No. 1: A typical Class I, Group D material is propane. [497:3.3.5.1.4]

Informational Note No. 2: For classification of areas involving ammonia atmospheres, see ANSI/ASHRAE 15-2016, *Safety Standard for Refrigeration Systems*.

(B) Class II Group Classifications. Class II groups shall be in accordance with 500.6(B)(1) through (B)(3).

(1) Group E. Atmospheres containing combustible metal dusts, including aluminum, magnesium, and their commercial alloys, or other combustible dusts whose particle size, abrasiveness, and conductivity present similar hazards in the use of electrical equipment. [499:3.3.4.1]

Informational Note: Certain metal dusts may have characteristics that require safeguards beyond those required for atmospheres containing the dusts of aluminum, magnesium, and their commercial alloys. For example, zirconium, thorium, and uranium dusts have extremely low ignition temperatures [as low as 20°C (68°F)] and minimum ignition energies lower than any material classified in any of the Class I or Class II groups.

- ▲ **(2) Group F.** Atmospheres containing combustible carbonaceous dusts that have more than 8 percent total entrapped volatiles (see ASTM D3175-2017, *Standard Test Method for Volatile Matter in the Analysis Sample of Coal and Coke*, for coal and coke dusts) or that have been sensitized by other materials so that they present an explosion hazard. [499:3.3.4.2] Coal, carbon black, charcoal, and coke dusts are examples of carbonaceous dusts. [499:A.3.3.4.2]

Informational Note: Testing of specific dust samples, following established ASTM testing procedures, is a method used to identify the combustibility of a specific dust and the need to classify those locations containing that material as Group F.

(3) Group G. Atmospheres containing combustible dusts not included in Group E or Group F, including flour, grain, wood, plastic, and chemicals. [499:3.3.4.3]

Informational Note No. 1: For additional information on group classification of Class II materials, see NFPA 499-2017, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

Informational Note No. 2: The explosion characteristics of air mixtures of dust vary with the materials involved. For Class II locations, Groups E, F, and G, the classification involves the tightness of the joints of assembly and shaft openings to prevent the entrance of dust in the dust-ignitionproof enclosure, the blanketing effect of layers of dust on the equipment that may cause overheating, and the ignition temperature of the dust. It is necessary, therefore, that equipment be identified not only for the class but also for the specific group of dust that will be present.

Informational Note No. 3: Certain dusts may require additional precautions due to chemical phenomena that can result in the generation of ignitable gases. See ANSI/IEEE C2-2017, *National Electrical Safety Code*, Section 127A, Coal Handling Areas.

▲ 500.7 Protection Techniques.

Electrical and electronic equipment in hazardous (classified) locations shall be protected by one or more of the techniques in 500.7(A) through (P).

(A) Explosionproof Equipment. This protection technique shall be permitted for equipment in Class I, Division 1 or 2 locations.

(B) Dust Ignitionproof. This protection technique shall be permitted for equipment in Class II, Division 1 or 2 locations.

(C) Dusttight. This protection technique shall be permitted for equipment in Class II, Division 2 or Class III, Division 1 or 2 locations.

(D) Purged and Pressurized. This protection technique shall be permitted for equipment in any hazardous (classified) location for which it is identified.

(E) Intrinsic Safety. This protection technique shall be permitted for equipment in Class I, Division 1 or 2; or Class II, Division 1 or 2; or Class III, Division 1 or 2 locations. The provisions of Articles 501 through 503 and Articles 510 through 516 shall not be considered applicable to such installations, except as required by Article 504, and installation of intrinsically safe apparatus and wiring shall be in accordance with the requirements of Article 504.

(F) Nonincendive Circuit. This protection technique shall be permitted for equipment in Class I, Division 2; Class II, Division 2; or Class III, Division 1 or 2 locations.

(G) Nonincendive Equipment. This protection technique shall be permitted for equipment in Class I, Division 2; Class II, Division 2; or Class III, Division 1 or 2 locations.

(H) Nonincendive Component. This protection technique shall be permitted for equipment in Class I, Division 2; Class II, Division 2; or Class III, Division 1 or 2 locations.

(I) Oil Immersion. This protection technique shall be permitted for current-interrupting contacts in Class I, Division 2 locations as described in 501.115(B)(1)(2).

(J) Hermetically Sealed. This protection technique shall be permitted for equipment in Class I, Division 2; Class II, Division 2; or Class III, Division 1 or 2 locations.

- ▲ **(K) Combustible Gas Detection System.** A combustible gas detection system shall be permitted as a means of protection in industrial establishments with restricted public access and where the conditions of maintenance and supervision ensure that only qualified persons service the installation.

■ **(1) General.** Any gas detection system utilized as a protection technique shall meet all of the requirements in 500.7(K)(1)(a) through (K)(1)(e).

- The gas detection equipment used shall be listed for Class I, Division 1 and listed for the detection of the specific gas or vapor to be encountered.
- The gas detection system shall not utilize portable or transportable equipment or temporary wiring methods.
- The gas detection system shall only use point-type sensors. The system shall be permitted to be augmented with open-path (line-of-sight)-type sensors, but open-path-type sensors shall not be the basis for this protection technique.

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- (d) The type of detection equipment, its listing, installation location(s), alarm and shutdown criteria, and calibration frequency shall be documented where combustible gas detectors are used as a protection technique.
- (e) The applications for the use of combustible gas detection systems as a protection technique shall be limited to 500.7(K)(2), (K)(3), or (K)(4).

Informational Note No. 1: For further information, see ISA-TR12.13.03-2009, *Guide for Combustible Gas Detection as a Method of Protection*.

Informational Note No. 2: For further information, see ANSI/ISA-60079-29-1 (12.13.01)-2013, *Explosive Atmospheres — Part 29-1: Gas detectors — Performance requirements of detectors for flammable gases*.

Informational Note No. 3: For further information, see ANSI/API RP 500-2012, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*.

Informational Note No. 4: For further information, see ANSI/ISA-60079-29-2 (12.13.02)-2012, *Explosive Atmospheres — Part 29-2: Gas detectors — Selection, installation, use and maintenance of detectors for flammable gases and oxygen*.

Δ (2) Inadequate Ventilation. A location, enclosed space, or building that is classified as a Class I, Division 1 location due to inadequate ventilation, that is provided with a combustible gas detection system shall be permitted to utilize electrical equipment, installation methods, and wiring practices suitable for Class I, Division 2 installations. Sensing a gas concentration of not more than 40 percent of the lower flammable limit or a gas detector system malfunction shall activate an alarm (audible or visual, or both, as most appropriate for the area).

(3) Interior of a Building or Enclosed Space. Any building or enclosed space that does not contain a source of flammable gas or vapors that is located in, or with an opening into, a Class I, Division 2 hazardous (classified) location that is provided with a combustible gas detection system shall be permitted to utilize electrical equipment, installation methods, and wiring practices suitable for unclassified installations under all of the following conditions:

- (1) An alarm (audible or visual, or both) shall be sounded at not more than 20 percent of the lower flammable limit.
- (2) Sensing a gas concentration of not more than 40 percent of the lower flammable limit or a gas detector system malfunction shall both activate an alarm (audible or visual, or both, as most appropriate for the area) and initiate automatic disconnection of power from all electrical devices in the area that are not suitable for Class I, Division 2.
- (3) The power disconnecting device(s) shall be suitable for Class I, Division 1 if located inside the building or enclosed space. If the disconnecting device(s) is located outside the building or enclosed space, it shall be suitable for the location in which it is installed.

Redundant or duplicate equipment (such as sensors) shall be permitted to be installed to avoid disconnecting electrical power when equipment malfunctions are indicated.

When automatic shutdown could introduce additional or increased hazard, this technique shall not be permitted.

(4) Interior of a Control Panel. Inside the interior of a control panel containing instrumentation or other equipment utilizing or measuring flammable liquids, gases, or vapors, which is provided with combustible gas detection equipment shall be permitted to utilize electrical equipment, installation methods, and wiring practices suitable for Class I, Division 2 installations.

An alarm (audible or visual, or both) shall be sounded at not more than 40 percent of the lower flammable limit.

N (L) Inherently Safe Optical Radiation “op is.” This protection technique shall be permitted for equipment in Class I or II, Division 1 or 2 locations for which the equipment is identified.

Informational Note: The identified class and division depends on the intended explosive atmosphere and the number of faults applied as part of the protection technique evaluation.

N (M) Protected Optical Radiation “op pr.” This protection technique shall be permitted for equipment in Class I or II, Division 2 locations for which the equipment is identified.

Informational Note: The identified class and division depends on the intended explosive atmosphere as part of the protection technique evaluation.

N (N) Optical System With Interlock “op sh.” This protection technique shall be permitted for equipment in Class I or II, Division 1 or 2 locations for which the equipment is identified.

Informational Note: The identified class and division depends on the intended explosive atmosphere and the number of faults applied as part of the protection technique evaluation.

N (O) Protection by Skin Effect Trace Heating “IEEE 844.1” This protection technique shall be permitted for skin effect trace heating equipment in Class I, Division 2; Class II, Division 2; or Class III, Division 2 for which it is listed.

(P) Other Protection Techniques. Other protection techniques used in equipment identified for use in hazardous (classified) locations.

500.8 Equipment.

Articles 500 through 504 require equipment construction and installation that ensure safe performance under conditions of proper use and maintenance.

Informational Note No. 1: It is important that inspection authorities and users exercise more than ordinary care with regard to installation and maintenance.

Informational Note No. 2: Since there is no consistent relationship between explosion properties and ignition temperature, the two are independent requirements.

Informational Note No. 3: Low ambient conditions require special consideration. Explosionproof or dust-ignitionproof equipment may not be suitable for use at temperatures lower than -25°C (-13°F) unless they are identified for low-temperature service. However, at low ambient temperatures, flammable concentrations of vapors may not exist in a location classified as Class I, Division 1 at normal ambient temperature.

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(A) Suitability.

Suitability of identified equipment shall be determined by one of the following:

- (1) Equipment listing or labeling
- (2) Evidence of equipment evaluation from a qualified testing laboratory or inspection agency concerned with product evaluation
- (3) Evidence acceptable to the authority having jurisdiction such as a manufacturer's self-evaluation or an owner's engineering judgment.

Informational Note: Additional documentation for equipment may include certificates demonstrating compliance with applicable equipment standards, indicating special conditions of use, and other pertinent information. Guidelines for certificates may be found in ANSI/UL 120002-2014, *Certificate Standard for AEx Equipment for Hazardous (Classified) Locations*.

(B) Approval for Class and Properties.

(1) Equipment shall be identified not only for the class of location but also for the explosive, combustible, or ignitable properties of the specific gas, vapor, dust, or fibers/flyings that will be present. In addition, Class I equipment shall not have any exposed surface that operates at a temperature in excess of the autoignition temperature of the specific gas or vapor. Class II equipment shall not have an external temperature higher than that specified in 500.8(D)(2). Class III equipment shall not exceed the maximum surface temperatures specified in 503.5.

Informational Note: Luminaires and other heat-producing apparatus, switches, circuit breakers, and plugs and receptacles are potential sources of ignition and are investigated for suitability in classified locations. Such types of equipment, as well as cable terminations for entry into explosionproof enclosures, are available as listed for Class I, Division 2 locations. Fixed wiring, however, may utilize wiring methods that are not evaluated with respect to classified locations. Wiring products such as cable, raceways, boxes, and fittings, therefore, are not marked as being suitable for Class I, Division 2 locations. Also see 500.8(C)(6)(a).

(2) Equipment that has been identified for a Division 1 location shall be permitted in a Division 2 location of the same class, group, and temperature class and shall comply with 500.8(B)(2)(a) or (B)(2)(b) as applicable.

(a) Intrinsically safe apparatus having a control drawing requiring the installation of associated apparatus for a Division 1 installation shall be permitted to be installed in a Division 2 location if the same associated apparatus is used for the Division 2 installation.

(b) Equipment that is required to be explosionproof shall incorporate seals in accordance with 501.15(A) or (D) when the wiring methods of 501.10(B) are employed.

(3) Where specifically permitted in Articles 501 through 503, general-purpose equipment or equipment in general-purpose enclosures shall be permitted to be installed in Division 2 locations if the equipment does not constitute a source of ignition under normal operating conditions.

(4) Equipment that depends on a single compression seal, diaphragm, or tube to prevent flammable or combustible fluids from entering the equipment shall be identified for a Class I, Division 2 location even if installed in an unclassified location. Equipment installed in a Class I, Division 1 location shall be identified for the Class I, Division 1 location.

Informational Note: Equipment used for flow measurement is an example of equipment having a single compression seal, diaphragm, or tube.

(5) Unless otherwise specified, normal operating conditions for motors shall be assumed to be rated full-load steady conditions.

(6) Where flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, or combustible dusts are or may be present at the same time, the simultaneous presence of both shall be considered when determining the safe operating temperature of the electrical equipment.

Informational Note: The characteristics of various atmospheric mixtures of gases, vapors, and dusts depend on the specific material involved.

(C) Marking. Equipment shall be marked to show the environment for which it has been evaluated. Unless otherwise specified or allowed in 500.8(C)(6), the marking shall include the information specified in 500.8(C)(1) through (C)(5).

(1) **Class.** The marking shall specify the class(es) for which the equipment is suitable.

(2) **Division.** The marking shall specify the division if the equipment is suitable for Division 2 only. Equipment suitable for Division 1 shall be permitted to omit the division marking.

Informational Note: Equipment not marked to indicate a division, or marked "Division 1" or "Div. 1," is suitable for both Division 1 and 2 locations; see 500.8(B)(2). Equipment marked "Division 2" or "Div. 2" is suitable for Division 2 locations only.

(3) **Material Classification Group.** The marking shall specify the applicable material classification group(s) or specific gas, vapor, dust, or fiber/flying in accordance with 500.6.

Exception: Fixed luminaires marked for use only in Class I, Division 2 or Class II, Division 2 locations shall not be required to indicate the group.

Informational Note: A specific gas, vapor, dust, or fiber/flying is typically identified by the generic name, chemical formula, CAS number, or combination thereof.

(4) **Equipment Temperature.** The marking shall specify the temperature class or operating temperature at a 40°C ambient temperature, or at the higher ambient temperature if the equipment is rated and marked for an ambient temperature of greater than 40°C. For equipment installed in a Class II, Division 1 location, the temperature class or operating temperature shall be based on operation of the equipment when blanketed with the maximum amount of dust that can accumulate on the equipment. The temperature class, if provided, shall be indicated using the temperature class (T codes) shown in Table 500.8(C). Equipment for Class I and Class II shall be marked with the maximum safe operating temperature, as determined by simultaneous exposure to the combinations of Class I and Class II conditions.

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Table 500.8(C) Classification of Maximum Surface Temperature

Maximum Temperature		Temperature Class (T Code)
°C	°F	
450	842	T1
300	572	T2
280	536	T2A
260	500	T2B
230	446	T2C
215	419	T2D
200	392	T3
180	356	T3A
165	329	T3B
160	320	T3C
135	275	T4
120	248	T4A
100	212	T5
85	185	T6

Exception: Equipment of the non-heat-producing type, such as junction boxes, conduit, and fittings, and equipment of the heat-producing type having a maximum temperature not more than 100°C shall not be required to have a marked operating temperature or temperature class.

Informational Note: More than one marked temperature class or operating temperature, for gases and vapors, dusts, and different ambient temperatures, may appear.

(5) Ambient Temperature Range. Electrical equipment designed for use in the ambient temperature range between -25°C to +40°C shall require no ambient temperature marking. For equipment rated for a temperature range other than -25°C to +40°C, the marking shall specify the special range of ambient temperatures in degrees Celsius. The marking shall include either the symbol "Ta" or "Tamb."

Informational Note: As an example, such a marking might be "-30°C ≤ Ta ≤ +40°C."

(6) Special Allowances.

(a) *General Purpose Equipment.* Fixed general-purpose equipment in Class I locations, other than fixed luminaires, that is acceptable for use in Class I, Division 2 locations shall not be required to be marked with the class, division, group, temperature class, or ambient temperature range.

(b) *Dusttight Equipment.* Fixed dusttight equipment, other than fixed luminaires, that is acceptable for use in Class II, Division 2 and Class III locations shall not be required to be marked with the class, division, group, temperature class, or ambient temperature range.

(c) *Associated Apparatus.* Associated intrinsically safe apparatus and associated nonincendive field wiring apparatus that are not protected by an alternative type of protection shall not be marked with the class, division, group, or temperature class. Associated intrinsically safe apparatus and associated nonincendive field wiring apparatus shall be marked with the class, division, and group of the apparatus to which it is to be connected.

(d) *Simple Apparatus.* "Simple apparatus" as defined in Article 100 Part III, shall not be required to be marked with class, division, group, temperature class, or ambient temperature range.

(D) Temperature.

(1) Class I Temperature. The temperature marking specified in 500.8(C) shall not exceed the autoignition temperature of the specific gas or vapor to be encountered.

Informational Note: For information regarding autoignition temperatures of gases and vapors, see NFPA 497-2017, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

(2) Class II Temperature. The temperature marking specified in 500.8(C) shall be less than the ignition temperature of the specific dust to be encountered. For organic dusts that may dehydrate or carbonize, the temperature marking shall not exceed the lower of either the ignition temperature or 165°C (329°F).

Informational Note: See NFPA 499-2017, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, for minimum ignition temperatures of specific dusts.

(E) Threading. The supply connection entry thread form shall be NPT or metric. Conduit and fittings shall be made wrenchtight to prevent sparking when fault current flows through the conduit system, and to ensure the explosionproof integrity of the conduit system where applicable. Equipment provided with threaded entries for field wiring connections shall be installed in accordance with 500.8(E)(1) or (E)(2) and with (E)(3).

(1) Equipment Provided with Threaded Entries for NPT-Threaded Conduit or Fittings. For equipment provided with threaded entries for NPT-threaded conduit or fittings, listed conduit, listed conduit fittings, or listed cable fittings shall be used. All NPT-threaded conduit and fittings shall be threaded with a National (American) Standard Pipe Taper (NPT) thread.

NPT-threaded entries into explosionproof equipment shall be made up with at least five threads fully engaged.

Exception: For listed explosionproof equipment, joints with factory-threaded NPT entries shall be made up with at least four and one-half threads fully engaged.

Informational Note No. 1: Thread specifications for male NPT threads are located in ASME B1.20.1-2013, *Pipe Threads, General Purpose (Inch)*.

Informational Note No. 2: Female NPT-threaded entries use a modified National Standard Pipe Taper (NPT) thread with thread form per ASME B1.20.1-2013, *Pipe Threads, General Purpose (Inch)*. See ANSI/UL 1203-2015, *Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations*.

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(2) Equipment Provided with Threaded Entries for Metric-Threaded Fittings. For equipment with metric-threaded entries, listed conduit fittings or listed cable fittings shall be used. Such entries shall be identified as being metric, or listed adapters to permit connection to conduit or NPT-threaded fittings shall be provided with the equipment and shall be used for connection to conduit or NPT-threaded fittings.

Metric-threaded fittings installed into explosionproof equipment shall have a class of fit of at least 6g/6H and shall be made up with at least five threads fully engaged.

Informational Note: Threading specifications for metric-threaded entries are located in ISO 965-1-2013, ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data, and ISO 965-3-2009, ISO general purpose metric screw threads — Tolerances — Part 3: Deviations for constructional screw threads.

(3) Unused Openings. All unused openings shall be closed with listed metal close-up plugs. The plug engagement shall comply with 500.8(E)(1) or (E)(2).

(F) Optical Fiber Cables. An optical fiber cable, with or without current-carrying conductors (composite optical fiber cable), shall be installed to address the associated fire hazard and sealed to address the associated explosion hazard in accordance with the requirements of Article 500, 501, 502, or 503, as applicable.

(G) Equipment Involving Optical Radiation. For equipment involving sources of optical radiation (such as laser or LED sources) in the wavelength range from 380 nm to 10 μ m, the risk of ignition from optical radiation shall be considered for all electrical parts and circuits that may be exposed to the radiation, both inside and outside the optical equipment. This includes optical equipment, which itself is located outside the explosive atmosphere, but its emitted optical radiation enters such atmospheres.

Informational Note: For additional information on types of protection that can be applied to minimize the risk of ignition in explosive atmospheres from optical radiation, see ANSI/UL 60079-28-2017, Explosive Atmospheres — Part 28: Protection of Equipment and Transmission Systems Using Optical Radiation.

Exception: All luminaires (fixed, portable, or transportable) and hand lights intended to be supplied by mains (with or without galvanic isolation) or powered by batteries, with any continuous divergent light source, including LEDs, shall be excluded from this requirement.

500.9 Specific Occupancies.

Articles 510 through 517 cover garages, aircraft hangars, motor fuel dispensing facilities, bulk storage plants, spray application, dipping and coating processes, and health care facilities.



EIB breaker assembly



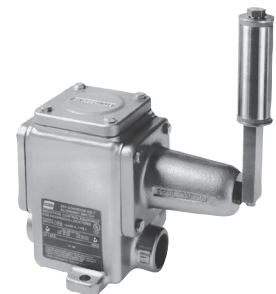
Vaporgard™ LED luminaire



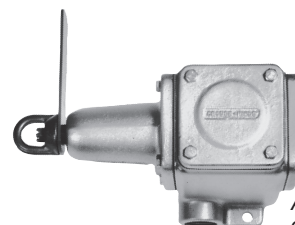
EBMS starter enclosure



DMV series CHAMP® H.I.D. lighting fixture – ceiling mount



AFAX conveyor belt alignment switch



AFUX conveyor control safety switch

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Article 501

Part I. General

501.1 Scope.

Article 501 covers the requirements for electrical and electronic equipment and wiring for all voltages in Class I, Division 1 and 2 locations where fire or explosion hazards may exist due to flammable gases or vapors or flammable liquids.

Informational Note: For the requirements for electrical and electronic equipment and wiring for all voltages in Zone 0, Zone 1, or Zone 2 hazardous (classified) locations where fire or explosion hazards may exist due to flammable gases or vapors or flammable liquids, refer to Article 505.

501.5 Zone Equipment.

Equipment listed and marked in accordance with 505.9(C)(2) for use in Zone 0, 1, or 2 locations shall be permitted in Class I, Division 2 locations for the same gas and with a suitable temperature class. Equipment listed and marked in accordance with 505.9(C)(2) for use in Zone 0 locations shall be permitted in Class I, Division 1 or Division 2 locations for the same gas and with a suitable temperature class.

Part II. Wiring

501.10 Wiring Methods.

Wiring methods shall comply with 501.10(A) or (B).

(A) Class I, Division 1.

- ▲ (1) **General.** In Class I, Division 1 locations, the following wiring methods shall be permitted:

(1) Threaded rigid metal conduit (Type RMC) or threaded steel intermediate metal conduit (Type IMC).

Exception: Type PVC conduit, Type RTRC conduit, and Type HDPE conduit shall be permitted where encased in a concrete envelope a minimum of 50 mm (2 in.) thick and provided with not less than 600 mm (24 in.) of cover measured from the top of the conduit to grade. The concrete encasement shall be permitted to be omitted where subject to the provisions of 514.8, Exception No. 2, or 515.8(A). Threaded rigid metal conduit or threaded steel intermediate metal conduit shall be used for the last 600 mm (24 in.) of the underground run to emergence or to the point of connection to the aboveground raceway. An equipment grounding conductor shall be included to provide for electrical continuity of the raceway system and for grounding of non-current-carrying metal parts.

(2) Type MI cable terminated with fittings listed for the location. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings.

(3) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Type MC-HL cable listed for use in Class I, Zone 1 or Division 1 locations, with a gas/vaportight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material, and a separate equipment grounding conductor(s) in accordance with 250.122, and terminated with fittings listed for the application. Type MC-HL cable shall be installed in accordance with the provisions of Article 330, Part II.

(4) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Type ITC-HL cable listed for use in Class I, Division 1 or Zone 1 locations, with a gas/vaportight continuous corrugated metallic sheath and an overall jacket of suitable polymeric material, and terminated with fittings listed for the application, and installed in accordance with 727.4.

(5) Optical fiber cable Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC shall be permitted to be installed in raceways in accordance with 501.10(A). These optical fiber cables shall be sealed in accordance with 501.15.

(6) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, for applications limited to 600 volts nominal or less, and where the cable is not subject to physical damage, and terminated with fittings listed for the location, Type TC-ER-HL cable. Type TC-ER-HL cable shall be listed for use in Class I, Division 1 or Zone 1 locations and shall be installed in accordance with 336.10.

Informational Note: See the information on construction, testing, and marking of cables and cable fittings in ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

(7) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type P cable with metal braid armor, with an overall jacket, terminated with fittings listed for the location, and installed in accordance with 337.10.

Informational Note No. 1: For information on construction, testing, and marking of Type P cable, see ANSI/UL 1309-2017, *Marine Shipboard Cable*.

Informational Note No. 2: For information on construction, testing, and marking of cable fittings, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

- ▲ (2) **Flexible Connections.** Where necessary to employ flexible connections, as at motor terminals, one of the following shall be permitted:

(1) Flexible fittings listed for the location.

(2) Flexible cord in accordance with the provisions of 501.140, terminated with cord connectors listed for the location.

(3) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, for applications limited to 600 volts nominal or less, and where the cable is not subject to physical damage, and terminated with fittings listed for the location, Type TC-ER-HL cable shall be listed for use in Class I, Division 1 or Zone 1 locations and shall be installed in accordance with 336.10.

Informational Note: See the information on construction, testing, and marking of cables and cable fittings in ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

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- (4) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type P cable with metal braid armor, with an overall jacket, terminated with fittings listed for the location, and installed in accordance with 337.10.

Informational Note No. 1: For information on construction, testing, and marking of Type P cable, see ANSI/UL 1309-2017, *Marine Shipboard Cable*.

Informational Note No. 2: For information on construction, testing, and marking of cable fittings, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

- (3) **Boxes and Fittings.** All boxes and fittings shall be approved for Class I, Division 1.

Informational Note: For entry into enclosures required to be explosionproof, see the information on construction, testing, and marking of cables, explosionproof cable fittings, and explosionproof cord connectors in ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

(B) Class I, Division 2.

- ▲ (1) **General.** In Class I, Division 2 locations, all wiring methods permitted in 501.10(A) and the following wiring methods shall be permitted:

- (1) Rigid metal conduit (Type RMC) and intermediate metal conduit (Type IMC) with listed threaded or threadless fittings.
- (2) Enclosed gasketed busways and enclosed gasketed wireways.
- (3) Types PLTC and PLTC-ER cable in accordance with Part II or III of Article 725, including installation in cable tray systems. The cable shall be terminated with listed fittings. Type PLTC-ER cable shall include an equipment grounding conductor in addition to a drain wire that might be present.
- (4) Types ITC and ITC-ER cable as permitted in 727.4 and terminated with listed fittings. Type ITC-ER cable shall include an equipment grounding conductor in addition to a drain wire.
- (5) Type MC, MV, TC, or TC-ER cable, including installation in cable tray systems. Type TC-ER cable shall include an equipment grounding conductor in addition to a drain wire that might be present. All cable types shall be terminated with listed fittings.
- (6) Where metal conduit will not provide sufficient corrosion resistance, any of the following shall be permitted:
 - a. Listed reinforced thermosetting resin conduit (RTRC), factory elbows, and associated fittings, all marked with the suffix -XW
 - b. PVC-coated rigid metal conduit (RMC), factory elbows, and associated fittings
 - c. PVC-coated intermediate metal conduit (IMC), factory elbows, and associated fittings
 - d. In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Schedule 80 PVC conduit, factory elbows, and associated fittings
- (7) Optical fiber cable Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC shall be permitted to be installed in cable trays or any other raceway in accordance with 501.10(B). Optical fiber cables shall be sealed in accordance with 501.15.
- (8) Cablebus.

- (9) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type P cable with or without metal braid armor, with an overall jacket, terminated with fittings listed for the location, and installed in accordance with 337.10.

Informational Note No. 1: For information on construction, testing, and marking of Type P cable, see ANSI/UL 1309-2017, *Marine Shipboard Cable*.

Informational Note No. 2: For information on construction, testing, and marking of cable fittings, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

Where seals are required for boundary conditions as defined in 501.15(A)(4), the Division 1 wiring method shall extend into the Division 2 area to the seal, which shall be located on the Division 2 side of the Division 1–Division 2 boundary.

- (2) **Flexible Connections.** Where provision must be made for flexibility, one or more of the following shall be permitted:

- (1) Listed flexible metal fittings.
- (2) Flexible metal conduit with listed fittings.
- (3) Interlocked armor Type MC cable with listed fittings.
- (4) Liquidtight flexible metal conduit with listed fittings.
- (5) Liquidtight flexible nonmetallic conduit with listed fittings.
- (6) Flexible cord listed for extra-hard usage and terminated with listed fittings. A conductor for use as an equipment grounding conductor shall be included in the flexible cord.
- (7) For elevator use, an identified elevator cable of Type EO, ETP, or ETT, shown under the “use” column in Table 400.4 for “hazardous (classified) locations” and terminated with listed fittings.

Informational Note: See 501.30(B) for grounding requirements where flexible conduit is used.

- (3) **Nonincendive Field Wiring.** Nonincendive field wiring shall be permitted using any of the wiring methods permitted for unclassified locations. Nonincendive field wiring systems shall be installed in accordance with the control drawing(s). Simple apparatus, not shown on the control drawing, shall be permitted in a nonincendive field wiring circuit, provided the simple apparatus does not interconnect the nonincendive field wiring circuit to any other circuit.

Informational Note: Simple apparatus is defined in Article 100 Part III.

Separate nonincendive field wiring circuits shall be installed in accordance with one of the following:

- (1) In separate cables
- (2) In multiconductor cables where the conductors of each circuit are within a grounded metal shield
- (3) In multiconductor cables or in raceways, where the conductors of each circuit have insulation with a minimum thickness of 0.25 mm (0.01 in.)

- (4) **Boxes and Fittings.** Boxes and fittings shall not be required to be explosionproof except as required by 501.105(B)(2), 501.115(B)(1), and 501.150(B)(1).

Informational Note: For entry into enclosures required to be explosionproof, see the information on construction, testing, and marking of cables, explosionproof cable fittings, and explosionproof cord connectors in ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

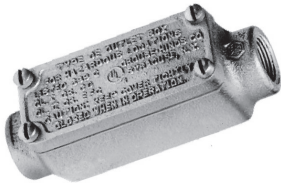
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Article 501

Class I Locations

Wiring Methods Class I, Division 1.

In Class I, Division 1 locations, all pull and junction boxes must be of a design suitable for such locations and threaded for rigid or IMC conduit. Type MI cable may be used and, under certain conditions, type MC-HL, ITC-HL, TC-ER-HL or Type P cable may be terminated with fittings listed for the application. Where necessary to use flexible connections, as at motor terminals, Class I, Division 1 flexible fittings must be used unless flexible cord is used in accordance with 501.140. A few of the many explosionproof fittings meeting the requirements of 501.10(A) are shown.



OEC conduit body
(Groups C, D)



EAJX conduit body
(Groups A, B, C, D)



EJB junction box
(Groups B, C, D)



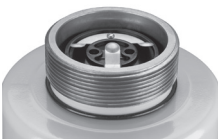
EBY heavy-duty
cord connector
Division 1 and Division 2
(Groups B, C, D)



Quick disconnect module
for EVLLA Division 1 fixtures



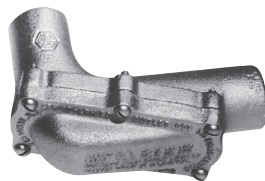
Hazard•Gard® XPLA series
linear LED luminaires



Quick disconnect module for
EVLS Division 1 fixtures



ECGJH flexible coupling



LBH conduit body



TMCX II Terminator™ cable
fittings for use with Type
MC-HL or TC-ER-HL cable in
Class I, Division 1 locations.

Wiring Methods Class I, Division 2.

In Class I, Division 2 locations, either threaded rigid or steel IMC conduit, or enclosed and gasketed busways or wireways, or Type ITC, ITC-ER, MI, MC, MV, PLTC, PLTC-ER, TC or TC-ER cable with termination fittings approved for Class I locations must be used when entering enclosures required to be explosionproof or as required for the boundary seal. Under certain restrictions, reinforced thermosetting resin conduit (RTRC) and Schedule 80 PVC conduit and associated fittings may be used. The junction and pull boxes need not be designed for Class I, Division 1 locations. A few of the many types of junction and pull boxes suitable for Division 2 locations (501.10(B)) are shown. Where provision must be made for limited flexibility, Type EBY heavy-duty cord connector may be used for both Division 1 and Division 2 locations.



LB



T



C

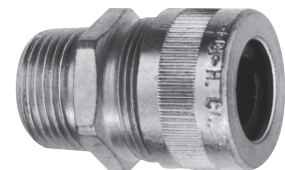
Form 7, Form 8 or
Mark 9 Conduit bodies



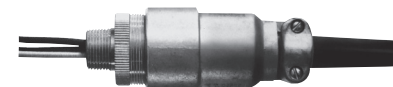
Champ FMVA LED
Division 2 fixture



WJB junction box



CGB connector for portable
cords and Types MV
(unarmored), PLTC, SE
(round), TC and UF cables



EBY factory sealed flexible cord connector. May be used
with flexible cord, where permitted, in Class I, Divisions 1
and 2 locations without a separate sealing fitting.



ADE-1F2
cable fitting
for tray cable



TMCX Terminator™ cable fittings for use
with Type MC jacketed metal clad cables
with interlocked or corrugated armor, or
types ITC, ITC-HL, TC, TC-ER, TC-ER-HL
or PLTC in Class I, Groups A, B, C, and
D, Division 2 locations.

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Class I Locations



Liquidtight conduit connectors

Liquidtight flexible conduit is sometimes permitted in Class I, Division 2 locations. When conductors contained in it are to enter or leave an explosionproof enclosure containing an arcing device, the liquidtight connector fitting should be connected to a sealing fitting (Type EYS or similar), which in turn is connected to the enclosure. Conductors are sealed in the sealing fitting in the normal manner. When used, this conduit must be grounded in accordance with Section 350.60 or 356.60 and 501.30.

501.15 Sealing and Drainage.

Seals in conduit and cable systems shall comply with 501.15(A) through (F). Sealing compound shall be used in Type MI cable termination fittings to exclude moisture and other fluids from the cable insulation.

Informational Note No. 1: Seals are provided in conduit and cable systems to minimize the passage of gases and vapors and prevent the passage of flames from one portion of the electrical installation to another through the conduit. Such communication through Type MI cable is inherently prevented by construction of the cable. Unless specifically designed and tested for the purpose, conduit and cable seals are not intended to prevent the passage of liquids, gases, or vapors at a continuous pressure differential across the seal. Even at differences in pressure across the seal equivalent to a few inches of water, there may be a slow passage of gas or vapor through a seal and through conductors passing through the seal. Temperature extremes and highly corrosive liquids and vapors can affect the ability of seals to perform their intended function.

Informational Note No. 2: Gas or vapor leakage and propagation of flames may occur through the interstices between the strands of standard stranded conductors larger than 2 AWG. Special conductor constructions, such as compacted strands or sealing of the individual strands, are means of reducing leakage and preventing the propagation of flames.

(A) Conduit Seals, Class I, Division 1. In Class I, Division 1 locations, conduit seals shall be located in accordance with 501.15(A)(1) through (A)(4).

(1) Entering Enclosures. Each conduit entry into an explosionproof enclosure shall have a conduit seal where either of the following conditions apply:

- (1) The enclosure contains apparatus, such as switches, circuit breakers, fuses, relays, or resistors that may produce arcs, sparks, or temperatures that exceed 80 percent of the autoignition temperature, in degrees Celsius, of the gas or vapor involved in normal operation.

Exception: Seals shall not be required for conduit entering an enclosure under any one of the following conditions:

- 1 The switch, circuit breaker, fuse, relay, or resistor is enclosed within a chamber hermetically sealed against the entrance of gases or vapors.
- 2 The switch, circuit breaker, fuse, relay, or resistor is immersed in oil in accordance with 501.115(B)(1)(2).

- 3 The switch, circuit breaker, fuse, relay, or resistor is enclosed within an enclosure, identified for the location, and marked "Leads Factory Sealed," or "Factory Sealed," "Seal not Required," or equivalent.

- 4 The switch, circuit breaker, fuse, relay, or resistor is part of a nonincendive circuit.

- (2) The entry is metric designator 53 (trade size 2) or larger, and the enclosure contains terminals, splices, or taps.

An enclosure, identified for the location, and marked "Leads Factory Sealed", or "Factory Sealed," or "Seal not Required," or equivalent shall not be considered to serve as a seal for another adjacent enclosure that is required to have a conduit seal.

Conduit seals shall be installed within 450 mm (18 in.) from the enclosure or as required by the enclosure marking. Only threaded couplings, or explosionproof fittings such as unions, reducers, elbows, and capped elbows that are not larger than the trade size of the conduit, shall be permitted between the sealing fitting and the explosionproof enclosure.

- (2) Pressurized Enclosures.** Conduit seals shall be installed within 450 mm (18 in.) of the enclosure in each conduit entry into a pressurized enclosure where the conduit is not pressurized as part of the protection system.

Informational Note No. 1: Installing the seal as close as possible to the enclosure will reduce problems with purging the dead airspace in the pressurized conduit.

Informational Note No. 2: For further information, see NFPA 496-2017, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*.

- (3) Two or More Explosionproof Enclosures.** Where two or more explosionproof enclosures that require conduit seals are connected by nipples or runs of conduit not more than 900 mm (36 in.) long, a single conduit seal in each such nipple connection or run of conduit shall be considered sufficient if the seal is located not more than 450 mm (18 in.) from either enclosure.

- (4) Class I, Division 1 Boundary.** A conduit seal shall be required in each conduit run leaving a Division 1 location. The sealing fitting shall be permitted to be installed on either side of the boundary within 3.05 m (10 ft) of the boundary, and it shall be designed and installed to minimize the amount of gas or vapor within the portion of the conduit installed in the Division 1 location that can be communicated beyond the seal. The conduit run between the conduit seal and the point at which the conduit leaves the Division 1 location shall contain no union, coupling, box, or other fitting except for a listed explosionproof reducer installed at the conduit seal.

Exception No. 1: Metal conduit that contains no unions, couplings, boxes, or fittings, that passes completely through a Division 1 location with no fittings installed within 300 mm (12 in.) of either side of the boundary, shall not require a conduit seal if the termination points of the unbroken conduit are located in unclassified locations.

Exception No. 2: For underground conduit installed in accordance with 300.5 where the boundary is below grade, the sealing fitting shall be permitted to be installed after the conduit emerges from below grade, but there shall be no union, coupling, box, or fitting, other than listed explosionproof reducers at the sealing fitting, in the conduit between the sealing fitting and the point at which the conduit emerges from below grade.

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(B) Conduit Seals, Class I, Division 2. In Class I, Division 2 locations, conduit seals shall be located in accordance with 501.15(B)(1) and (B)(2).

(1) Entering Enclosures. For connections to enclosures that are required to be explosionproof, a conduit seal shall be provided in accordance with 501.15(A)(1)(1) and (A)(3). All portions of the conduit run or nipple between the seal and enclosure shall comply with 501.10(A).

(2) Class I, Division 2 Boundary. A conduit seal shall be required in each conduit run leaving a Class I, Division 2 location. The sealing fitting shall be permitted to be installed on either side of the boundary within 3.05 m (10 ft) of the boundary and it shall be designed and installed to minimize the amount of gas or vapor within the portion of the conduit installed in the Division 2 location that can be communicated beyond the seal. Rigid metal conduit or threaded steel intermediate metal conduit shall be used between the sealing fitting and the point at which the conduit leaves the Division 2 location, and a threaded connection shall be used at the sealing fitting. The conduit run between the conduit seal and the point at which the conduit leaves the Division 2 location shall contain no union, coupling, box, or other fitting except for a listed explosionproof reducer installed at the conduit seal. Such seals shall not be required to be explosionproof but shall be identified for the purpose of minimizing the passage of gases permitted under normal operating conditions and shall be accessible.

Informational Note: For further information, refer to ANSI/UL 514B-2012, *Conduit, Tubing, and Cable Fittings*.

Exception No. 1: Metal conduit that contains no unions, couplings, boxes, or fittings, that passes completely through a Division 2 location with no fittings installed within 300 mm (12 in.) of either side of the boundary, shall not be required to be sealed if the termination points of the unbroken conduit are located in unclassified locations.

Exception No. 2: Conduit systems terminating in an unclassified location where the metal conduit transitions to cable tray, cablebus, ventilated busway, or Type MI cable, or to cable not installed in any cable tray or raceway system, shall not be required to be sealed where passing from the Division 2 location into the unclassified location under the following conditions:

- (1) The unclassified location is outdoors or the unclassified location is indoors and the conduit system is entirely in one room.*
- (2) The conduits shall not terminate at an enclosure containing an ignition source in normal operation*

Exception No. 3: Conduit systems passing from an enclosure or a room that is unclassified, as a result of pressurization, into a Division 2 location shall not require a seal at the boundary.

Informational Note: For further information, refer to NFPA 496-2017, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*.

Exception No. 4: Segments of aboveground conduit systems shall not be required to be sealed where passing from a Division 2 location into an unclassified location if all of the following conditions are met:

- (1) No part of the conduit system segment passes through a Division 1 location where the conduit segment contains unions, couplings, boxes, or fittings that are located within 300 mm (12 in.) of the Division 1 location.*
- (2) The conduit system segment is located entirely in outdoor locations.*
- (3) The conduit system segment is not directly connected to canned pumps, process or service connections for flow, pressure, or analysis measurement, and so forth, that depend on a single compression seal, diaphragm, or tube to prevent flammable or combustible fluids from entering the conduit system.*

(4) The conduit system segment contains only threaded metal conduit, unions, couplings, conduit bodies, and fittings in the unclassified location.

(5) The conduit system segment is sealed at its entry to each enclosure or fitting located in the Division 2 location that contains terminals, splices, or taps.

(C) Class I, Divisions 1 and 2. Seals installed in Class I, Division 1 and Division 2 locations shall comply with 501.15(C)(1) through (C)(6).

Exception: Seals that are not required to be explosionproof by 501.15(B)(2) or 504.70 shall not be required to comply with 501.15(C).

(1) Fittings. Enclosures that contain connections or equipment shall be provided with an integral sealing means, or sealing fittings listed for the location shall be used. Sealing fittings shall be listed for use with one or more specific compounds and shall be accessible.

(2) Compound. The compound shall provide a seal to minimize the passage of gas and/or vapors through the sealing fitting and shall not be affected by the surrounding atmosphere or liquids. The melting point of the compound shall not be less than 93°C (200°F).

(3) Thickness of Compounds. The thickness of the sealing compound installed in completed seals, other than listed cable sealing fittings, shall not be less than the metric designator (trade size) of the sealing fitting expressed in the units of measurement employed; however, in no case shall the thickness of the compound be less than 16 mm (⁵/₈-in.).

(4) Splices and Taps. Splices and taps shall not be made in fittings intended only for sealing with compound; nor shall other fittings in which splices or taps are made be filled with compound.

(5) Assemblies. An entire assembly shall be identified for the location where the equipment that may produce arcs, sparks, or high temperatures is located in a compartment that is separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other. In Division 1 locations, seals shall be provided in conduit connecting to the compartment containing splices or taps where required by 501.15(A)(1)(2).

(6) Conductor or Optical Fiber Fill. The cross-sectional area of the conductors or optical fiber tubes (metallic or nonmetallic) permitted in a seal shall not exceed 25 percent of the cross-sectional area of a rigid metal conduit of the same trade size unless the seal is specifically identified for a higher percentage of fill.

(D) Cable Seals, Class I, Division 1. In Division 1 locations, cable seals shall be located according to 501.15(D)(1) through (D)(3).

(1) At Terminations. Cables shall be sealed with sealing fittings that comply with 501.15(C) at all terminations. Type MC-HL cables with a gas/vaportight continuous corrugated metallic sheath and an overall jacket of suitable polymeric material shall be sealed with a listed fitting after the jacket and any other covering have been removed so that the sealing compound can surround each individual insulated conductor in such a manner as to minimize the passage of gases and vapors.

Seals for cables entering enclosures shall be installed within 450 mm (18 in.) of the enclosure or as required by the enclosure marking. Only threaded couplings, or explosionproof fittings such as unions, reducers, elbows, and capped elbows that are not larger than the trade size of the conduit, shall be permitted between the sealing fitting and the enclosure.

Exception: Shielded cables and twisted pair cables shall not require the removal of the shielding material or separation of the twisted pairs, provided the termination is sealed by an approved means to minimize the entrance of gases or vapors and prevent propagation of flame into the cable core.

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(2) Cables Capable of Transmitting Gases or Vapors. Cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core, installed in conduit, shall be sealed in the Class 1, Division 1 location after the jacket and any other coverings have been removed so that the sealing compound can surround each individual insulated conductor or optical fiber tube and the outer jacket.

Exception: Multiconductor cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core shall be permitted to be considered as a single conductor by sealing the cable in the conduit within 450 mm (18 in.) of the enclosure and the cable end within the enclosure by an approved means to minimize the entrance of gases or vapors and prevent the propagation of flame into the cable core, or by other approved methods. It shall not be required to remove the shielding material or separate the twisted pairs of shielded cables and twisted pair cables.

(3) Cables Incapable of Transmitting Gases or Vapors. Each multiconductor cable installed in conduit shall be considered as a single conductor if the cable is incapable of transmitting gases or vapors through the cable core. These cables shall be sealed in accordance with 501.15(A).

(E) Cable Seals, Class I, Division 2. In Division 2 locations, cable seals shall be located in accordance with 501.15(E)(1) through (E)(4).

Exception: Cables with an unbroken gas/vaportight continuous sheath shall be permitted to pass through a Division 2 location without seals.

(1) Terminations. Cables entering enclosures that are required to be explosionproof shall be sealed at the point of entrance. The sealing fitting shall comply with 501.15(B)(1) or be explosionproof. Multiconductor or optical multifiber cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core that are installed in a Division 2 location shall be sealed with a listed fitting after the jacket and any other coverings have been removed, so that the sealing compound can surround each individual insulated conductor or optical fiber tube in such a manner as to minimize the passage of gases and vapors. Multiconductor or optical multifiber cables installed in conduit shall be sealed as described in 501.15(D).

Exception No. 1: Cables leaving an enclosure or room that is unclassified as a result of Type Z pressurization and entering into a Division 2 location shall not require a seal at the boundary.

Exception No. 2: Shielded cables and twisted pair cables shall not require the removal of the shielding material or separation of the twisted pairs, provided the termination is by an approved means to minimize the entrance of gases or vapors and prevent propagation of flame into the cable core.

(2) Cables That Do Not Transmit Gases or Vapors. Cables that have a gas/vaportight continuous sheath and do not transmit gases or vapors through the cable core in excess of the quantity permitted for seal fittings shall not be required to be sealed except as required in 501.15(E)(1). The minimum length of such a cable run shall not be less than the length needed to limit gas or vapor flow through the cable core, excluding the interstices of the conductor strands, to the rate permitted for seal fittings [200 cm³/hr (0.007 ft³/hr) of air at a pressure of 1500 pascals (6 in. of water)].

(3) Cables Capable of Transmitting Gases or Vapors. Cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core shall not be required to be sealed except as required in 501.15(E)(1), unless the cable is attached to process equipment or devices that may cause a pressure in excess of 1500 pascals (6 in. of water) to be exerted at a cable end, in which case a seal, a barrier, or other means shall be provided to prevent migration of flammables into an unclassified location.

(4) Cables Without Gas/Vaportight Sheath. Cables that do not have a gas/vaportight continuous sheath shall be sealed at the boundary of the Division 2 and unclassified location in such a manner as to minimize the passage of gases or vapors into an unclassified location.

(F) Drainage.

(1) Control Equipment. Where there is a probability that liquid or other condensed vapor may be trapped within enclosures for control equipment or at any point in the raceway system, approved means shall be provided to prevent accumulation or to permit periodic draining of such liquid or condensed vapor.

(2) Motors and Generators. Where liquid or condensed vapor may accumulate within motors or generators, joints and conduit systems shall be arranged to minimize the entrance of liquid. If means to prevent accumulation or to permit periodic draining are necessary, such means shall be provided at the time of manufacture and shall be considered an integral part of the machine.

Sealing Fittings:

- Minimize the passage of gases, vapors, or flames from one portion of the electrical installation to another at atmospheric pressure and normal ambient temperatures.
- Limit explosions to the sealed-off enclosure.
- Prevent precompression or “pressure piling” in conduit systems.

Sealing Fittings are required for installation:

- At each entrance to an explosionproof enclosure housing an arcing or sparking device when used in Class I, Division 1 and 2 classified hazardous areas. To be located as close as practicable and, in no case, more than 18 inches from such enclosures, or in accordance with the manufacturer’s instructions.
- In Class I, Division 1, at each entrance of 2-inch trade size or larger conduit entering an enclosure housing terminals, splices, or taps. To be located as close as practicable and, in no case, more than 18 inches from such enclosures, or in accordance with the manufacturer’s instructions.
- In conduit systems when leaving the Class I, Division 1 or Division 2 classified hazardous locations.
- In cable systems when the cables are capable of transmitting gases or vapors through the cable core and when these cables leave the Class I, Division 1 or Division 2 classified hazardous locations.

Note that in Division 2, the conduit between the seal and the explosionproof enclosure must be rigid or steel IMC conduit with threaded joints because threadless connections are not flame-tight (501.15(B)).

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Factory-Sealed Units for Class I, Division 1 or 2 Hazardous Areas.

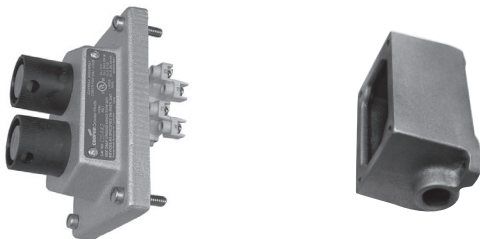
Eaton's Crouse-Hinds factory-sealed devices eliminate the time-consuming handwork of field-poured seals. The seal is designed into the device and it's ready for installation as it comes from the box. No costly time is spent in damming the conduit run and mixing and pouring compounds. Installation is quick and easy. All the installer does is connect the pigtail leads or terminal screws on the back of the factory-sealed element to incoming wires, push the sealed device into the box and bolt down the cover.

Factory-sealed control stations include pushbutton stations, selector switches, tumbler switches, manual motor-starting switches, and pilot lights, all for surface mounting in single-gang or two-gang (EDS Series) housings and modular body assemblies (EDSCM Series). Add these to the present line of Eaton's Crouse-Hinds factory-sealed control devices, panelboards, luminaires, plugs and receptacles, bell and horn signals and clocks, and you have the widest selection of factory-sealed devices available to meet your needs.

Eaton's Crouse-Hinds offers an innovative method of factory sealing by utilizing an explosionproof contact block. Terminal connections/contacts are permanently molded, and sealed, into the device. The factory-sealed contact block mounts onto the cover by means of a mounting strap; cover and device can then be easily mounted on the backbox.

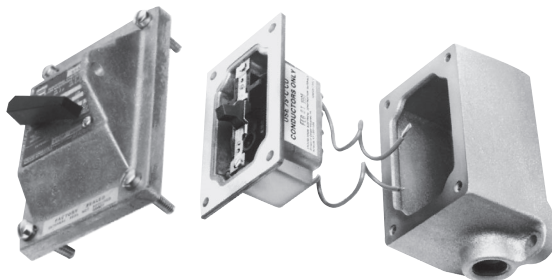
Compliances.

These devices meet the *NEC* hazardous-area compliances for: Class I, Groups B (optional), C, D; Class II, Groups E, F, G; Class III areas; and NEMA 3, 7CD, 9EFG, and 12 requirements.



EFS/EDS pushbutton selector switch

This factory-sealed control station requires field-installed seals on each hub only for EDS Class I, Group B Division 1 applications. Seals are not required for all other compliance applications.



EDS factory sealed snap switch

In this factory-sealed unit the arcing device is completely enclosed and sealed, making it safe for use in hazardous areas. No external field-installed seals are required.

Factory-Sealed Delayed Action Circuit Breaking Plugs and Receptacles –Medium Duty.

ARK-GARD® incorporates a spring loaded face plate in the receptacle. When engaged by the plug this plate moves forward and is rotated, closing the circuit. As rotation proceeds, the plug becomes locked in the receptacle and cannot be withdrawn until this procedure is reversed. In making or breaking the circuit, any resulting electrical arc is confined in a sealed chamber.

The factory-sealed chamber encloses the arcing components between two explosionproof threaded joints. These joints are coated to guarantee against seizure between the receptacle insert and housing.



ENR receptacle with ENP plug

Factory-Sealed Industrial Heavy-Duty Plugs and Receptacles.



CPS delayed action circuit breaking receptacle 20-30 amp.

CES delayed action circuit breaking receptacle 30-60 amp.

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To connect portable or movable electrical equipment, such as motors, motor-generator sets, tools, or lighting systems.

Factory-Sealed Control Stations.

For remote and local motor control and visual indication. A wide selection of pushbuttons, snap and selector switches, and pilot lights for surface and panel mounting are available.

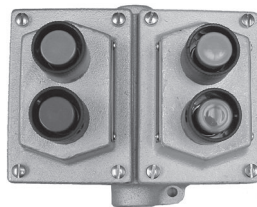
EDSCM Control device bodies are available for surface mounting of factory-sealed control stations. Up to five 1, 2, or 3-gang body modules can be joined together without an intervening seal, thus providing mounting for up to 15 control devices.



EDSC selector switch, surface mounting



EDSC pushbutton with side rocker handle



EDSC front-operated pushbutton

Factory-Sealed Units for Class I, Division 2 Hazardous Areas.

Eaton's Crouse-Hinds N2S and N2SC factory-sealed pushbutton stations, selector switches, and pilot lights meet the *NEC* requirements for Class I, Division 2, Groups B, C, D; and NEMA types 3, 4X, 7BCD (Division 2), and 12.

External seals are not required. N2S/N2SC pushbutton stations and selector switches are explosionproof. A closed-ended labyrinth contact block assures a factory-sealed device.



GHG43 control station



ESWP factory-sealed contact block

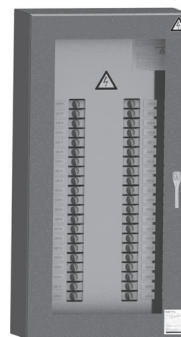
In this factory-sealed control station the arcing device is explosionproof, making it safe for use in Class I, Division 2, Groups B, C, and D hazardous areas. No external field installed seals are required.

Factory-Sealed Power Switch.



The RSWP factory-sealed motor control switch also eliminates the need for seals in most applications. It is available in non-metallic enclosures and receptacles for Division 2 applications, such as the N2RS Industrial Control Switch.

Factory-Sealed Panelboards.



SynergEX Panel

Two types of factory-sealed panelboards are used for central control and protection for large numbers of feeders and branch circuits and for housing circuit breakers. An example of the type suitable for Division 2 is the SynergEX, in which each branch circuit breaker is explosionproof, eliminating the need for an overall explosionproof enclosure and the associated conduit seals.

The second type is used for both Division 1 and 2 applications and is illustrated by Eaton's Crouse-Hinds EPL and EXD panelboards. The circuit breaker housing is explosionproof since the individual breakers, including the main, are not. All field wiring, however, is done in a separate wiring compartment with all leads between the two sections being sealed at the factory. It is interesting to note that, while the *NEC* uses the term "factory-sealed" it is also known as the "indirect entry" method.

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D2L panelboard with inverted option

Field Sealing Fittings.

For sealing conduit 2-inch trade size or larger in accordance with 501.15(A)(1)(2), and for sectionalizing long runs of conduit to eliminate pressure piling, several types of sealing fittings are available. These include EYS seals for vertical or horizontal conduit runs; EZS for sealing conduit at any angle; EYD and EZD drain seals for vertical conduit runs; and EZD inspection seals.

If water accumulation is possible in horizontal conduit runs, conduit should be graded away from seals to enclosures where ECD breather drains can be installed.

Note: Information on “Selection of Seals and Drains” and an “Installation Diagram for Sealing” may be found in Appendices III and IV.

Field Sealing Fittings.



*For sealing in vertical or horizontal positions
EYS 1/2-6 inches*



*For retro fit sealing
EYSR 3/4-4 inches*



*For sealing at any angle
EZS 1/2-3 inches*

For vertical conduit only



EYD Drain Seal 1/2-1 inch



EYD Drain Seal 1 1/4-4inch



EZD with drain inspection cover



Type 4X drain



Type 4X breather



“Standard” ECD breather drain



“Standard” ECD drain



“Universal” ECD breather or drain



EYSX



EYDX



Combination ECD breather and drain

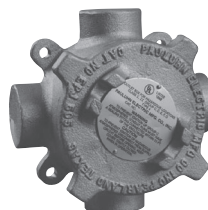
An alternative to the traditional sealing fitting is shown below. It is a conduit outlet box that can be fitted with a sealing cover. These are available in a variety of hub arrangements, can be installed vertically or horizontally, and have ample room and access for the maximum allowable forty percent wire fill.



GUAT outlet box



GUA sealing cover



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An exception to 501.15(D)(2) for multiconductor cables in conduit permits them to be sealed, in an EYS for example, as an individual conductor with the cable end in the enclosure being sealed by an approved means such as Eaton's Crouse-Hinds TSC epoxy sealing compound. This eliminates the difficult task of removing the jacket and sealing around the individual conductors in the sealing fitting.



TSC



ES sealing hub

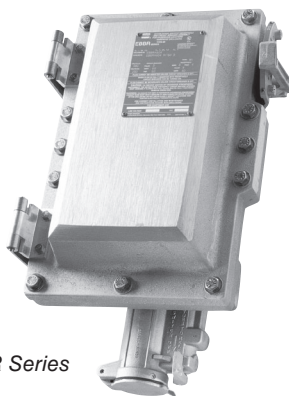
The TSC compound can also be used with Eaton's Crouse-Hinds' ES sealing hub shown above. While the ES was originally designed for use with the poured CHICO compound, using it with the TSC sealing compound allows the sealing hub to be used in any orientation, side or top, as well as bottom.

Receptacles and Attachment Plugs, Class I, Divisions 1 and 2.

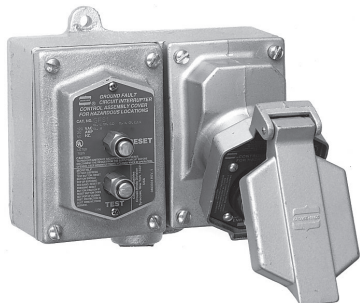
To be safe for use in Class I, Division 1 or Division 2 locations, arcing at exposed contacts must be prevented. This may be achieved in two ways: (1) by enclosing the mating parts of plug and receptacle in a chamber designed for use in these locations and by a delayed action construction which prevents complete removal of the plug until the flame, sparks, or hot metal have cooled before final withdrawal of the plug; or (2) by interlocking the plug with a properly enclosed switch whereby the mating parts are de-energized when the plug is inserted or withdrawn. Either method may be used to comply with 501.145.



NPJ Plug



EBBR Series



GFS and CPS receptacle mounted in a two-gang EDS box



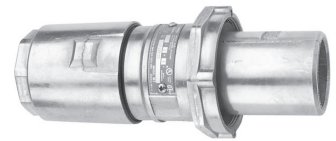
CPP plug



CPH plug



FSQC receptacle



APJ plug

501.17 Process Sealing.

This section shall apply to process-connected equipment, which includes, but is not limited to, canned pumps, submersible pumps, flow, pressure, temperature, or analysis measurement instruments. A process seal is a device to prevent the migration of process fluids from the designed containment into the external electrical system. Process-connected electrical equipment that incorporates a single process seal, such as a single compression seal, diaphragm, or tube to prevent flammable or combustible fluids from entering a conduit or cable system capable of transmitting fluids, shall be provided with an additional means to mitigate a single process seal failure. The additional means may include, but are not limited to, the following:

- (1) A suitable barrier meeting the process temperature and pressure conditions that the barrier will be subjected to upon failure of the single process seal. There shall be a vent or drain between the single process seal and the suitable barrier. Indication of the single process seal failure shall be provided by visible leakage, an audible whistle, or other means of monitoring.
- (2) A listed Type MI cable assembly, rated at not less than 125 percent of the process pressure and not less than 125 percent of the maximum process temperature (in degrees Celsius), installed between the cable or conduit and the single process seal.
- (3) A drain or vent located between the single process seal and a conduit or cable seal. The drain or vent shall be sufficiently sized to prevent overpressuring the conduit or cable seal above 6 in. water column (1493 Pa). Indication of the single process seal failure shall be provided by visible leakage, an audible whistle, or other means of monitoring.
- (4) An add-on secondary seal marked "secondary seal" and rated for the pressure and temperature conditions to which it will be subjected upon failure of the single process seal.

Process-connected electrical equipment that does not rely on a single process seal or is listed and marked "single seal", "dual seal", or "dual seal without annunciation" shall not be required to be provided with an additional means of sealing.

Process-connected electrical equipment marked "single seal — install conduit or cable seal" shall be sealed in accordance with 501.15.

Informational Note: For construction and testing requirements for process sealing for listed and marked single seal, dual seal, or secondary seal equipment, refer to ANSI/UL 122701-2017, *Requirements for Process Sealing Between Electrical Systems and Flammable or Combustible Process Fluids*.

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501.20 Conductor Insulation, Class I, Divisions 1 and 2.

Where condensed vapors or liquids may collect on, or come in contact with, the insulation on conductors, such insulation shall be of a type identified for use under such conditions; or the insulation shall be protected by a sheath of lead or by other approved means.

501.25 Uninsulated Exposed Parts, Class I, Divisions 1 and 2.

There shall be no uninsulated exposed parts, such as electrical conductors, buses, terminals, or components, that operate at more than 30 volts (15 volts in wet locations). These parts shall additionally be protected by a protection technique according to 500.7(E), (F), or (G) that is suitable for the location.

501.30 Grounding and Bonding, Class I, Divisions 1 and 2.

Regardless of the voltage of the electrical system, wiring and equipment in Class I, Division 1 and 2 locations shall be grounded as specified in Article 250 and in accordance with the requirements of 501.30(A) and (B).

(A) Bonding. The locknut-bushing and double-locknut types of contacts shall not be depended on for bonding purposes, but bonding jumpers with proper fittings or other approved means of bonding shall be used. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, and so forth between Class I locations and the point of grounding for service equipment or point of grounding of a separately derived system.

Exception: The specific bonding means shall be required only to the nearest point where the grounded circuit conductor and the grounding electrode are connected together on the line side of the building or structure disconnecting means as specified in 250.32(B), provided the branch-circuit overcurrent protection is located on the load side of the disconnecting means.

(B) Types of Equipment Grounding Conductors. Flexible metal conduit and liquidtight flexible metal conduit shall include an equipment bonding jumper of the wire type in compliance with 250.102.

Exception: In Class I, Division 2 locations, the bonding jumper shall be permitted to be deleted where all of the following conditions are met:

- (1) Listed liquidtight flexible metal conduit 1.8 m (6 ft) or less in length, with fittings listed for grounding, is used.*
- (2) Overcurrent protection in the circuit is limited to 10 amperes or less.*
- (3) The load is not a power utilization load.*

501.35 Surge Protection.

(A) Class I, Division 1. Surge arresters, surge-protective devices, and capacitors shall be installed in enclosures identified for Class I, Division 1 locations. Surge-protective capacitors shall be of a type designed for specific duty.

(B) Class I, Division 2. Surge arresters and surge-protective devices shall be nonarcing, such as metal-oxide varistor (MOV) sealed type, and surge-protective capacitors shall be of a type designed for specific duty. Enclosures shall be permitted to be of the general-purpose type. Surge protection of types other than described in this paragraph shall be installed in enclosures identified for Class I, Division 1 locations.

Part III. Equipment

501.100 Transformers and Capacitors.

(A) Class I, Division 1. In Class I, Division 1 locations, transformers and capacitors shall comply with 501.100(A)(1) and (A)(2).

(1) Containing Liquid That Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed only in vaults that comply with 450.41 through 450.48 and with (1) through (4) as follows:

- (1) There shall be no door or other communicating opening between the vault and the Division 1 location.
- (2) Ample ventilation shall be provided for the continuous removal of flammable gases or vapors.
- (3) Vent openings or ducts shall lead to a safe location outside of buildings.
- (4) Vent ducts and openings shall be of sufficient area to relieve explosion pressures within the vault, and all portions of vent ducts within the buildings shall be of reinforced concrete construction.

(2) Not Containing Liquid That Will Burn. Transformers and capacitors that do not contain a liquid that will burn shall be installed in vaults complying with 501.100(A)(1) or be identified for Class I locations.

(B) Class I, Division 2. In Class I, Division 2 locations, transformers shall comply with 450.21 through 450.27, and capacitors shall comply with 460.3 through 460.28.



XDT hazardous
transformer

501.105 Meters, Instruments, and Relays.

(A) Class I, Division 1. In Class I, Division 1 locations, meters, instruments, and relays, including kilowatt-hour meters, instrument transformers, resistors, rectifiers, and thermionic tubes, shall be provided with enclosures identified for Class I, Division 1 locations. Enclosures for Class I, Division 1 locations include explosionproof enclosures and purged and pressurized enclosures.

Informational Note: See NFPA 496-2017, Standard for Purged and Pressurized Enclosures for Electrical Equipment.

(B) Class I, Division 2. In Class I, Division 2 locations, meters, instruments, and relays shall comply with 501.105(B)(2) through (B)(6).

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(1) General-Purpose Assemblies. Where an assembly is made up of components for which general-purpose enclosures are acceptable as provided in 501.105(B)(1), (B)(2), and (B)(3), a single general-purpose enclosure shall be acceptable for the assembly. Where such an assembly includes any of the equipment described in 501.105(B)(1), 501.105(B)(2), and 501.105(B)(3), the maximum obtainable surface temperature of any component of the assembly that exceeds 100°C shall be clearly and permanently indicated on the outside of the enclosure. Alternatively, equipment shall be permitted to be marked to indicate the temperature class for which it is suitable, using the temperature class (T Code) of Table 500.8(C).

(2) Contacts. Switches, circuit breakers, and make-and-break contacts of pushbuttons, relays, alarm bells, and horns shall have enclosures identified for Class I, Division 1 locations in accordance with 501.105(A).

Exception: General-purpose enclosures shall be permitted if current-interrupting contacts comply with one of the following

(1) Are immersed in oil

(2) Are enclosed within a chamber that is hermetically sealed against the entrance of gases or vapors

(3) Are in nonincendive circuits

(4) Are listed for Division 2

(3) Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment that are used in or in connection with meters, instruments, and relays shall comply with 501.105(A).

Exception: General-purpose-type enclosures shall be permitted if such equipment is without make-and-break or sliding contacts [other than as provided in 501.105(B)(2)] and if the marked maximum operating temperature of any exposed surface will not exceed 80 percent of the autoignition temperature in degrees Celsius of the gas or vapor involved or has been tested and found incapable of igniting the gas or vapor. This exception shall not apply to thermionic tubes.

(4) Without Make-or-Break Contacts. Transformer windings, impedance coils, solenoids, and other windings that do not incorporate sliding or make-or-break contacts shall be provided with enclosures. General-purpose-type enclosures shall be permitted.

(5) Fuses. Where general-purpose enclosures are permitted in 501.105(B)(2) through (B)(4), fuses for overcurrent protection of instrument circuits not subject to overloading in normal use shall be permitted to be mounted in general-purpose enclosures if each such fuse is preceded by a switch complying with 501.105(B)(2).

(6) Connections. To facilitate replacements, process control instruments shall be permitted to be connected through flexible cord, attachment plug and receptacle, provided that all of the following conditions apply:

(1) The attachment plug and receptacle are listed for use in Class I, Division 2 locations and **listed** for use with flexible cords.

Exception No. 1: A Class I, Division 2 listing is not required if the circuit involves only nonincendive field wiring.

Exception No. 2: In industrial establishments where the conditions of maintenance and supervision ensure that only qualified individuals service the installation, the Class I, Division 2 listing is not required when the requirements of 501.105(B)(6)(2), (B)(6)(3), and (B)(6)(4) are satisfied and the receptacle carries a label warning against plugging or unplugging when energized.

(2) The flexible cord does not exceed 900 mm (3 ft), is of a type listed for extra-hard usage, or if listed for hard usage is protected by location.

(3) Only necessary receptacles are provided.

(4) Unless the attachment plug and receptacle are interlocked mechanically or electrically, or otherwise designed so that they cannot be separated when the contacts are energized and the contacts cannot be energized when the plug and socket outlet are separated, a switch complying with 501.105(B)(2) **shall be** provided so that the attachment plug or receptacle is not depended on to interrupt current. Exception: The switch shall not be required if the circuit is nonincendive field wiring.

Exception: The switch shall not be required if the circuit is nonincendive field wiring.

Meters, Instruments, and Relays

Class I, Divisions 1 and 2.

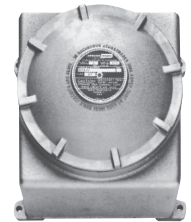
GUB and EIH hazardous location (Class I) enclosures are for meters or other instruments that must be visible to an observer.



TCH electric clock



EIH instrument enclosures



GUB with flat cover (window optional)



V2PC series photocell

GUB Junction boxes are suitable for use in Class I, Division 1 and 2 locations and provide convenient means for making branch circuit taps from main feeders. When gasketed, GUB junction boxes are ideal for outdoor use.

Note:

- Diagrams for Class I Lighting and Power Installations appear in Appendices V through X.
- A "Quick-Selector" Guide for Class I Electrical Equipment appears in Appendix XI.

501.115 Switches, Circuit Breakers, Motor Controllers, and Fuses.

(A) Class I, Division 1. In Class I, Division 1 locations, switches, circuit breakers, motor controllers, and fuses, including pushbuttons, relays, and similar devices, shall be provided with enclosures, and the enclosure in each case, together with the enclosed apparatus, shall be identified as a complete assembly for use in Class I locations.

(B) Class I, Division 2. Switches, circuit breakers, motor controllers, and fuses in Class I, Division 2 locations shall comply with 501.115(B)(1) through (B)(4).

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Class I Locations

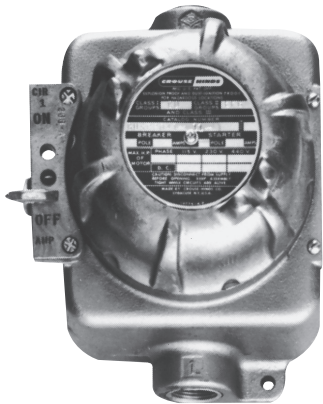
(1) Type Required. Circuit breakers, motor controllers, and switches intended to interrupt current in the normal performance of the function for which they are installed shall be provided with enclosures identified for Class I, Division 1 locations in accordance with 501.105(A), unless general-purpose enclosures are provided and any of the following apply:

- (1) The interruption of current occurs within a chamber hermetically sealed against the entrance of gases and vapors.
- (2) The current make-and-break contacts are oil-immersed and of the general-purpose type having a 50-mm (2-in.) minimum immersion for power contacts and a 25-mm (1-in.) minimum immersion for control contacts.
- (3) The interruption of current occurs within an enclosure, identified for the location, and marked “Leads Factory Sealed”, or “Factory Sealed”, or “Seal not Required”, or equivalent.
- (4) The device is a solid state, switching control without contacts, where the surface temperature does not exceed 80 percent of the autoignition temperature in degrees Celsius of the gas or vapor involved.

(2) Isolating Switches. Fused or unfused disconnect and isolating switches for transformers or capacitor banks that are not intended to interrupt current in the normal performance of the function for which they are installed shall be permitted to be installed in general-purpose enclosures.

(3) Fuses. For the protection of motors, appliances, and lamps, other than as provided in 501.115(B)(4), standard plug or cartridge fuses shall be permitted, provided they are placed within enclosures identified for the location; or fuses shall be permitted if they are within general-purpose enclosures, and if they are of a type in which the operating element is immersed in oil or other approved liquid, or the operating element is enclosed within a chamber hermetically sealed against the entrance of gases and vapors, or the fuse is a nonindicating, filled, current-limiting type.

(4) Fuses Internal to Luminaires. Listed cartridge fuses shall be permitted as supplementary protection within luminaires.



GUSC With switch or circuit breaker with external handle lock on or off position.

Switches, Circuit-Breakers, Ground Fault Circuit Interrupters, Controllers, Panelboards, etc. Class I, Divisions 1 and 2.

Exposed arcs in locations which are hazardous because of flammable gases or vapors are a positive source of ignition. Because switches, circuit breakers, motor controllers, relays, fuses, etc. produce arcs, safety requires that these arcs be rendered harmless. This objective can be accomplished by placing all arcing devices in explosionproof enclosures designed for use in hazardous locations. These enclosures will withstand the force of any internal explosions which may occur and are designed to prevent the passage of flames or gases hot enough to ignite the surrounding atmospheres. Therefore, explosions which occur due to arcs are confined within the enclosures.

Hazardous location enclosures for arcing devices are required for both Division 1 and Division 2. Exceptions are permitted in Division 2 as stated in 501.115(B).



GFS-1 ground fault circuit interrupter



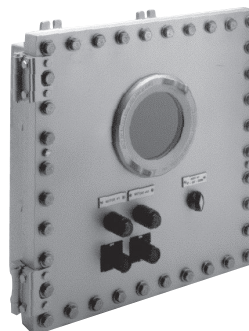
EFS pushbutton station



EBMC series motor control enclosure with combination line starter



EIB breaker assembly



EJB control panel

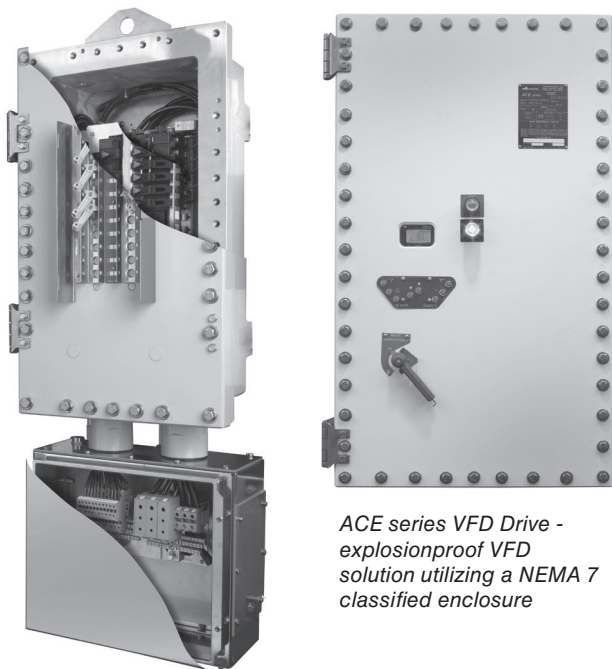


SynergEX panel

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ACE series VFD Drive -
explosionproof VFD
solution utilizing a NEMA 7
classified enclosure

PowerPlus™ panelboards are fully wired for breakers and additional spaces. Factory-sealed Multi-Sleeve Modules™ are removable, so conductors can be replaced and retain third-party approval.

501.120 Control Transformers and Resistors.

Transformers, impedance coils, and resistors used as, or in conjunction with, control equipment for motors, generators, and appliances shall comply with 501.120(A) and (B).

(A) Class I, Division 1. In Class I, Division 1 locations, transformers, impedance coils, and resistors, together with any switching mechanism associated with them, shall be provided with enclosures identified for Class I, Division 1 locations in accordance with 501.105(A).

(B) Class I, Division 2. In Class I, Division 2 locations, control transformers and resistors shall comply with 501.120(B)(1) through (B)(3).

(1) Switching Mechanisms. Switching mechanisms used in conjunction with transformers, impedance coils, and resistors shall comply with 501.115(B).

(2) Coils and Windings. Enclosures for windings of transformers, solenoids, or impedance coils shall be permitted to be of the general-purpose type.

(3) Resistors. Resistors shall be provided with enclosures; and the assembly shall be identified for Class I locations, unless resistance is nonvariable and maximum operating temperature, in degrees Celsius, will not exceed 80 percent of the autoignition temperature of the gas or vapor involved or the resistor has been tested and found incapable of igniting the gas or vapor.

501.125 Motors and Generators.

(A) Class I, Division 1. In Class I, Division 1 locations, motors, generators, and other rotating electrical machinery shall be one of the following:

- (1) Identified for Class I, Division 1 locations
- (2) Of the totally enclosed type supplied with positive-pressure ventilation from a source of clean air with discharge to a safe area, so arranged to prevent energizing of the machine until ventilation has been established and the enclosure has been purged with at least 10 volumes of air, and also arranged to automatically de-energize the equipment when the air supply fails
- (3) Of the totally enclosed inert gas-filled type supplied with a suitable reliable source of inert gas for pressurizing the enclosure, with devices provided to ensure a positive pressure in the enclosure and arranged to automatically de-energize the equipment when the gas supply fails
- (4) For machines that are for use only in industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, the machine is permitted to be of a type designed to be submerged in a liquid that is flammable only when vaporized and mixed with air, or in a gas or vapor at a pressure greater than atmospheric and that is flammable only when mixed with air; and the machine is so arranged to prevent energizing it until it has been purged with the liquid or gas to exclude air, and also arranged to automatically de-energize the equipment when the supply of liquid or gas or vapor fails or the pressure is reduced to atmospheric

Totally enclosed motors of the types specified in 501.125(A)(2) or (A)(3) shall have no external surface with an operating temperature in degrees Celsius in excess of 80 percent of the autoignition temperature of the gas or vapor involved. Appropriate devices shall be provided to detect and automatically de-energize the motor or provide an adequate alarm if there is any increase in temperature of the motor beyond designed limits. Auxiliary equipment shall be of a type identified for the location in which it is installed.

(B) Class I, Division 2. In Class I, Division 2 locations, motors, generators, and other rotating electrical machinery shall comply with (1), (2), or (3). They shall also comply with (4) and (5), if applicable.

- (1) Be identified for Class I, Division 2 locations, or
- (2) Be identified for Class I, Division 1 locations where sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent, overloading, and overtemperature devices), or integral resistance devices, either while starting or while running, are employed, or
- (3) Be open or nonexplosionproof enclosed motors, such as squirrel-cage induction motors without brushes, switching mechanisms, or similar arc-producing devices that are not identified for use in a Class I, Division 2 location.
- (4) The exposed surface of space heaters used to prevent condensation of moisture during shutdown periods shall not exceed 80 percent of the autoignition temperature in degrees Celsius of the gas or vapor involved when operated at rated voltage, and the maximum space heater surface temperature [based on a 40°C or higher marked ambient] shall be permanently marked on a visible nameplate mounted on the motor. Otherwise, space heaters shall be identified for Class I, Division 2 locations.

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- (5) A sliding contact shaft bonding device used for the purpose of maintaining the rotor at ground potential, shall be permitted where the potential discharge energy is determined to be nonincendive for the application. The shaft bonding device shall be permitted to be installed on the inside or the outside of the motor.

Informational Note No. 1: It is important to consider the temperature of internal and external surfaces that may be exposed to the flammable atmosphere.

Informational Note No. 2: It is important to consider the risk of ignition due to currents arcing across discontinuities and overheating of parts in multisection enclosures of large motors and generators. Such motors and generators may need equipotential bonding jumpers across joints in the enclosure and from enclosure to ground. Where the presence of ignitable gases or vapors is suspected, clean-air purging may be needed immediately prior to and during start-up periods.

Informational Note No. 3: For further information on the application of electric motors in Class I, Division 2 hazardous (classified) locations, see IEEE 1349-2011, *IEEE Guide for the Application of Electric Motors in Class I, Division 2 and Class I, Zone 2 Hazardous (Classified) Locations*.

Informational Note No. 4: Reciprocating engine-driven generators, compressors, and other equipment installed in Class I, Division 2 locations may present a risk of ignition of flammable materials associated with fuel, starting, compression, and so forth, due to inadvertent release or equipment malfunction by the engine ignition system and controls. For further information on the requirements for ignition systems for reciprocating engines installed in Class I, Division 2 hazardous (classified) locations, see ANSI/UL 122001-2014, *General Requirements for Electrical Ignition Systems for Internal Combustion Engines in Class I, Division 2 or Zone 2, Hazardous (Classified) Locations*.

Informational Note No. 5: For details of the evaluation process to determine incendivity, refer to Annex A and Figure A1 of UL 1836-2014, *Outline of Investigation for Electric Motors and Generators for Use in Class I, Division 2, Class I, Zone 2, Class II, Division 2 and Zone 22 Hazardous (Classified) Locations*.

501.130 Luminaires.

Luminaires shall comply with 501.130(A) or (B).

(A) Class I, Division 1. In Class I, Division 1 locations, luminaires shall comply with 501.130(A)(1) through (A)(4).

(1) Luminaires. Each luminaire shall be identified as a complete assembly for the Class I, Division 1 location and shall be clearly marked to indicate the maximum wattage of lamps for which it is identified. Luminaires intended for portable use shall be specifically listed as a complete assembly for that use.

(2) Physical Damage. Each luminaire shall be protected against physical damage by a suitable guard or by location.

3) Pendant Luminaires. Pendant luminaires shall be suspended by and supplied through threaded rigid metal conduit stems or threaded steel intermediate conduit stems, and threaded joints shall be provided with set-screws or other effective means to prevent loosening. For stems longer than 300 mm (12 in.), permanent and effective bracing against lateral displacement shall be provided at a level not more than 300 mm (12 in.) above the lower end of the stem, or flexibility in the form of a fitting or flexible connector identified for the Class I, Division 1 location shall be provided not more than 300 mm (12 in.) from the point of attachment to the supporting box or fitting.



EVLP Lo-Pro Hazard•Gard fixture

(4) Supports. Boxes, box assemblies, or fittings used for the support of luminaires shall be identified for Class I locations.

(B) Class I, Division 2. In Class I, Division 2 locations, luminaires shall comply with 501.130(B)(1) through (B)(6).

(1) Luminaires. Where lamps are of a size or type that may, under normal operating conditions, reach surface temperatures exceeding 80 percent of the autoignition temperature in degrees Celsius of the gas or vapor involved, luminaires shall comply with 501.130(A)(1) or shall be of a type that has been tested in order to determine the marked operating temperature or temperature class (T code).

(2) Physical Damage. Luminaires shall be protected from physical damage by suitable guards or by location. Where there is danger that falling sparks or hot metal from lamps or luminaires might ignite localized concentrations of flammable vapors or gases, suitable enclosures or other effective protective means shall be provided.

(3) Pendant Luminaires. Pendant luminaires shall be suspended by threaded rigid metal conduit stems, threaded steel intermediate metal conduit stems, or other approved means. For rigid stems longer than 300 mm (12 in.), permanent and effective bracing against lateral displacement shall be provided at a level not more than 300 mm (12 in.) above the lower end of the stem, or flexibility in the form of an identified fitting or flexible connector shall be provided not more than 300 mm (12 in.) from the point of attachment to the supporting box or fitting.

(4) Portable Lighting Equipment. Portable lighting equipment shall comply with 501.130(A)(1).

Exception: Where portable lighting equipment is mounted on movable stands and is connected by flexible cords, as covered in 501.140, it shall be permitted to comply with 501.130(B)(1), where mounted in any position, provided that it also complies with 501.130(B)(2).

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(5) Switches. Switches that are a part of a luminaire or of an individual lampholder shall comply with 501.115(B)(1).

(6) Starting Equipment. Starting and control equipment for electric-discharge lamps shall comply with 501.120(B).

Exception: A thermal protector potted into a thermally protected fluorescent lamp ballast if the luminaire is identified for the location.

Luminaires Class I, Division 1.

In locations where explosive gases or vapors exist, bare lamps or nonexplosionproof enclosed luminaires constitute hazards. Bare lamps may be broken, thereby causing explosions. For this reason, such lamps must be enclosed in luminaires designed for Class I, Division 1 locations (501.130(A)). Eaton's Crouse-Hinds luminaires are designed to provide easy installation, easy maintenance, and high efficiency; many types are available. Handlamps and a number of special-purpose luminaires are also available in Class I, Division 1 designs.

In hazardous locations of all classes, pendant-mounted luminaires must be suspended by flexible hangers unless rigid stems not over 12 inches long are used, or longer stems are permanently braced within 12 inches of the luminaire.

A variety of installations that meet *Code* requirements are shown.

Note: Diagrams for Class I Lighting Installations appear in Appendix VI.

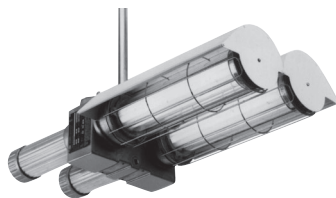
- A "Quick-Selector" Guide for Class I, Division 1 electrical equipment appears in Appendix XI.



EVLED series
luminaire – LED



Pauluhn™ ZonePro
fluorescent luminaire



The Illuminator™ EVFT four
lamp fixture, utilizes single-ended
fluorescent lamp technology



Commander series



Pauluhn™ ZPLA series
linear LED luminaire



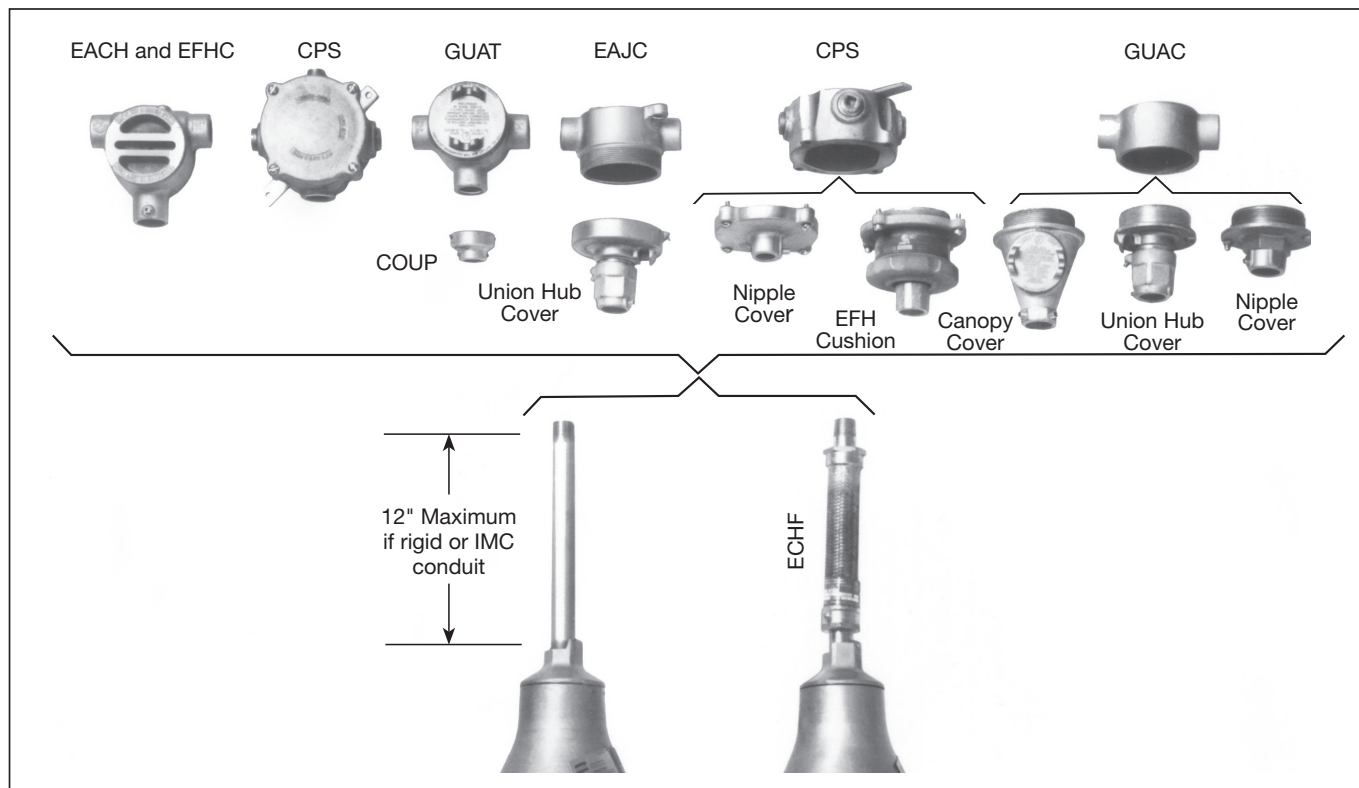
EVLLA luminaire

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Pendant luminaire hangers



Luminaires Class I, Division 2.

In locations which are classified Class I, Division 2, fixed luminaires which have been tested may operate up to the ignition temperature of the gas or vapor involved. Since it is assumed that a flammable vapor can find its way into the luminaire, this temperature is measured at the hottest accessible point, typically the lamp surface.

Another type of luminaire suitable for Class I, Division 2 has an operating temperature that is measured on its outside surface, resulting in a significantly lower temperature and, therefore, T-rating than that of the lamp. The type of protection is called "restricted breathing" and was originally developed for Zone 2 applications. Since the *NEC*, in 501.5, permits equipment rated for Zones to be used in Division 2, this type of luminaire may be used in this application.

The principle of restricted breathing involves making sure a flammable vapor is not able to enter the enclosure, which means that any conduit entries must be sealed as part of the installation. The method of sealing is not required to be explosionproof and is covered by the installation instructions.

Taking this another step forward is a luminaire that incorporates another Zone 2 protection technique as well: "non-arcing." While the lamp compartment is "restricted-breathing," the ballast compartment is "non-arcing" and there is a factory-installed seal between the two. This eliminates the need for any field installed seals. See figure below.

Eaton's Crouse-Hinds will supply specific information on operating temperatures of its luminaires on request.

Note: A "Quick Selector" Guide for Class I, Division 2 electrical equipment appears in Appendix XI. Diagrams for Class I Lighting Installations appear in Appendix VI.



VAPORGARD™ luminaires
in oil refinery



Eaton's Crouse-Hinds luminaires
are certified as ExnR "restricted
breathing" for Division 2 locations



LED N2LPS Light-Pak
emergency lighting system

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Luminaires for Class I, Division 2 areas

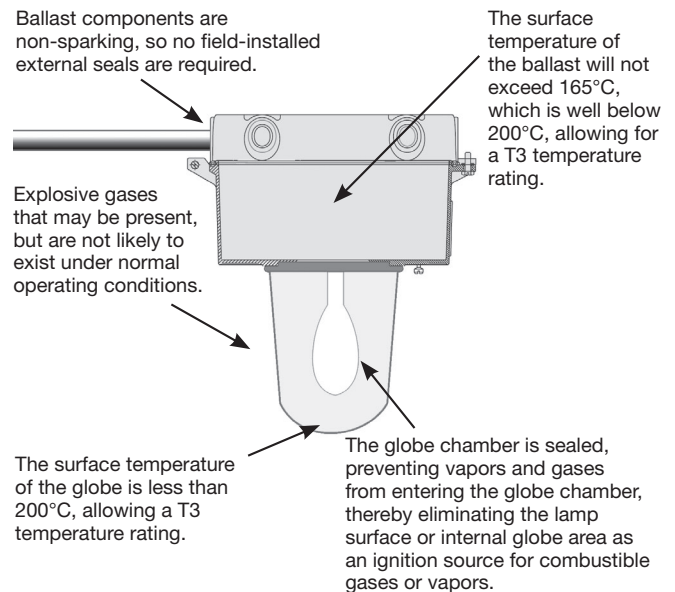


Diagram shows nA or ec factory sealed non-sparking apparatus method of protection luminaire

501.135 Utilization Equipment.

(A) Class I, Division 1. In Class I, Division 1 locations, all utilization equipment shall be identified for Class I, Division 1 locations.

(B) Class I, Division 2. In Class I, Division 2 locations, all utilization equipment shall comply with 501.135(B)(1) through (B)(3).

(1) Heaters. Electrically heated utilization equipment shall conform with either item (1) or item (2):

- (1) The heater shall not exceed 80 percent of the autoignition temperature in degrees Celsius of the gas or vapor involved on any surface that is exposed to the gas or vapor when continuously energized at the maximum rated ambient temperature. If a temperature controller is not provided, these conditions shall apply when the heater is operated at 120 percent of rated voltage.

Exception No. 1: For motor-mounted anticondensation space heaters, see 501.125.

Exception No. 2: Where a current-limiting device is applied to the circuit serving the heater to limit the current in the heater to a value less than that required to raise the heater surface temperature to 80 percent of the autoignition temperature.

- (2) The heater shall be identified for Class I, Division 1 locations.

Exception to (2): Electrical resistance and skin effect heat tracing identified for Class I, Division 2 locations.

Informational Note No. 1: For further information on electric resistance heat tracing, see ANSI/UL 60079-30-1-2017, *Standard for Explosive Atmospheres — Part 30-1: Electrical Resistance Trace Heating — General and Testing Requirements.*

Informational Note No. 2: For further information on electric skin effect heat tracing, see ANSI/IEEE 844.1/CSA C22.2 No. 293.1-2017, *Standard for Skin Effect Trace Heating of Pipelines, Vessels, Equipment, and Structures — General, Testing, Marking, and Documentation Requirements.*

(2) Motors. Motors of motor-driven utilization equipment shall comply with 501.125(B).

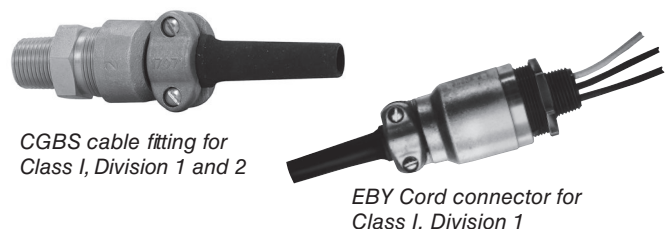
(3) Switches, Circuit Breakers, and Fuses. Switches, circuit breakers, and fuses shall comply with 501.115(B).

501.140 Flexible Cords, Class I, Divisions 1 and 2.

(A) Permitted Uses. Flexible cord shall be permitted:

- (1) For connection between portable lighting equipment or other portable utilization equipment and the fixed portion of their supply circuit. The flexible cord shall be attached to the utilization equipment with a cord connector listed for the protection technique of the equipment wiring compartment. An attachment plug in accordance with 501.140(B)(4) shall be employed.
- (2) For that portion of the circuit where the fixed wiring methods of 501.10(A) cannot provide the necessary degree of movement for fixed and mobile electrical utilization equipment, and the flexible cord is protected by location or by a suitable guard from damage and only in an industrial establishment where conditions of maintenance and engineering supervision ensure that only qualified persons install and service the installation.
- (3) For electric submersible pumps with means for removal without entering the wet-pit. The extension of the flexible cord within a suitable raceway between the wet-pit and the power source shall be permitted.
- (4) For electric mixers intended for travel into and out of open-type mixing tanks or vats.
- (5) For temporary portable assemblies consisting of receptacles, switches, and other devices that are not considered portable utilization equipment but are individually listed for the location.

Cable glands for Class I, Division 1 and 2.



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Class I Locations

(B) Installation. Where flexible cords are used, the cords shall comply with all of the following:

- (1) Be of a type listed for extra-hard usage
- (2) Contain, in addition to the conductors of the circuit, an equipment grounding conductor complying with 400.23
- (3) Be supported by clamps or by other suitable means in such a manner that there is no tension on the terminal connections
- (4) In Division 1 locations or in Division 2 locations where the boxes, fittings, or enclosures are required to be explosionproof, the cord shall be terminated with a cord connector or attachment plug listed for the location or a listed cord connector installed with a seal listed for the location. In Division 2 locations where explosionproof equipment is not required, the cord shall be terminated with a listed cord connector or listed attachment plug.
- (5) Be of continuous length. Where 501.140(A)(5) is applied, cords shall be of continuous length from the power source to the temporary portable assembly and from the temporary portable assembly to the utilization equipment.

Informational Note: See 501.20 for flexible cords exposed to liquids having a deleterious effect on the conductor insulation.

▲ 501.145 Receptacles and Attachment Plugs, Class I, Divisions 1 and 2.

(A) Receptacles. Receptacles shall be part of the premises wiring, except as permitted by 501.140(A).

(B) Attachment Plugs. Attachment plugs shall be of the type providing for connection to the equipment grounding conductor of a permitted flexible cord and shall be identified for the location.

501.150 Signaling, Alarm, Remote-Control, and Communications Systems.

(A) Class I, Division 1. In Class I, Division 1 locations, all apparatus and equipment of signaling, alarm, remote-control, and communications systems, regardless of voltage, shall be identified for Class I, Division 1 locations, and all wiring shall comply with 501.10(A), 501.15(A), and 501.15(C).

(B) Class I, Division 2. In Class I, Division 2 locations, signaling, alarm, remote-control, and communications systems shall comply with 501.150(B)(1) through (B)(4).

(1) Contacts. Switches, circuit breakers, and make-and-break contacts of pushbuttons, relays, alarm bells, and horns shall have enclosures identified for Class I, Division 1 locations in accordance with 501.105(A).

Exception: General-purpose enclosures shall be permitted if current-interrupting contacts are one of the following:

- (1) Immersed in oil
- (2) Enclosed within a chamber hermetically sealed against the entrance of gases or vapors
- (3) In nonincendive circuits
- (4) Part of a listed nonincendive component

(2) Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment shall comply with 501.105(B)(3).

(3) Protectors. Enclosures shall be provided for lightning protective devices and for fuses. Such enclosures shall be permitted to be of the general-purpose type.

(4) Wiring and Sealing. All wiring shall comply with 501.10(B), 501.15(B), and 501.15(C).

Signal, Alarm, Remote-Control, and Communications Systems Class I, Divisions 1 and 2.



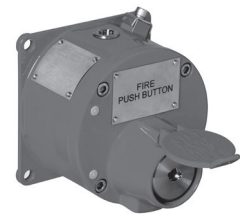
ETW telephone, pushbutton, wall mount and tone or pulse compatible



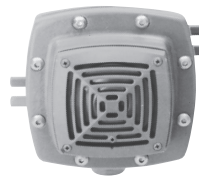
ETH Flex-Tone™ Series factory-sealed signal with programmable tone selection



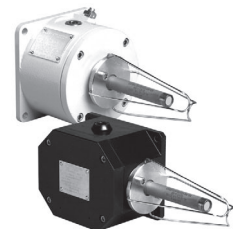
XB16 strobe light, FB15 steady-on beacon and EXR rotating beacon



SM87PBL explosionproof push button fire alarm call point



ETH horn signal



HD1 explosionproof heat detector



HRC thermostat



Ex-ResistTel hazardous area telephone

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Article 502

Class II Locations

Article 502

Part I. General

502.1 Scope.

Article 502 covers the requirements for electrical and electronic equipment and wiring for all voltages in Class II, Division 1 and 2 locations where fire or explosion hazards may exist due to combustible dust.

502.5 Explosionproof Equipment.

Explosionproof equipment and wiring shall not be required and shall not be acceptable in Class II locations unless also identified for such locations.

502.6 Zone Equipment.

Equipment listed and marked in accordance with 506.9(C)(2) for Zone 20 locations shall be permitted in Class II, Division 1 locations for the same dust atmosphere; and with a suitable temperature class.

Equipment listed and marked in accordance with 506.9(C)(2) for Zone 20, 21, or 22 locations shall be permitted in Class II, Division 2 locations for the same dust atmosphere and with a suitable temperature class.

Part II. Wiring

502.10 Wiring Methods.

Wiring methods shall comply with 502.10(A) or (B).

(A) Class II, Division 1.

- ▲ (1) General.** In Class II, Division 1 locations, the following wiring methods shall be permitted:
- (1) Threaded rigid metal conduit (Type RMC) or threaded steel intermediate metal conduit (Type IMC).
 - (2) Type MI cable with termination fittings listed for the location. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings.
 - (3) In industrial establishments with limited public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Type MC-HL cable, listed for use in Class II, Division 1 locations, with a gas/vaportight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material, a separate equipment grounding conductor(s) in accordance with 250.122, and provided with termination fittings listed for the location, shall be permitted.
 - (4) Optical fiber cable Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC shall be permitted to be installed in raceways in accordance with 502.10(A). Optical fiber cables shall be sealed in accordance with 502.15.
 - (5) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type ITC-HL cable with a gas/vaportight continuous corrugated metallic sheath and an overall jacket of suitable polymeric material, and terminated with fittings listed for the application, and installed in accordance with 727.4.
 - (6) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, for applications limited to 600 volts nominal or less, and where the cable is not subject to physical damage, and terminated with fittings listed for the location, listed Type TC-ER-HL cable. When installed in ladder, ventilated trough, or ventilated channel cable trays, cables shall be installed in a single layer, with a space not less than the larger

cable diameter between the two adjacent cables, unless otherwise protected against dust buildup resulting in increased heat. Type TC-ER-HL cable shall be installed in accordance with 336.10.

Informational Note: See the information on construction, testing, and marking of cables and cable fittings in ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

- (7) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type P cable with metal braid armor, with an overall jacket, terminated with fittings listed for the location and installed in accordance with 337.10. When installed in ladder, ventilated trough, or ventilated channel cable trays, cables shall be installed in a single layer, with a space not less than the larger cable diameter between the two adjacent cables, unless otherwise protected against dust buildup resulting in increased heat.

Informational Note No. 1: For information on construction, testing, and marking of Type P cable, see ANSI/UL 1309-2017, *Marine Shipboard Cable*.

Informational Note No. 2: For information on construction, testing, and marking of cable fittings, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

- (2) Flexible Connections.** Where necessary to employ flexible connections, one or more of the following shall also be permitted:

- (1) Dusttight flexible connectors.
- (2) Liquidtight flexible metal conduit (Type LFMC) with listed fittings.
- (3) Liquidtight flexible nonmetallic conduit (Type LFNC) with listed fittings.
- (4) Interlocked armor Type MC cable having an overall jacket of suitable polymeric material and provided with termination fittings listed for Class II, Division 1 locations.
- (5) Flexible cord listed for extra-hard usage and terminated with listed dusttight cord connectors. Where flexible cords are used, they shall comply with 502.140.
- (6) For elevator use, an identified elevator cable of Type EO, ETP, or ETT, shown under the "use" column in Table 400.4 for "hazardous (classified) locations" and terminated with listed dusttight fittings.

Informational Note: See 502.30(B) for grounding requirements where flexible conduit is used.

- (7) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, for applications limited to 600 volts nominal or less, and where the cable is not subject to physical damage, and terminated with fittings listed for the location, listed Type TC-ER-HL cable. Type TC-ER-HL cable shall be installed in accordance with 336.10.

Informational Note: See the information on construction, testing, and marking of cables and cable fittings in ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

- (8) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type P cable with metal braid armor, with an overall jacket, terminated with fittings listed for the location, and installed in accordance with 337.10.

Informational Note No. 1: For information on construction, testing, and marking of Type P cable, see ANSI/UL 1309-2017, *Marine Shipboard Cable*.

Informational Note No. 2: For information on construction, testing, and marking of cable fittings, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

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Article 502

Class II Locations

(3) Boxes and Fittings. Boxes and fittings shall be provided with threaded bosses for connection to conduit or cable terminations and shall be dusttight. Boxes and fittings in which taps, joints, or terminal connections are made, or that are used in Group E locations, shall be identified for Class II locations.

Informational Note: For entry into enclosures required to be dust-ignitionproof, see the information on construction, testing, and marking of cables, dust-ignitionproof cable fittings, and dust-ignitionproof cord connectors in ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Location*.

(B) Class II, Division 2.

(1) General. In Class II, Division 2 locations, the following wiring methods shall be permitted:

- (1) All wiring methods permitted in 502.10(A).
- (2) Rigid metal conduit (Type RMC), intermediate metal conduit (Type IMC), with listed threaded or threadless fittings.
- (3) Electrical metallic tubing (Type EMT) or dusttight wireways.
- (4) Type MC, MV, TC, or TC-ER cable, including installation in cable tray systems. Type TC-ER cable shall include an equipment grounding conductor in addition to a drain wire that might be present. The cable shall be terminated with listed fittings.
- (5) Types PLTC and PLTC-ER cable in accordance with Part II or III of Article 725, including installation in cable tray systems. The cable shall be terminated with listed fittings. Type PLTC-ER cable shall include an equipment grounding conductor in addition to a drain wire that might be present.
- (6) Types ITC and ITC-ER cable as permitted in 727.4 and terminated with listed fittings. Type ITC-ER cable shall include an equipment grounding conductor in addition to a drain wire.
- (7) Where metal conduit will not provide sufficient corrosion resistance, any of the following shall be permitted:
 - a. Listed reinforced thermosetting resin conduit (RTRC), factory elbows, and associated fittings, all marked with suffix -XW
 - b. PVC-coated rigid metal conduit (RMC), factory elbows, and associated fittings
 - c. PVC-coated intermediate metal conduit (IMC), factory elbows, and associated fittings
 - d. In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Schedule 80 PVC conduit, factory elbows, and associated fittings
- (8) Optical fiber cable Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC shall be permitted to be installed in cable trays or any other raceway in accordance with 502.10(B). Optical fiber cables shall be sealed in accordance with 502.15.
- (9) Cablebus.
- (10) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type P cable with or without metal braid armor, with an overall jacket, terminated with listed fittings, and installed in accordance with 337.10.

Informational Note: For information on construction, testing, and marking of Type P cable, see ANSI/UL 1309-2017, *Marine Shipboard Cable*.

(2) Flexible Connections. Where provision must be made for flexibility, 502.10(A)(2) shall apply.

(3) Nonincendive Field Wiring. Nonincendive field wiring shall be permitted using any of the wiring methods permitted for unclassified locations. Nonincendive field wiring systems shall be installed in accordance with the control drawing(s). Simple apparatus, not shown on the control drawing, shall be permitted in a nonincendive field wiring circuit, provided the simple apparatus does not interconnect the nonincendive field wiring circuit to any other circuit.

Informational Note: Simple apparatus is defined in Article 100 Part III.

Separate nonincendive field wiring circuits shall be installed in accordance with one of the following:

- (1) In separate cables
- (2) In multiconductor cables where the conductors of each circuit are within a grounded metal shield
- (3) In multiconductor cables or in raceways where the conductors of each circuit have insulation with a minimum thickness of 0.25 mm (0.01 in.)

(4) Boxes and Fittings. All boxes and fittings shall be dusttight.

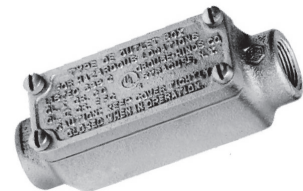
Wiring Methods Class II, Division 1.

In Class II, Division 1 locations, all boxes containing taps, joints, or terminal connections or which are used in locations where the dusts are electrically conductive, must be dust-ignitionproof. Boxes that do not contain splices or taps, and boxes to be used where dusts are non-conductive, do not have to be dust-ignitionproof, but must be dusttight.

Conduit Bodies and Outlet Boxes



GUAT



OEC



CPS

Wiring Methods Class II, Division 2.

In Class II, Division 2 locations, the junction and pull boxes must be dusttight but need not be dust-ignitionproof. It should be noted that 502.30 prohibits reliance on locknut-bushing or double-locknut bonding.



WAB junction box for drilled and tapped conduit openings

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502.15 Sealing, Class II, Divisions 1 and 2.

Where a raceway provides communication between an enclosure that is required to be dust-ignitionproof and one that is not, suitable means shall be provided to prevent the entrance of dust into the dust-ignitionproof enclosure through the raceway. One of the following means shall be permitted:

- (1) A permanent and effective seal
- (2) A horizontal raceway not less than 3.05 m (10 ft) long
- (3) A vertical raceway not less than 1.5 m (5 ft) long and extending downward from the dust-ignitionproof enclosure
- (4) A raceway installed in a manner equivalent to (2) or (3) that extends only horizontally and downward from the dust-ignition proof enclosures

Where a raceway provides communication between an enclosure that is required to be dust-ignitionproof and an enclosure in an unclassified location, seals shall not be required.

Sealing fittings shall be accessible.

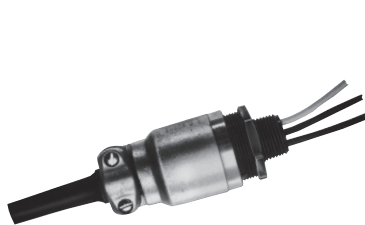
Seals shall not be required to be explosionproof.

Informational Note: Electrical sealing putty is a method of sealing.

Flexible Cord Connectors and Sealing Fittings, Class II, Divisions 1 and 2.

These connectors are well suited for use where flexible connections are required (502.10(A) and 502.10(B)). Types EYS, EZS or other suitable sealing fittings may be used for sealing in both Division 1 and Division 2, but in Class II locations, seals need not meet the stringent requirements of Class I (501.15).

Note: Information on “Selection of Seals and Drains” and an “Installation Diagram for Sealing” may be found in Appendices III and IV.



EBY cord connector, Group F & G—factory-sealed



EZS sealing fitting for sealing conduit at any angle

502.25 Uninsulated Exposed Parts, Class II, Divisions 1 and 2.

There shall be no uninsulated exposed parts, such as electrical conductors, buses, terminals, or components, that operate at more than 30 volts (15 volts in wet locations). These parts shall additionally be protected by a protection technique according to 500.7(E), (F), or (G) that is suitable for the location.

502.30 Grounding and Bonding, Class II, Divisions 1 and 2.

Regardless of the voltage of the electrical system, wiring and equipment in Class II, Division 1 and 2 locations shall be grounded as specified in Article 250 and in accordance with the requirements of 502.30(A) and (B).

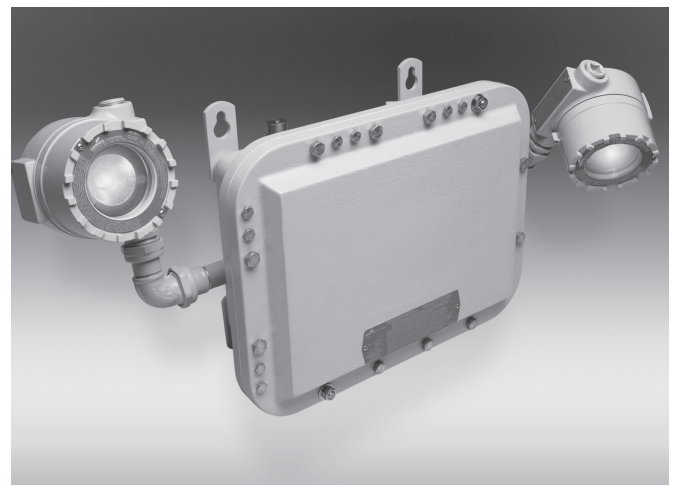
(A) Bonding. The locknut-bushing and double-locknut types of contact shall not be depended on for bonding purposes, but bonding jumpers with proper fittings or other approved means of bonding shall be used. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, and so forth, between Class II locations and the point of grounding for service equipment or point of grounding of a separately derived system.

Exception: The specific bonding means shall only be required to the nearest point where the grounded circuit conductor and the grounding electrode conductor are connected together on the line side of the building or structure disconnecting means as specified in 250.32(B) if the branch-circuit overcurrent protection is located on the load side of the disconnecting means.

(B) Types of Equipment Grounding Conductors. Liquidtight flexible metal conduit shall include an equipment bonding jumper of the wire type in compliance with 250.102.

Exception: In Class II, Division 2 locations, the bonding jumper shall be permitted to be deleted where all of the following conditions are met:

- (1) Listed liquidtight flexible metal conduit 1.8 m (6 ft) or less in length, with fittings listed for grounding, is used.*
- (2) Overcurrent protection in the circuit is limited to 10 amperes or less.*
- (3) The load is not a power utilization load.*



ELPS Light-Pak™ emergency lighting system

502.35 Surge Protection — Class II, Divisions 1 and 2.

Surge arresters and surge-protective devices installed in a Class II, Division 1 location shall be in suitable enclosures. Surge-protective capacitors shall be of a type designed for specific duty.

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Part III. Equipment

502.100 Transformers and Capacitors.

(A) Class II, Division 1. In Class II, Division 1 locations, transformers and capacitors shall comply with 502.100(A)(1) through (A)(3).

(1) Containing Liquid That Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed only in vaults complying with 450.41 through 450.48, and, in addition, (1), (2), and (3) shall apply.

(1) Doors or other openings communicating with the Division 1 location shall have self-closing fire doors on both sides of the wall, and the doors shall be carefully fitted and provided with suitable seals (such as weather stripping) to minimize the entrance of dust into the vault.

(2) Vent openings and ducts shall communicate only with the outside air.

(3) Suitable pressure-relief openings communicating with the outside air shall be provided.

(2) Not Containing Liquid That Will Burn. Transformers and capacitors that do not contain a liquid that will burn shall be installed in vaults complying with 450.41 through 450.48 or be identified as a complete assembly, including terminal connections.

(3) Group E. No transformer or capacitor shall be installed in a Class II, Division 1, Group E location.

(B) Class II, Division 2. In Class II, Division 2 locations, transformers and capacitors shall comply with 502.100(B)(1) through (B)(3).

(1) Containing Liquid That Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed in vaults that comply with 450.41 through 450.48.

(2) Containing Askarel. Transformers containing askarel and rated in excess of 25 kVA shall be as follows:

(1) Provided with pressure-relief vents

(2) Provided with a means for absorbing any gases generated by arcing inside the case, or the pressure-relief vents shall be connected to a chimney or flue that will carry such gases outside the building

(3) Have an airspace of not less than 150 mm (6 in.) between the transformer cases and any adjacent combustible material

(3) Dry-Type Transformers. Dry-type transformers shall be installed in vaults or shall have their windings and terminal connections enclosed in tight metal housings without ventilating or other openings and shall operate at not over 600 volts, nominal.

502.115 Switches, Circuit Breakers, Motor Controllers, and Fuses.

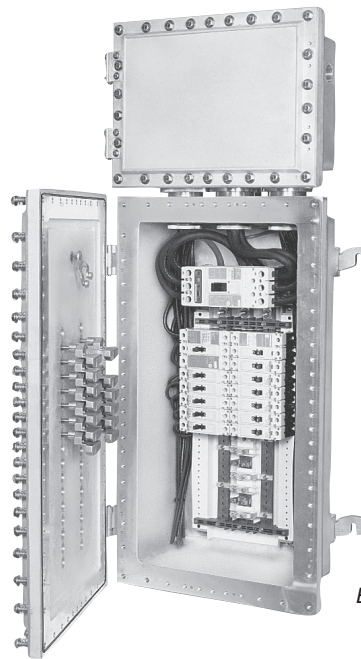
(A) Class II, Division 1. In Class II, Division 1 locations, switches, circuit breakers, motor controllers, fuses, push-buttons, relays, and similar devices shall be provided with enclosures identified for the location.

(B) Class II, Division 2. In Class II, Division 2 locations, enclosures for fuses, switches, circuit breakers, and motor controllers, including push buttons, relays, and similar devices, shall be dusttight or otherwise identified for the location.

Switches, Circuit Breakers, Motor Controllers, and Fuses, Class II, Division 1.

Arcing devices in enclosures not dust-ignitionproof are unsafe for use in Class II, Division 1 locations because in operation they are likely to ignite dust accumulations in the enclosures and, in turn, the surrounding dust-laden atmosphere. Also they must provide protection against weather, dampness, and corrosion.

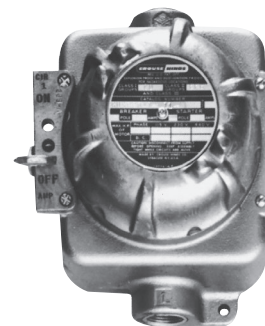
These enclosures meet the requirements of 502.115(A) and, therefore, are suitable for use in Class II hazardous locations.



EXD panelboard



EFS pushbutton station



GUSC
with switch or circuit breaker
with external handle lock on
or off position

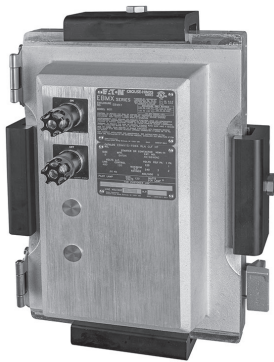


XDT transformer

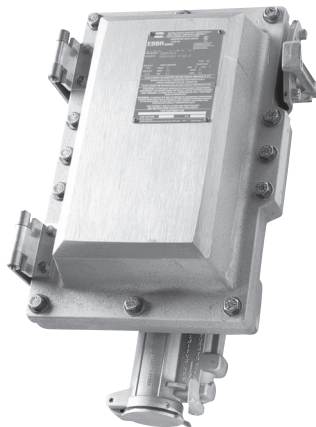
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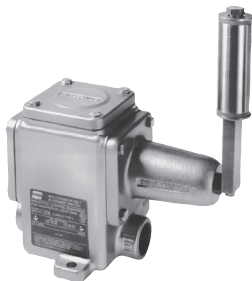
Class II Locations



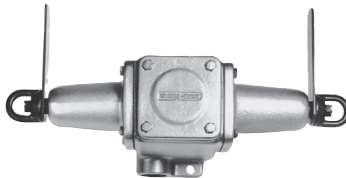
EBMX series combination
starter and breaker



EBBR series circuit breaker
and interlocked receptacle



AFA conveyor belt
alignment switch



AFU conveyor control
safety switch

502.120 Control Transformers and Resistors.

(A) Class II, Division 1. In Class II, Division 1 locations, control transformers, solenoids, impedance coils, resistors, and any overcurrent devices or switching mechanisms associated with them shall be provided with enclosures identified for the location.

(B) Class II, Division 2. In Class II, Division 2 locations, transformers and resistors shall comply with 502.120(B)(1) through (B)(3).

(1) Switching Mechanisms. Switching mechanisms (including overcurrent devices) associated with control transformers, solenoids, impedance coils, and resistors shall be provided with enclosures that are dusttight or otherwise identified for the location.

(2) Coils and Windings. Where not located in the same enclosure with switching mechanisms, control transformers, solenoids, and impedance coils shall be provided with enclosures that are dusttight or otherwise identified for the location.

(3) Resistors. Resistors and resistance devices shall have dust-ignitionproof enclosures that are dusttight or otherwise identified for the location.

502.125 Motors and Generators.

(A) Class II, Division 1. In Class II, Division 1 locations, motors, generators, and other rotating electrical machinery shall be in conformance with either of the following:

- (1) Identified for the location
- (2) Totally enclosed pipe-ventilated

(B) Class II, Division 2. In Class II, Division 2 locations, motors, generators, and other rotating electrical equipment shall be totally enclosed nonventilated, totally enclosed pipe-ventilated, totally enclosed water-air-cooled, totally enclosed fan-cooled, or dust-ignitionproof, for which maximum full-load external temperature shall be in accordance with 500.8(D)(2) for normal operation when operating in free air (not dust blanketed) and shall have no external openings.

Exception: If the authority having jurisdiction believes accumulations of nonconductive, nonabrasive dust will be moderate and if machines can be easily reached for routine cleaning and maintenance, the following shall be permitted to be installed:

- (1) Standard open-type machines without sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent, overloading, and overtemperature devices), or integral resistance devices
- (2) Standard open-type machines with such contacts, switching mechanisms, or resistance devices enclosed within dusttight housings without ventilating or other openings
- (3) Self-cleaning textile motors of the squirrel-cage type
- (4) Machines with sealed bearings, bearing isolators, and seals

502.128 Ventilating Piping.

Ventilating pipes for motors, generators, or other rotating electrical machinery, or for enclosures for electrical equipment, shall be of metal not less than 0.53 mm (0.021 in.) in thickness or of equally substantial noncombustible material and shall comply with all of the following:

- (1) Lead directly to a source of clean air outside of buildings
- (2) Be screened at the outer ends to prevent the entrance of small animals or birds
- (3) Be protected against physical damage and against rusting or other corrosive influences

Ventilating pipes shall also comply with 502.128(A) and (B).

(A) Class II, Division 1. In Class II, Division 1 locations, ventilating pipes, including their connections to motors or to the dust-ignitionproof enclosures for other equipment, shall be dusttight throughout their length. For metal pipes, seams and joints shall comply with one of the following:

- (1) Be riveted and soldered
- (2) Be bolted and soldered
- (3) Be welded
- (4) Be rendered dusttight by some other equally effective means

(B) Class II, Division 2. In Class II, Division 2 locations, ventilating pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of dust into the ventilated equipment or enclosure and to prevent the escape of sparks, flame, or burning material that might ignite dust accumulations or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints shall be permitted; and tight-fitting slip joints shall be permitted where some flexibility is necessary, as at connections to motors.

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Article 502

Class II Locations

502.130 Luminaires.

(A) Class II, Division 1. In Class II, Division 1 locations, luminaires for fixed and portable lighting shall comply with 502.130(A)(1) through (A)(4).

(1) Marking. Each luminaire shall be identified for the location and shall be clearly marked to indicate the type and maximum wattage of the lamp for which it is designed.

(2) Physical Damage. Each luminaire shall be protected against physical damage by a suitable guard or by location.

(3) Pendant Luminaires. Pendant luminaires shall be suspended by threaded rigid metal conduit stems, by threaded steel intermediate metal conduit stems, by chains with approved fittings, or by other approved means. For rigid stems longer than 300 mm (12 in.), permanent and effective bracing against lateral displacement shall be provided at a level not more than 300 mm (12 in.) above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector listed for the location shall be provided not more than 300 mm (12 in.) from the point of attachment to the supporting box or fitting. Threaded joints shall be provided with set screws or other effective means to prevent loosening. Where wiring between an outlet box or fitting and a pendant luminaire is not enclosed in conduit, flexible cord listed for hard usage shall be permitted to be used in accordance with 502.10(A)(2)(5). Flexible cord shall not serve as the supporting means for a luminaire.

(4) Supports. Boxes, box assemblies, or fittings used for the support of luminaires shall be identified for Class II locations.

(B) Class II, Division 2. In Class II, Division 2 locations, luminaires shall comply with 502.130(B)(1) through (B)(5).

(1) Portable Lighting Equipment. Portable lighting equipment shall be identified for the location. They shall be clearly marked to indicate the maximum wattage of lamps for which they are designed.

(2) Fixed Lighting. Luminaires for fixed lighting shall be provided with enclosures that are dusttight or otherwise identified for the location. Each luminaire shall be clearly marked to indicate the maximum wattage of the lamp that shall be permitted without exceeding an exposed surface temperature in accordance with 500.8(D)(2) under normal conditions of use.

(3) Physical Damage. Luminaires for fixed lighting shall be protected from physical damage by suitable guards or by location.

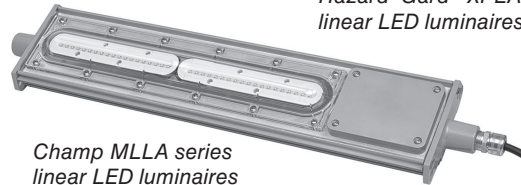
(4) Pendant Luminaires. Pendant luminaires shall be suspended by threaded rigid metal conduit stems, by threaded steel intermediate metal conduit stems, by chains with approved fittings, or by other approved means. For rigid stems longer than 300 mm (12 in.), permanent and effective bracing against lateral displacement shall be provided at a level not more than 300 mm (12 in.) above the lower end of the stem, or flexibility in the form of an identified fitting or a flexible connector shall be provided not more than 300 mm (12 in.) from the point of attachment to the supporting box or fitting. Where wiring between an outlet box or fitting and a pendant luminaire is not enclosed in conduit, flexible cord listed for hard usage shall be permitted if terminated with a listed cord connector that maintains the protection technique. Flexible cord shall not serve as the supporting means for a luminaire.

(5) Electric-Discharge Lamps. Starting and control equipment for electric-discharge lamps shall comply with the requirements of 502.120(B).

Luminaires, Class II, Division 1.



*Hazard•Gard® XPLA series
linear LED luminaires*



*Champ MLLA series
linear LED luminaires*



Champ® VMV LED series luminaire



*HAZARD•GARD® EVM
series H.I.D. luminaire*



Radia fluorescent luminaire

Luminaires, Class II, Division 2.

In accordance with 502.130(B)(2), Eaton's Crouse-Hinds will supply specific information on operating temperatures of these luminaires on request.

Note: A "Quick Selector" Guide for Class II electrical equipment appears in Appendix XI.

Diagrams for Class II lighting installations appear in Appendix IX.



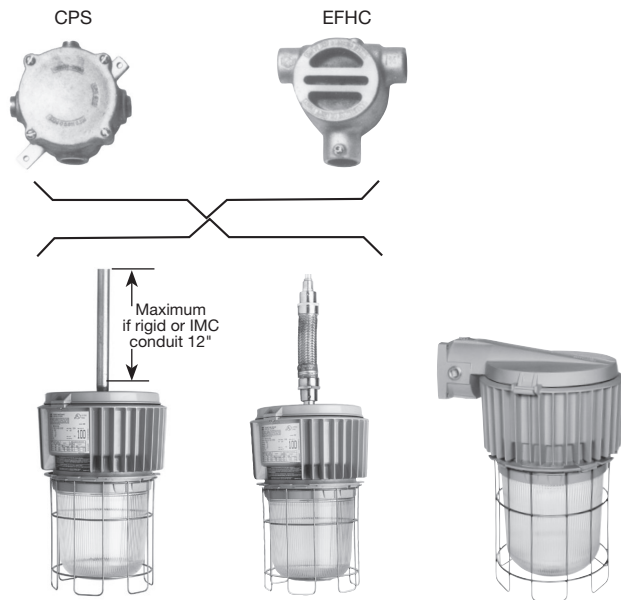
*Pauluhn™ WashPro series linear
fluorescent luminaire*

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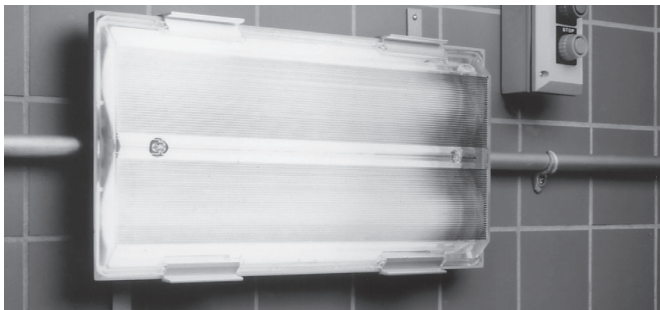
Article 502

Class II Locations

Pendant Fixtures and Supports, Class II. Suggested Installation Methods



CHAMP® DMV enclosed and gasketed H.I.D. luminaire with integral ballast



FVS compact fluorescent luminaire features a compact, low profile design for almost any mounting application.



Class II luminaires allow lights to be placed where they are needed most, without fear of causing a fire from sparks or overheating.

502.135 Utilization Equipment.

(A) Class II, Division 1. In Class II, Division 1 locations, all utilization equipment shall be identified for the location.

(B) Class II, Division 2. In Class II, Division 2 locations, all utilization equipment shall comply with 502.135(B)(1) through (B)(4).

(1) Heaters. Electrically heated utilization equipment shall be identified for the location.

Exception: Metal-enclosed radiant heating panel equipment shall be permitted to be dusttight and marked in accordance with 500.8(C).

(2) Motors. Motors of motor-driven utilization equipment shall comply with 502.125(B).

(3) Switches, Circuit Breakers, and Fuses. Enclosures for switches, circuit breakers, and fuses shall comply with 502.115(B).

(4) Transformers, Solenoids, Impedance Coils, and Resistors. Transformers, solenoids, impedance coils, and resistors shall comply with 502.120(B).

▲ 502.140 Flexible Cords — Class II, Divisions 1 and 2.

(A) Permitted Uses. Flexible cords used in Class II locations shall comply with all of the following.

- (1) For connection between portable lighting equipment or other portable utilization equipment and the fixed portion of its supply circuit. The flexible cord shall be attached to the utilization equipment with a cord connector listed for the protection technique of the equipment wiring compartment. An attachment plug in accordance with 502.145 shall be employed.
- (2) Where flexible cord is permitted by 502.10(A)(2) for fixed and mobile electrical utilization equipment; where the flexible cord is protected by location or by a suitable guard from damage; and only in an industrial establishment where conditions of maintenance and engineering supervision ensure that only qualified persons install and service the installation.
- (3) For electric submersible pumps with means for removal without entering the wet-pit. The extension of the flexible cord within a suitable raceway between the wet-pit and the power source shall be permitted.
- (4) For electric mixers intended for travel into and out of open-type mixing tanks or vats.
- (5) For temporary portable assemblies consisting of receptacles, switches, and other devices that are not considered portable utilization equipment but are individually listed for the location.

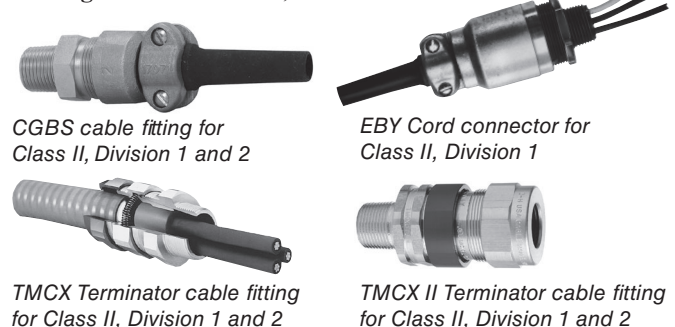
(B) Installation. Where flexible cords are used, the cords shall comply with all of the following:

- (1) Be of a type listed for extra-hard usage.

Exception: Flexible cord listed for hard usage as permitted by 502.130(A)(3) and (B)(4).

- (2) Contain, in addition to the conductors of the circuit, an equipment grounding conductor complying with 400.23.
- (3) Be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connections.

Cable glands for Class II, Division 1 and 2.



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Article 502

Class II Locations

- (4) In Division 1 locations, the cord shall be terminated with a cord connector listed for the location or a listed cord connector installed with a seal listed for the location. In Division 2 locations, the cord shall be terminated with a listed dusttight cord connector.
- (5) Be of continuous length. Where 502.140(A)(5) is applied, cords shall be of continuous length from the power source to the temporary portable assembly and from the temporary portable assembly to the utilization equipment.

502.145 Receptacles and Attachment Plugs.

Receptacles and attachment plugs shall be identified for the location.

(A) Class II, Division 1.

(1) Receptacles. In Class II, Division 1 locations, receptacles shall be part of the premises wiring.

(2) Attachment Plugs. Attachment plugs shall be of the type that provides for connection to the equipment grounding conductor of the flexible cord.

(B) Class II, Division 2.

(1) Receptacles. In Class II, Division 2 locations, receptacles shall be part of the premises wiring.

(2) Attachment Plugs. Attachment plugs shall be of the type that provides for connection to the equipment grounding conductor of the flexible cord.

Receptacles and Attachment Plugs, Class II, Groups F and G, Division 1.

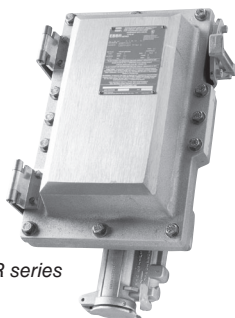
Some Class I equipment is also suitable for Class II, Groups F and G, Division 1. See catalog listing for suitability.



DBR series circuit breaker and interlocking receptacle



FSQC interlocked receptacle and switch



EBBR series

502.150 Signaling, Alarm, Remote-Control, and Communications Systems; and Meters, Instruments, and Relays.

Informational Note: See Article 805 for rules governing the installation of communications circuits.

(A) Class II, Division 1. In Class II, Division 1 locations, signaling, alarm, remote-control, and communications systems; and meters, instruments, and relays shall comply with 502.150(A)(1) through (A)(3).

(1) Contacts. Switches, circuit breakers, relays, contactors, fuses and current-breaking contacts for bells, horns, howlers, sirens, and other devices in which sparks or arcs may be produced shall be provided with enclosures identified for the location.

Exception: Where current-breaking contacts are immersed in oil or where the interruption of current occurs within a chamber sealed against the entrance of dust, enclosures shall be permitted to be of the general-purpose type.

(2) Resistors and Similar Equipment. Resistors, transformers, choke coils, rectifiers, thermionic tubes, and other heat-generating equipment shall be provided with enclosures identified for the location.

Exception: Where resistors or similar equipment are immersed in oil or enclosed in a chamber sealed against the entrance of dust, enclosures shall be permitted to be of the general-purpose type.

(3) Rotating Machinery. Motors, generators, and other rotating electrical machinery shall comply with 502.125(A).

(B) Class II, Division 2. In Class II, Division 2 locations, signaling, alarm, remote-control, and communications systems; and meters, instruments, and relays shall comply with 502.150(B)(1) through (B)(4).

(1) Contacts. Contacts shall comply with 502.150(A)(1) or shall be installed in enclosures that are dusttight or otherwise identified for the location.

Exception: In nonincendive circuits, enclosures shall be permitted to be of the general-purpose type.

(2) Transformers and Similar Equipment. The windings and terminal connections of transformers, choke coils, and similar equipment shall comply with 502.120(B)(2).

(3) Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment shall comply with 502.120(B)(3).

(4) Rotating Machinery. Motors, generators, and other rotating electric machinery shall comply with 502.125(B).

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(5) Connections. To facilitate replacements, process control instruments shall be permitted to be connected through flexible cord, attachment plug, and receptacle, provided that all of the following conditions apply:

- (1) Attachment plug and receptacle are listed for use in Class II, Division 2 locations, and listed for use with flexible cords.

Exception No. 1: A Class II, Division 2 listing is not required if the circuit involves only nonincendive field wiring.

Exception No. 2: In industrial establishments where the conditions of maintenance and supervision ensure that only qualified individuals service the installation, the Class II, Division 2 listing is not required when the requirements of list items 502.150(B)(5)(2), (B)(5)(3), and (B)(5)(4) are satisfied and the receptacle carries a label warning against plugging or unplugging when energized.

- (2) The flexible cord does not exceed 900 mm (3 ft), is of a type listed for extra-hard usage, or if listed for hard usage is protected by location.
- (3) Only necessary receptacles are provided.
- (4) Unless the attachment plug and receptacle are interlocked mechanically or electrically, or otherwise designed so that they cannot be separated when the contacts are energized, and the contacts cannot be energized when the plug and socket outlet are separated, a switch complying with 502.115(B) shall be provided so that the attachment plug or receptacle is not depended on to interrupt current.

Exception: The switch shall not be required if the circuit is nonincendive field wiring..

Class II and III locations.

Class II locations are defined by Article 500 of the *National Electrical Code*. Article 502 describes equipment suitable for use in Class II. These locations are hazardous because of the presence of combustible dust, or locations in which accumulated dust on electrical apparatus may cause overheating with resultant fire or explosions. Many persons who realize that grain and other organic dust clouds explode do not realize that many inorganic dusts, including those of several metals, also explode with great violence and therefore require similar safeguards. Furthermore, some dusts are electrically conductive and therefore must be prevented from lodging on live parts where they could cause short circuits and grounds.

Many enclosed devices and luminaires are satisfactory for use in dirty locations where the dusts present are not combustible and/or conductive. Equipment designed for use in Class II locations must not only exclude dust from the interiors of enclosures but the complete assembly must be designed to operate, even when blanketed with dust, at a temperature below the ignition point of the dust. Exacting standards for the construction of joints in enclosures, and temperature of operation have been established by UL LLC. Design of dust-ignitionproof equipment for Class II hazardous locations must comply with these standards and devices must be marked for this special use.

Note:

- Diagrams for Class II lighting and power installations appear in Appendices IX and X.
- A “Quick Selector” Guide for Class II electrical equipment appears in Appendix XI.

In Class III locations, the hazardous materials are easily ignitable fibers or materials which produce combustible flyings. These fibers and flyings are decidedly dangerous not only because they are easily ignited, but also because of the speed at which flames spread through them.

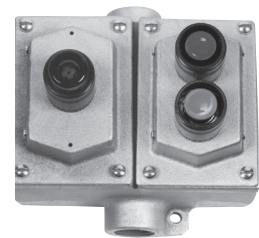
When a fibrous material such as cotton is distributed in the form of lint or “flyings,” as a thin film over machinery and portions of the building, fire travels with a rapidity approaching an explosion. Such fires, usually called “flash fires,” have been the origin of tremendous disasters.

In the *NEC*, Class III includes all locations in which ignitable fibers or materials producing combustible flyings are handled, manufactured, used, or stored. Division 1 of this class applies to locations where the material is handled, manufactured or used. Division 2 applies to locations where these materials are stored, or handled but where no manufacturing processes are performed.

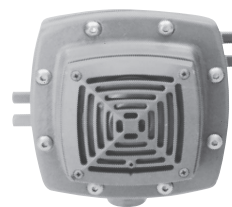
Note: A “Quick Selector” Guide for Class III electrical equipment appears in Appendix XI. **Signaling, Alarm, Remote-Control, and Communications Systems.**



ETH Flex-Tone signaling device



EFS pushbutton station and pilot light



ETH horn signal



EXSO, FB15 steady-on beacon, EXR rotating beacon, EXS strobe lights



ETW telephone

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Article 503

Class III Locations

Article 503



ECOS fluorescent luminaire

Part I. General

503.1 Scope.

Article 503 covers the requirements for electrical and electronic equipment and wiring for all voltages in Class III, Division 1 and 2 locations where fire or explosion hazards may exist due to ignitable fibers/flyings.

▲ 503.5 General.

Equipment installed in Class III locations shall be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of accumulated fibers/flyings. Organic material that is carbonized or excessively dry is highly susceptible to spontaneous ignition. The maximum surface temperatures under operating conditions shall not exceed 165°C (329°F) for equipment that is not subject to overloading, and 120°C (248°F) for equipment (such as motors or power transformers) that may be overloaded.

Informational Note: For electric trucks, see NFPA 505-2018, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*.

503.6 Zone Equipment.

Equipment listed and marked in accordance with 506.9(C)(2) for Zone 20 locations and with a temperature class of not greater than T120°C (for equipment that may be overloaded) or not greater than T165°C (for equipment not subject to overloading) shall be permitted in Class III, Division 1 locations.

Equipment listed and marked in accordance with 506.9(C)(2) for Zone 20, 21, or 22 locations and with a temperature class of not greater than T120°C (for equipment that may be overloaded) or not greater than T165°C (for equipment not subject to overloading) shall be permitted in Class III, Division 2 locations.

Part II. Wiring

503.10 Wiring Methods.

Wiring methods shall comply with 503.10(A) or (B).

(A) Class III, Division 1.

▲ (1) **General.** In Class III, Division 1 locations, the following wiring methods shall be permitted:

- (1) Rigid metal conduit (Type RMC), Type PVC conduit, Type RTRC conduit, intermediate metal conduit (Type IMC), electrical metallic tubing (EMT), dusttight wireways, or Type MC or MI cable with listed termination fittings.
- (2) Types PLTC and PLTC-ER cable in accordance with Part II or III of Article 725, including installation in cable tray systems. The cable shall be terminated with listed fittings. Type PLTC-ER cable shall include an equipment grounding conductor in addition to a drain wire that might be present.
- (3) Types ITC and ITC-ER cable as permitted in 727.4 and terminated with listed fittings. Type ITC-ER cable shall include an equipment grounding conductor in addition to a drain wire.
- (4) Type MV, TC, or TC-ER cable, including installation in cable tray systems. Type TC-ER cable shall include an equipment grounding conductor in addition to a drain wire that might be present. The cable shall be terminated with listed fittings.

(5) Cablebus.

(2) **Boxes and Fittings.** All boxes and fittings shall be dusttight.

(3) **Flexible Connections.** Where necessary to employ flexible connections, one or more of the following shall be permitted:

- (1) Dusttight flexible connectors
- (2) Liquidtight flexible metal conduit (Type LFMC) with listed fittings
- (3) Liquidtight flexible nonmetallic conduit (Type LFNC) with listed fittings
- (4) Interlocked armor Type MC cable having an overall jacket of suitable polymeric material and installed with listed dusttight termination fittings
- (5) Flexible cord in compliance with 503.140

Informational Note: See 503.30(B) for grounding requirements where flexible conduit is used.

(6) For elevator use, an identified elevator cable of Type EO, ETP, or ETT, shown under the “use” column in Table 400.4 for “hazardous (classified) locations” and terminated with listed dusttight fittings.

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Class III Locations

(4) Nonincendive Field Wiring. Nonincendive field wiring shall be permitted using any of the wiring methods permitted for unclassified locations. Nonincendive field wiring systems shall be installed in accordance with the control drawing(s). Simple apparatus, not shown on the control drawing, shall be permitted in a nonincendive field wiring circuit, provided the simple apparatus does not interconnect the nonincendive field wiring circuit to any other circuit.

Informational Note: Simple apparatus is defined in Article 100 Part III.

Separate nonincendive field wiring circuits shall be installed in accordance with one of the following:

- (1) In separate cables
- (2) In multiconductor cables where the conductors of each circuit are within a grounded metal shield
- (3) In multiconductor cables where the conductors of each circuit have insulation with a minimum thickness of 0.25 mm (0.01 in.)

(B) Class III, Division 2. In Class III, Division 2 locations, the wiring method shall comply with 503.10(A).

Exception: In sections, compartments, or areas used solely for storage and containing no machinery, open wiring on insulators shall be permitted where installed in accordance with Article 398, but only on condition that protection as required by 398.15(C) be provided where conductors are not run in roof spaces and are well out of reach of sources of physical damage.

Wiring Methods, Class III, Division 1.

In Class III, Division 1 locations, the junction and pull boxes must be dusttight but need not be dust-ignitionproof.



WAB

503.25 Uninsulated Exposed Parts, Class III, Divisions 1 and 2.

There shall be no uninsulated exposed parts, such as electrical conductors, buses, terminals, or components, that operate at more than 30 volts (15 volts in wet locations). These parts shall additionally be protected by a protection technique according to 500.7(E), (F), or (G) that is suitable for the location.

Exception: As provided in 503.155.

503.30 Grounding and Bonding — Class III, Divisions 1 and 2.

Regardless of the voltage of the electrical system, wiring and equipment in Class III, Division 1 and 2 locations shall be grounded as specified in Article 250 and with the following additional requirements in 503.30(A) and (B).

(A) Bonding. The locknut-bushing and double-locknut types of contacts shall not be depended on for bonding purposes, but bonding jumpers with proper fittings or other approved means of bonding shall be used. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, and so forth, between Class III locations and the point of grounding for service equipment or point of grounding of a separately derived system.

Exception: The specific bonding means shall only be required to the nearest point where the grounded circuit conductor and the grounding electrode conductor are connected together on the line side of the building or structure disconnecting means as specified in 250.32(B) if the branch-circuit overcurrent protection is located on the load side of the disconnecting means.

(B) Types of Equipment Bonding Conductors. Liquidtight flexible metal conduit shall include an equipment bonding jumper of the wire type in compliance with 250.102.

Exception: In Class III, Division 1 and 2 locations, the bonding jumper shall be permitted to be deleted where all of the following conditions are met:

- (1) Listed liquidtight flexible metal conduit 1.8 m (6 ft) or less in length, with fittings listed for grounding, is used.
- (2) Overcurrent protection in the circuit is limited to 10 amperes or less.
- (3) The load is not a power utilization load.

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Article 503

Class III Locations

Part III. Equipment

503.100 Transformers and Capacitors — Class III, Divisions 1 and 2.

Transformers and capacitors shall comply with 502.100(B).

503.115 Switches, Circuit Breakers, Motor Controllers, and Fuses — Class III, Divisions 1 and 2.

Switches, circuit breakers, motor controllers, and fuses, including pushbuttons, relays, and similar devices, shall be provided with dusttight enclosures.



N2RS factory-sealed industrial control switch



EDS selector switch with pilot light

503.120 Control Transformers and Resistors — Class III, Divisions 1 and 2.

Transformers, impedance coils, and resistors used as, or in conjunction with, control equipment for motors, generators, and appliances shall be provided with dusttight enclosures complying with the temperature limitations in 503.5.

503.125 Motors and Generators — Class III, Divisions 1 and 2.

In Class III, Divisions 1 and 2 locations, motors, generators, and other rotating machinery shall be totally enclosed nonventilated, totally enclosed pipe ventilated, or totally enclosed fan cooled.

Exception: In locations where, in the judgment of the authority having jurisdiction, only moderate accumulations of lint or flyings are likely to collect on, in, or in the vicinity of a rotating electrical machine and where such machine is readily accessible for routine cleaning and maintenance, one of the following shall be permitted:

- (1) Self-cleaning textile motors of the squirrel-cage type
- (2) Standard open-type machines without sliding contacts, centrifugal or other types of switching mechanisms, including motor overload devices
- (3) Standard open-type machines having such contacts, switching mechanisms, or resistance devices enclosed within tight housings without ventilating or other openings

503.128 Ventilating Piping — Class III, Divisions 1 and 2.

Ventilating pipes for motors, generators, or other rotating electrical machinery, or for enclosures for electric equipment, shall be of metal not less than 0.53 mm (0.021 in.) in thickness, or of equally substantial noncombustible material, and shall comply with the following:

- (1) Lead directly to a source of clean air outside of buildings
- (2) Be screened at the outer ends to prevent the entrance of small animals or birds
- (3) Be protected against physical damage and against rusting or other corrosive influences

Ventilating pipes shall be sufficiently tight, including their connections, to prevent the entrance of appreciable quantities of fibers/flyings into the ventilated equipment or enclosure and to prevent the escape of sparks, flame, or burning material that might ignite accumulations of fibers/flyings or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints shall be permitted; and tight-fitting slip joints shall be permitted where some flexibility is necessary, as at connections to motors.

503.130 Luminaires — Class III, Divisions 1 and 2.

(A) Fixed Lighting. Luminaires for fixed lighting shall provide enclosures for lamps and lampholders that are designed to minimize entrance of fibers/flyings and to prevent the escape of sparks, burning material, or hot metal. Each luminaire shall be clearly marked to show the maximum wattage of the lamps that shall be permitted without exceeding an exposed surface temperature of 165°C (329°F) under normal conditions of use.

(B) Physical Damage. A luminaire that may be exposed to physical damage shall be protected by a suitable guard.

(C) Pendant Luminaires. Pendant luminaires shall be suspended by stems of threaded rigid metal conduit, threaded intermediate metal conduit, threaded metal tubing of equivalent thickness, or by chains with approved fittings. For stems longer than 300 mm (12 in.), permanent and effective bracing against lateral displacement shall be provided at a level not more than 300 mm (12 in.) above the lower end of the stem, or flexibility in the form of an identified fitting or a flexible connector shall be provided not more than 300 mm (12 in.) from the point of attachment to the supporting box or fitting.

(D) Portable Lighting Equipment. Portable lighting equipment shall be equipped with handles and protected with substantial guards. Lampholders shall be of the unswitched type with no provision for receiving attachment plugs. There shall be no exposed current-carrying metal parts, and all exposed non-current-carrying metal parts shall be grounded. In all other respects, portable lighting equipment shall comply with 503.130(A).

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Class III Locations



This CHAMP® DMV luminaire guard provides aisle lighting in a storage facility



Summit high output fluorescent luminaire



Pauluhn Summit linear LED luminaire

Luminaires, Class III.

Guards are provided to protect against damage, and enclosures are designed to minimize entrance of fibers and flyings, and to prevent the escape of sparks, burning material, or hot metal. Eaton's Crouse-Hinds will supply specific information on operating temperatures of these luminaires, on request. (503.130).

503.135 Utilization Equipment — Class III, Divisions 1 and 2.

(A) Heaters. Electrically heated utilization equipment shall be identified for Class III locations.

(B) Motors. Motors of motor-driven utilization equipment shall comply with 503.125.

(C) Switches, Circuit Breakers, Motor Controllers, and Fuses.

Switches, circuit breakers, motor controllers, and fuses shall comply with 503.115.

503.140 Flexible Cords — Class III, Divisions 1 and 2.

Flexible cords shall comply with the following:

- (1) Be of a type listed for extra-hard usage
- (2) Contain, in addition to the conductors of the circuit, an equipment grounding conductor complying with 400.23
- (3) Be supported by clamps or other suitable means in such a manner that there will be no tension on the terminal connections
- (4) Be terminated with a listed dusttight cord connector.

Cable glands for Class III



CGBS cable fitting for Class I, Division 1 and 2



EBY Cord connector for Class I, Division 1

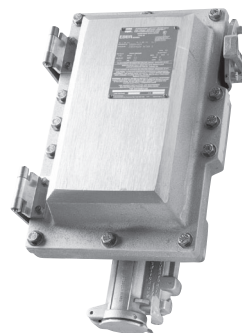
503.145 Receptacles and Attachment Plugs — Class III, Divisions 1 and 2.

Receptacles and attachment plugs shall be of the grounding type, shall be designed so as to minimize the accumulation or the entry of fibers/flyings, and shall prevent the escape of sparks or molten particles.

Exception: In locations where, in the judgment of the authority having jurisdiction, only moderate accumulations of lint or flyings are likely to collect in the vicinity of a receptacle, and where such receptacle is readily accessible for routine cleaning, general-purpose grounding-type receptacles mounted so as to minimize the entry of fibers/flyings shall be permitted.



ARE receptacle with spring door



EBBR series



WSQC receptacle

503.150 Signaling, Alarm, Remote-Control, and Local Loudspeaker Intercommunications Systems — Class III, Divisions 1 and 2.

Signaling, alarm, remote-control, and local loudspeaker intercommunications systems shall comply with the requirements of Article 503 regarding wiring methods, switches, transformers, resistors, motors, luminaires, and related components.

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Article 503 Class III Locations

503.155 Electric Cranes, Hoists, and Similar Equipment — Class III, Divisions 1 and 2.

Where installed for operation over combustible fibers or accumulations of flyings, traveling cranes and hoists for material handling, traveling cleaners for textile machinery, and similar equipment shall comply with 503.155(A) through (D).

(A) Power Supply. The power supply to contact conductors shall be electrically isolated from all other systems, ungrounded, and shall be equipped with an acceptable ground detector that gives an alarm and automatically de-energizes the contact conductors in case of a fault to ground or gives a visual and audible alarm as long as power is supplied to the contact conductors and the ground fault remains.

(B) Contact Conductors. Contact conductors shall be located or guarded so as to be inaccessible to other than authorized persons and shall be protected against accidental contact with foreign objects.

(C) Current Collectors. Current collectors shall be arranged or guarded so as to confine normal sparking and prevent escape of sparks or hot particles. To reduce sparking, two or more separate surfaces of contact shall be provided for each contact conductor. Reliable means shall be provided to keep contact conductors and current collectors free of accumulations of lint or flyings.

(D) Control Equipment. Control equipment shall comply with 503.115 and 503.120.

503.160 Storage Battery Charging Equipment — Class III, Divisions 1 and 2.

Storage battery charging equipment shall be located in separate rooms built or lined with substantial noncombustible materials. The rooms shall be constructed to prevent the entrance of ignitable amounts of flyings or lint and shall be well ventilated.

Article 504

504.1 Scope.

This article covers the installation of intrinsically safe (I.S.) apparatus, wiring, and systems for Articles 500 through 516.

Informational Note: For further information, see ANSI/ISA-RP 12.06.01-2003, *Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation — Part 1: Intrinsic Safety*.

504.3 Application of Other Articles.

Except as modified by this article, all applicable articles of this Code shall apply.

504.4 Equipment.

All intrinsically safe apparatus and associated apparatus shall be listed.

Exception: Simple apparatus, as described on the control drawing, shall not be required to be listed.

Article 504 Intrinsically Safe Systems

504.10 Equipment Installation.

(A) Control Drawing. Intrinsically safe apparatus, associated apparatus, and other equipment shall be installed in accordance with the control drawing(s).

A simple apparatus, whether or not shown on the control drawing(s), shall be permitted to be installed provided the simple apparatus does not interconnect intrinsically safe circuits.

Informational Note No. 1: The control drawing identification is marked on the apparatus.

Informational Note No. 2: Associated apparatus with a marked U_m of less than 250 V may require additional overvoltage protection at the inputs to limit any possible fault voltages to less than the U_m marked on the product.

(B) Location. Intrinsically safe apparatus shall be permitted to be installed in any hazardous (classified) location for which it has been identified.

Associated apparatus shall be permitted to be installed in any hazardous (classified) location for which it has been identified.

Simple apparatus shall be permitted to be installed in any hazardous (classified) location in accordance with 504.10(D).

(C) Enclosures. General-purpose enclosures shall be permitted for intrinsically safe apparatus and associated apparatus unless otherwise specified in the manufacturer's documentation.

(D) Simple Apparatus. Simple apparatus shall be permitted to be installed in any hazardous (classified) location in which the maximum surface temperature of the simple apparatus does not exceed the ignition temperature of the flammable gases or vapors, flammable liquids, combustible dusts, or ignitable fibers/flyings present. The maximum surface temperature can be determined from the values of the output power from the associated apparatus or apparatus to which it is connected to obtain the temperature class. The temperature class can be determined by:

(1) Reference to Table 504.10(D)

(2) Calculation using the following equation:

$$T = P_o R_{th} + T_{amb}$$

where:

T = surface temperature

P_o = output power marked on the associated apparatus or intrinsically safe apparatus

R_{th} = thermal resistance of the simple apparatus

T_{amb} = ambient temperature (normally 40°C) and reference Table 500.8(C)

In addition, components with a surface area smaller than 10 cm² (excluding lead wires) may be classified as T5 if their surface temperature does not exceed 150°C.

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Article 504

Intrinsically Safe Systems

Table 504.10(D) Assessment for T4 Classification According to Component Size and Temperature

Total Surface Area Excluding Lead Wires	Requirement for T4 Classification
<20 mm ²	Surface temperature ≤275°C
≥20 mm ² ≤10 cm ²	Surface temperature ≤200°C
≥20 mm ²	Power not exceeding 1.3 W*

*Based on 40°C ambient temperature. Reduce to 1.2 W with an ambient of 60°C or 1.0 W with 80°C ambient temperature.

504.20 Wiring Methods.

Any of the wiring methods suitable for unclassified locations, including those covered by Chapter 7 and Chapter 8, shall be permitted for installing intrinsically safe apparatus. Sealing shall be as provided in 504.70, and separation shall be as provided in 504.30.

▲ 504.30 Separation of Intrinsically Safe Conductors.

(A) From Nonintrinsically Safe Circuit Conductors.

(1) In Raceways, Cable Trays, and Cables. Conductors of intrinsically safe circuits shall not be placed in any raceway, cable tray, or cable with conductors of any nonintrinsically safe circuit.

Exception No. 1: Where conductors of intrinsically safe circuits are separated from conductors of nonintrinsically safe circuits by a distance of at least 50 mm (2 in.) and secured, or by a grounded metal partition or an approved insulating partition.

Informational Note: No. 20 gauge sheet metal partitions 0.91 mm (0.0359 in.) or thicker are generally considered acceptable.

Exception No. 2: Where either (1) all of the intrinsically safe circuit conductors or (2) all of the nonintrinsically safe circuit conductors are in grounded metal-sheathed or metal-clad cables where the sheathing or cladding is capable of carrying fault current to ground.

Informational Note: Cables meeting the requirements of Articles 330 and 332 are typical of those considered acceptable.

Exception No. 3: Intrinsically safe circuits in a Division 2 or Zone 2 location shall be permitted to be installed in a raceway, cable tray, or cable along with nonincendive field wiring circuits when installed in accordance with 504.30(B).

Exception No. 4: Intrinsically safe circuits passing through a Division 2 or Zone 2 location to supply apparatus that is located in a Division 1, Zone 0 or Zone 1 location shall be permitted to be installed in a raceway, cable tray, or cable along with nonincendive field wiring circuits when installed in accordance with 504.30(B).

Informational Note: Nonincendive field wiring circuits are described in 501.10(B)(3), 502.10(B)(3), and 503.10(A)(4).

(2) Within Enclosures. Conductors of intrinsically safe circuits shall be secured so that any conductor that might come loose from a terminal is unlikely to come into contact with another terminal. The conductors shall be separated from conductors of nonintrinsically safe circuits by one of the methods in (1) through (4).

(1) Separation by at least 50 mm (2 in.) from conductors of any nonintrinsically safe circuits

Note: When installed in a hazardous area, intrinsically safe barriers must be mounted in an appropriate explosionproof enclosure. EJB and GUB enclosures will fulfill this need. Similarly, corrosive environments will need enclosures made from materials such as our Krydon® material enclosures.

(2) Separation from conductors of nonintrinsically safe circuits by use of a grounded metal partition 0.91 mm (0.0359 in.) or thicker

(3) Separation from conductors of nonintrinsically safe circuits by use of an approved insulating partition that extends to within 1.5 mm (0.0625 in.) of the enclosure walls

(4) Where either (1) all of the intrinsically safe circuit conductors or (2) all of the nonintrinsically safe circuit conductors are in grounded metal-sheathed or metal-clad cables where the sheathing or cladding is capable of carrying fault current to ground

Informational Note No. 1: Cables meeting the requirements of Articles 330 and 332 are typical of those considered acceptable.

Informational Note No. 2: The use of separate wiring compartments for the intrinsically safe and nonintrinsically safe terminals is a typical method of complying with this requirement.

Informational Note No. 3: Physical barriers such as grounded metal partitions or approved insulating partitions or approved restricted access wiring ducts separated from other such ducts by at least 19 mm (¾ in.) can be used to help ensure the required separation of the wiring.

(3) Other (Not in Raceway or Cable Tray Systems). Conductors and cables of intrinsically safe circuits run in other than raceway or cable tray systems shall be separated by at least 50 mm (2 in.) and secured from conductors and cables of any nonintrinsically safe circuits.

Exception: Where either (1) all of the intrinsically safe circuit conductors are in Type MI or MC cables or (2) all of the nonintrinsically safe circuit conductors are in raceways or Type MI or MC cables where the sheathing or cladding is capable of carrying fault current to ground.

(B) From Different Intrinsically Safe Circuit Conductors. The clearance between two terminals for connection of field wiring of different intrinsically safe circuits shall be at least 6 mm (0.25 in.), unless this clearance is permitted to be reduced by the control drawing. Different intrinsically safe circuits shall be separated from each other by one of the following means:

(1) The conductors of each circuit are within a grounded metal shield.

(2) The conductors of each circuit have insulation with a minimum thickness of 0.25 mm (0.01 in.).

Exception: Unless otherwise identified.

(C) From Grounded Metal. The clearance between the uninsulated parts of field wiring conductors connected to terminals and grounded metal or other conducting parts shall be at least 3 mm (0.125 in.).

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Article 504 Intrinsically Safe Systems

504.50 Grounding

(A) Intrinsically Safe Apparatus, Enclosures, and Raceways.

Intrinsically safe apparatus, enclosures, and raceways, if of metal, shall be connected to the equipment grounding conductor.

Informational Note: In addition to an equipment grounding conductor connection, a connection to a grounding electrode may be needed for some associated apparatus; for example, zener diode barriers, if specified in the control drawing. See ANSI/ISA-RP 12.06.01-2003, *Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation — Part 1: Intrinsic Safety*.

(B) Associated Apparatus and Cable Shields.

Associated apparatus and cable shields shall be grounded in accordance with the required control drawing. See 504.10(A).

Informational Note: Supplementary connection(s) to the grounding electrode may be needed for some associated apparatus; for example, zener diode barriers, if specified in the control drawing. See ANSI/ISA RP 12.06.01-2003, *Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation — Part 1: Intrinsic Safety*.

(C) Connection to Grounding Electrodes.

Where connection to a grounding electrode is required, the grounding electrode shall be as specified in 250.52(A) (1), (A) (2), (A) (3), and (A) (4) and shall comply with 250.30(A) (4). Sections 250.52(A) (5), (A) (7), and (A) (8) shall not be used if any of the electrodes specified in 250.52(A) (1), (A) (2), (A) (3), or (A) (4) are present.

504.60 Bonding.

(A) Intrinsically Safe Apparatus.

Intrinsically safe apparatus, if of metal, shall be bonded in the hazardous (classified) location in accordance with 501.30(A), 502.30(A), 503.30(A), 505.25, or 506.25, as applicable.

(B) Metal Raceways.

Where metal raceways are used for intrinsically safe system wiring, bonding at all ends of the raceway, regardless of the location, shall be in accordance with 501.30(A), 502.30(A), 503.30(A), 505.25, or 506.25, as applicable.

504.70 Sealing.

Conduits and cables that are required to be sealed by 501.15, 502.15, 505.16, and 506.16 shall be sealed to minimize the passage of gases, vapors, or dusts. Such seals shall not be required to be explosionproof or flameproof but shall be identified for the purpose of minimizing passage of gases, vapors, or dusts under normal operating conditions and shall be accessible.

Exception: Seals shall not be required for enclosures that contain only intrinsically safe apparatus, except as required by 501.17.

504.80 Identification.

Labels required by this section shall be suitable for the environment where they are installed, with consideration given to exposure to chemicals and sunlight.

(A) Terminals.

Intrinsically safe circuits shall be identified at terminal and junction locations in a manner that is intended to prevent unintentional interference with the circuits during testing and servicing.

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(B) Wiring.

Raceways, cable trays, and other wiring methods for intrinsically safe system wiring shall be identified with permanently affixed labels with the wording “Intrinsic Safety Wiring” or equivalent. The labels shall be located so as to be visible after installation and placed so that they may be readily traced through the entire length of the installation. Intrinsic safety circuit labels shall appear in every section of the wiring system that is separated by enclosures, walls, partitions, or floors. Spacing between labels shall not be more than 7.5 m (25 ft).

Exception: Circuits run underground shall be permitted to be identified where they become accessible after emergence from the ground.

Informational Note No. 1: Wiring methods permitted in unclassified locations may be used for intrinsically safe systems in hazardous (classified) locations. Without labels to identify the application of the wiring, enforcement authorities cannot determine that an installation is in compliance with this Code.

Informational Note No. 2: In unclassified locations, identification is necessary to ensure that nonintrinsically safe wire will not be inadvertently added to existing raceways at a later date.

(C) Color Coding.

Color coding shall be permitted to identify intrinsically safe conductors where they are colored light blue and where no other conductors colored light blue are used. Likewise, color coding shall be permitted to identify raceways, cable trays, and junction boxes where they are colored light blue and contain only intrinsically safe wiring.

Article 505

505.1 Scope.

This article covers the requirements for the zone classification system as an alternative to the division classification system covered in Article 500 for electrical and electronic equipment and wiring for all voltages in Zone 0, Zone 1, and Zone 2 hazardous (classified) locations where fire or explosion hazards may exist due to flammable gases, vapors, or liquids.

Informational Note No. 1: The term “Class I” was originally included as a prefix to Zone 0, Zone 1, Zone 2 locations and references as an identifier for flammable gases, vapors, or liquids to differentiate from Class II and Class III locations. Zone 0, Zone 1, and Zone 2 only apply to flammable gases, vapors, or liquids so the “Class I” prefix is redundant and has been deleted. However, the marking of “Class I” is left as an optional marking within this Article.

Informational Note No. 2: For the requirements for electrical and electronic equipment and wiring for all voltages in Class I, Division 1 or Division 2; Class II, Division 1 or Division 2; and Class III, Division 1 or Division 2 hazardous (classified) locations where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, or combustible dusts or fibers, refer to Articles 500 through 504.

Informational Note No. 3: Text that is followed by a reference in brackets has been extracted from NFPA 497-2017, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*. Only editorial changes were made to the extracted text to make it consistent with this Code.

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505.3 Other Articles.

All other applicable rules contained in this Code shall apply to electrical equipment and wiring installed in hazardous (classified) locations.

Exception: As modified by Article 504 and this article.

Where the term “Class I” is used with respect to Zone classifications within other articles of the Code, it shall apply to Zone 0, Zone 1, and Zone 2 designations.

Informational Note: The term “Class I” was originally included as a prefix to Zone 0, Zone 1, and Zone 2 locations and references as an identifier for flammable gases, vapors, or liquids to differentiate from Class II and Class III locations. Zone 0, Zone 1, and Zone 2 only apply to flammable gases, vapors, or liquids so the “Class I” prefix is redundant and has been deleted, except for text that is extracted from other documents or to remain consistent throughout an article.

505.4 Documentation.

All areas in industrial occupancies designated as hazardous (classified) locations shall be properly documented. This documentation shall be available to those authorized to design, install, inspect, maintain, or operate electrical equipment at the location.

Informational Note No. 1: For examples of area classification drawings, see ANSI/API RP 505-2018, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*; ANSI/ISA-60079-10-1 (12.24.01)-2014 *Explosive Atmospheres — Part 10-1: Classification of Areas — Explosive gas atmospheres*; and *Model Code of Safe Practice, Part 15: Area Classification Code for Installations Handling Flammable Fluids*, EI 15:2015, Energy Institute, London.

Informational Note No. 2: Where gas detection equipment is used as a means of protection in accordance with 505.8(I)(2), (I)(3), or (I)(4), the documentation typically includes the type of detection equipment, its listing, installation location(s), alarm and shutdown criteria, and calibration frequency.

Informational Note No. 3: For further information on the classification of locations, see NFPA 497-2017, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*; ANSI/API RP 505-2018, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*; ANSI/ISA-60079-10-1 (12.24.01)-2014, *Explosive Atmospheres — Part 10-1: Classification of Areas — Explosive gas atmospheres*; and *Model Code of Safe Practice, Part 15: Area Classification Code for Installations Handling Flammable Fluids*, EI 15:2015, Energy Institute, London.

Informational Note No. 4: For further information on protection against static electricity and lightning hazards in hazardous (classified) locations, see NFPA 77-2019, *Recommended Practice on Static Electricity*; NFPA 780-2017, *Standard for the Installation of Lightning Protection Systems*; and API RP 2003-2015, *Protection Against Ignitions Arising Out of Static Lightning and Stray Currents*.

Informational Note No. 5: For further information on ventilation, see NFPA 30-2018, *Flammable and Combustible Liquids Code*, and ANSI/API RP 505-2018, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*.

Informational Note No. 6: For further information on electrical systems for hazardous (classified) locations on offshore oil and gas producing platforms, drilling rigs, and workover rigs, see ANSI/API RP 14FZ-2013, *Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1, and Zone 2 Locations*.

Informational Note No. 7: For further information on application of electrical equipment in hazardous (classified) locations in general, see ANSI/ISA-60079-0 (12.00.01)-2013, *Explosive Atmospheres — Part 0: Equipment — General Requirements*; ANSI/ISA-12.01.01-2013, *Definitions and Information Pertaining to Electrical Apparatus in Hazardous (Classified) Locations*; and ANSI/UL 60079-0:2013, *Electrical Apparatus for Explosive Gas Atmospheres — Part 0: General Requirements*.

Informational Note No. 8: Portable or transportable equipment having self-contained power supplies, such as battery-operated equipment, could potentially become an ignition source in hazardous (classified) locations. See ANSI/UL 121203-2011, *Standard for Portable Electronic Products Suitable for Use in Class I and II, Division 2, Class I Zone 2 and Class III, Division 1 and 2 Hazardous (Classified) Locations*.

Informational Note No. 9: For additional information concerning the installation of equipment utilizing optical emissions technology (such as laser equipment) that could potentially become an ignition source in hazardous (classified) locations, see ANSI/UL-60079-28-2017, *Explosive Atmospheres — Part 28: Protection of equipment and transmission systems using optical radiation*.

Informational Note No. 10: For information on electrical resistance trace heating for hazardous (classified) locations, see ANSI/IEEE 60079-30-2:2015, *IEEE/IEC International Standard for Explosive Atmospheres — Part 30-2: Electrical resistance trace heating — Application guide for design, installation and maintenance*.

Informational Note No. 11: For information on electric skin effect trace heating for hazardous (classified) locations, IEEE 844.1-2017/CSA C22.2 No. 293.1-17, *IEEE/CSA Standard for Skin Effect Trace Heating of Pipelines, Vessels, Equipment, and Structures — General, Testing, Marking, and Documentation Requirements*, and IEEE 844.2-2017/CSA C293.2:17, *IEEE/CSA Standard for Skin Effect Trace Heating of Pipelines, Vessels, Equipment, and Structures — Application Guide for Design, Installation, Testing, Commissioning, and Maintenance*.

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Article 505

Zone 0, 1, and 2 Locations

505.5 Classifications of Locations.

▲ **(A) General.** Locations shall be classified depending on the properties of the flammable gases, flammable liquid–produced vapors, combustible liquid–produced vapors, combustible dusts, or fibers/flyings that could 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.

Informational Note No. 1: See 505.7 for restrictions on area classification.

Informational Note No. 2: Through the exercise of ingenuity in the layout of electrical installations for hazardous (classified) locations, it is frequently possible to locate much of the equipment in reduced level of classification or in an unclassified location and, thus, to reduce the amount of special equipment required.

Refrigerant machinery rooms that contain ammonia refrigeration systems and are equipped with adequate mechanical ventilation that operates continuously or is initiated by a detection system at a concentration not exceeding 150 ppm shall be permitted to be classified as “unclassified” locations.

Informational Note: For further information regarding classification and ventilation of areas involving closed-circuit ammonia refrigeration systems, see ANSI/IIAR 2-2014, *Standard for Safe Design of Closed-Circuit Ammonia Refrigeration Systems*.

▲ **(B) Zone 0, 1, and 2 Locations.** Zone 0, 1, and 2 locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Zone 0, 1, and 2 locations shall include those specified in 505.5(B)(1), (B)(2), and (B)(3).

▲ **(1) Zone 0.** A Zone 0 location is a location in which one of the following conditions exists:

- (1) Ignitable concentrations of flammable gases or vapors are present continuously
- (2) Ignitable concentrations of flammable gases or vapors are present for long periods of time.

Informational Note No. 1: As a guide in determining when flammable gases or vapors are present continuously or for long periods of time, refer to ANSI/API RP 505-2018, *Recommended Practice for Classification of Locations for Electrical Installations of Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*, and ANSI/ISA 60079-10-1-2014, *Explosive Atmospheres — Part 10-1: Classification of Areas — explosive gas atmospheres*.

Informational Note No. 2: This classification includes locations inside vented tanks or vessels that contain volatile flammable liquids; inside inadequately vented spraying or coating enclosures where volatile flammable solvents are used; between the inner and outer roof sections of a floating roof tank containing volatile flammable liquids; inside open vessels, tanks, and pits containing volatile flammable liquids; the interior of an exhaust duct that is used to vent ignitable concentrations of gases or vapors; and inside inadequately ventilated enclosures that contain normally venting instruments utilizing or analyzing flammable fluids and venting to the inside of the enclosures.

▲ **(2) Zone 1.** A Zone 1 location is a location

- (1) In which ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or
- (2) In which ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or
- (3) In which equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or
- (4) That is adjacent to a Zone 0 location from which ignitable concentrations of vapors could be communicated, unless communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

Informational Note No. 1: Normal operation is considered the situation when plant equipment is operating within its design parameters. Minor releases of flammable material may be part of normal operations. Minor releases include the releases from mechanical packings on pumps. Failures that involve repair or shutdown (such as the breakdown of pump seals and flange gaskets, and spillage caused by accidents) are not considered normal operation.

Informational Note No. 2: This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another. In areas in the vicinity of spraying and painting operations where flammable solvents are used; adequately ventilated drying rooms or compartments for evaporation of flammable solvents; adequately ventilated locations containing fat and oil extraction equipment using volatile flammable solvents; portions of cleaning and dyeing plants where volatile flammable liquids are used; adequately ventilated gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile flammable materials are stored in the open, lightly stoppered, or in easily ruptured containers; and other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operation but not classified Zone 0.

▲ **(3) Zone 2.** A Zone 2 location is a location

- (1) In which ignitable concentrations of flammable gases or vapors are not likely to occur in normal operation and, if they do occur, will exist only for a short period; or
- (2) In which volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used but in which the liquids, gases, or vapors normally are confined within closed containers of closed systems from which they can escape, only as a result of accidental rupture or breakdown of the containers or system, or as a result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or
- (3) In which ignitable concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation but which may become hazardous as a result of failure or abnormal operation of the ventilation equipment; or

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(4) That is adjacent to a Zone 1 location, from which ignitable concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

Informational Note: The Zone 2 classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but which would become hazardous only in case of an accident or of some unusual operating condition.

This alternate Zone Classification is based on the IEC three-zone system; the Table below briefly illustrates the relationship between Zones and Divisions. The above definitions of Zones 1 and 2, however, are different from the IEC definitions.

Area Classification			
Class	Zone	Description	Typical Example
Class I Liquids, Vapors & Gases	Zone 0	Similar to Division 1, continuously hazardous	vapor space in a vented tank
	Zone 1	Similar to Division 1, frequently hazardous under normal conditions	container filling area in a refinery
	Zone 2	Similar to Division 2, hazardous under abnormal conditions	container storage area

Since the introduction of the Zone classification system into the 1996 NEC, however, these national documents contain guidelines for its application:

- ANSI/NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*
- ANSI/API RP505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1 and Zone 2*

NFPA 497 includes Zone classifications as an alternative to Divisions for areas and processes typical to the chemical industry. API RP505 is a companion to RP500 for Divisions and contains recommended Zone classifications related to the petroleum industry. The NFPA and API documents contain numerous diagrams with specific dimensions of classified areas and it should be noted that, for a given process or piece of equipment, the recommended extent of Zone 1 areas is the same as for Division 1, and similarly for Zone 2 and Division 2. In the end, the only essential difference between the two systems is that a few of the Zone diagrams contain a small Zone 0.

It has been estimated that less than one percent of classified areas would qualify as Zone 0. It is also generally accepted that Division 1 constitutes 10 percent or less of classified areas in the U.S. In countries using the IEC classification system, however, Zone 1 commonly represents up to 60 percent of classified areas. The disparity between these two ratios is another indication that Zone 0 is not the only difference between the Division and the IEC Zone system.

▲ 505.6 Material Groups.

For purposes of testing, approval, and area classification, various air mixtures (not oxygen enriched) shall be grouped as required in 505.6(A), (B), and (C).

Informational Note No. 1: Group I is intended for use in describing atmospheres that contain firedamp (a mixture of gases, composed mostly of methane, found underground, usually in mines). This Code does not apply to installations underground in mines. See 90.2(B).

Informational Note No. 2: The gas and vapor subdivision as described above is based on the maximum experimental safe gap (MESG), minimum igniting current (MIC), or both. The test equipment for determining MIC is described in ANSI/UL 60079-11-2014, *Explosive Atmospheres — Part 11: Equipment Protection by Intrinsic Safety "i"*. The classification of gases or vapors according to their maximum experimental safe gaps and minimum igniting currents is described in ISO/IEC 80079-20-1-2018, *Explosive atmospheres — Part 20-1: Material characteristics for gas and vapour classification — Test methods and data*.

Informational Note No. 3: Group II is currently subdivided into Group IIA, Group IIB, and Group IIC. Prior marking requirements permitted some types of protection to be marked without a subdivision, showing only Group II.

Informational Note No. 4: It is necessary that the meanings of the different equipment markings and Group II classifications be carefully observed to avoid confusion with Class I, Divisions 1 and 2, Groups A, B, C, and D.

Zone 0, 1, and 2, groups shall be as follows:

(A) Group IIC. Atmospheres containing acetylene, hydrogen, or flammable gas, flammable liquid–produced vapor, or combustible liquid–produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value less than or equal to 0.50 mm or minimum igniting current (MIC) ratio less than or equal to 0.45. [497:3.3.5.2.3]

Informational Note: Group IIC is equivalent to a combination of Class I, Group A, and Class I, Group B, as described in 500.6(A)(1) and (A)(2).

(B) Group IIB. Atmospheres containing acetaldehyde, ethylene, or flammable gas, flammable liquid–produced vapor, or combustible liquid–produced vapor mixed with air that may burn or explode, having either maximum experimental safe gap (MESG) values greater than 0.50 mm and less than or equal to 0.90 mm or minimum igniting current ratio (MIC ratio) greater than 0.45 and less than or equal to 0.80. [497:3.3.5.2.2]

Informational Note: Group IIB is equivalent to Class I, Group C, as described in 500.6(A)(3).

(C) Group IIA. Atmospheres containing acetone, ammonia, ethyl alcohol, gasoline, methane, propane, or flammable gas, flammable liquid–produced vapor, or combustible liquid–produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value greater than 0.90 mm or minimum igniting current (MIC) ratio greater than 0.80. [497:3.3.5.2.1]

Informational Note: Group IIA is equivalent to Class I, Group D as described in 500.6(A)(4).

The grouping of flammable materials in the Zone system is considerably different than in the Divisions' Groups A, B, C, and D. Zone Group I relates to mines and is not covered by the NEC. Zone Group II applies to other than mines and is subdivided into Groups IIA, IIB, and IIC. As explained in Fine Print Notes, Group IIA is equivalent to the Division Group D, IIB is equivalent to C, and IIC is equivalent to a combination of A and B. Because flameproof (similar to explosionproof) equipment rated for hydrogen (Group B) has become widely available, but little is rated for acetylene (Group A), it is common to find enclosures marked IIB + Hydrogen or IIB + H₂. This marking is permitted, but not explicitly, by the rules in 505.9(C). See the FPN under 505.9(B)(2).

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▲ 505.7 Special Precaution.

Article 505 requires equipment construction and installation that ensures safe performance under conditions of proper use and maintenance.

Informational Note No. 1: It is important that inspection authorities and users exercise more than ordinary care with regard to the installation and maintenance of electrical equipment in hazardous (classified) locations.

Informational Note No. 2: Low ambient conditions require special consideration. Electrical equipment depending on the protection techniques described by 505.8(A) may not be suitable for use at temperatures lower than -20°C (-4°F) unless they are identified for use at lower temperatures. However, at low ambient temperatures, flammable concentrations of vapors may not exist in a location classified Zones 0, 1, or 2 at normal ambient temperature.

(A) Implementation of Zone Classification System. Classification of areas, engineering and design, selection of equipment and wiring methods, installation, and inspection shall be performed by qualified persons.

▲ **(B) Dual Classification.** In instances of areas within the same facility classified separately, Zone 2 locations shall be permitted to abut, but not overlap, Class I, Division 2 locations. Zone 0 or Zone 1 locations shall not abut Class I, Division 1 or Division 2 locations.

▲ **(C) Reclassification Permitted.** A Class I, Division 1 or Division 2 location shall be permitted to be reclassified as a Zone 0, Zone 1, or Zone 2 location, provided all of the space that is classified because of a single flammable gas or vapor source is reclassified under the requirements of this article.

(D) Solid Obstacles. Flameproof equipment with flanged joints shall not be installed such that the flange openings are closer than the distances shown in Table 505.7(D) to any solid obstacle that is not a part of the equipment (such as steelworks, walls, weather guards, mounting brackets, pipes, or other electrical equipment) unless the equipment is listed for a smaller distance of separation.

Table 505.7(D) Minimum Distance of Obstructions from Flameproof “d” Flange Openings

Gas Group	Minimum Distance	
	mm	in.
IIC	40	1 ³ / ₄
IIB	30	1 ¹ / ₆
IIA	10	2 ⁵ / ₆₄

(E) Simultaneous Presence of Flammable Gases and Combustible Dusts or Fibers/Flyings. Where flammable gases, combustible dusts, or fibers/flyings are or may be present at the same time, the simultaneous presence shall be considered during the selection and installation of the electrical equipment and the wiring methods, including the determination of the safe operating temperature of the electrical equipment.

(F) Available Fault Current for Type of Protection “e.” Unless listed and marked for connection to circuits with higher available fault current, the available fault current for electrical equipment using type of protection “e” for the field wiring connections in Zone 1 locations shall be limited to 10,000 rms symmetrical amperes to reduce the likelihood of ignition of a flammable atmosphere by an arc during a short-circuit event.

Informational Note: Limitation of the available fault current to this level may require the application of current-limiting fuses or current-limiting circuit breakers.

Studies have shown that flameproof enclosures installed closer to obstacles than the distances required by this Section may cause a propagation to the surrounding atmosphere. This is not the case for explosionproof enclosures.

▲ 505.8 Protection Techniques.

Acceptable protection techniques for electrical and electronic equipment in hazardous (classified) locations shall be as described in 505.8(A) through (N).

Informational Note No. 1: For additional information, see ANSI/ISA-60079-0-2013, *Explosive Atmospheres — Part 0: Equipment — General Requirements*; ANSI/ISA-12.01.01-2013, *Definitions and Information Pertaining to Electrical Equipment in Hazardous (Classified) Locations*; and ANSI/UL 60079-0-2013, *Explosive Atmospheres — Part 0: Equipment General Requirements*.

Informational Note No. 2: See Table 505.9(C)(2)(4) for descriptions of subdivisions of protection techniques.

▲ **(A) Flameproof Enclosure “d.”** This protection technique shall be permitted for equipment in Zone 1 or Zone 2 locations.

▲ **(B) Pressurized Enclosure “p.”** This protection technique shall be permitted for equipment in those Zone 1 or Zone 2 locations for which it is identified.

(C) Intrinsic Safety “i.” This protection technique shall be permitted for apparatus and associated apparatus for Zone 0, Zone 1, or Zone 2 locations for which it is listed.

▲ **(D) Type of Protection “n.”** This protection technique shall be permitted for equipment in Zone 2 locations. Type of protection “n” is further subdivided into nA, nC, and nR.

▲ **(E) Liquid Immersion “o.”** This protection technique shall be permitted for equipment in Zone 1 or Zone 2 locations.

▲ **(F) Increased Safety “e.”** This protection technique shall be permitted for equipment in Zone 1 or Zone 2 locations.

▲ **(G) Encapsulation “m.”** This protection technique shall be permitted for equipment in Zone 0, Zone 1, or Zone 2 locations for which it is identified.

▲ **(H) Powder Filling “q.”** This protection technique shall be permitted for equipment in Zone 1 or Zone 2 locations.

▲ **(I) Combustible Gas Detection System.** A combustible gas detection system shall be permitted as a means of protection in industrial establishments with restricted public access and where the conditions of maintenance and supervision ensure that only qualified persons service the installation.

N (1) General. Any gas detection system utilized as a protection technique shall meet all of the requirements in 505.8(l)(1)(a) through (l)(1)(e).

(a) The gas detection equipment used shall be listed for Zone 1 and listed for the detection of the specific gas or vapor to be encountered.

(b) The gas detection system shall not utilize portable or transportable equipment, or temporary wiring methods.

(c) The gas detection system shall only use point-type sensors. The system shall be permitted to be augmented with open-path (line-of-sight)-type sensors, but open-path type sensors shall not be the basis for this protection technique.

(d) The type of detection equipment, its listing, installation location(s), alarm and shutdown criteria, and calibration frequency shall be documented where combustible gas detectors are used as a protection technique.

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- (e) The applications for the use of combustible gas detection systems as a protection technique shall be limited to 505.8(l)(2), (l)(3), or (l)(4).

Informational Note No. 1: For further information, see ANSI/ISA-TR12.13.03-2009, *Guide for Combustible Gas Detection as a Method of Protection*.

Informational Note No. 2: For further information, see ANSI/ISA-60079-29-1 (12.13.01)-2013, *Explosive Atmospheres — Part 29-1: Gas detectors — Performance requirements of detectors for flammable gases*.

Informational Note No. 3: For further information, see ANSI/API RP 505-2018, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*.

Informational Note No. 4: For further information, see ANSI/ISA-60079-29-2-2012, *Explosive Atmospheres — Part 29-2: Gas detectors — Selection, installation, use and maintenance of detectors for flammable gases and oxygen*.

(2) Inadequate Ventilation. A location, enclosed space, or building that is classified as a Zone 1 location due to inadequate ventilation, that is provided with a combustible gas detection system will be allowed to utilize electrical equipment, installation methods, and wiring practices suitable for Zone 2 installations. Sensing a gas concentration of not more than 40 percent of the lower flammable limit or a gas detector system malfunction shall activate an alarm (audible or visual, or both, as most appropriate for the area).

(3) Interior of a Building or Enclosed Space. Any building or enclosed space that does not contain a source of flammable gas or vapors that is located in, or with an opening into, a Zone 2 hazardous (classified) location that is provided with a combustible gas detection system will be permitted to utilize electrical equipment, installation methods, and wiring practices suitable for unclassified installations under all of the following conditions:

- (1) An alarm (audible or visual, or both) shall be sounded at not more than 20 percent of the lower flammable limit.
- (2) Sensing a gas concentration of not more than 40 percent of the lower flammable limit or a gas detector system malfunction shall both activate an alarm (audible or visual, or both, as most appropriate for the area) and initiate automatic disconnection of power from all electrical devices in the area that are not suitable for Zone 2.
- (3) The power disconnecting device(s) shall be suitable for Zone 1 if located inside the building or enclosed space. If the disconnecting device(s) is located outside the building or enclosed space, it shall be suitable for the location in which it is installed.

Redundant or duplicate equipment (such as sensors) shall be permitted to be installed to avoid disconnecting electrical power when equipment malfunctions are indicated.

When automatic shutdown could introduce additional or increased hazard, this technique shall not be permitted.

(4) Interior of a Control Panel. Inside the interior of a control panel containing instrumentation or other equipment utilizing or measuring flammable liquids, gases, or vapors, that is provided with combustible gas detection equipment will be allowed to utilize electrical equipment, installation methods, and wiring practices suitable for Zone 2 installations.

An alarm (audible or visual, or both) shall be sounded at not more than 40 percent of the lower flammable limit.

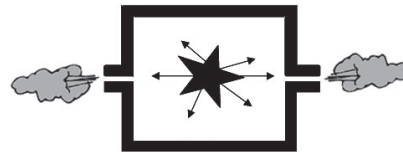
(J) Protection by Electrical Resistance Trace Heating “60079-30-1”. This protection technique shall be permitted for electrical resistance trace heating equipment in Zone 1 or Zone 2 for which it is listed.

(K) Inherently Safe Optical Radiation “op is”. This protection technique shall be permitted for equipment in Zone 0, Zone 1, or Zone 2 locations for which the equipment is identified.

(L) Protected Optical Radiation “op pr”. This protection technique shall be permitted for equipment in Zone 1 or Zone 2 locations for which the equipment is identified.

(M) Optical System With Interlock “op sh”. This protection technique shall be permitted for equipment in Zone 0, Zone 1, or Zone 2 locations for which the equipment is identified.

(N) Protection by Skin Effect Trace Heating “IEEE 844.1”. This protection technique shall be permitted for skin effect trace heating equipment in Zone 1 or Zone 2 for which it is listed.



Flameproof enclosures contain the explosion and allow gases to cool as they escape across the joints.

Flameproof Type “d” Protection

Ex-d is a type of Ex Protection in which the parts that can ignite an explosive gas air mixture are placed in an enclosure that can withstand the pressure developed during an internal explosion, and that prevents transmission of the explosion to the surrounding external atmosphere.

Field drilling of flameproof, Ex-d enclosures is not allowed. To maintain the certification, flameproof enclosures can only be modified by the manufacturer.

Flameproof enclosures may differ from explosionproof enclosures in their design. The major difference is that explosionproof enclosures are constructed to withstand 4 times the explosive pressure of the gases. With flameproof enclosures, manufacturers can construct the enclosure to meet only 1.5 times the explosive pressure if each enclosure is tested to this pressure before leaving the factory, referred to as a routine test. Otherwise, construction to 4 times the explosive pressure is required. The minimum joint lengths and maximum joint clearances are generally more restrictive for explosionproof than flameproof enclosures.

These switching devices pass the explosionproof tests because the internal volume containing the contacts and the gas-air mixture is very small so the explosive force is limited. The hot gases, which are minimized, escape through more elaborate labyrinth or cylindrical joints. These switches are now widely used in control stations and panels where the current levels are typically less than 16 amps.

Other innovative enclosure techniques use sintered bronze plates as flame paths in non-metallic enclosures to make larger switches up to 100 amps explosionproof.

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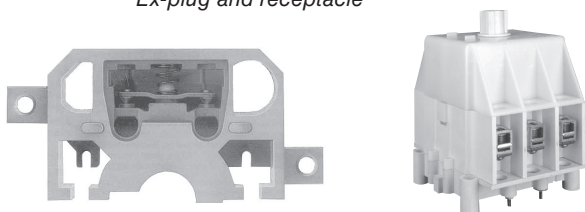
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ADE series cable fittings and Redapt accessories offer flameproof and increased safety protection.



IEC60309
Ex-plug and receptacle

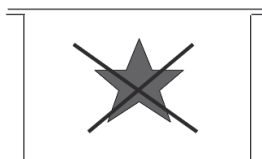


The Ex-d non-metallic switch has a small internal volume.

Larger amperage switches such as the non-metallic 100 amp RSWP use sintered bronze plates as the explosionproof joint.

Increased Safety Type “e” Protection

The definition of Type “e” Protection is where increased measures are taken to prevent the possibility of excessive heat, arcs, or sparks occurring on internal or external parts of the apparatus in normal operation. The increased safety concept can be used for electrical equipment such as terminal boxes, lighting, transformers, instruments, and motors.



Ex-e prevents the possibility of excessive heat, arcs or sparks from occurring on internal or external parts of the apparatus in normal operation.

General requirements for enclosures are: ingress protection to at least IP 54 and additional tests for non-metallic parts including thermal endurance, resistance to solvents, ultraviolet light, surface conductivity and mechanical impact resistance to either 4 or 7 joules depending on the use of the enclosure. The increased safety concept is only suitable for nonsparking apparatus and is commonly used in Zone 1 hazardous areas.



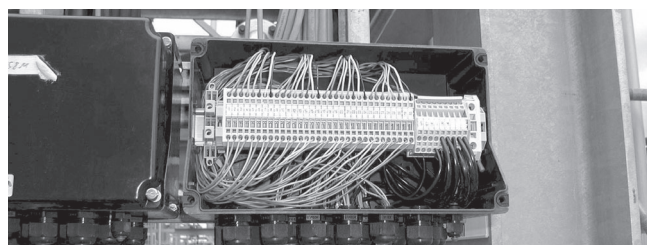
Eaton's Crouse-Hinds manufactures non-metallic and stainless steel Ex-e enclosures.



EX-Cell stainless steel enclosure.

General requirements for terminals are:

- They must be designed so the conductor can be easily inserted and clamped. Contact pressure must be maintained without reducing the cross sectional area of the conductor and a positive locking device must prevent conductors from working loose by vibration.
- Specified creepage distances as detailed in UL60079-7 for the grade of insulation material (CTI) and subsequent maximum voltage rating.
- Temperature limitation,
- Current de-rating of the terminals (and conductors)



Rail mounted Ex-e terminal assembly terminal boxes in the Eaton's Crouse-Hinds GHG74 Terminal box.

Nonsparking Type “n” Protection

For Zone 2 applications there is an option different from Zone 1 referred to as a type of protection “n,” sometimes called “Ex-n” or *nonsparking*. Type “n” apparatus is standard industrial equipment that in normal operation will not produce arcs, sparks or surface temperatures high enough to cause ignition. The apparatus has an IP rating called *Ingress Protection* which is similar to NEMA enclosure ratings such as NEMA 4, hose tight. A non-incendive component is limited in use to the particular circuit for which it has been shown to be non-ignition capable. Unlike intrinsic safety, there is no restriction on the energy levels.



Ex-n prevents or limits electrical apparatus sparking in Zone 2.

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- Motors must have secure rotor bars and fans, ventilation screens, adequate clearances and tight terminal boxes.
- Plugs and receptacles must be of the locking type, designed so incorrect connection is not possible, and labeled, "Do Not Disconnect When Energized."
- Luminaires may be LED, incandescent, fluorescent, or other high intensity discharge lamp except for low-pressure sodium, but must be marked with the lamp rating and information relevant to the temperature class. Lamps must be enclosed, nonsparking, and meet other safety requirements.

Type "n" is very similar to nonincendive that has been used by North American manufacturers for many years. UL60079-15 defines requirements for this equipment.

Contained within the Type "n" guidelines are the following definitions of hazardous area protection.

Enclosed-break devices—These devices are applied when energy is limited. They have small internal volume, use resilient gasket seals, and are subject to ignition testing similar to a Westerberg test, i.e. the device is put in a box and both the device and the box are filled with a flammable mixture. The device is operated with maximum rated voltage and current and if no damage or external ignition occurs, the device passes the test.

Nonincendive components—Energy is limited and external ignition may not occur. Nonincendive components do not contain an explosion.

Hermetically sealed devices—Reliability requirements are applied to fusion seals.

Sealed devices—Requirements cover construction and resilient gasket seals.

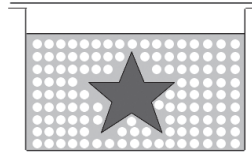
Energy limited apparatus and circuits—This is similar to North American nonincendive, except that the device and circuits need not be tested with ground faults or short circuits.

Powder Filled Type "q" Protection

Powder filling originated in France as a concept in 1954, but it was not generally recognized as an Ex Protection concept until the publication of IEC Standard 60079-5 in 1967.

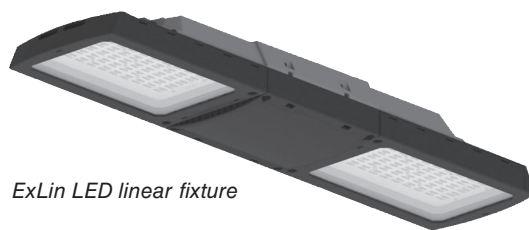
This protection method is typically only used for small transformers, capacitors and on electrical components that have no moving parts. The protection consists of a sealed enclosure (normally with a vent) containing quartz sand (the origin of the "q" description), powder or glass beads.

The enclosed electrical components are covered and surrounded by the filling medium. This ensures that under normal use no arc can be created which is able to ignite the explosive mixture inside the enclosure and the surrounding hazardous area.



Ex-q surrounds electrical apparatus in sand.

The Ex-q concept is used for the control gear in the PXLED and ExLin LED lighting fixtures.



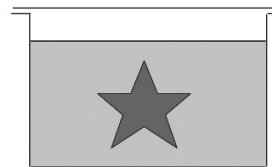
ExLin LED linear fixture



CEAG PX LED floodlight

Oil Immersion Type "o" Protection

The Oil Immersion Ex-o concept has historically been used for heavy duty switchgear, motor starters and transformers. The standard for design and testing of Ex-o type electrical apparatus is UL 60079-6.



Ex-o immerses electrical apparatus in oil to prevent arcs or sparks from igniting volatile gases.

The basic principle as shown above is to immerse the electrical parts in mineral oil, which will prevent any exposure of the arcing or sparking to an explosive atmosphere. It will also quench arcs and limit the temperature rise on electrical parts.

Standards for oil immersion protection, Ex-o, require that all parts capable of producing arcs or sparks must be immersed in the oil at a depth not less than 25 mm. A method to check the oil level must be provided, e.g., by a sight glass or by some other reliable method.

Some mineral oils used in switchgear apparatus produce acetylene and hydrogen gas when arcing occurs. Because of the risk of fire or an explosion with oil immersion, this application for apparatus in hazardous areas has been generally restricted. In the Petro-Chemical industries there are very few examples of Ex-o certified products installed in hazardous areas even though the standards permit its use in Zones 1 and 2.

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Encapsulation Type “m” Protection

Encapsulation is a type of protection whereby parts that are capable of igniting an explosive atmosphere, by either sparking or heating, are enclosed in a compound in such a way that the explosive atmosphere cannot be ignited under operating or installation conditions. The selected compound must be in line with the requirements given in UL60079-18 and may be any thermosetting, thermoplastic, epoxy, resin (cold curing) or elastomeric material with or without fillers and/or additives, in their solid state. The temperature range must satisfy the requirements of an appropriate standard for this type of protection. (Thermal stability at maximum operating temperature.)



Ex-m encloses all ignitable component parts in resin, preventing contact with explosive gases.

When considering the safety aspects of Ex-m encapsulation, the design must account for:

- Resistors, capacitors, optoisolators, diodes etc., must not operate at more than 2/3 of their rated voltage.
- The temperature rise of components and wiring must be limited.
- Voids and air pockets other than those for relays or other devices must be avoided.
- The effect of a component's short-circuit during fault conditions.

The Ex-m encapsulation protects electronic circuit relays, timers, lamp test devices and components in Zones 1 or 2 hazardous areas. Encapsulation is finding increased usage for printed circuit boards that are assembled in small rail-mounted housings similar to terminals.

505.9 Equipment.

(A) Suitability. Suitability of identified equipment shall be determined by one of the following:

- (1) Equipment listing or labeling
- (2) Evidence of equipment evaluation from a qualified testing laboratory or inspection agency concerned with product evaluation
- (3) Evidence acceptable to the authority having jurisdiction such as a manufacturer's self-evaluation or an owner's engineering judgment

Informational Note: Additional documentation for equipment may include certificates demonstrating compliance with applicable equipment standards, indicating special conditions of use, and other pertinent information.

(B) Listing.

- (1) Equipment that is listed for a Zone 0 location shall be permitted in a Zone 1 or Zone 2 location of the same gas or vapor, provided that it is installed in accordance with the requirements for the marked type of protection. Equipment that is listed for a Zone 1 location shall be permitted in a Zone 2 location of the same gas or vapor, provided that it is installed in accordance with the requirements for the marked type of protection.

- (2) Equipment shall be permitted to be listed for a specific gas or vapor, specific mixtures of gases or vapors, or any specific combination of gases or vapors.

Informational Note: One common example is equipment marked for “IIB. + H2.”

(C) Marking. Equipment shall be marked in accordance with 505.9(C)(1) or (C)(2).

(1) Division Equipment. Equipment identified for Class I, Division 1 or Class I, Division 2 shall, in addition to being marked in accordance with 500.8(C), be permitted to be marked with all of the following:

- (1) Class I, Zone 1 or **Zone 1**; Class I, Zone 2 or **Zone 2** (as applicable)
- (2) Applicable gas classification group(s) in accordance with Table 505.9(C)(1)(2)
- (3) Temperature classification in accordance with **505.9(D)(1)**

Equipment approved for Division 1 may be used in Zone 1 or Zone 2, and Division 2 equipment is suitable for Zone 2. Note, however, that the converse is not entirely true; 501.5 only permits equipment listed and marked for use in Zone 0, 1, or 2 locations to be used in Division 2 locations for the same gas and with a suitable temperature rating. It also permits equipment listed and marked for use in Zone 0 to be used in Division 1. No other zone-rated equipment is permitted in Division 1 since that classification includes areas that might be considered Zone 0.

There are American standards covering all the types of protection listed in Table 505.9(C)(2)(4). They are based on IEC standards but have been adapted to reflect North American practice.

Table 505.9(C)(1)(2) Material Groups

Material Group	Comment
IIC	See 505.6(A)
IIB	See 505.6(B)
IIA	See 505.6(C)

⚠ (2) Zone Equipment. Equipment meeting one or more of the protection techniques described in 505.8 shall be marked with all of the following in the order shown:

- (1) Class **I** (equipment shall be permitted to omit the Class **I** marking)
- (2) Zone [in accordance with Table 505.9(C)(2)(4)]
- (3) Symbol “AEx”
- (4) Protection technique(s) in accordance with Table 505.9(C)(2)(4)
- (5) Applicable material group in accordance with Table 505.9(C)(1)(2) or a specific gas or vapor
- (6) Temperature classification in accordance with **505.9(D)(1)**
- (7) Equipment protection level (EPL)

Exception No. 1: Associated apparatus NOT suitable for installation in a hazardous (classified) location shall be required to be marked only with (3), (4), and (5), but BOTH the symbol AEx (3) and the symbol for the type of protection (4) shall be enclosed within the same square brackets, for example, [AEx ia Ga] IIC.

Exception No. 2: Simple apparatus as defined in Article 100 Part III shall not be required to have a marked operating temperature or temperature class.

Exception No. 3: Fittings for the termination of cables shall not be required to have a marked operating temperature or temperature class.

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Informational Note No. 1: An example of the required marking for intrinsically safe apparatus for installation in Zone 0 is “Class I, Zone 0, AEx ia IIC T6 Ga” or “Zone 0, AEx, ia, IIC T6 Gb.” An explanation of the marking that is required is shown in Informational Note Figure 505.9(C)(2), No. 1.

Informational Note No. 2: An example of the required marking for intrinsically safe associated apparatus mounted in a flameproof enclosure for installation in Zone 1 is “Class I, Zone 1 AEx db[ia] IIC T4 Gb” or “Zone 1, AEx, db[ia Ga] IIC T4 Gb.”

Informational Note No. 3: An example of the required marking for intrinsically safe associated apparatus NOT for installation in a hazardous (classified) location is “[AEx ia Ga] IIC.”

Informational Note No. 4: EPLs (or equipment protection levels) are designated as G for gas or D for dust and are then followed by a letter (a, b, or c) to give the user a better understanding as to

whether the equipment provides either (a) a “very high,” (b) a “high,” or (c) an “enhanced” level of protection against ignition of an explosive atmosphere. For example, a Zone 1, AEx db IIC T4 Gb motor (which is suitable by protection concept for application in Zone 1) is marked with an EPL of “Gb” to indicate that it was provided with a high level of protection.

Informational Note No. 5: Equipment installed outside a Zone 0 location, electrically connected to equipment located inside a Zone 0 location, may be marked Zone 0/1. The “/” indicates that equipment contains a separation element and can be installed at the boundary between a Zone 0 and a Zone 1 location. See ANSI/UL-60079-26-2017, *Explosive Atmospheres — Part 26: Equipment with Equipment Protection Level (EPL) Ga*.

Table 505.9(C)(2)(4) Equipment Suitability

Type of Protection	Marking	Permitted Location
Associated apparatus for Zone 0	[ia]	Unclassified ¹
Associated apparatus for Zone 1	[ib]	Unclassified ¹
Associated apparatus for Zone 2	[ic]	Unclassified ¹
Associated pressurization equipment	[p]	Unclassified ¹
Intrinsic safety	ia; Class I, Division 1 Intrinsic Safety	Zone 0
Encapsulation	ma	
Optical radiation, inherently safe	op is, with EPL Ga ²	
Optical radiation, with interlock	op sh, with EPL Ga ²	
EPL Ga, with suitable type of protection ³		
Equipment Suitable for Use in Zone 0		Zone 1
Equipment Suitable for Use in Class I, Division 1		
Flameproof enclosure	d; db	
Intrinsic safety	ib	
Increased safety	e; eb	
Pressurized enclosure	p; px, pxb; py; pyb	
Encapsulation	m; mb	
Powder filling	q; qb	
Liquid immersion	o; ob	
Electrical resistance trace heating	60079-30-1, with EPL Gb ²	
Skin effect trace heating	IEEE 844.1, with EPL Gb ²	
Optical radiation, inherently safe	op is, with EPL Gb ²	
Optical radiation, with interlock	op sh, with EPL Gb ²	
Optical radiation, protected	op pr, with EPL Gb ²	
EPL Gb, with suitable type of protection ³		
Equipment Suitable for Use in Zone 1		Zone 2
Equipment Suitable for Use in Class I, Division 2		
Type of protection “n”	nA; nC; nR	
Pressurized enclosure	pz, pzc	
Intrinsic safety	ic	
Flameproof enclosure	dc	
Increased safety	ec	
Liquid immersion	oc	
Encapsulation	mc	
Electrical resistance trace heating	60079-30-1, with EPL Gc ²	
Skin effect trace heating	IEEE 844.1, with EPL Gc ²	
Optical radiation, inherently safe	op is, with EPL Gc ²	
Optical radiation, with interlock	op sh, with EPL Gc ²	
Optical radiation, protected	op pr, with EPL Gc ²	
EPL Gc, with suitable type of protection ³		
Other electrical equipment — general purpose motors ⁴		

¹Permitted to be installed in a hazardous (classified) location if suitably protected using another type of protection.

²Equipment marked with these types of protection is available in multiple levels of protection that are not specifically identified within the AEx marking.

³The EPL takes precedence over the types of protection. For example, “ia Gb” is suitable for Zone 1 (not Zone 0). “60079-30-1 Gc” is suitable for Zone 2 (not Zone 1).

⁴Selection according to the marked EPL is critical to the safe application of this equipment.

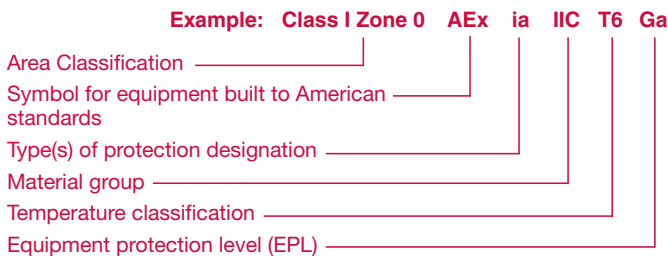
⁵“Other electrical equipment — general purpose motors” refers to motors in accordance with Exception No. 4 to 505.20(C).

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▲ Informational Note: Figure 505.9(C)(2), No. 1 Zone Equipment Marking.



▲ (D) Class I Temperature. The temperature marking specified in 505.9(D)(1) shall not exceed the autoignition temperature of the specific gas or vapor to be encountered.

Informational Note: For information regarding autoignition temperatures of gases and vapors, see NFPA 497-2017, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*; and ISO/IEC 80079-20-1-2017, *Explosive atmospheres — Part 20-1: Material characteristics for gas and vapour classification — Test methods and data*.

(1) Temperature Classifications. Equipment shall be marked to show the operating temperature or temperature class referenced to a 40°C ambient, or at the higher ambient temperature if the equipment is rated and marked for an ambient temperature of greater than 40°C. The temperature class, if provided, shall be indicated using the temperature class (T code) shown in Table 505.9(D)(1).

Table 505.9(D)(1) Classification of Maximum Surface Temperature for Group II Electrical Equipment

Temperature Class (T Code)	Maximum Surface Temperature (°C)
T1	≤ 450
T2	≤ 300
T3	≤ 200
T4	≤ 135
T5	≤ 100
T6	≤ 85

Electrical equipment designed for use in the ambient temperature range between -20°C and +40°C shall require no ambient temperature marking.

Electrical equipment that is designed for use in a range of ambient temperatures other than -20°C to +40°C is considered to be special; and the ambient temperature range shall then be marked on the equipment, including either the symbol “Ta” or “Tamb” together with the special range of ambient temperatures, in degrees Celsius.

Informational Note: As an example, such a marking might be “-30°C to +40°C.”

Exception No. 1: Equipment of the non-heat-producing type, such as conduit fittings, and equipment of the heat-producing type having a maximum temperature of not more than 100°C (212°F) shall not be required to have a marked operating temperature or temperature class.

Exception No. 2: Equipment identified for Class I, Division 1 or Division 2 locations as permitted by 505.20(A), (B), and (C) shall be permitted to be marked in accordance with 505.8(C) and Table 500.8(C).

(E) Threading. The supply connection entry thread form shall be NPT or metric. Conduit and fittings shall be made wrenchtight to prevent sparking when fault current flows through the conduit system, and to ensure the explosionproof or flameproof integrity of the conduit system where applicable. Equipment provided with threaded entries for field wiring connections shall be installed in accordance with 505.9(E)(1) or (E)(2) and with (E)(3).

(1) Equipment Provided with Threaded Entries for NPT Threaded Conduit or Fittings. For equipment provided with threaded entries for NPT threaded conduit or fittings, listed conduit, listed conduit fittings, or listed cable fittings shall be used.

All NPT threaded conduit and fittings shall be threaded with a National (American) Standard Pipe Taper (NPT) thread.

NPT threaded entries into explosionproof or flameproof equipment shall be made up with at least five threads fully engaged.

Exception: For listed explosionproof or flameproof equipment, factory-threaded NPT entries shall be made up with at least 4½ threads fully engaged.

Informational Note No. 1: Thread specifications for male NPT threads are located in ASME B1.20.1-2013, *Pipe Threads, General Purpose (Inch)*.

Informational Note No. 2: Female NPT threaded entries use a modified National Standard Pipe Taper (NPT) thread with thread form per ASME B1.20.1-2013, *Pipe Threads, General Purpose (Inch)*. See ANSI/UL 60079-1-2015, *Explosive Atmospheres — Part 1: Equipment Protection by Flameproof Enclosures “d.”*

▲ **(2) Equipment Provided with Threaded Entries for Metric Threaded Conduit or Fittings.** For equipment with metric threaded entries, listed conduit fittings or listed cable fittings shall be used. Such entries shall be identified as being metric, or listed adapters to permit connection to conduit or NPT threaded fittings shall be provided with the equipment and shall be used for connection to conduit or NPT threaded fittings.

Metric threaded fittings installed into explosionproof or flameproof equipment entries shall have a class of fit of at least 6g/6H and be made up with at least five threads fully engaged.

Informational Note: Threading specifications for metric threaded entries are located in ISO 965-1-2013, *ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data*, and ISO 965-3-2009, *ISO general purpose metric screw threads — Tolerances — Part 3: Deviations for constructional screw threads*.

(3) Unused Openings. All unused openings shall be closed with close-up plugs listed for the location and shall maintain the type of protection. The plug engagement shall comply with 505.9(E)(1) or 505.9(E)(2).

(F) Optical Fiber Cables. An optical fiber cable, with or without current-carrying current (composite optical fiber cable), shall be installed to address the associated fire hazard and sealed to address the associated explosion hazard in accordance with the requirements of 505.15 and 505.16.

■ **(G) Equipment Involving Optical Radiation.** For equipment involving sources of optical radiation (such as laser or LED sources) in the wavelength range from 380 nm to 10 µm, the risk of ignition from optical radiation shall be considered for all electrical parts and circuits that may be exposed to the radiation, both inside and outside the optical equipment. This includes optical equipment, which itself is located outside the explosive atmosphere, but its emitted optical radiation enters such atmospheres.

Informational Note: For additional information on types of protection that can be applied to minimize the risk of ignition in explosive atmospheres from optical radiation, see ANSI/UL 60079-28-2017, *Explosive Atmospheres — Part 28: Protection of Equipment and Transmission Systems Using Optical Radiation*.

Exception: All luminaires (fixed, portable, or transportable) and hand lights, intended to be supplied by mains (with or without galvanic isolation) or powered by batteries, with any continuous divergent light source, including LEDs, shall be excluded from this requirement.

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505.15 Wiring Methods.

Wiring methods shall maintain the integrity of protection techniques and shall comply with 505.15(A) through (C).

- ▲ (A) **Zone 0.** In Zone 0 locations, equipment protected by intrinsic safety “ia” and equipment protected by encapsulation “ma” shall be connected using intrinsically safe “ia” circuits with wiring methods in accordance with Article 504.

▲ (B) **Zone 1.**

- ▲ (1) **General.** In Zone 1 locations, the following wiring methods shall be permitted:

(1) All wiring methods permitted by 505.15(A).

(2) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, and where the cable is not subject to physical damage, Type MC-HL cable listed for use in Zone 1 or Class I, Division 1 locations, with a gas/vaportight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material, and a separate equipment grounding conductor(s) in accordance with 250.122, and terminated with fittings listed for the application. Type MC-HL cable shall be installed in accordance with Part II of Article 330.

(3) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, and where the cable is not subject to physical damage, Type ITC-HL cable listed for use in Zone 1 or Class I, Division 1 locations, with a gas/vaportight continuous corrugated metallic sheath and an overall jacket of suitable polymeric material, and terminated with fittings listed for the application. Type ITC-HL cable shall be installed in accordance with 727.4.

Informational Note: See 727.4 and 727.5 for restrictions on use of Type ITC cable.

(4) Type MI cable terminated with fittings listed for Zone 1 or Class I, Division 1 locations. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings.

(5) Threaded rigid metal conduit (Type RMC) or threaded steel intermediate metal conduit (Type IMC).

(6) Type PVC or RTRC conduit shall be permitted where encased in a concrete envelope a minimum of 50 mm (2 in.) thick and provided with not less than 600 mm (24 in.) of cover measured from the top of the conduit to grade. Threaded rigid metal conduit or threaded steel intermediate metal conduit shall be used for the last 600 mm (24 in.) of the underground run to emergence or to the point of connection to the aboveground raceway. An equipment grounding conductor shall be included to provide for electrical continuity of the raceway system and for grounding of non-current-carrying metal parts.

(7) Intrinsic safety type of protection “ib” shall be permitted using the wiring methods in accordance with 504.20.

(8) Optical fiber cable Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC shall be permitted to be installed in raceways in accordance with 505.15(B). Optical fiber cable shall be sealed in accordance with 505.16.

(9) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, for applications limited to 600 volts nominal or less, and where the cable is not subject to physical damage and terminated with fittings listed for the location, Type TC-ER-HL cable shall be listed for use in Class I, Division 1 or Zone 1 locations and shall be installed in accordance with 336.10.

Informational Note: See the information on construction, testing, and marking of cables and cable fittings in ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

(10) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type P cable with metal braid armor, with an overall jacket, and terminated with fittings listed for the location, and installed in accordance with 337.10.

Informational Note No. 1: For information on construction, testing, and marking of Type P cable, see ANSI/UL 1309-2017, *Marine Shipboard Cable*.

Informational Note No. 2: For information on construction, testing, and marking of cable fittings, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

(2) **Flexible Connections.** Where necessary to employ flexible connections, as at motor terminals, one of the following shall be permitted:

(1) Flexible fittings listed for the location.

(2) Flexible cord in accordance with 505.17(A), terminated with cord connectors listed for the location.

(3) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, for applications limited to 600 volts nominal or less, and where the cable is not subject to physical damage, and terminated with fittings listed for the location, Type TC-ER-HL cable. Type TC-ER-HL cable shall be listed for use in Class I, Division 1 or Zone 1 locations and shall be installed in accordance with 336.10.

Informational Note: See the information on construction, testing, and marking of cables and cable fittings in ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

(4) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type P cable with metal braid armor, with an overall jacket, and terminated with fittings listed for the location, and installed in accordance with 337.10.

Informational Note No. 1: For information on construction, testing, and marking of Type P cable, see ANSI/UL 1309-2017, *Marine Shipboard Cable*.

Informational Note No. 2: For information on construction, testing, and marking of cable fittings, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

▲ (C) **Zone 2.**

- ▲ (1) **General.** In Zone 2 locations, the following wiring methods shall be permitted:

(1) All wiring methods permitted by 505.15(B).

(2) Type MC, MV, TC, or TC-ER cable, including installation in cable tray systems. Type TC-ER shall include a separate equipment grounding conductor in addition to a drain wire that might be present. The cable shall be terminated with listed fittings. Single conductor Type MV cables shall be shielded or metallic-armored.

(3) Types ITC and ITC-ER cable as permitted in 727.4 and terminated with listed fittings. Type ITC-ER shall include a separate insulated equipment grounding conductor in addition to a drain wire.

(4) Types PLTC and PLTC-ER cable in accordance with Part II or III of Article 725, including installation in cable tray systems. The cable shall be terminated with listed fittings. Type PLTC-ER shall include a separate insulated equipment grounding conductor in addition to a drain wire that might be present.

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- (5) Enclosed gasketed busways, enclosed gasketed wireways.
- (6) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, and where metallic conduit does not provide sufficient corrosion resistance, listed reinforced thermosetting resin conduit (Type RTRC), factory elbows, and associated fittings, all marked with the suffix -XW, and Schedule 80 PVC conduit, factory elbows, and associated fittings shall be permitted. Where seals are required for boundary conditions as defined in 505.16(C)(1)(b), the Zone 1 wiring method shall extend into the Zone 2 area to the seal, which shall be located on the Zone 2 side of the Zone 1/Zone 2 boundary.
- (7) Intrinsic safety type of protection “ic” shall be permitted using any of the wiring methods permitted for unclassified locations. Intrinsic safety type of protection “ic” systems shall be installed in accordance with the control drawing(s). Simple apparatus, not shown on the control drawing, shall be permitted in an intrinsic safety type of protection “ic” circuit, provided that the simple apparatus does not interconnect the intrinsic safety type of protection “ic” systems to any other circuit. **Separate intrinsic safety type of protection “ic” systems shall be installed in accordance with one of the following:**
- In separate cables
 - In multiconductor cables where the conductors of each circuit are within a ground-ed metal shield
 - In multiconductor cables where the conductors of each circuit have insulation with a minimum thickness of 0.25 mm (0.01 in.)
- Informational Note: Simple apparatus is defined in Article 100 Part III.
- (8) Optical fiber cable of Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC shall be permitted to be installed in cable trays or any other raceway in accordance with 505.15(C). Optical fiber cable shall be sealed in accordance with 505.16.
- (9) Cablebus.
- (10) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Type P cable with or without metal braid armor, with an overall jacket, and terminated with fittings listed for the location, and installed in accordance with 337.10.

Informational Note No. 1: For information on construction, testing, and marking of Type P cable, see ANSI/UL 1309-2017, *Marine Shipboard Cable*.

Informational Note No. 2: For information on construction, testing, and marking of cable fittings, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

- ▲ **(2) Flexible Connections.** Where provision must be made for flexibility, one or more of the following shall be permitted:

- Listed flexible metal fittings.
- Flexible metal conduit with listed fittings.
- Interlocked armor Type MC cable with listed fittings.
- Type P cable.
- Type TC-ER or Type TC-ER-HL cable.

(6) Type ITC-ER or Type ITC-HL cable.

(7) Type PLTC-ER cable.

(8) Liquidtight flexible metal conduit with listed fittings.

(9) Liquidtight flexible nonmetallic conduit with listed fittings.

(10) Flexible cord in accordance with the provisions of 505.17 terminated with a listed cord connector that maintains the type of protection of the terminal compartment shall be permitted.

(11) For elevator use, an identified elevator cable of Type EO, ETP, or ETT, shown under the “use” column in Table 400.4 for “hazardous (classified) locations” and terminated with listed fittings.

Informational Note: See 505.25(B) for grounding requirements where flexible conduit is used.

505.16 Sealing and Drainage.

Seals in conduit and cable systems shall comply with 505.16(A) through (E). Sealing compound shall be used in Type MI cable termination fittings to exclude moisture and other fluids from the cable insulation.

Informational Note No. 1: Seals are provided in conduit and cable systems to minimize the passage of gases and vapors and prevent the passage of flames from one portion of the electrical installation to another through the conduit. Such communication through Type MI cable is inherently prevented by construction of the cable. Unless specifically designed and tested for the purpose, conduit and cable seals are not intended to prevent the passage of liquids, gases, or vapors at a continuous pressure differential across the seal. Even at differences in pressure across the seal equivalent to a few inches of water, there may be a slow passage of gas or vapor through a seal and through conductors passing through the seal. See 505.16(C)(2)(b). Temperature extremes and highly corrosive liquids and vapors can affect the ability of seals to perform their intended function. See 505.16(D)(2).

Informational Note No. 2: Gas or vapor leakage and propagation of flames may occur through the interstices between the strands of standard stranded conductors larger than 2 AWG. Special conductor constructions, for example, compacted strands or sealing of the individual strands, are means of reducing leakage and preventing the propagation of flames.

- ▲ **(A) Zone 0.** In Zone 0 locations, seals shall be located according to 505.16(A)(1), (A)(2), and (A)(3).

(1) Conduit Seals. Seals shall be provided within 3.05 m (10 ft) of where a conduit leaves a Zone 0 location. There shall be no unions, couplings, boxes, or fittings, except listed reducers at the seal, in the conduit run between the seal and the point at which the conduit leaves the location.

Exception: A rigid unbroken conduit that passes completely through the Zone 0 location with no fittings less than 300 mm (12 in.) beyond each boundary shall not be required to be sealed if the termination points of the unbroken conduit are in unclassified locations.

(2) Cable Seals. Seals shall be provided on cables at the first point of termination after entry into the Zone 0 location.

(3) Not Required to Be Explosionproof or Flameproof. Seals shall not be required to be explosionproof or flameproof.

- ▲ **(B) Zone 1.** In Zone 1 locations, seals shall be located in accordance with 505.16(B)(1) through (B)(8).

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(1) Type of Protection “d”, “db”, “e”, or “eb” Enclosures.

Conduit seals shall be provided within 50 mm (2 in.) for each conduit entering enclosures having type of protection “d”, “db”, “e”, or “eb”.

Exception No. 1: Where the enclosure having type of protection “d” or “db” is marked to indicate that a seal is not required.

Exception No. 2: For type of protection “e” or “eb”, conduit and fittings employing only NPT to NPT raceway joints or fittings listed for type of protection “e” or “eb” shall be permitted between the enclosure and the seal, and the seal shall not be required to be within 50 mm (2 in.) of the entry.

Informational Note: Examples of fittings employing other than NPT threads include conduit couplings, capped elbows, unions, and breather drains.

Exception No. 3: For conduit installed between type of protection “e” or “eb” enclosures employing only NPT to NPT raceway joints or conduit fittings listed for type of protection “e” or “eb”, a seal shall not be required.

(2) Explosionproof Equipment. Conduit seals shall be provided for each conduit entering explosionproof equipment according to 505.16(B)(2)(a), (B)(2)(b), and (B)(2)(c).

(a) In each conduit entry into an explosionproof enclosure where either of the following conditions apply.

- (1) The enclosure contains apparatus, such as switches, circuit breakers, fuses, relays, or resistors that may produce arcs, sparks, or high temperatures that are considered to be an ignition source in normal operation. For the purposes of this section, high temperatures shall be considered to be any temperatures exceeding 80 percent of the autoignition temperature in degrees Celsius of the gas or vapor involved.

Exception: Seals shall not be required for conduit entering an enclosure where such switches, circuit breakers, fuses, relays, or resistors comply with one of the following:

- (a) Are enclosed within a chamber hermetically sealed against the entrance of gases or vapors.
 - (b) Are immersed in oil.
 - (c) Are enclosed within an enclosure, identified for the location, and marked “Leads Factory Sealed,” “Factory Sealed,” “Seal not Required,” or equivalent.
- (2) The entry is metric designator 53 (trade size 2) or larger and the enclosure contains terminals, splices, or taps. An enclosure, identified for the location, and marked “Leads Factory Sealed,” or “Factory Sealed,” Seal not Required,” or equivalent shall not be considered to serve as a seal for another adjacent explosionproof enclosure that is required to have a conduit seal.

(b) Conduit seals shall be installed within 450 mm (18 in.) from the enclosure. Only threaded couplings, or explosionproof fittings such as unions, reducers, elbows, and capped elbows that are not larger than the trade size of the conduit, shall be permitted between the sealing fitting and the explosionproof enclosure.

(c) Where two or more explosionproof enclosures for which conduit seals are required under 505.16(B)(2) are connected by nipples or by runs of conduit not more than 900 mm (36 in.) long, a single conduit seal in each such nipple connection or run of conduit shall be considered sufficient if located not more than 450 mm (18 in.) from either enclosure.

(3) Pressurized Enclosures. Conduit seals shall be provided in each conduit entry into a pressurized enclosure where the conduit is not pressurized as part of the protection system. Conduit seals shall be installed within 450 mm (18 in.) from the pressurized enclosure.

Informational Note No. 1: Installing the seal as close as possible to the enclosure reduces problems with purging the dead airspace in the pressurized conduit.

Informational Note No. 2: For further information, see NFPA 496-2017, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*.

(4) Zone 1 Boundary. Conduit seals shall be provided in each conduit run leaving a Zone 1 location. The sealing fitting shall be permitted on either side of the boundary of such location within 3.05 m (10 ft) of the boundary and shall be designed and installed so as to minimize the amount of gas or vapor within the Zone 1 portion of the conduit from being communicated to the conduit beyond the seal. Except for listed explosionproof reducers at the conduit seal, there shall be no union, coupling, box, or fitting between the conduit seal and the point at which the conduit leaves the Zone 1 location.

Exception: Exception: Metal conduit containing no unions, couplings, boxes, or fittings and passing completely through a Zone 1 location with no fittings less than 300 mm (12 in.) beyond each boundary shall not require a conduit seal if the termination points of the unbroken conduit are in unclassified locations.

(5) Cables Capable of Transmitting Gases or Vapors. Conduits containing cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core shall be sealed in the Zone 1 location after removing the jacket and any other coverings so that the sealing compound surrounds each individual insulated conductor or optical fiber tube and the outer jacket.

Exception: Multiconductor cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core shall be permitted to be considered as a single conductor by sealing the cable in the conduit within 450 mm (18 in.) of the enclosure and the cable end within the enclosure by an approved means to minimize the entrance of gases or vapors and prevent the propagation of flame into the cable core, or by other approved methods. For shielded cables and twisted pair cables, it shall not be required to remove the shielding material or separate the twisted pair.

(6) Cables Incapable of Transmitting Gases or Vapors.

Each multiconductor or optical multifiber cable in conduit shall be considered as a single conductor or single optical fiber tube if the cable is incapable of transmitting gases or vapors through the cable core. These cables shall be sealed in accordance with 505.16(D).

(7) Cables Entering Enclosures. Cable seals shall be provided for each cable entering flameproof or explosionproof enclosures. The seal shall comply with 505.16(D).

(8) Zone 1 Boundary. Cables shall be sealed at the point at which they leave the Zone 1 location.

Exception: Where cable is sealed at the termination point.

(C) Zone 2. In Zone 2 locations, seals shall be located in accordance with 505.16(C)(1) and (C)(2).

(1) Conduit Seals. Conduit seals shall be located in accordance with 505.16(C)(1)(a) and (C)(1)(b).

(a) For connections to enclosures that are required to be flameproof or explosionproof, a conduit seal shall be provided in accordance with 505.16(B)(1) and (B)(2). All portions of the conduit run or nipple between the seal and enclosure shall comply with 505.16(B).

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(b) In each conduit run passing from a Zone 2 location into an unclassified location. The sealing fitting shall be permitted on either side of the boundary of such location within 3.05 m (10 ft) of the boundary and shall be designed and installed so as to minimize the amount of gas or vapor within the Zone 2 portion of the conduit from being communicated to the conduit beyond the seal. Rigid metal conduit or threaded steel intermediate metal conduit shall be used between the sealing fitting and the point at which the conduit leaves the Zone 2 location, and a threaded connection shall be used at the sealing fitting. Except for listed explosionproof reducers at the conduit seal, there shall be no union, coupling, box, or fitting between the conduit seal and the point at which the conduit leaves the Zone 2 location. Conduits shall be sealed to minimize the amount of gas or vapor within the Zone 2 portion of the conduit from being communicated to the conduit beyond the seal. Such seals shall not be required to be flameproof or explosionproof but shall be identified for the purpose of minimizing passage of gases under normal operating conditions and shall be accessible.

Exception No. 1: Metal conduit containing no unions, couplings, boxes, or fittings and passing completely through a Zone 2 location with no fittings less than 300 mm (12 in.) beyond each boundary shall not be required to be sealed if the termination points of the unbroken conduit are in unclassified locations.

Exception No. 2: Conduit systems terminating at an unclassified location where a wiring method transition is made to cable tray, cablebus, ventilated busway, Type MI cable, or cable that is not installed in a raceway or cable tray system shall not be required to be sealed where passing from the Zone 2 location into the unclassified location. The unclassified location shall be outdoors or, if the conduit system is all in one room, it shall be permitted to be indoors. The conduits shall not terminate at an enclosure containing an ignition source in normal operation.

Exception No. 3: Conduit systems passing from an enclosure or room that is unclassified as a result of pressurization into a Zone 2 location shall not require a seal at the boundary.

Informational Note: For further information, refer to NFPA 496-2013, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*.

Exception No. 4: Segments of aboveground conduit systems shall not be required to be sealed where passing from a Zone 2 location into an unclassified location if all the following conditions are met:

- (1) No part of the conduit system segment passes through a Zone 0 or Zone 1 location where the conduit contains unions, couplings, boxes, or fittings within 300 mm (12 in.) of the Zone 0 or Zone 1 location.*
- (2) The conduit system segment is located entirely in outdoor locations.*
- (3) The conduit system segment is not directly connected to canned pumps, process or service connections for flow, pressure, or analysis measurement, and so forth, that depend on a single compression seal, diaphragm, or tube to prevent flammable or combustible fluids from entering the conduit system.*
- (4) The conduit system segment contains only threaded metal conduit, unions, couplings, conduit bodies, and fittings in the unclassified location.*
- (5) The conduit system segment is sealed at its entry to each enclosure or fitting housing terminals, splices, or taps in Zone 2 locations.*

▲ (2) Cable Seals. Cable seals shall be located in accordance with 505.16(C)(2)(a), (C)(2)(b), and (C)(2)(c).

(a) Explosionproof and Flameproof Enclosures. Cables entering enclosures required to be flameproof or explosionproof shall be sealed at the point of entrance. The seal shall comply with 505.16(D). Multiconductor or optical multifiber cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core shall be sealed in the Zone 2 location after removing the jacket and any other coverings so that the sealing compound surrounds each individual insulated conductor or optical fiber tube in such a manner as to minimize the passage of gases and vapors. Multiconductor or optical multifiber cables in conduit shall be sealed as described in 505.16(B)(4).

Exception No. 1: Cables passing from an enclosure or room that is unclassified as a result of Type Z pressurization into a Zone 2 location shall not require a seal at the boundary.

Exception No. 2: Shielded cables and twisted pair cables shall not require the removal of the shielding material or separation of the twisted pairs, provided the termination is by an approved means to minimize the entrance of gases or vapors and prevent propagation of flame into the cable core.

(b) Cables That Will Not Transmit Gases or Vapors. Cables with a gas/vaportight continuous sheath and that will not transmit gases or vapors through the cable core in excess of the quantity permitted for seal fittings shall not be required to be sealed except as required in 505.16(C)(2)(b). The minimum length of such cable run shall not be less than the length that limits gas or vapor flow through the cable core to the rate permitted for seal fittings [200 cm³/hr (0.007 ft³/hr) of air at a pressure of 1500 pascals (6 in. of water)].

Informational Note No. 1: For further information on construction, testing, and marking of cables, cable fittings, and cord connectors, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

Informational Note No. 2: The cable core does not include the interstices of the conductor strands.

(c) Cables Capable of Transmitting Gases or Vapors. Cables with a gas/vaportight continuous sheath capable of transmitting gases or vapors through the cable core shall not be required to be sealed except as required in 505.16(C)(2)(b), unless the cable is attached to process equipment or devices that may cause a pressure in excess of 1500 pascals (6 in. of water) to be exerted at a cable end, in which case a seal, barrier, or other means shall be provided to prevent migration of flammables into an unclassified area.

Exception: Cables with an unbroken gas/vaportight continuous sheath shall be permitted to pass through a Zone 2 location without seals.

(d) Cables Without Gas/Vaportight Continuous Sheath. Cables that do not have gas/vaportight continuous sheath shall be sealed at the boundary of the Zone 2 and unclassified location in such a manner as to minimize the passage of gases or vapors into an unclassified location.

Informational Note: The cable sheath may be either metal or a nonmetallic material.

▲ (D) Zones 0, 1, and 2. Where required, seals in Zones 0, 1, and 2 locations shall comply with 505.16(D)(1) through (D)(5).

(1) Fittings. Enclosures for connections or equipment shall be provided with an integral means for sealing, or sealing fittings listed for the location shall be used. Sealing fittings shall be listed for use with one or more specific compounds and shall be accessible.

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(2) Compound. The compound shall provide a seal against passage of gas or vapors through the seal fitting, shall not be affected by the surrounding atmosphere or liquids, and shall not have a melting point less than 93°C (200°F).

(3) Thickness of Compounds. In a completed seal, the minimum thickness of the sealing compound shall not be less than the trade size of the sealing fitting and, in no case, less than 16 mm (5/8 in.).

Exception: Listed cable sealing fittings shall not be required to have a minimum thickness equal to the trade size of the fitting.

(4) Splices and Taps. Splices and taps shall not be made in fittings intended only for sealing with compound, nor shall other fittings in which splices or taps are made be filled with compound.

(5) Conductor or Optical Fiber Fill. The cross-sectional area of the conductors or optical fiber tubes (metallic or nonmetallic) permitted in a seal shall not exceed 25 percent of the cross-sectional area of a rigid metal conduit of the same trade size unless it is specifically listed for a higher percentage of fill.

(E) Drainage.

(1) Control Equipment. Where there is a probability that liquid or other condensed vapor may be trapped within enclosures for control equipment or at any point in the raceway system, approved means shall be provided to prevent accumulation or to permit periodic draining of such liquid or condensed vapor.

(2) Motors and Generators. Where liquid or condensed vapor may accumulate within motors or generators, joints and conduit systems shall be arranged to minimize entrance of liquid. If means to prevent accumulation or to permit periodic draining are necessary, such means shall be provided at the time of manufacture and shall be considered an integral part of the machine.

▲ 505.17 Flexible Cables, Cords and Connections.

▲ (A) Flexible Cords, Zones 1 and 2. A flexible cord shall be permitted for connection between portable lighting equipment or other portable utilization equipment and the fixed portion of their supply circuit. Flexible cord shall also be permitted for that portion of the circuit where the fixed wiring methods of 505.15(B) and (C) cannot provide the necessary degree of movement for fixed and mobile electrical utilization equipment in an industrial establishment where conditions of maintenance and engineering supervision ensure that only qualified persons install and service the installation, and where the flexible cord is protected by location or by a suitable guard from damage. The length of the flexible cord shall be continuous. Where flexible cords are used, the cords shall comply with the following:

- (1) Be of a type listed for extra-hard usage.
- (2) Contain, in addition to the conductors of the circuit, an equipment grounding conductor complying with 400.23.
- (3) Be connected to terminals or to supply conductors in an approved manner.
- (4) Be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connections.
- (5) Be terminated with a listed cord connector that maintains the type of protection where the flexible cord enters boxes, fittings, or enclosures that are required to be explosionproof or flameproof.
- (6) Cord entering an increased safety “e” enclosure shall be terminated with a listed increased safety “e” cord connector.

Informational Note: See 400.10 for permitted uses of flexible cords.

Electric submersible pumps with means for removal without entering the wet-pit shall be considered portable utilization equipment. The extension of the flexible cord within a suitable raceway between the wet-pit and the power source shall be permitted.

Electric mixers intended for travel into and out of open-type mixing tanks or vats shall be considered portable utilization equipment.

Informational Note: See 505.18 for flexible cords exposed to liquids having a deleterious effect on the conductor insulation.

(B) Instrumentation Connections for Zone 2. To facilitate replacements, process control instruments shall be permitted to be connected through flexible cords, attachment plugs, and receptacles, provided that all of the following conditions apply:

- (1) A switch listed for Zone 2 is provided so that the attachment plug is not depended on to interrupt current, unless the circuit is type “ia,” “ib,” or “ic” protection, in which case the switch is not required.
- (2) The current does not exceed 3 amperes at 120 volts, nominal.
- (3) The power-supply cord does not exceed 900 mm (3 ft), is of a type listed for extra-hard usage or for hard usage if protected by location, and is supplied through an attachment plug and receptacle of the locking and grounding type.
- (4) Only necessary receptacles are provided.
- (5) The receptacle carries a label warning against unplugging under load.

505.18 Conductors and Conductor Insulation.

(A) Conductors. For type of protection “e,” field wiring conductors shall be copper. Every conductor (including spares) that enters Type “e” equipment shall be terminated at a Type “e” terminal.

(B) Conductor Insulation. Where condensed vapors or liquids may collect on, or come in contact with, the insulation on conductors, such insulation shall be of a type identified for use under such conditions, or the insulation shall be protected by a sheath of lead or by other approved means.

▲ 505.19 Uninsulated Exposed Parts.

There shall be no uninsulated exposed parts, such as electrical conductors, buses, terminals, or components, that operate at more than 30 volts (15 volts in wet locations). These parts shall additionally be protected by type of protection “ia,” “ib,” or “ic” that is suitable for the location.

505.20 Equipment Requirements.

▲ (A) Zone 0. In Zone 0 locations, only equipment specifically listed and marked as suitable for the location shall be permitted.

Exception: Intrinsically safe apparatus listed for use in Class I, Division 1 locations for the same gas, or as permitted by 505.9(B)(2), and with a suitable temperature class shall be permitted.

▲ (B) Zone 1. In Zone 1 locations, only equipment specifically listed and marked as suitable for the location shall be permitted.

Exception No. 1: Equipment identified for use in Class I, Division 1 or listed for use in Zone 0 locations for the same gas, or as permitted by 505.9(B)(2), and with a suitable temperature class shall be permitted.

Exception No. 2: Equipment identified for Zone 1 or Zone 2 type of protection “p” shall be permitted.

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▲ (C) Zone 2. In Zone 2 locations, only equipment specifically listed and marked as suitable for the location shall be permitted.

Exception No. 1: Equipment listed for use in Zone 0 or Zone 1 locations for the same gas, or as permitted by 505.9(B)(2), and with a suitable temperature class, shall be permitted.

Exception No. 2: Equipment identified for Zone 1 or Zone 2 type of protection “p” shall be permitted.

Exception No. 3: Equipment identified for use in Class I, Division 1 or Division 2 locations for the same gas, or as permitted by 505.9(B)(2), and with a suitable temperature class shall be permitted.

Exception No. 4: In Zone 2 locations, the installation of open or nonexplosionproof or nonflameproof enclosed motors, such as squirrel-cage induction motors without brushes, switching mechanisms, or similar arc-producing devices that are not identified for use in a Zone 2 location shall be permitted.

Informational Note No. 1: It is important to consider the temperature of internal and external surfaces that may be exposed to the flammable atmosphere.

Informational Note No. 2: It is important to consider the risk of ignition due to currents arcing across discontinuities and overheating of parts in multisection enclosures of large motors and generators. Such motors and generators may need equipotential bonding jumpers across joints in the enclosure and from enclosure to ground. Where the presence of ignitable gases or vapors is suspected, clean air purging may be needed immediately prior to and during start-up periods.

Informational Note No. 3: For further information on the application of electric motors in Class I, Zone 2 hazardous (classified) locations, see *IEEE 1349-2011, IEEE Guide for the Application of Electric Motors in Class I, Division 2 and Class I, Zone 2 Hazardous (Classified) Locations*.

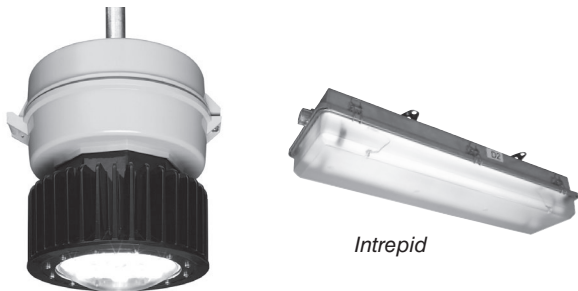
(D) Materials. Equipment marked Group IIC shall be permitted for applications requiring Group IIA or Group IIB equipment. Similarly, equipment marked Group IIB shall be permitted for applications requiring Group IIA equipment.

Equipment marked for a specific gas or vapor shall be permitted for applications where the specific gas or vapor may be encountered.

Informational Note: One common example combines these markings with equipment marked IIB +H₂. This equipment is suitable for applications requiring Group IIA equipment, Group IIB equipment, or equipment for hydrogen atmospheres.

(E) Manufacturer’s Instructions. Electrical equipment installed in hazardous (classified) locations shall be installed in accordance with the instructions (if any) provided by the manufacturer.

Products shown here are suitable for Class I, Zone 2 locations; see 505.20



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▲ 505.22 Increased Safety “e” Motors and Generators.

In Zone 1 locations, increased safety “e” motors and generators of all voltage ratings shall be listed for Zone 1 locations, and shall comply with all of the following:

- (1) Motors shall be marked with the current ratio, I_A / I_N , and time, t_E .
- (2) Motors shall have controllers marked with the model or identification number, output rating (horsepower or kilowatt), full-load amperes, starting current ratio (I_A / I_N), and time (t_E) of the motors that they are intended to protect; the controller marking shall also include the specific overload protection type (and setting, if applicable) that is listed with the motor or generator.
- (3) Connections shall be made with the specific terminals listed with the motor or generator.
- (4) Terminal housings shall be permitted to be of substantial, nonmetallic, nonburning material, provided an internal grounding means between the motor frame and the equipment grounding connection is incorporated within the housing.
- (5) The provisions of Part III of Article 430 shall apply regardless of the voltage rating of the motor.
- (6) The motors shall be protected against overload by a separate overload device that is responsive to motor current. This device shall be selected to trip or shall be rated in accordance with the listing of the motor and its overload protection.
- (7) Sections 430.32(C) and 430.44 shall not apply to such motors.
- (8) The motor overload protection shall not be shunted or cut out during the starting period.

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Informational Note: Reciprocating engine-driven generators, compressors, and other equipment installed in Zone 2 locations may present a risk of ignition of flammable materials associated with fuel, starting, compression, and so forth, due to inadvertent release or equipment malfunction by the engine ignition system and controls. For further information on the requirements for ignition systems for reciprocating engines installed in Zone 2 hazardous (classified) locations, see ANSI/UL 122001-2014, *General Requirements for Electrical Ignition Systems for Internal Combustion Engines in Class I, Division 2 or Zone 2, Hazardous (Classified) Locations*.

505.25 Grounding and Bonding.

Regardless of the voltage of the electrical system, grounding and bonding shall comply with Article 250 and the requirements in 505.25(A) and (B).

(A) Bonding. The locknut-bushing and double-locknut types of contacts shall not be depended on for bonding purposes, but bonding jumpers with proper fittings or other approved means of bonding shall be used. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, and so forth, between Class I locations and the point of grounding for service equipment or point of grounding of a separately derived system.

Exception: The specific bonding means shall be required only to the nearest point where the grounded circuit conductor and the grounding electrode are connected together on the line side of the building or structure disconnecting means as specified in 250.32(B), provided the branch-circuit overcurrent protection is located on the load side of the disconnecting means.

▲ (B) Types of Equipment Grounding Conductors. Flexible metal conduit and liquidtight flexible metal conduit shall include an equipment bonding jumper of the wire type in compliance with 250.102.

Exception: In Zone 2 locations, the bonding jumper shall be permitted to be deleted where all of the following conditions are met:

- (1) Listed liquidtight flexible metal conduit 1.8 m (6 ft) or less in length, with fittings listed for grounding, is used.
- (2) Overcurrent protection in the circuit is limited to 10 amperes or less.
- (c) The load is not a power utilization load.

505.26 Process Sealing.

This section shall apply to process-connected equipment, which includes, but is not limited to, canned pumps, submersible pumps, flow, pressure, temperature, or analysis measurement instruments. A process seal is a device to prevent the migration of process fluids from the designed containment into the external electrical system. Process-connected electrical equipment that incorporates a single process seal, such as a single compression seal, diaphragm, or tube to prevent flammable or combustible fluids from entering a conduit or cable system capable of transmitting fluids, shall be provided with an additional means to mitigate a single process seal failure. The additional means may include, but is not limited to, the following:

- (1) A suitable barrier meeting the process temperature and pressure conditions that the barrier is subjected to upon failure of the single process seal. There shall be a vent or drain between the single process seal and the suitable barrier. Indication of the single process seal failure shall be provided by visible leakage, an audible whistle, or other means of monitoring.

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- (2) A listed Type MI cable assembly, rated at not less than 125 percent of the process pressure and not less than 125 percent of the maximum process temperature (in degrees Celsius), installed between the cable or conduit and the single process seal.
- (3) A drain or vent located between the single process seal and a conduit or cable seal. The drain or vent shall be sufficiently sized to prevent overpressuring the conduit or cable seal above 6 in. water column (1493 Pa). Indication of the single process seal failure shall be provided by visible leakage, an audible whistle, or other means of monitoring.
- (4) An add-on secondary seal marked “secondary seal” and rated for the pressure and temperature conditions to which it will be subjected upon failure of the single process seal.

Process-connected electrical equipment that does not rely on a single process seal or is listed and marked “single seal”, “dual seal”, or “dual seal without annunciation” shall not be required to be provided with an additional means of sealing.

Process-connected electrical equipment marked “single seal — install conduit or cable seal” shall be sealed in accordance with 505.16.

Informational Note: For construction and testing requirements for process sealing for listed and marked single seal, dual seal, or secondary seal equipment, refer to ANSI/UL 122701-2017, *Requirements for Process Sealing Between Electrical Systems and Flammable or Combustible Process Fluids*.

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Article 506 has been expanded to include additional protection techniques. It follows the IEC method of dealing with combustible dusts, fibers, and flyings and is intended to be an alternative to Articles 502, and 503 as well since fibers and flyings are included, just as Article 505 is an alternative to Article 501.

▲ 506.1 Scope.

This article covers the requirements for the zone classification system as an alternative to the division classification system covered in Article 500, Article 502, and Article 503 for electrical and electronic equipment and wiring for all voltages in Zone 20, Zone 21, and Zone 22 hazardous (classified) locations where fire and explosion hazards may exist due to combustible dusts or ignitable fibers/flyings.

Informational Note No. 1: For the requirements for electrical and electronic equipment and wiring for all voltages in Class I, Division 1 or Division 2; Class II, Division 1 or Division 2; Class III, Division 1 or Division 2; Zone 0; Zone 1; or Zone 2 hazardous (classified) locations where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, or combustible dusts or ignitable fibers/flyings, refer to Articles 500 through 505.

Informational Note No. 2: Zone 20, Zone 21, and Zone 22 area classifications are based on the modified IEC area classification system as defined in ANSI/ISA 60079-10-2 (12.10.05)-2013, *Explosive Atmospheres — Part 10-2: Classification of Areas — Combustible Dust Atmospheres*.

Informational Note No. 3: The unique hazards associated with explosives, pyrotechnics, and blasting agents are not addressed in this article.

Informational Note No. 4: NFPA 499-2017, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, provides additional information for classification of hazardous (classified) locations using Zone methodology.

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506.3 Other Articles.

All other applicable rules contained in this Code shall apply to electrical equipment and wiring installed in hazardous (classified) locations.

Exception: As modified by Article 504 and this article:

506.4 Documentation.

Areas designated as hazardous (classified) locations shall be properly documented. This documentation shall be available to those authorized to design, install, inspect, maintain, or operate electrical equipment.

Informational Note No. 1: For additional information concerning the installation of equipment utilizing optical emissions technology (such as laser equipment) that could potentially become an ignition source in hazardous (classified) locations, see ANSI/UL 60079-28-2017, *Explosive Atmospheres — Part 28: Protection of equipment and transmission systems using optical radiation*.

Informational Note No. 2: For information on electrical resistance trace heating for hazardous (classified) locations, see ANSI/UL 60079-30-1-2017, *Standard for Explosive Atmospheres — Part 30-1: Electrical Resistance Trace Heating — General and Testing Requirements*, and ANSI/IEEE 60079-30-2-2015, *Explosive Atmospheres — Part 30-2: Electrical resistance trace heating — Application guide for design, installation and maintenance*.

Informational Note No. 3: For information on electric skin effect trace heating for hazardous (classified) locations, see IEEE 844.1-2017/CSA C22.2 No. 293.1-17, *IEEE/CSA Standard for Skin Effect Trace Heating of Pipelines, Vessels, Equipment, and Structures — General, Testing, Marking, and Documentation Requirements*, and IEEE 844.2-2017/CSA C293.2-17, *IEEE/CSA Standard for Skin Effect Trace Heating of Pipelines, Vessels, Equipment, and Structures — Application Guide for Design, Installation, Testing, Commissioning, and Maintenance*.

506.5 Classification of Locations.

(A) Classifications of Locations. Locations shall be classified on the basis of the properties of the combustible dust or ignitable fibers/flyings that may be present, and the likelihood that a combustible 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 of the scope of this article.

(B) Zone 20, Zone 21, and Zone 22 Locations. Zone 20, Zone 21, and Zone 22 locations are those in which combustible dust or ignitable fibers/flyings are or may be present in the air or in layers, in quantities sufficient to produce explosive or ignitable mixtures. Zone 20, Zone 21, and Zone 22 locations shall include those specified in 506.5(B)(1), (B)(2), and (B)(3).

Informational Note: Through the exercise of ingenuity in the layout of electrical installations for hazardous (classified) locations, it is frequently possible to locate much of the equipment in a reduced level of classification and, thus, to reduce the amount of special equipment required.

(1) Zone 20. A Zone 20 location is a location in which any of the following occur:

- (1) Ignitable concentrations of combustible dust or ignitable fibers/flyings are present continuously.
- (2) Ignitable concentrations of combustible dust or ignitable fibers/flyings are present for long periods of time.

Informational Note No. 1: As a guide to classification of Zone 20 locations, refer to ANSI/ISA 60079-10-2 (12.10.05)-2013, *Explosive Atmospheres — Part 10-2: Classification of areas — Combustible dust atmospheres*.

Informational Note No. 2: Zone 20 classification includes locations inside dust containment systems; hoppers, silos, etc., cyclones and filters, dust transport systems, except some parts of belt and chain conveyors, etc.; blenders, mills, dryers, bagging equipment, etc.

(3) Group IIIC combustible dusts are present in quantities sufficient to be hazardous continuously or for long periods of time.

(2) Zone 21. A Zone 21 location is a location where one of the following apply:

- (1) Ignitable concentrations of combustible dust or ignitable fibers/flyings are likely to exist occasionally under normal operating conditions; or
- (2) Ignitable concentrations of combustible dust or ignitable fibers/flyings may exist frequently because of repair or maintenance operations or because of leakage; or
- (3) Equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of combustible dust or ignitable fibers/flyings and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or
- (4) The location is adjacent to a Zone 20 location from which ignitable concentrations of dust or ignitable fibers/flyings could be communicated.

Exception: When communication from an adjacent Zone 20 location is minimized by adequate positive pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

(5) Group IIIC combustible dusts are present in quantities sufficient to be hazardous occasionally; under normal or abnormal operating conditions; or frequently because of repair or maintenance operations or because of leakage.

Informational Note No. 1: As a guide to classification of Zone 21 locations, refer to ANSI/ISA 60079-10-2 (12.10.05)-2013, *Explosive Atmospheres — Part 10-2: Classification of areas — Combustible dust atmospheres*.

Informational Note No. 2: This classification usually includes locations outside dust containment and in the immediate vicinity of access doors subject to frequent removal or opening for operation purposes when internal combustible mixtures are present; locations outside dust containment in the proximity of filling and emptying points, feed belts, sampling points, truck dump stations, belt dump over points, etc., where no measures are employed to prevent the formation of combustible mixtures; locations outside dust containment where dust accumulates and where due to process operations the dust layer is likely to be disturbed and form combustible mixtures; locations inside dust containment where explosive dust clouds are likely to occur (but neither continuously, nor for long periods, nor frequently) as, for example, silos (if filled and/or emptied only occasionally) and the dirty side of filters if large self-cleaning intervals are occurring.

(3) Zone 22. A Zone 22 location is a location where one of the following apply:

- (1) Ignitable concentrations of combustible dust or ignitable fibers/flyings are not likely to occur in normal operation and, if they do occur, will only persist for a short period; or
- (2) Combustible dust or fibers/flyings are handled, processed, or used but in which the dust or fibers/flyings are normally confined within closed containers of closed systems from which they can escape only as a result of the abnormal operation of the equipment with which the dust or fibers/flyings are handled, processed, or used; or

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- (3) The location is adjacent to a Zone 21 location, from which ignitable concentrations of dust or fibers/flyings could be communicated.

Exception No. 1: When communication from an adjacent Zone 21 location is minimized by adequate positive pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Exception No. 2: For Group IIIC combustible dusts, there are only Zone 20 or 21 locations.

Informational Note No. 1: As a guide to classification of Zone 22 locations, refer to ANSI/ISA 60079-10-2 (12.10.05)-2013, *Explosive Atmospheres — Part 10-2: Classification of areas — Combustible dust atmospheres*.

Informational Note No. 2: Zone 22 locations usually include outlets from bag filter vents, because in the event of a malfunction there can be emission of combustible mixtures; locations near equipment that has to be opened at infrequent intervals or equipment that from experience can easily form leaks where, due to pressure above atmospheric, dust will blow out; pneumatic equipment, flexible connections that can become damaged, etc.; storage locations for bags containing dusty product, since failure of bags can occur during handling, causing dust leakage; and locations where controllable dust layers are formed that are likely to be raised into explosive dust-air mixtures. Only if the layer is removed by cleaning before hazardous dust-air mixtures can be formed is the area designated unclassified.

Informational Note No. 3: Locations that normally are classified as Zone 21 can fall into Zone 22 when measures are employed to prevent the formation of explosive dust-air mixtures. Such measures include exhaust ventilation. The measures should be used in the vicinity of (bag) filling and emptying points, feed belts, sampling points, truck dump stations, belt dump over points, etc.

506.6 Material Groups.

For the purposes of testing, approval, and area classification, various air mixtures (not oxygen enriched) shall be grouped as required in 506.6(A), (B), and (C).

(A) Group IIIC. Combustible metal dust. Group IIIC shall be considered to be equivalent to Class II, Group E.

(B) Group IIIB. Combustible dust other than combustible metal dust. Group IIIB shall be considered to be equivalent to Class II, Groups F and G.

(C) Group IIIA. Solid particles, including fibers, greater than 500 µm in nominal size, which could be suspended in air and could settle out of the atmosphere under their own weight. Group IIIA shall be considered to be equivalent to Class III.

Informational Note: Examples of flyings include rayon, cotton (including cotton linters and cotton waste), sisal, jute, hemp, cocoa fiber, oakum, and baled waste kapok.

506.7 Special Precaution.

Article 506 requires equipment construction and installation that ensures safe performance under conditions of proper use and maintenance.

Informational Note: It is important that inspection authorities and users exercise more than ordinary care with regard to the installation and maintenance of electrical equipment in hazardous (classified) locations.

(A) Implementation of Zone Classification System. Classification of areas, engineering and design, selection of equipment and wiring methods, installation, and inspection shall be performed by qualified persons.

(B) Dual Classification. In instances of areas within the same facility classified separately, Zone 22 locations shall be permitted to abut, but not overlap, Class II or Class III, Division 2 locations. Zone 20 or Zone 21 locations shall not abut Class II or Class III, Division 1 or Division 2 locations.

(C) Reclassification Permitted. A Class II or Class III, Division 1 or Division 2 location shall be permitted to be reclassified as a Zone 20, Zone 21, or Zone 22 location, provided that all of the space that is classified because of a single combustible dust or ignitable fiber/flying source is reclassified under the requirements of this article.

(D) Simultaneous Presence of Flammable Gases and Combustible Dusts or Fibers/Flyings. Where flammable gases, combustible dusts, or fibers/flyings are or may be present at the same time, the simultaneous presence shall be considered during the selection and installation of the electrical equipment and the wiring methods, including the determination of the safe operating temperature of the electrical equipment.

506.8 Protection Techniques.

Acceptable protection techniques for electrical and electronic equipment in hazardous (classified) locations shall be as described in 506.8(A) through (N).

Informational Note: See Table 506.9(C)(2)(3) for descriptions of subdivisions of protection techniques.

(A) Dust Ignitionproof. This protection technique shall be permitted for equipment in Zone 20, Zone 21, and Zone 22 locations for which it is identified.

(B) Pressurized. This protection technique shall be permitted for equipment in Zone 21 and Zone 22 locations for which it is identified.

(C) Intrinsic Safety. This protection technique shall be permitted for equipment in Zone 20, Zone 21, and Zone 22 locations for which it is identified.

(D) Dusttight. This protection technique shall be permitted for equipment in Zone 22 locations for which it is identified.

(E) Protection by Encapsulation “m”. This protection technique shall be permitted for equipment in Zone 20, Zone 21, and Zone 22 locations for which it is identified.

(F) Nonincendive Equipment. This protection technique shall be permitted for equipment in Zone 22 locations for which it is identified.

(G) Protection by Enclosure “t”. This protection technique shall be permitted for equipment in Zone 20, Zone 21, and Zone 22 locations for which it is identified.

(H) Protection by Pressurized Enclosure “p”. This protection technique shall be permitted for equipment in Zone 21 and Zone 22 locations for which it is identified.

(I) Protection by Intrinsic Safety “i”. This protection technique shall be permitted for equipment in Zone 20, Zone 21, and Zone 22 locations for which it is listed.

(J) Protection by Electrical Resistance Trace Heating “60079-30-1”. This protection technique shall be permitted for electrical resistance trace heating equipment in Zone 21 or Zone 22 for which it is listed.

(K) Inherently Safe Optical Radiation “op is”. This protection technique shall be permitted for equipment in Zone 20, 21, or 22 locations for which the equipment is identified.

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(L) Protected Optical Radiation “op pr”. This protection technique shall be permitted for equipment in Zone 21 or 22 locations for which the equipment is identified.

(M) Optical System with Interlock “op sh”. This protection technique shall be permitted for equipment in Zone 20, 21, or 22 locations for which the equipment is identified.

(N) Protection by Skin Effect Trace Heating “IEEE 844.1”. This protection technique shall be permitted for skin effect trace heating equipment in Zone 21 or Zone 22 for which it is listed.

506.9 Equipment Requirements.

(A) Suitability. Suitability of identified equipment shall be determined by one of the following:

- (1) Equipment listing or labeling
- (2) Evidence of equipment evaluation from a qualified testing laboratory or inspection agency concerned with product evaluation
- (3) Evidence acceptable to the authority having jurisdiction such as a manufacturer's self-evaluation or an owner's engineering judgment

Informational Note: Additional documentation for equipment may include certificates demonstrating compliance with applicable equipment standards, indicating special conditions of use, and other pertinent information.

(B) Listing. Equipment that is listed for Zone 20 shall be permitted in a Zone 21 or Zone 22 location of the same dust or ignitable fiber/flying. Equipment that is listed for Zone 21 may be used in a Zone 22 location of the same dust or ignitable fiber/flying.

(C) Marking.

(1) Division Equipment. Equipment identified for Class II, Division 1 or Class II, Division 2 shall, in addition to being marked in accordance with 500.8(C), be permitted to be marked with all of the following:

- (1) Zone 20, 21, or 22 (as applicable)
- (2) Material group in accordance with 506.6
- (3) Maximum surface temperature in accordance with 506.9(D), marked as a temperature value in degrees C, preceded by “T” and followed by the symbol “°C”

(2) Zone Equipment. Equipment meeting one or more of the protection techniques described in 506.8 shall be marked with the following in the order shown:

- (1) Zone in accordance with Table 506.9(C)(2)(3)
- (2) Symbol “AEx”
- (3) Protection technique(s) in accordance with Table 506.9(C)(2)(3)
- (4) Material group in accordance with 506.6
- (5) Maximum surface temperature in accordance with 506.9(D), marked as a temperature value in degrees Celsius, preceded by “T” and followed by the symbol “°C”
- (6) Ambient temperature marking in accordance with 506.9(D)

(7) Equipment protection level (EPL)

Informational Note: EPLs (or equipment protection levels) are designated as G for gas, or D for dust, and are then followed by a letter (a, b, or c) to give the user a better understanding as to whether the equipment provides (a) a “very high,” (b) a “high,” or (c) an “enhanced” level of protection against ignition of an explosive atmosphere. For example, a Zone 21 AEx pb IIIB T165°C Db motor is marked with an EPL of “Db”.

Exception: Associated apparatus NOT suitable for installation in a hazardous (classified) location shall be required to be marked only with 506.9(C)(2)(2) and (3), and where applicable (4), but BOTH the symbol AEx in 506.9(C)(2)(2) and the symbol for the type of protection in 506.9(C)(2)(3) shall be enclosed within the same square brackets; for example, [AEx ia] IIIC.

Table 506.9(C)(2)(3) Equipment Suitability

Type of Protection	Marking	Permitted Location
Associated apparatus for Zone 20	[ia]	Unclassified*
Associated apparatus for Zone 21	[ib]	Unclassified*
Associated apparatus for Zone 22	[ic]	Unclassified*
Associated pressurization equipment	[p]	Unclassified*
Equipment Suitable for Class II, Division 1		
Intrinsic safety	ia; Class II, Division 1 Intrinsic Safety	Zone 20
Protection by enclosure	ta	
Encapsulation	ma	
Optical radiation, inherently safe	op is, with EPL Da#	
Optical radiation, with interlock	op sh, with EPL Da#	
EPL Da, with suitable type of protection†		
Equipment Suitable for Use in Zone 20		
Equipment Suitable for Use in Class II, Division 1		
Intrinsic safety	ib	Zone 21
Protection by enclosure	tb	
Pressurized enclosure	p; px, pxb; py; pyb	
Encapsulation	mb	
Electrical resistance trace heating	60079-30-1, with EPL Db#	
Skin effect trace heating	IEEE 844.1, with EPL Db#	
Optical radiation, inherently safe	op is, with EPL Db#	
Optical radiation, with interlock	op sh, with EPL Db#	
Optical radiation, protected	op pr, with EPL Db#	
EPL Db, with suitable type of protection†		
Equipment Suitable for Use in Zone 21		
Equipment Suitable for Use in Class II, Division 2		
Intrinsic safety	ic	Zone 22
Protection by enclosure	tc	
Pressurized enclosure	pz; pzc	
Encapsulation	mc	
Electrical resistance trace heating	60079-30-1, with EPL Dc#	
Skin effect trace heating	IEEE 844.1, with EPL Dc#	
Optical radiation, inherently safe	op is, with EPL Dc#	
Optical radiation, with interlock	op sh, with EPL Dc#	
Optical radiation, protected	op pr, with EPL Dc#	
EPL Dc, with suitable type of protection†		

#: Equipment marked with these types of protection is available in multiple levels of protection that are not specifically identified within the Ex marking.

*Permitted to be installed in a hazardous (classified) location if suitably protected using another type of protection.

†The EPL takes precedence over the types of protection. For example, “op is Db” is suitable for Zone 21 (not Zone 20). “60079-30-1 Dc” is suitable for Zone 22 (not Zone 21). Selection according to the marked EPL is critical to the safe application of this equipment.

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Informational Note: The “D” suffix on the type of protection designation was employed prior to the introduction of Group IIIA, IIIB, and IIIC, which is now used to distinguish between the type of protection employed for Group II (Gases) or Group III (Dusts).

(D) Temperature Classifications. Equipment shall be marked to show the maximum surface temperature referenced to a 40°C ambient, or at the higher marked ambient temperature if the equipment is rated and marked for an ambient temperature of greater than 40°C. For equipment installed in a Zone 20 or Zone 21 location, the operating temperature shall be based on operation of the equipment when blanketed with the maximum amount of dust (or with dust-simulating fibers/flyings) that can accumulate on the equipment. Electrical equipment designed for use in the ambient temperature range between -20°C and +40°C shall require no additional ambient temperature marking. Electrical equipment that is designed for use in a range of ambient temperatures other than -20°C and +40°C is considered to be special; and the ambient temperature range shall then be marked on the equipment, including either the symbol “Ta” or “Tamb” together with the special range of ambient temperatures.

Informational Note: As an example, such a marking might be “-30°C ≤ Ta ≤ +40°C.”

Exception No. 1: Equipment of the non-heat-producing type, such as conduit fittings, shall not be required to have a marked operating temperature.

Exception No. 2: Equipment identified for Class II, Division 1 or Class II, Division 2 locations as permitted by 506.20(B) and (C) shall be permitted to be marked in accordance with 500.8(C) and Table 500.8(C).

(E) Threading. The supply connection entry thread form shall be NPT or metric. Conduit and fittings shall be made wrenchtight to prevent sparking when the fault current flows through the conduit system and to ensure the integrity of the conduit system. Equipment provided with threaded entries for field wiring connections shall be installed in accordance with 506.9(E)(1) or (E)(2) and with (E)(3).

(1) Equipment Provided with Threaded Entries for NPT-Threaded Conduit or Fittings. For equipment provided with threaded entries for NPT-threaded conduit or fittings, listed conduit fittings or listed cable fittings shall be used. All NPT-threaded conduit and fittings shall be threaded with a National (American) Standard Pipe Taper (NPT) thread.

Informational Note: Thread specifications for NPT threads are located in ASME B1.20.1-2013, *Pipe Threads, General Purpose (Inch)*.

(2) Equipment Provided with Threaded Entries for Metric-Threaded Fittings. For equipment with metric-threaded entries, listed conduit fittings or listed cable fittings shall be used. Such entries shall be identified as being metric, or listed adapters to permit connection to conduit or NPT-threaded fittings shall be provided with the equipment and shall be used for connection to conduit or NPT-threaded fittings. Metric-threaded fittings installed into equipment entries shall be made up with at least five threads fully engaged.

(3) Unused Openings. All unused openings shall be closed with listed metal close-up plugs. The plug engagement shall comply with 506.9(E)(1) or (E)(2).

(F) Optical Fiber Cables. An optical fiber cable, with or without current-carrying conductors (composite optical fiber cable), shall be installed to address the associated fire hazard and sealed to address the associated explosion hazard in accordance with the requirements of 506.15 and 506.16.

(G) Equipment Involving Optical Radiation. For equipment involving sources of optical radiation (such as laser or LED sources) in the wavelength range from 380 nm to 10 μm, the risk of ignition from optical radiation shall be considered for all electrical parts and circuits that may be exposed to the radiation, both inside and outside the optical equipment. This includes optical equipment, which itself is located outside the explosive atmosphere, but its emitted optical radiation enters such atmospheres.

Informational Note: For additional information on types of protection that can be applied to minimize the risk of ignition in explosive atmospheres from optical radiation, see ANSI/UL 60079-28-2017, *Explosive Atmospheres — Part 28: Protection of Equipment and Transmission Systems Using Optical Radiation*.

Exception: All luminaires (fixed, portable, or transportable) and hand lights intended to be supplied by mains (with or without galvanic isolation) or powered by batteries, with any continuous divergent light source, including LEDs, shall be excluded from this requirement.

506.15 Wiring Methods.

Wiring methods shall maintain the integrity of the protection techniques and shall comply with 506.15(A), (B), or (C).

(A) Zone 20. In Zone 20 locations, the following wiring methods shall be permitted:

- (1) Threaded rigid metal conduit (Type RMC) or threaded steel intermediate metal conduit (Type IMC).
- (2) Type MI cable terminated with fittings listed for the location. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings.

Exception No. 1: Type MI cable and fittings listed for Class II, Division 1 locations shall be permitted to be used.

Exception No. 2: Equipment identified as intrinsically safe “ia” shall be permitted to be connected using the wiring methods identified in 504.20.

- (3) In industrial establishments with limited public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Type MC-HL cable listed for use in Zone 20 locations, with a continuous corrugated metallic sheath, an overall jacket of suitable polymeric material, and a separate equipment grounding conductor(s) in accordance with 250.122, and terminated with fittings listed for the application, shall be permitted. Type MC-HL cable shall be installed in accordance with Part II of Article 330.

Exception: Type MC-HL cable and fittings listed for Class II, Division 1 locations shall be permitted to be used.

- (4) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, and where the cable is not subject to physical damage, Type ITC-HL cable listed for use in Zone 1 or Class I, Division 1 locations, with a gas/vaportight continuous corrugated metallic sheath and an overall jacket of suitable polymeric material, and terminated with fittings listed for the application. Type ITC-HL cable shall be installed in accordance with 727.4.

- (5) Fittings and boxes shall be identified for use in Zone 20 locations.

Exception: Boxes and fittings listed for Class II, Division 1 locations shall be permitted to be used.

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- (6) Where necessary to employ flexible connections, liquidtight flexible metal conduit (Type LFMC) with listed fittings, liquidtight flexible nonmetallic conduit (Type LFNC) with listed fittings, or flexible cord listed for extra-hard usage and provided with listed fittings shall be used. Where flexible cords are used, they shall also comply with 506.17 and shall be terminated with a listed cord connector that maintains the type of protection of the terminal compartment. Where flexible connections are subject to oil or other corrosive conditions, the insulation of the conductors shall be of a type listed for the condition or shall be protected by means of a suitable sheath.

Exception No. 1: Liquidtight flexible conduit (Type LFMC or LFNC), flexible conduit fittings, and cord fittings listed for Class II, Division 1 locations shall be permitted.

Exception No. 2: For elevator use, an identified elevator cable of Type EO, ETP, or ETT, shown under the "use" column in Table 400.4 for "hazardous (classified) locations," and terminated with listed connectors that maintain the type of protection of the terminal compartment shall be permitted.

Informational Note No. 1: See 506.25 for grounding requirements where flexible conduit is used.

Informational Note No. 2: For further information on construction, testing, and marking of cables, cable fittings, and cord connectors, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

- (7) Optical fiber cable Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC shall be permitted to be installed in raceways in accordance with 506.15(A). Optical fiber cables shall be sealed in accordance with 506.16.

▲ (B) Zone 21. In Zone 21 locations, the following wiring methods shall be permitted:

- (1) All wiring methods permitted in 506.15(A)
- (2) Fittings and boxes that are dusttight, provided with threaded bosses for connection to conduit, in which taps, joints, or terminal connections are not made, and are not used in locations where metal dust is present, may be used.

Informational Note: For further information on construction, testing, and marking of cables, cable fittings, and cord connectors, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

Exception: Equipment identified as intrinsically safe "ib" shall be permitted to be connected using the wiring methods identified in 504.20.

▲ (C) Zone 22. In Zone 22 locations, the following wiring methods shall be permitted:

- (1) All wiring methods permitted in 506.15(B).
- (2) Rigid metal conduit (Type RMC) or intermediate metal conduit (Type IMC) with listed threaded or threadless fittings.
- (3) Electrical metallic tubing (Type EMT) or dusttight wireways.
- (4) Type MC or MI cable with listed termination fittings.
- (5) Type PLTC or PLTC-ER cable in accordance with Part II or III of Article 725, including installation in cable tray systems. The cable shall be terminated with listed fittings. Type PLTC-ER cable shall include an equipment grounding conductor in addition to a drain wire that might be present.

- (6) Type ITC or ITC-ER cable as permitted in 727.4 and terminated with listed fittings. Type ITC-ER cable shall include an equipment grounding conductor in addition to a drain wire.

- (7) Type MV, TC, or TC-ER cable, including installation in cable tray systems. Type TC-ER cable shall include an equipment grounding conductor in addition to a drain wire that might be present. The cable shall be terminated with listed fittings.

- (8) Intrinsic safety type of protection "ic" shall be permitted using any of the wiring methods permitted for unclassified locations. Intrinsic safety type of protection "ic" systems shall be installed in accordance with the control drawing(s). Simple apparatus, not shown on the control drawing, shall be permitted in a circuit of intrinsic safety type of protection "ic", provided that the simple apparatus does not interconnect the intrinsic safety type of protection "ic" circuit to any other circuit. Separation of circuits of intrinsic safety type of protection "ic" shall be in accordance with one of the following:

- (a) Be in separate cables
- (b) Be in multiconductor cables where the conductors of each circuit are within a grounded metal shield
- (c) Be in multiconductor cables where the conductors have insulation with a minimum thickness of 0.25 mm (0.01 in.)

Informational Note: The term **simple apparatus** is defined in Part III of Article 100.

- (9) Boxes and fittings shall be dusttight.

- (10) Optical fiber cable Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC shall be permitted to be installed in cable trays or any raceway in accordance with 506.15(C). Optical fiber cables shall be sealed in accordance with 506.16.

- (11) Cablebus.

506.16 Sealing.

Where necessary to protect the ingress of combustible dust or ignitable fibers/flyings, or to maintain the type of protection, seals shall be provided. The seal shall be identified as capable of preventing the ingress of combustible dust or ignitable fibers/flyings and maintaining the type of protection but need not be explosionproof or flameproof.

506.17 Flexible Cords.

Flexible cords used in Zone 20, Zone 21, and Zone 22 locations shall comply with all of the following:

- (1) Be of a type listed for extra-hard usage
- (2) Contain, in addition to the conductors of the circuit, an equipment grounding conductor complying with 400.23
- (3) Be connected to terminals or to supply conductors in an approved manner
- (4) Be supported by clamps or by other suitable means in such a manner to minimize tension on the terminal connections
- (5) Be terminated with a listed cord connector that maintains the protection technique of the terminal compartment

Informational Note: For further information on construction, testing, and marking of cables, cable fittings, and cord connectors, see ANSI/UL 2225-2013, *Cables and Cable-Fittings for Use in Hazardous (Classified) Locations*.

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506.20 Equipment Installation.

(A) Zone 20. In Zone 20 locations, only equipment listed and marked as suitable for the location shall be permitted.

Exception: Equipment listed for use in Class II, Division 1 locations with a suitable temperature class shall be permitted.

(B) Zone 21. In Zone 21 locations, only equipment listed and marked as suitable for the location shall be permitted.

Exception No. 1: Apparatus listed for use in Class II, Division 1 locations with a suitable temperature class shall be permitted.

Exception No. 2: Pressurized equipment identified for Class II, Division 1 shall be permitted.

(C) Zone 22. In Zone 22 locations, only equipment listed and marked as suitable for the location shall be permitted.

Exception No. 1: Apparatus listed for use in Class II, Division 1 or Class II, Division 2 locations with a suitable temperature class shall be permitted.

Exception No. 2: Pressurized equipment identified for Class II, Division 1 or Division 2 shall be permitted.

(D) Material Group. Equipment marked Group IIIC shall be permitted for applications requiring IIIA or IIIB equipment. Similarly, equipment marked Group IIIB shall be permitted for applications requiring IIIA equipment.

(E) Manufacturer's Instructions. Electrical equipment installed in hazardous (classified) locations shall be installed in accordance with the instructions (if any) provided by the manufacturer.

(F) Temperature. The temperature marking specified in 506.9(C)(2) (5) shall comply with (F)(1) or (F)(2):

- (1) For combustible dusts, less than the lower of either the layer or cloud ignition temperature of the specific combustible dust. For organic dusts that may dehydrate or carbonize, the temperature marking shall not exceed the lower of either the ignition temperature or 165°C (329°F).
- (2) For ignitable fibers/flyings, less than 165°C (329°F) for equipment that is not subject to overloading, or 120°C (248°F) for equipment (such as motors or power transformers) that may be overloaded.

Informational Note: See NFPA 499-2017, Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas, for minimum ignition temperatures of specific dusts.

506.25 Grounding and Bonding.

Regardless of the voltage of the electrical system, grounding and bonding shall comply with Article 250 and the requirements in 506.25(A) and (B).

(A) Bonding. The locknut-bushing and double-locknut types of contacts shall not be depended on for bonding purposes, but bonding jumpers with proper fittings or other approved means of bonding shall be used. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, and so forth, between Zone 20, Zone 21, and Zone 22 locations and the point of grounding for service equipment or point of grounding of a separately derived system.

Exception: The specific bonding means shall be required only to the nearest point where the grounded circuit conductor and the grounding electrode conductor are connected together on the line side of the building or structure disconnecting means as specified in 250.32(B) if the branch side overcurrent protection is located on the load side of the disconnecting means.

Article 510 Hazardous (Classified) Locations - Specific

Article 511 Commercial Garages, Repair and Storage

(B) Types of Equipment Grounding Conductors. Liquidtight flexible metal conduit shall include an equipment bonding jumper of the wire type in compliance with 250.102.

Exception: In Zone 22 locations, the bonding jumper shall be permitted to be deleted where all of the following conditions are met:

- (1) Listed liquidtight flexible metal conduit 1.8 m (6 ft) or less in length, with fittings listed for grounding, is used.
- (2) Overcurrent protection in the circuit is limited to 10 amperes or less.
- (3) The load is not a power utilization load.

Article 510

510.1 Scope.

Articles 511 through 517 cover occupancies or parts of occupancies that are or may be hazardous because of atmospheric concentrations of flammable liquids, gases, or vapors, or because of deposits or accumulations of materials that may be readily ignitable.

510.2 General.

The general rules of this Code and the provisions of Articles 500 through 504 shall apply to electrical wiring and equipment in occupancies within the scope of Articles 511 through 517, except as such rules are modified in Articles 511 through 517. Where unusual conditions exist in a specific occupancy, the authority having jurisdiction shall judge with respect to the application of specific rules.

Article 511

511.1 Scope.

These occupancies shall include locations used for service and repair operations in connection with self-propelled vehicles (including, but not limited to, passenger automobiles, buses, trucks, and tractors) in which volatile flammable liquids or flammable gases are used for fuel or power.

Informational Note: Text that is followed by a reference in brackets has been extracted from NFPA 30A-2018, Code for Motor Fuel Dispensing Facilities and Repair Garages. Only editorial changes were made to the extracted text to make it consistent with this Code.

511.3 Area Classification, General.

Where Class I liquids or gaseous fuels are stored, handled, or transferred, electrical wiring and electrical utilization equipment shall be designed in accordance with the requirements for Class I, Division 1 or 2 hazardous (classified) locations as classified in accordance with 500.5 and 500.6, and this article. A Class I location shall not extend beyond an unpierced wall, roof, or other solid partition that has no openings. [30A:8.3.1, 8.3.3]

Where the term "Class I" is used with respect to Zone classifications within this article of the Code, it shall apply to Zone 0, Zone 1, and Zone 2 designations.

Informational Note: The term "Class I" was originally included as a prefix to Zone 0, Zone 1, and Zone 2 locations and references as an identifier for flammable gases, vapors, or liquids to differentiate from Class II and Class III locations. Zone 0, Zone 1, and Zone 2 only apply to flammable gases, vapors, or liquids so the "Class I" prefix is redundant and has been deleted, except for text that is extracted from other documents or to remain consistent throughout this article.

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(A) Parking Garages. Parking garages used for parking or storage shall be permitted to be unclassified.

Informational Note: For further information, see NFPA 88A-2019, *Standard for Parking Structures*, and NFPA 30A-2018, *Code for Motor Fuel Dispensing Facilities and Repair Garages*.

(B) Repair Garages, With Dispensing. Major and minor repair garages that dispense motor fuels into the fuel tanks of vehicles, including flammable liquids having a flash point below 38°C (100°F) such as gasoline, or gaseous fuels such as natural gas, hydrogen, or LPG, shall have the dispensing functions and components classified in accordance with Table 514.3(B)(1) in addition to any classification required by this section. Where Class I liquids, other than fuels, are dispensed, the area within 900 mm (3 ft) of any fill or dispensing point, extending in all directions, shall be a Class I, Division 2 location.

(C) Repair Garages, Major and Minor. Where vehicles using Class I liquids or heavier-than-air gaseous fuels (such as LPG) are repaired, hazardous area classification guidance is found in Table 511.3(C).

Informational Note: For additional information, see NFPA 30A-2018, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, Table 8.3.2.

Table 511.3(C) Extent of Classified Locations for Major and Minor Repair Garages with Heavier-Than-Air Fuel

Location	Class I		Extent of Classified Location
	Division (Group D)	Zone (Group IIA)	
Repair garage, major (where Class I liquids or gaseous fuels are transferred or dispensed*)	1	1	Entire space within any pit, belowgrade work area, or subfloor work area that is not ventilated
	2	2	Entire space within any pit, belowgrade work area, or subfloor work area that is provided with ventilation of at least 0.3 m ³ /min/m ² (1 ft ³ /min/ft ²) of floor area, with suction taken from a point within 300 mm (12 in.) of floor level
	2	2	Up to 450 mm (18 in.) above floor level of the room, except as noted below, for entire floor area
	Unclassified	Unclassified	Up to 450 mm (18 in.) above floor level of the room where room is provided with ventilation of at least 0.3 m ³ /min/m ² (1 ft ³ /min/ft ²) of floor area, with suction taken from a point within 300 mm (12 in.) of floor level
	2	2	Within 0.9 m (3 ft) of any fill or dispensing point, extending in all directions
Specific areas adjacent to classified locations	Unclassified	Unclassified	Areas adjacent to classified locations where flammable vapors are not likely to be released, such as stock rooms, switchboard rooms, and other similar locations, where mechanically ventilated at a rate of four or more air changes per hour or designed with positive air pressure or where effectively cut off by walls or partitions
Repair garage, minor (where Class I liquids or gaseous fuels are not transferred or dispensed*)	2	2	Entire space within any pit, belowgrade work area, or subfloor work area that is not ventilated
	2	2	Up to 450 mm (18 in.) above floor level, extending 0.9 m (3 ft) horizontally in all directions from opening to any pit, belowgrade work area, or subfloor work area that is not ventilated
	Unclassified	Unclassified	Entire space within any pit, belowgrade work area, or subfloor work area that is provided with ventilation of at least 0.3 m ³ /min/m ² (1 ft ³ /min/ft ²) of floor area, with suction taken from a point within 300 mm (12 in.) of floor level
Specific areas adjacent to classified locations	Unclassified	Unclassified	Areas adjacent to classified locations where flammable vapors are not likely to be released, such as stock rooms, switchboard rooms, and other similar locations, where mechanically ventilated at a rate of four or more air changes per hour or designed with positive air pressure, or where effectively cut off by walls or partitions

* Includes draining of Class I liquids from vehicles.

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(D) Repair Garages, Major. Where vehicles using lighter-than-air gaseous fuels (such as hydrogen and natural gas) are repaired or stored, hazardous area classification guidance is found in Table 511.3(D).

Informational Note: For additional information see NFPA 30A-2018, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, Table 8.3.2.

(E) Modifications to Classification.

(1) Specific Areas Adjacent to Classified Locations. Areas adjacent to classified locations in which flammable vapors are not likely to be released, such as stock rooms, switchboard rooms, and other similar locations, shall be unclassified where mechanically ventilated at a rate of four or more air changes per hour, or designed with positive air pressure, or where effectively cut off by walls or partitions.

(2) Alcohol-Based Windshield Washer Fluid. The area used for storage, handling, or dispensing into motor vehicles of alcohol-based windshield washer fluid in repair garages shall be unclassified unless otherwise classified by a provision of 511.3. [30A: 8.3.1, Exception]

511.4 Wiring and Equipment in Class I Locations.

(A) Wiring Located in Class I Locations. Within Class I locations as classified in 511.3, wiring shall conform to applicable provisions of Article 501.

(B) Equipment Located in Class I Locations. Within Class I locations as defined in 511.3, equipment shall conform to applicable provisions of Article 501.

(1) Fuel-Dispensing Units. Where fuel-dispensing units (other than liquid petroleum gas, which is prohibited) are located within buildings, the requirements of Article 514 shall govern.

Where mechanical ventilation is provided in the dispensing area, the control shall be interlocked so that the dispenser cannot operate without ventilation, as prescribed in 500.5(B)(2).

(2) Portable Lighting Equipment. Portable lighting equipment shall be equipped with handle, lampholder, hook, and substantial guard attached to the lampholder or handle. All exterior surfaces that might come in contact with battery terminals, wiring terminals, or other objects shall be of nonconducting material or shall be effectively protected with insulation. Lampholders shall be of an unswitched type and shall not provide means for plug-in of attachment plugs. The outer shell shall be of molded composition or other suitable material. Unless the lamp and its cord are supported or arranged in such a manner that they cannot be used in the locations classified in 511.3, they shall be of a type identified for Class I, Division 1 locations.

511.7 Wiring and Equipment Installed Above Class I Locations.

(A) Wiring in Spaces Above Class I Locations.

(1) Fixed Wiring Above Class I Locations. All fixed wiring above Class I locations shall be in metal raceways, rigid nonmetallic conduit, electrical nonmetallic tubing, flexible metal conduit, liquidtight flexible metal conduit, or liquidtight flexible nonmetallic conduit, or shall be Type MC, AC, MI, manufactured wiring systems, or PLTC cable in accordance with Article 725, or Type TC cable or Type ITC cable in accordance with Article 727. Cellular metal floor raceways or cellular concrete floor raceways shall be permitted to be used only for supplying ceiling outlets or extensions to the area below the floor, but such raceways shall have no connections leading into or through any Class I location above the floor.

(2) Pendant. For pendants, flexible cord suitable for the type of service and listed for hard usage shall be used.

(B) Electrical Equipment Installed Above Class I Locations.

(1) Fixed Electrical Equipment. Electrical equipment in a fixed position shall be located above the level of any defined Class I location or shall be identified for the location.

(a) *Arcing Equipment.* Equipment that is less than 3.7 m (12 ft) above the floor level and that may produce arcs, sparks, or particles of hot metal, such as cutouts, switches, charging panels, generators, motors, or other equipment (excluding receptacles, lamps, and lampholders) having make-and-break or sliding contacts, shall be of the totally enclosed type or constructed so as to prevent the escape of sparks or hot metal particles.

Table 511.3(D) Extent of Classified Locations for Major Repair Garages with Lighter-than-Air Fuel

Location	Class I		Extent of Classified Location
	Division ²	Zone ³	
Repair garage, major (where lighter-than-air gaseous fueled ¹ vehicles are repaired or stored)	2	2	Within 450 mm (18 in.) of ceiling, except as noted below
	Unclassified	Unclassified	Within 450 mm (18 in.) of ceiling where ventilation of at least 0.3 m ³ /min/m ² (1 ft ³ /min/ft ²) of floor area, with suction taken from a point within 450 mm (18 in.) of the highest point in the ceiling
Specific areas adjacent to classified locations	Unclassified	Unclassified	Areas adjacent to classified locations where flammable vapors are not likely to be released, such as stock rooms, switchboard rooms, and other similar locations, where mechanically ventilated at a rate of four or more air changes per hour or designed with positive air pressure, or where effectively cut off by walls or partitions

¹Includes fuels such as hydrogen and natural gas, but not LPG.

²For hydrogen (lighter than air) Group B, or natural gas Group D.

³For hydrogen (lighter than air) Group IIC or IIB+H2, or natural gas Group IIA

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(b) *Fixed Lighting.* Lamps and lampholders for fixed lighting that is located over lanes through which vehicles are commonly driven or that may otherwise be exposed to physical damage shall be located not less than 3.7 m (12 ft) above floor level, unless of the totally enclosed type or constructed so as to prevent escape of sparks or hot metal particles.

511.8 Underground Wiring Below Class I Locations.

Underground wiring shall be installed in threaded rigid metal conduit or intermediate metal conduit.

Exception: Type PVC conduit, Type RTRC conduit, and Type HDPE conduit shall be permitted where buried under not less than 600 mm (2 ft) of cover. Where Type PVC conduit, Type RTRC conduit, or Type HDPE conduit is used, threaded rigid metal conduit or threaded steel intermediate metal conduit shall be used for the last 600 mm (2 ft) of the underground run to emergence or to the point of connection to the aboveground raceway, and an equipment grounding conductor shall be included to provide electrical continuity of the raceway system and for grounding of non-current-carrying metal parts.

511.9 Sealing.

Seals complying with the requirements of 501.15 and 501.15(B)(2) shall be provided and shall apply to horizontal as well as vertical boundaries of the defined Class I locations.

511.10 Special Equipment.

(A) Battery Charging Equipment. Battery chargers and their control equipment, and batteries being charged, shall not be located within locations classified in 511.3.

(B) Electric Vehicle Charging Equipment.

(1) General. All electrical equipment and wiring shall be installed in accordance with Article 625, except as noted in 511.10(B)(2) and (B)(3). Flexible cords shall be of a type identified for extra-hard usage.

(2) Connector Location. No connector shall be located within a Class I location as defined in 511.3.

(3) Plug Connections to Vehicles. Where the cord is suspended from overhead, it shall be arranged so that the lowest point of sag is at least 150 mm (6 in.) above the floor. Where an automatic arrangement is provided to pull both cord and plug beyond the range of physical damage, no additional connector shall be required in the cable or at the outlet.

511.12 Ground-Fault Circuit-Interrupter Protection for Personnel.

Ground-fault circuit-interrupter protection for personnel shall be provided as required in 210.8(B).

511.16 Grounding and Bonding Requirements.

(A) General Grounding Requirements. All metal raceways, the metal armor or metallic sheath on cables, and all non-current-carrying metal parts of fixed or portable electrical equipment, regardless of voltage, shall be grounded.

(B) Supplying Circuits with Grounded and Grounding Conductors in Class I Locations. Grounding in Class I locations shall comply with 501.30.

(1) Circuits Supplying Portable Equipment or Pendants.

Where a circuit supplies portables or pendants and includes a grounded conductor as provided in Article 200, receptacles, attachment plugs, connectors, and similar devices shall be of the grounding type, and the grounded conductor of the flexible cord shall be connected to the screw shell of any lampholder or to the grounded terminal of any utilization equipment supplied.

(2) Approved Means. Approved means shall be provided for maintaining continuity of the equipment grounding conductor between the fixed wiring system and the non-current-carrying metal portions of pendant luminaires, portable luminaires, and portable utilization equipment.



Champ® FMVA
LED floodlight



Vaporguard
LED luminaire



707 marine
brass luminaire

CHAMP and VAPORGARD Series enclosed and gasketed luminaires are suitable for use in areas where moisture, dirt, vibration, or rough usage are encountered.



SLB service entrance elbow



F service entrance head

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Recommended installation for commercial garages



Pauluhn™ Commander series linear fluorescent luminaire

Form 7 conduit bodies



FSC cast device boxes



FSC two-gang tandem



FSC



EYS Seal 1/2-6 inches



EYS 1/2-3 inches

Article 513 Aircraft Hangars

513.1 Scope.

This article shall apply to buildings or structures in any part of which aircraft containing Class I (flammable) liquids or Class II (combustible) liquids whose temperatures are above their flash points are housed or stored and in which aircraft might undergo service, repairs, or alterations. It shall not apply to locations used exclusively for aircraft that have never contained fuel or unfueled aircraft.

Informational Note No. 1: For definitions of aircraft hangar and unfueled aircraft, see NFPA 409-2016, *Standard on Aircraft Hangars*.

Informational Note No. 2: For further information on fuel classification see NFPA 30-2018, *Flammable and Combustible Liquids Code*.

• 513.3 Classification of Locations.

Where the term “Class I” is used with respect to Zone classifications within this article of the Code, it shall apply to Zone 0, Zone 1, and Zone 2 designations.

Informational Note: The term “Class I” was originally included as a prefix to Zone 0, Zone 1, and Zone 2 locations and references as an identifier for flammable gases, vapors, or liquids to differentiate from Class II and Class III locations. Zone 0, Zone 1, and Zone 2 only apply to flammable gases, vapors, or liquids so the “Class I” prefix is redundant and has been deleted, except for text that is extracted from other documents or to remain consistent throughout this article.

(A) Below Floor Level. Any pit or depression below the level of the hangar floor shall be classified as a Class I, Division 1 or Zone 1 location that shall extend up to said floor level.

(B) Areas Not Cut Off or Ventilated. The entire area of the hangar, including any adjacent and communicating areas not suitably cut off from the hangar, shall be classified as a Class I, Division 2 or Zone 2 location up to a level 450 mm (18 in.) above the floor.

(C) Vicinity of Aircraft.

(1) Aircraft Maintenance and Storage Hangars. The area within 1.5 m (5 ft) horizontally from aircraft power plants or aircraft fuel tanks shall be classified as a Class I, Division 2 or Zone 2 location that shall extend upward from the floor to a level 1.5 m (5 ft) above the upper surface of wings and of engine enclosures.

(2) Aircraft Painting Hangars. The area within 3 m (10 ft) horizontally from aircraft surfaces from the floor to 3 m (10 ft) above the aircraft shall be classified as Class I, Division 1 or Zone 1. The area horizontally from aircraft surfaces between 3.0 m (10 ft) and 9.0 m (30 ft) from the floor to 9.0 m (30 ft) above the aircraft surface shall be classified as Class I, Division 2 or Zone 2.

Informational Note: See NFPA 33-2015, *Standard for Spray Application Using Flammable or Combustible Materials*, for information on ventilation and grounding for static protection in spray painting areas.

(D) Areas Suitably Cut Off and Ventilated. Adjacent areas in which flammable liquids or vapors are not likely to be released, such as stock rooms, electrical control rooms, and other similar locations, shall be unclassified where mechanically ventilated at a rate of four or more air changes per hour, or designed with positive air pressure, or where effectively cut off from the hangar itself by walls or partitions.

513.4 Wiring and Equipment in Class I Locations.

(A) General. All wiring and equipment that is or may be installed or operated within any of the Class I locations defined in 513.3 shall comply with the applicable provisions of Article 501 or Article 505 for the division or zone in which they are used.

Attachment plugs and receptacles in Class I locations shall be identified for Class I locations or shall be designed such that they cannot be energized while the connections are being made or broken.

(B) Stanchions, Rostrums, and Docks. Electrical wiring, outlets, and equipment (including lamps) on or attached to stanchions, rostrums, or docks that are located or likely to be located in a Class I location, as defined in 513.3(C), shall comply with the applicable provisions of Article 501 or Article 505 for the division or zone in which they are used.

Equipment for Hazardous Locations.



FSQC interlocked
receptacle and switch

513.7 Wiring and Equipment Not Installed in Class I Locations.

(A) Fixed Wiring. All fixed wiring in a hangar but not installed in a Class I location as classified in 513.3 shall be installed in metal raceways or shall be Type MI, TC, or MC cable.

Exception: Wiring in unclassified locations, as described in 513.3(D), shall be permitted to be any suitable type wiring method recognized in Chapter 3.

(B) Pendants. For pendants, flexible cord suitable for the type of service and identified for hard usage or extra-hard usage shall be used. Each such cord shall include a separate equipment grounding conductor.

(C) Arcing Equipment. In locations above those described in 513.3, equipment that is less than 3.0 m (10 ft) above wings and engine enclosures of aircraft and that may produce arcs, sparks, or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, charging panels, generators, motors, or other equipment having make-and-break or sliding contacts, shall be of the totally enclosed type or constructed so as to prevent the escape of sparks or hot metal particles.

Exception: Equipment in areas described in 513.3(D) shall be permitted to be of the general-purpose type.

(D) Lampholders. Lampholders of metal-shell, fiber-lined types shall not be used for fixed incandescent lighting.

Equipment for Nonhazardous Locations.



WSRD interlocked
receptacle

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Article 513

Aircraft Hangars

(E) Stanchions, Rostrums, or Docks. Where stanchions, rostrums, or docks are not located or likely to be located in a Class I location, as defined in 513.3(C), wiring and equipment shall comply with 513.7, except that such wiring and equipment not more than 457 mm (18 in.) above the floor in any position shall comply with 513.4(B). Receptacles and attachment plugs shall be of a locking type that will not readily disconnect.

(F) Mobile Stanchions. Mobile stanchions with electrical equipment complying with 513.7(E) shall carry at least one permanently affixed warning sign with the following words or equivalent:

WARNING
KEEP 5 FT CLEAR OF AIRCRAFT ENGINES
AND FUEL TANK AREAS
or
WARNING
KEEP 1.5 METERS CLEAR OF AIRCRAFT
ENGINES AND FUEL TANK AREAS

513.8 Underground Wiring.

(A) Wiring and Equipment Embedded, Under Slab, or Underground. All wiring installed in or under the hangar floor shall comply with the requirements for Class I, Division 1 locations. Where such wiring is located in vaults, pits, or ducts, adequate drainage shall be provided.

(B) Uninterrupted Raceways, Embedded, Under Slab, or Underground. Uninterrupted raceways that are embedded in a hangar floor or buried beneath the hangar floor shall be considered to be within the Class I location above the floor, regardless of the point at which the raceway descends below or rises above the floor.

513.9 Sealing.

Seals shall be provided in accordance with 501.15 or 505.16, as applicable. Sealing requirements specified shall apply to horizontal as well as to vertical boundaries of the defined Class I locations.

513.10 Special Equipment.

(A) Aircraft Electrical Systems.

(1) De-energizing Aircraft Electrical Systems. Aircraft electrical systems shall be de-energized when the aircraft is stored in a hangar and, whenever possible, while the aircraft is undergoing maintenance.

(2) Aircraft Batteries. Aircraft batteries shall not be charged where installed in an aircraft located inside or partially inside a hangar.

(B) Aircraft Battery Charging and Equipment. Battery chargers and their control equipment shall not be located or operated within any of the Class I locations defined in 513.3 and shall preferably be located in a separate building or in an area such as defined in 513.3(D). Mobile chargers shall carry at least one permanently affixed warning sign with the following words or equivalent:

WARNING
KEEP 5 FT CLEAR OF AIRCRAFT ENGINES
AND FUEL TANK AREAS
or
WARNING
KEEP 1.5 METERS CLEAR OF AIRCRAFT
ENGINES AND FUEL TANK AREAS

Tables, racks, trays, and wiring shall not be located within a Class I location and, in addition, shall comply with Article 480.

(C) External Power Sources for Energizing Aircraft.

(1) Not Less Than 450 mm (18 in.) Above Floor. Aircraft energizers shall be designed and mounted such that all electrical equipment and fixed wiring will be at least 450 mm (18 in.) above floor level and shall not be operated in a Class I location as defined in 513.3(C).

(2) Marking for Mobile Units. Mobile energizers shall carry at least one permanently affixed warning sign with the following words or equivalent:

WARNING
KEEP 5 FT CLEAR OF AIRCRAFT ENGINES
AND FUEL TANK AREAS
or
WARNING
KEEP 1.5 METERS CLEAR OF AIRCRAFT
ENGINES AND FUEL TANK AREAS

(3) Cords. Flexible cords for aircraft energizers and ground support equipment shall be identified for the type of service and extra-hard usage and shall include an equipment grounding conductor.

(D) Mobile Servicing Equipment with Electrical Components.

(1) General. Mobile servicing equipment (such as vacuum cleaners, air compressors, air movers) having electrical wiring and equipment not suitable for Class I, Division 2 or Zone 2 locations shall be so designed and mounted that all such fixed wiring and equipment will be at least 450 mm (18 in.) above the floor. Such mobile equipment shall not be operated within the Class I location defined in 513.3(C) and shall carry at least one permanently affixed warning sign with the following words or equivalent:

WARNING
KEEP 5 FT CLEAR OF AIRCRAFT ENGINES
AND FUEL TANK AREAS
or
WARNING
KEEP 1.5 METERS CLEAR OF AIRCRAFT
ENGINES AND FUEL TANK AREAS

(2) Cords and Connectors. Flexible cords for mobile equipment shall be suitable for the type of service and identified for extra-hard usage and shall include an equipment grounding conductor. Attachment plugs and receptacles shall be identified for the location in which they are installed and shall provide for connection of the equipment grounding conductor.

(3) Restricted Use. Equipment that is not identified as suitable for Class I, Division 2 locations shall not be operated in locations where maintenance operations likely to release flammable liquids or vapors are in progress.

(E) Portable Equipment.

(1) Portable Lighting Equipment. Portable lighting equipment that is used within a hangar shall be identified for the location in which they are used. For portable luminaires, flexible cord suitable for the type of service and identified for extra-hard usage shall be used. Each such cord shall include a separate equipment grounding conductor.

(2) Portable Utilization Equipment. Portable utilization equipment that is or may be used within a hangar shall be of a type suitable for use in Class I, Division 2 or Zone 2 locations. For portable utilization equipment, flexible cord suitable for the type of service and approved for extra-hard usage shall be used. Each such cord shall include a separate equipment grounding conductor.

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Article 513 Aircraft Hangars

513.12 Ground-Fault Circuit-Interrupter Protection for Personnel.

Ground-fault circuit-interrupter protection for personnel shall be provided as required in 210.8(B).

513.16 Grounding and Bonding Requirements.

- ▲ (A) **General Grounding Requirements.** All metal raceways, the metal armor or metallic sheath on cables, and all non-current-carrying metal parts of fixed or portable electrical equipment, regardless of voltage, shall be grounded. Grounding in Class I locations shall comply with 501.30 for Class I, Division 1 and 2 locations and 505.25 for Zone 0, 1, and 2 locations.

(B) Supplying Circuits with Grounded and Equipment Grounding Conductors in Class I Locations.

- ▲ (1) **Circuits Supplying Portable Equipment or Pendants.** Where a circuit supplies portables or pendants and includes a grounded conductor, receptacles, attachment plugs, connectors, and similar devices shall be of the grounding type, and the grounded conductor of the flexible cord shall be connected to the screw shell of any lampholder or to the grounded terminal of any utilization equipment supplied.

(2) **Approved Means.** Approved means shall be provided for maintaining continuity of the equipment grounding conductor between the fixed wiring system and the non-current-carrying metal portions of pendant luminaires, portable luminaires, and portable utilization equipment.

Article 514 Motor Fuel Dispensing Facilities

▲ Article 514

▲ 514.1 Scope.

This article shall apply to motor fuel dispensing facilities, marine/motor fuel dispensing facilities, motor fuel dispensing facilities located inside buildings, and fleet vehicle motor fuel dispensing facilities.

Informational Note No. 1: For further information regarding safeguards for motor fuel dispensing facilities, see NFPA 30A-2018, *Code for Motor Fuel Dispensing Facilities and Repair Garages*.

Informational Note No. 2: Text that is followed by a reference in brackets has been extracted from NFPA 30A-2018, *Code for Motor Fuel Dispensing Facilities and Repair Garages*. Only editorial changes were made to the extracted text to make it consistent with this Code.

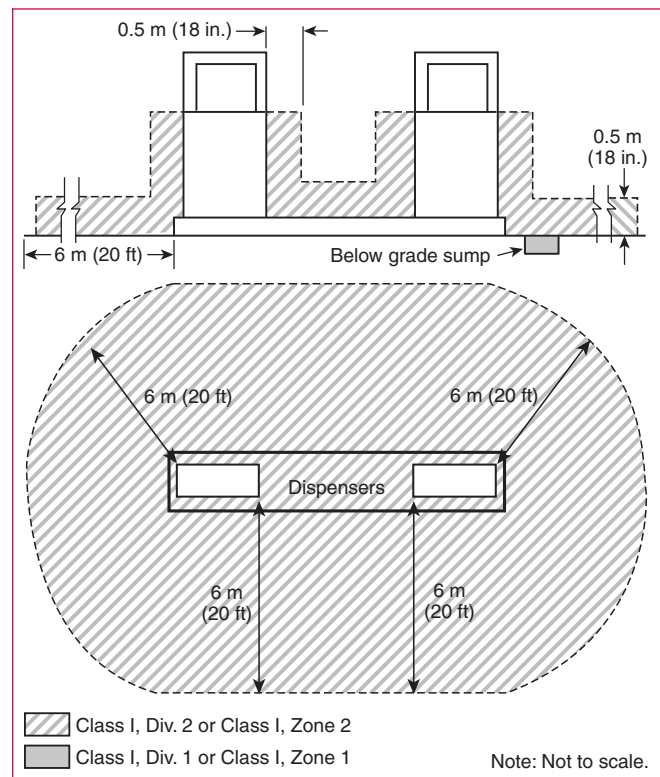
● 514.3 Classification of Locations.

Where the term “Class I” is used with respect to Zone classifications within this article of the Code, it shall apply to Zone 0, Zone 1, and Zone 2 designations.

Informational Note: The term “Class I” was originally included as a prefix to Zone 0, Zone 1, and Zone 2 locations and references as an identifier for flammable gases, vapors, or liquids to differentiate from Class II and Class III locations. Zone 0, Zone 1, and Zone 2 only apply to flammable gases, vapors, or liquids so the “Class I” prefix is redundant and has been deleted, except for text that is extracted from other documents or to remain consistent throughout this article.

[See Figure 514.3.]

Figure 514.3 Classified Areas Adjacent to Dispensers.
[30A: Figure 8.3.2(a)]



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Motor Fuel Dispensing Facilities

(A) Unclassified Locations. Where the authority having jurisdiction can satisfactorily determine that flammable liquids having a flash point below 38°C (100°F), such as gasoline, will not be handled, such location shall not be required to be classified.

(B) Classified Locations. [See Figure 514.3(B).]

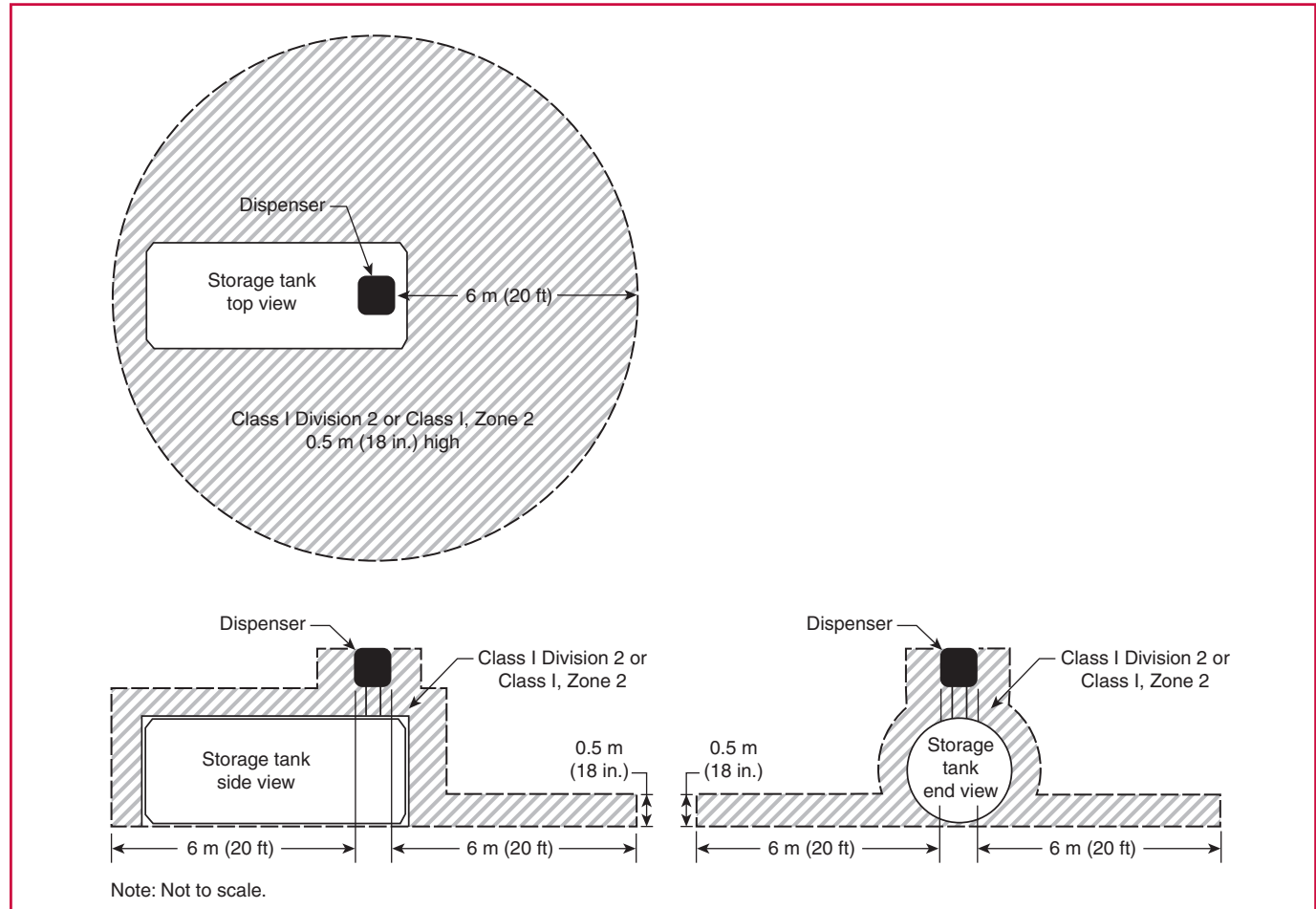


Figure 514.3(B) Classified Areas Adjacent to Dispenser Mounted on Aboveground Storage Tank. [30A: Figure 8.3.2(b)]

(1) Class I Locations. Table 514.3(B)(1) shall be applied where Class I liquids are stored, handled, or dispensed and shall be used to delineate and classify motor fuel dispensing facilities and commercial garages as defined in Article 511. Table 515.3 shall be used for the purpose of delineating and classifying aboveground tanks. A Class I location shall not extend beyond an unpierced wall, roof, or other solid partition. [30A: 8.1, 8.2, 8.3]

(2) Compressed Natural Gas, Liquefied Natural Gas, and Liquefied Petroleum Gas Areas. Table 514.3(B)(2) shall be used to delineate and classify areas where CNG, LNG, compressed or liquefied hydrogen, LP-Gas, or combinations of these, are dispensed as motor vehicle fuels along with Class I or Class II liquids that are also dispensed as motor vehicle fuels. [30A:12.1]

Where CNG or LNG dispensers are installed beneath a canopy or enclosure, either the canopy or enclosure shall be designed to prevent accumulation or entrapment of ignitable vapors or all electrical equipment installed beneath the canopy or enclosure shall be suitable for Class I, Division 2 hazardous (classified) locations. [30A:12.4]

Dispensing devices for LP-Gas shall be located as follows:

- (1) At least 3 m (10 ft) from any dispensing device for Class I liquids
 - (2) At least 1.5 m (5 ft) from any dispensing device for Class I liquids where the following conditions exist:
 - a. The LP-Gas deliver nozzle and filler valve release no more than 4 cm³ (0.1 oz) of liquid upon disconnection.
 - b. The fixed maximum liquid level gauge remains closed during the entire refueling process.
- [30A:12.5.2]

Informational Note No. 1: Applicable requirements for dispensing devices for LP-Gas is found in NFPA 58-2017, *Liquefied Petroleum Gas Code*.

Informational Note No. 2: For information on classified areas pertaining to LP-Gas systems other than residential or commercial, see NFPA 58-2017, *Liquefied Petroleum Gas Code*, and NFPA 59-2018, *Utility LP-Gas Plant Code*.

Informational Note No. 3: See 514.3(C) for motor fuel dispensing stations in marinas and boatyards.

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Table 514.3(B)(1) Class I Locations – Motor Fuel Dispensing Facilities

Location	Division (Group D)	Zone (Group IIA)	Extent of Classified Location ¹
Dispensing Device (except Overhead Type)^{2,3}			
Under dispenser containment	1	1	Entire space within and under dispenser pit or containment
Dispenser	2	2	Within 450 mm (18 in.) of dispenser enclosure or that portion of dispenser enclosure containing liquid-handling components, extending horizontally in all directions and down to grade level
Outdoor	2	2	Up to 450 mm (18 in.) above grade level, extending 6 m (20 ft) horizontally in all directions from dispenser enclosure
Indoor			
- with mechanical ventilation	2	2	Up to 450 mm (18 in.) above floor level, extending 6 m (20 ft) horizontally in all directions from dispenser enclosure
- with gravity ventilation	2	2	Up to 450 mm (18 in.) above floor level, extending 7.5 m (25 ft) horizontally in all directions from dispenser enclosure
Dispensing Device — Overhead Type⁴			
	1	1	Space within dispenser enclosure and all electrical equipment integral with dispensing hose or nozzle
	2	2	Within 450 mm (18 in.) of dispenser enclosure, extending horizontally in all directions and down to grade level
	2	2	Up to 450 mm (18 in.) above grade level, extending 6 m (20 ft) horizontally in all directions from a point vertically below edge of dispenser enclosure
Remote Pump —			
Outdoor	1	1	Entire space within any pit or box below grade level, any part of which is within 3 m (10 ft) horizontally from any edge of pump
	2	2	Within 900 mm (3 ft) of any edge of pump, extending horizontally in all directions
	2	2	Up to 450 mm (18 in.) above grade level, extending 3 m (10 ft) horizontally in all directions from any edge of pump
Indoor	1	1	Entire space within any pit
	2	2	Within 1.5 m (5 ft) of any edge of pump, extending in all directions
	2	2	Up to 900 mm (3 ft) above floor level, extending 7.5 m (25 ft) horizontally in all directions from any edge of pump
Sales, Storage, Rest Rooms including structures (such as the attendant's kiosk) on or adjacent to dispensers			
	unclassified	unclassified	Except as noted below
	1	1	Entire volume, if there is any opening to room within the extent of a Division 1 or Zone 1 location
	2	2	Entire volume, if there is any opening to room within the extent of a Division 2 or Zone 2 location
Tank, Aboveground			
Inside tank	1	0	Entire inside volume
Shell, ends, roof, dike area	1	1	Entire space within dike, where dike height exceeds distance from tank shell to inside of dike wall for more than 50 percent of tank circumference
	2	2	Entire space within dike, where dike height does not exceed distance from tank shell to inside of dike wall for more than 50 percent of tank circumference
Vent	2	2	Within 3 m (10 ft) of shell, ends, or roof of tank
	1	1	Within 1.5 m (5 ft) of open end of vent, extending in all directions
	2	2	Between 1.5 m and 3 m (5 ft and 10 ft) from open end of vent, extending in all directions

(Continues)

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Table 514.3(B)(1) Continued

Location	Division (Group D)	Zone (Group IIA)	Extent of Classified Location ¹
Tank, Underground			
Inside tank	1	0	Entire inside volume
Fill Opening	1	1	Entire space within any pit or box below grade level, any part of which is within a Division 1 or Division 2 classified location or within a Zone 1 or Zone 2 classified location
	2	2	Up to 450 mm (18 in.) above grade level, extending 1.5 m (5 ft) horizontally in all directions from any tight-fill connection and extending 3 m (10 ft) horizontally in all directions from any loose-fill connection
Vent	1	1	Within 1.5 m (5 ft) of open end of vent, extending in all directions
	2	2	Between 1.5 m and 3 m (5 ft and 10 ft) from open end of vent, extending in all directions
Vapor Processing System			
Pits	1	1	Entire space within any pit or box below grade level, any part of which: (1) is within a Division 1 or Division 2 classified location; (2) is within a Zone 1 or Zone 2 classified location; (3) houses any equipment used to transfer or process vapors
Equipment in protective enclosures	2	2	Entire space within enclosure
Equipment not within protective enclosure	2	2	Within 450 mm (18 in.) of equipment containing flammable vapors or liquid, extending horizontally in all directions and down to grade level
	2	2	Up to 450 mm (18 in.) above grade level within 3 m (10 ft) horizontally of the vapor processing equipment
- Equipment enclosure	1	1	Entire space within enclosure, if flammable vapor or liquid is present under normal operating conditions
	2	2	Entire space within enclosure, if flammable vapor or liquid is not present under normal operating conditions
- Vacuum assist blower	2	2	Within 450 mm (18 in.) of blower, extending horizontally in all directions and down to grade level
	2	2	Up to 450 mm (18 in.) above grade level, extending 3 m (10 ft) horizontally in all directions
Vault	1	1	Entire interior space, if Class I liquids are stored within

¹For marine application, *grade level* means the surface of a pier, extending down to water level.

²Refer to Figure 514.3 and Figure 514.3(B) for an illustration of classified location around dispensing devices.

³Area classification inside the dispenser enclosure is covered in UL 87, *Standard for Power-Operated Dispensing Devices for Petroleum Products*.

⁴Ceiling-mounted hose reel [30A: Table 8.3.1].

Table 514.3(B)(2) Electrical Equipment Classified Areas for Dispensing Devices

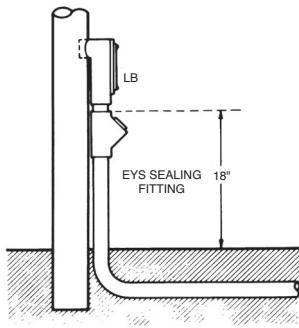
Dispensing Device	Extent of Classified Area	
	Class I, Division 1	Class I, Division 2
Compressed natural gas (CNG)	Entire space within the dispenser enclosure	1.5 m (5 ft) in all directions from dispenser enclosure
Liquefied natural gas (LNG)	Entire space within the dispenser enclosure	3 m (10 ft) in all directions from the dispenser enclosure
Liquefied petroleum gas (LP-Gas)	Entire space within the dispenser enclosure; 450 mm (18 in.) from the exterior surface of the dispenser enclosure to an elevation of 1.22 m (4 ft) above the base of the dispenser; the entire pit or open space beneath the dispenser and within 6 m (20 ft) horizontally from any edge of the dispenser when the pit or trench is not mechanically ventilated	Up to 450 mm (18 in.) above ground and within 6 m (20 ft) horizontally from any edge of the dispenser enclosure, including pits or trenches within this area when provided with adequate mechanical ventilation

[30A: Table 12.6.2]

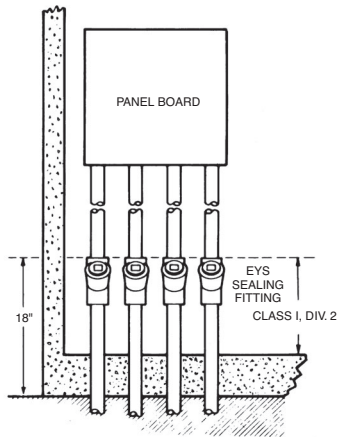
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Motor Fuel Dispensing Facilities



Pole standard within 20 ft. horizontally from any dispensing pump is Class I, Division 2. See Table 514.3(B)(1).



A building less than 20 ft. from any island, pump, tank fill-pipe, or tank vent-pipe is a Class I, Division 2 location up to 18 inches above grade.

NOTE: If a building is over 20 feet from any island, pump, tank fill-pipe, or tank vent-pipe it is not a hazardous location. But in either case seals must be placed in all underground conduits to prevent explosions in conduits from reaching panelboard. See 514.9.

(3) Fuel Storage.

(a) Aboveground tanks storing CNG or LNG shall be separated from any adjacent property line that is or can be built upon, any public way, and the nearest important building on the same property. [30A:12.3.1].

Informational Note: The relevant distances are given in Section 8.4 of NFPA 52-2019, *Vehicular Natural Gas Fuel Systems Code*.

(b) Aboveground tanks storing hydrogen shall be separated from any adjacent property line that is or can be built upon, any public way, and the nearest important building on the same property. [30A:12.3.2].

Informational Note: The relevant distances given in NFPA 2-2016, *Hydrogen Technologies Code*.

(c) Aboveground tanks storing LP-Gas shall be separated from any adjacent property line that is or can be built upon, any public way, and the nearest important building on the same property. [30A:12.3.3].

Informational Note: The relevant distances are given in Section 6.3 of NFPA 58-2017, *Liquefied Petroleum Gas Code*.

(d) Aboveground tanks storing CNG, LNG, or LP-Gas shall be separated from each other by at least 6 m (20 ft) and from dispensing devices that dispense liquid or gaseous motor vehicle fuels by at least 6 m (20 ft). [30A:12.3.3].

Exception No. 1: The required separation shall not apply to tanks or dispensers storing or handling fuels of the same chemical composition.

Exception No. 2: The required separation shall not apply when both the gaseous fuel storage and dispensing equipment are at least 15 m (50 ft) from any other aboveground motor fuel storage or dispensing equipment.

Informational Note: For further information, see NFPA 52-2019, *Vehicular Natural Gas Fuel Systems Code*, or NFPA 58-2017, *Liquefied Petroleum Gas Code*, as applicable.

(e) *Dispenser Installations Beneath Canopies.* Where CNG or LNG dispensers are installed beneath a canopy or enclosure, either the canopy or enclosure shall be designed to prevent accumulation or entrapment of ignitable vapors or all electrical equipment installed beneath the canopy or enclosure shall be suitable for Class I, Division 2 hazardous (classified) locations. [30A:12.4].

(f) *Specific Requirements for LP-Gas Dispensing Devices.* [30A:12.5] Dispensing devices for LP-Gas shall be located as follows:

(1) At least 3 m (10 ft) from any dispensing device for Class I liquids.

(2) At least 1.5 m (5 ft) from any dispensing device for Class I liquids where the following conditions exist:

- The LP-Gas deliver nozzle and filler valve release no more than 4 cm³ (0.1 oz) of liquid upon disconnection.
- The fixed maximum liquid level gauge remains closed during the entire refueling process [30A:12.5.2]

Table 514.3(B)(2) shall be used to delineate and classify areas for the purpose of installation of electrical wiring and electrical utilization equipment.

(C) Motor Fuel Dispensing Stations in Boatyards and Marinas.

Informational Note: For additional information, see NFPA 303-2016, *Fire Protection Standard for Marinas and Boatyards*, and NFPA 30A-2018, *Code for Motor Fuel Dispensing Facilities and Repair Garages*.

(1) **General.** Electrical wiring and equipment located at or serving motor fuel dispensing locations shall be installed on the side of the wharf, pier, or dock opposite from the liquid piping system.

(2) **Classification of Class I, Division 1 and 2 Areas.** The following criteria shall be used for the purposes of applying Table 514.3(B)(1) and Table 514.3(B)(2) to motor fuel dispensing equipment on floating or fixed piers, wharfs, or docks.

(D) Closed Construction. Where the construction of floating docks, piers, or wharfs is closed so that there is no space between the bottom of the dock, pier, or wharf and the water, as in the case of concrete-enclosed expanded foam or similar construction, and the construction includes integral service boxes with supply chases, the following shall apply:

(1) The space above the surface of the floating dock, pier, or wharf shall be a Class I, Division 2 location with distances as specified in Table 514.3(B)(1) for dispenser and outdoor locations.

(2) Spaces below the surface of the floating dock, pier, or wharf that have areas or enclosures, such as tubs, voids, pits, vaults, boxes, depressions, fuel piping chases, or similar spaces, where flammable liquid or vapor can accumulate shall be a Class I, Division 1 location.

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Exception No. 1: Dock, pier, or wharf sections that do not support fuel dispensers and abut, but are located 6.0 m (20 ft) or more from, dock sections that support a fuel dispenser(s) shall be permitted to be Class I, Division 2 locations where documented air space is provided between dock sections to allow flammable liquids or vapors to dissipate without traveling to such dock sections. The documentation shall comply with 500.4.

Exception No. 2: Dock, pier, or wharf sections that do not support fuel dispensers and do not directly abut sections that support fuel dispensers shall be permitted to be unclassified where documented air space is provided and where flammable liquids or vapors cannot travel to such dock sections. The documentation shall comply with 500.4.

(E) Open Construction. Where the construction of piers, wharfs, or docks is open, as in the case of decks built on stringers supported by pilings, floats, pontoons, or similar construction, the following shall apply:

- (1) The area 450 mm (18 in.) above the surface of the dock, pier, or wharf and extending 6.0 m (20 ft) horizontally in all directions from the outside edge of the dispenser and down to the water level shall be a Class 1, Division 2 location.
- (2) Enclosures such as tubs, voids, pits, vaults, boxes, depressions, piping chases, or similar spaces where flammable liquids or vapors can accumulate within 6.0 m (20 ft) of the dispenser shall be a Class I, Division 1 location.

514.4 Wiring and Equipment Installed in Class I Locations.

All electrical equipment and wiring installed in Class I locations as classified in 514.3 shall comply with the applicable provisions of Article 501.

Exception: As permitted in 514.8.

Informational Note: For special requirements for conductor insulation, see 501.20.

514.7 Wiring and Equipment Above Class I Locations.

Wiring and equipment above the Class I locations as classified in 514.3 shall comply with 511.7.

514.8 Underground Wiring.

Underground wiring shall be installed in threaded rigid metal conduit or threaded steel intermediate metal conduit. Any portion of electrical wiring that is below the surface of a Class I, Division 1 or a Class I, Division 2 location [as classified in Table 514.3(B)(1) and Table 514.3(B)(2)] shall be sealed within 3.05 m (10 ft) of the point of emergence above grade. Except for listed explosionproof reducers at the conduit seal, there shall be no union, coupling, box, or fitting between the conduit seal and the point of emergence above grade. Refer to Table 300.5.

Exception No. 1: Type MI cable shall be permitted where it is installed in accordance with Article 332.

Exception No. 2: Type PVC conduit, Type RTRC conduit, and Type HDPE conduit shall be permitted where buried under not less than 600 mm (2 ft) of cover. Where Type PVC conduit, Type RTRC conduit, or Type HDPE conduit is used, threaded rigid metal conduit or threaded steel intermediate metal conduit shall be used for the last 600 mm (2 ft) of the underground run to emergence or to the point of connection to the aboveground raceway, and an equipment grounding conductor shall be included to provide electrical continuity of the raceway system and for grounding of non-current-carrying metal parts.

514.9 Sealing.

(A) At Dispenser. A listed seal shall be provided in each conduit run entering or leaving a dispenser or any cavities or enclosures in direct communication therewith. The sealing fitting or listed explosionproof reducer at the seal shall be the first fitting after the conduit emerges from the earth or concrete.

(B) At Boundary. Additional seals shall be provided in accordance with 501.15. Sections 501.15(A)(4) and (B)(2) shall apply to horizontal as well as to vertical boundaries of the defined Class I locations.

514.11 Circuit Disconnects.

(A) Emergency Electrical Disconnects. Fuel dispensing systems shall be provided with one or more clearly identified emergency shutoff devices or electrical disconnects. Such devices or disconnects shall be installed in approved locations but not less than 6 m (20 ft) or more than 30 m (100 ft) from the fuel dispensing devices that they serve. Emergency shutoff devices or electrical disconnects shall disconnect power to all dispensing devices; to all remote pumps serving the dispensing devices; to all associated power, control, and signal circuits; and to all other electrical equipment in the hazardous (classified) locations surrounding the fuel dispensing devices. When more than one emergency shutoff device or electrical disconnect is provided, all devices shall be interconnected. Resetting from an emergency shutoff condition shall require manual intervention and the manner of resetting shall be approved by the authority having jurisdiction. **[30A:6.7] The emergency shutoff device shall disconnect simultaneously from the source of supply, all conductors of the circuits, including the grounded conductor, if any. Equipment grounding conductors shall remain connected.**

Exception: Intrinsically safe electrical equipment need not meet this requirement. [30A:6.7]

(B) Attended Self-Service Motor Fuel Dispensing Facilities.

At attended motor fuel dispensing facilities, the devices or disconnects shall be readily accessible to the attendant. **[30A:6.7.1]**

(C) Unattended Self-Service Motor Fuel Dispensing Facilities.

At unattended motor fuel dispensing facilities, the devices or disconnects shall be readily accessible to patrons and at least one additional device or disconnect shall be readily accessible to each group of dispensing devices on an individual island. **[30A:6.7.2]**

514.13 Provisions for Maintenance and Service of Dispensing Equipment.

Each dispensing device shall be provided with a means to remove all external voltage sources, including power, communications, data, and video circuits and including feedback, during periods of maintenance and service of the dispensing equipment. The location of this means shall be permitted to be other than inside or adjacent to the dispensing device. The means shall be capable of being locked in the open position in accordance with 110.25.

514.16 Grounding and Bonding.

All metal raceways, the metal armor or metallic sheath on cables, and all non-current-carrying metal parts of fixed and portable electrical equipment, regardless of voltage, shall be grounded and bonded. Grounding and bonding in Class I locations shall comply with 501.30.

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Article 515

Bulk Storage Plants



Tank vessel loading platform



EVLLA luminaire



CPS interlocked receptacle

Article 515

515.1 Scope.

This article covers a property or portion of a property where flammable liquids are received by tank vessel, pipelines, tank car, or tank vehicle and are stored or blended in bulk for the purpose of distributing such liquids by tank vessel, pipeline, tank car, tank vehicle, portable tank, or container.

Informational Note: Text that is followed by a reference in brackets has been extracted from NFPA 30-2018, *Flammable and Combustible Liquids Code*. Only editorial changes were made to the extracted text to make it consistent with this Code.

515.3 Classified Locations.

Where the term “Class I” is used with respect to Zone classifications within this article of the Code, it shall apply to Zone 0, Zone 1, and Zone 2 designations.

Informational Note: The term “Class I” was originally included as a prefix to Zone 0, Zone 1, and Zone 2 locations and references as an identifier for flammable gases, vapors, or liquids to differentiate from Class II and Class III locations. Zone 0, Zone 1, and Zone 2 only apply to flammable gases, vapors, or liquids so the “Class I” prefix is redundant and has been deleted, except for text that is extracted from other documents or to remain consistent throughout this article.

Table 515.3 shall be applied where Class I flammable liquids are stored, handled, or dispensed and shall be used to delineate and classify bulk storage plants. The classified location shall not extend beyond a floor, wall, roof, or other solid partition that has no communicating openings.

Informational Note No. 1: The area classifications listed in Table 515.3 are based on the premise that the installation meets the applicable requirements of NFPA 30-2018, *Flammable and Combustible Liquids Code*, Chapter 5, in all respects. Should this not be the case, the authority having jurisdiction has the authority to classify the extent of the classified space.

Informational Note No. 2: See 514.3(C) through (E) for gasoline dispensing stations in marinas and boatyards.

515.4 Wiring and Equipment Located in Class I Locations.

All electrical wiring and equipment within the Class I locations defined in 515.3 shall comply with the applicable provisions of Article 501 or Article 505 for the division or zone in which they are used.

Exception: As permitted in 515.8.

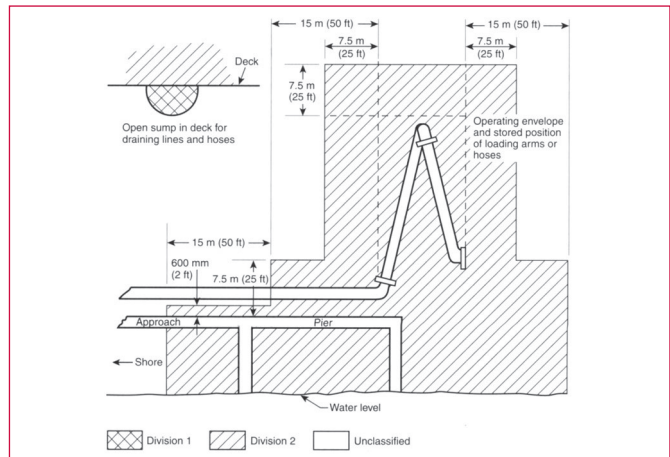


Figure 515.3 Area Classification for a Marine Terminal Handling Flammable Liquids. [30:Figure 29.3.22]

Notes:

- (1) For SI units, 1 in. = 25mm; 1 ft = 0.3m.
- (2) The “source of vapor” shall be the operating envelope and stored position of the outboard flange connection of the loading arm (or hose).
- (3) The berth area adjacent to tanker and barge cargo tanks is to be Division 2 to the following extent:
 - a. 7.6 m (25 ft) horizontally in all directions on the pier side from that portion of the hull containing cargo tanks
 - b. From the water level to 7.6 m (25 ft) above the cargo tanks at their highest position
- (4) Additional locations may have to be classified as required by the presence of other sources of flammable liquids on the berth, by Coast Guard, or other regulations.

515.7 Wiring and Equipment Above Class I Locations.

(A) Fixed Wiring. All fixed wiring above Class I locations shall be in metal raceways, Schedule 80 PVC conduit, Type RTRC marked with the suffix -XW, or Type MI, Type TC, or Type MC cable, or Type PLTC and Type PLTC-ER cable in accordance with the provisions of Article 725, including installation in cable tray systems or Type ITC and Type ITC-ER cable as permitted in 727.4. The cable shall be terminated with listed fittings.

(B) Fixed Equipment. Fixed equipment that may produce arcs, sparks, or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make-and-break or sliding contacts, shall be of the totally enclosed type or be constructed so as to prevent the escape of sparks or hot metal particles.

(C) Portable Luminaires or Other Utilization Equipment. Portable luminaires or other utilization equipment and their flexible cords shall comply with the provisions of Article 501 or Article 505 for the class of location above which they are connected or used.

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Article 515 Bulk Storage Plants

515.8 Underground Wiring.

(A) Wiring Method. Underground wiring shall be installed in threaded rigid metal conduit or threaded steel intermediate metal conduit or, where buried under not less than 600 mm (2 ft) of cover, shall be permitted in Type PVC conduit, Type RTRC conduit, or a listed cable. Where Type PVC conduit or Type RTRC conduit is used, threaded rigid metal conduit or threaded steel intermediate metal conduit shall be used for not less than the last 600 mm (2 ft) of the conduit run to the conduit point of emergence from the underground location or to the point of connection to an aboveground raceway. Where cable is used, it shall be enclosed in threaded rigid metal conduit or threaded steel intermediate metal conduit from the point of lowest buried cable level to the point of connection to the aboveground raceway.

(B) Insulation. Conductor insulation shall comply with 501.20.

(C) Nonmetallic Wiring. Where Type PVC conduit, Type RTRC conduit, or cable with a nonmetallic sheath is used, an equipment grounding conductor shall be included to provide for electrical continuity of the raceway system and for grounding of non-current-carrying metal parts.

515.9 Sealing.

Sealing requirements shall apply to horizontal as well as to vertical boundaries of the defined Class I locations. Buried raceways and cables under defined Class I locations shall be considered to be within a Class I, Division 1 or Zone 1 location.

515.10 Special Equipment – Gasoline Dispensers.

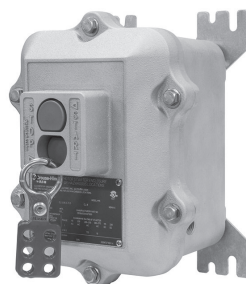
Where gasoline or other volatile flammable liquids or liquefied flammable gases are dispensed at bulk stations, the applicable provisions of Article 514 shall apply.

▲ 515.16 Grounding and Bonding.

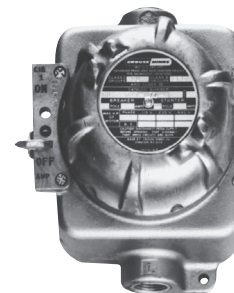
All metal raceways, the metal armor or metallic sheath on cables, and all non-current-carrying metal parts of fixed or portable electrical equipment, regardless of voltage, shall be grounded and bonded.

Grounding and bonding in Class I locations shall comply with 501.30 for Class I, Division 1 and 2 locations and 505.25 for Zone 0, 1, and 2 locations.

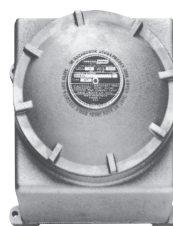
Informational Note: For information on grounding for static protection, see 6.5.4 of NFPA 30-2018, *Flammable and Combustible Liquids Code*.



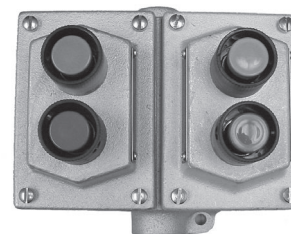
EMN manual line starter for use in Class I, Division 1 hazardous areas



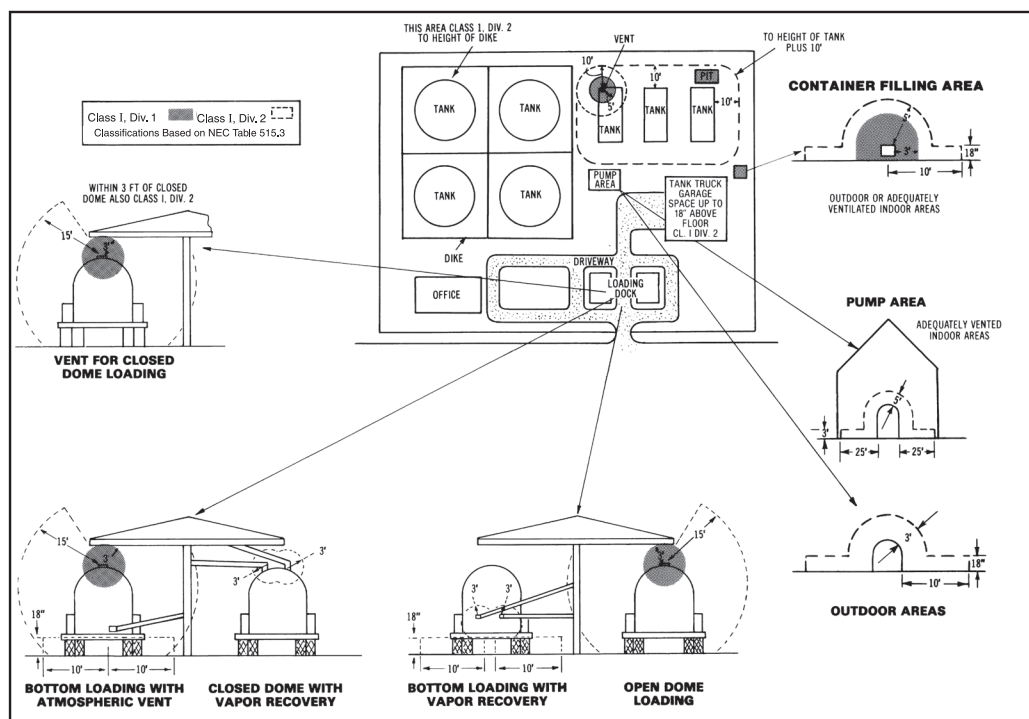
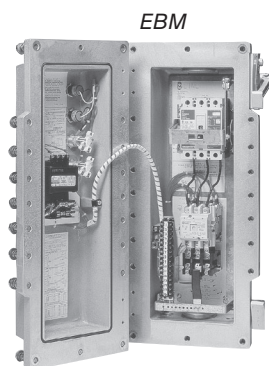
GUSC auxiliary circuit breaker assembly



GUB junction boxes available in a variety of sizes with many conduit entrance arrangements



EFS pushbutton station and pilot light



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Article 515

Bulk Storage Plants

Table 515.3 Electrical Area Classifications

Location	Division	Zone	Extent of Classified Area
Indoor equipment installed where flammable vapor–air mixtures can exist under normal operation (see Informational Note)	1	0	The entire area associated with such equipment where flammable gases or vapors are present continuously or for long periods of time
	1	1	Area within 1.5 m (5 ft) of any edge of such equipment, extending in all directions
	2	2	Area between 1.5 m and 2.5 m (5 ft and 8 ft) of any edge of such equipment, extending in all directions; also, space up to 900 mm (3 ft) above floor or grade level within 1.5 m to 7.5 m (5 ft to 25 ft) horizontally from any edge of such equipment ¹
Outdoor equipment installed where flammable vapor–air mixtures can exist under normal operation	1	0	The entire area associated with such equipment where flammable gases or vapors are present continuously or for long periods of time
	1	1	Area within 900 mm (3 ft) of any edge of such equipment, extending in all directions
	2	2	Area between 900 mm (3 ft) and 2.5 m (8 ft) of any edge of such equipment, extending in all directions; also, space up to 900 mm (3 ft) above floor or grade level within 900 mm to 3.0 m (3 ft to 10 ft) horizontally from any edge of such equipment
Tank storage installations inside buildings	1	1	All equipment located below grade level
	2	2	Any equipment located at or above grade level
Tank — aboveground, fixed roof	1	0	Inside fixed roof tank
	1	1	Area inside dike where dike height is greater than the distance from the tank to the dike for more than 50 percent of the tank circumference
	2	2	Within 3.0 m (10 ft) from shell, ends, or roof of tank; also, area inside dike to level of top of dike wall
	1	0	Area inside of vent piping or opening
	1	1	Within 1.5 m (5 ft) of open end of vent, extending in all directions
	2	2	Area between 1.5 m and 3.0 m (5 ft and 10 ft) from open end of vent, extending in all directions
Tank — aboveground, floating roof	1	0	Area between the floating and fixed roof sections and within the shell
With fixed outer roof	1	1	Area above the floating roof and within the shell
With no fixed outer roof	1	1	Area above the floating roof and within the shell
Tank vault — interior	1	1	Entire interior volume, if Class I liquids are stored within
Underground tank fill opening	1	1	Any pit, box, or space below grade level, if any part is within a Division 1 or 2, or Zone 1 or 2, classified location
	2	2	Up to 450 mm (18 in.) above grade level within a horizontal radius of 3.0 m (10 ft) from a loose fill connection, and within a horizontal radius of 1.5 m (5 ft) from a tight fill connection
Vent – discharging upward	1	0	Area inside of vent piping or opening
	1	1	Within 900 mm (3 ft) of open end of vent, extending in all directions
	2	2	Area between 900 mm and 1.5 m (3 ft and 5 ft) of open end of vent, extending in all directions
Drum and container filling – outdoors or indoors	1	0	Area inside the drum or container
	1	1	Within 900 mm (3 ft) of vent and fill openings, extending in all directions
	2	2	Area between 900 mm and 1.5 m (3 ft and 5 ft) from vent or fill opening, extending in all directions; also, up to 450 mm (18 in.) above floor or grade level within a horizontal radius of 3.0 m (10 ft) from vent or fill opening
Pumps, bleeders, withdrawal fittings	2	2	Within 1.5 m (5 ft) of any edge of such devices, extending in all directions; also, up to 900 mm (3 ft) above floor or grade level within 7.5 m (25 ft) horizontally from any edge of such devices
Indoor	2	2	Within 1.5 m (5 ft) of any edge of such devices, extending in all directions; also, up to 900 mm (3 ft) above floor or grade level within 7.5 m (25 ft) horizontally from any edge of such devices
Outdoor	2	2	Within 900 mm (3 ft) of any edge of such devices, extending in all directions. Also, up to 450 mm (18 in.) above grade level within 3.0 m (10 ft) horizontally from any edge of such devices

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Article 515

Bulk Storage Plants

Table 515.3 Electrical Area Classifications Continued

Location	Division	Zone	Extent of Classified Area
Pits and sumps			
Without mechanical ventilation	1	1	Entire area within a pit or sump if any part is within a Division 1 or 2, or Zone 1 or 2, classified location
With adequate mechanical ventilation	2	2	Entire area within a pit or sump if any part is within a Division 1 or 2, or Zone 1 or 2, classified location
Containing valves, fittings, or piping, and not within a Division 1 or 2, or Zone 1 or 2, classified location	2	2	Entire pit or sump
Drainage ditches, separators, impounding basins			
Outdoor	2	2	Area up to 450 mm (18 in.) above ditch, separator, or basin; also, area up to 450 mm (18 in.) above grade within 4.5 m (15 ft) horizontally from any edge
Indoor			Same as pits and sump
Tank vehicle and tank car ² Loading through open dome	1	0	Area inside of the tank
	1	1	Within 900 mm (3 ft) of edge of dome, extending in all directions
	2	2	Area between 900 mm and 4.5 m (3 ft and 15 ft) from edge of dome, extending in all directions
Loading through bottom connections with atmospheric venting	1	0	Area inside of the tank
	1	1	Within 900 mm (3 ft) of point of venting to atmosphere, extending in all directions
	2	2	Area between 900 mm and 4.5 m (3 ft and 15 ft) from point of venting to atmosphere, extending in all directions; also, up to 450 mm (18 in.) above grade within a horizontal radius of 3.0 m (10 ft) from point of loading connection
Loading through closed dome with atmospheric venting	1	1	Within 900 mm (3 ft) of open end of vent, extending in all directions
	2	2	Area between 900 mm and 4.5 m (3 ft and 15 ft) from open end of vent, extending in all directions; also, within 900 mm (3 ft) of edge of dome, extending in all directions
Loading through closed dome with vapor control	2	2	Within 900 mm (3 ft) of point of connection of both fill and vapor lines extending in all directions
Bottom loading with vapor control or any bottom unloading	2	2	Within 900 mm (3 ft) of point of connections, extending in all directions; also up to 450 mm (18 in.) above grade within a horizontal radius of 3.0 m (10 ft) from point of connections
Storage and repair garage for tank vehicles	1	1	All pits or spaces below floor level
	2	2	Area up to 450 mm (18 in.) above floor or grade level for entire storage or repair garage
Garages for other than tank vehicles	Unclassified		If there is any opening to these rooms within the extent of an outdoor classified location, the entire room shall be classified the same as the area classification at the point of the opening.
Outdoor drum storage	Unclassified		
Inside rooms or storage lockers used for the storage of Class I liquids	2	2	Entire room or locker
Indoor warehousing where there is no flammable liquid transfer	Unclassified		If there is any opening to these rooms within the extent of an indoor classified location, the classified location shall extend through the opening to the same extent as if the wall, curb, or partition did not exist.
Office and rest rooms	Unclassified		If there is any opening to these rooms within the extent of an indoor classified location, the room shall be classified the same as if the wall, curb, or partition did not exist.
Piers and wharves			See Figure 515.3.

¹ The release of Class I liquids can generate vapors to the extent that the entire building, and possibly an area surrounding it, should be considered a Class I, Division 2 or Zone 2 location.

² When classifying extent of area, consideration shall be given to the fact that tank cars or tank vehicles can be spotted at varying points. Therefore, the extremities of the loading or unloading positions shall be used. [30:Table 7.3.3]

Informational Note: See Section 7.3 of NFPA 30-2018, *Flammable and Combustible Liquids Code*, for additional information.

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Article 516

Spray Application, Dipping, Coating, and Printing Processes Using Flammable or Combustible Materials

Article 516

Part I. General

▲ 516.1 Scope.

This article covers the regular or frequent application of flammable liquids, combustible liquids, and combustible powders by spray operations and the application of flammable liquids or combustible liquids at temperatures above their flashpoint by spraying, dipping, coating, printing, or other means.

Informational Note No. 1: For further information regarding safeguards for these processes, such as fire protection, posting of warning signs, and maintenance, see NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*, and NFPA 34-2018, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*. For additional information regarding ventilation, see NFPA 91-2015, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*.

Informational Note No. 2: Text that is followed by a reference in brackets has been extracted from NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*, or NFPA 34-2018, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*. Only editorial changes were made to the extracted text to make it consistent with this Code

● N 516.3 Class I Locations.

Where the term Class I is used with respect to Zone classifications within this article of the Code, it shall apply to Zone 0, Zone 1, and Zone 2 designations.

Informational Note: The term Class I was originally included as a prefix to Zone 0, Zone 1, and Zone 2 locations and references as an identifier for flammable gases, vapors, or liquids to differentiate from Class II and Class III locations. Zone 0, Zone 1, and Zone 2 only apply to flammable gases, vapors, or liquids so the Class I prefix is redundant and has been deleted, except for text that is extracted from other documents or to remain consistent throughout this article.

Part II. Open Containers

516.4 Area Classification.

For open containers, supply containers, waste containers, spray gun cleaners, and solvent distillation units that contain Class I liquids that are located in ventilated areas, area classification shall be in accordance with the following:

- (1) The area within 915 mm (3 ft) in all directions from any such container or equipment and extending to the floor or grade level shall be classified as Class I, Division 1 or Class I, Zone 1, whichever is applicable. [33:6.5.5.1]
- (2) The area extending 610 mm (2 ft) beyond the Division 1 or Zone 1 location shall be classified as Class I, Division 2 or Class I, Zone 2, whichever is applicable. [33:6.5.5.1]
- (3) The area extending 1525 mm (5 ft) horizontally beyond the area described in 516.4(2) up to a height of 460 mm (18 in.) above the floor or grade level shall be classified as Class I, Division 2 or Class I, Zone 2, whichever is applicable. [33:6.5.5.1]
- (4) The area inside any tank or container shall be classified as Class I, Division 1 or Class I, Zone 0, whichever is applicable. [33:6.5.5.1]
- (5) Sumps, pits, or below grade channels within 3.5 m (10 ft) horizontally of a vapor source shall be classified as Class I, Division 1 or Zone 1. If the sump, pit, or channel extends beyond 3.5 m (10 ft) from the vapor source, it shall be provided with a vapor stop or it shall be classified as Class I, Division 1 or Zone 1 for its entire length.

For the purposes of electrical area classification, the Division system and the Zone system shall not be intermixed for any given source of release. [33:6.2.3]

Electrical wiring and utilization equipment installed in these areas shall be suitable for the location, as shown in Figure 516.4. [33:6.5.5.2]

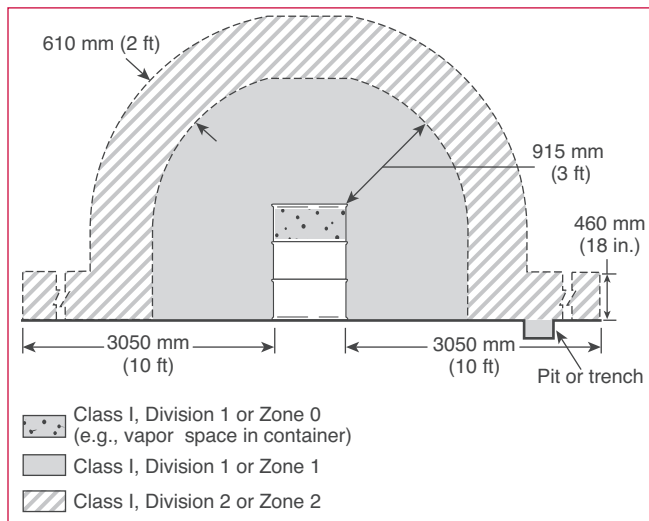


Figure 516.4 Electrical Area Classification for Class I Liquid Operations Around Open Containers, Supply Containers, Waste Containers, Spray Gun Cleaners, and Solvent Distillation Units. [33:Figure 6.5.5.2]

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Article 516

Spray Application, Dipping, Coating, and Printing Processes Using Flammable or Combustible Materials

Part III. Spray Application Processes

516.5 Area Classification.

For spray application processes, the area classification is based on quantities of flammable vapors, combustible mists, residues, dusts, or deposits that are present or might be present in quantities sufficient to produce ignitable or explosive mixtures with air.

(A) Zone Classification of Locations.

(1) Classification of Locations. The Zone system of electrical area classification shall be applied as follows:

- (1) The inside of closed containers or vessels shall be considered a Class I, Zone 0 location.
- (2) A Class I, Division 1 location shall be permitted to be alternatively classified as a Class I, Zone 1 location.
- (3) A Class I, Division 2 location shall be permitted to be alternatively classified as a Class I, Zone 2 location.
- (4) A Class II, Division 1 location shall be permitted to be alternatively classified as a Zone 21 location.
- (5) A Class II, Division 2 location shall be permitted to be alternatively classified as a Zone 22 location. [33:6.2.2].

(2) Classification Systems. For the purposes of electrical area classification, the Division system and the Zone system shall not be intermixed for any given source of release. [33:6.2.3]

In instances of areas within the same facility classified separately, Class I, Zone 2 locations shall be permitted to abut, but not overlap, Class I, Division 2 locations. Class I, Zone 0 or Zone 1 locations shall not abut Class I, Division 1 or Division 2 locations. [33:6.2.4]

(3) Equipment. Open flames, spark-producing equipment or processes, and equipment whose exposed surfaces exceed the autoignition temperature of the material being sprayed shall not be located in a spray area or in any surrounding area that is classified as Division 2, Zone 2, or Zone 22. [33:6.2.5]

Exception: This requirement shall not apply to drying, curing, or fusing apparatus.

Any utilization equipment or apparatus that is capable of producing sparks or particles of hot metal and that is located above or adjacent to either the spray area or the surrounding Division 2, Zone 2, or Zone 22 areas shall be of the totally enclosed type or shall be constructed to prevent the escape of sparks or particles of hot metal. [33:6.2.6].

(B) Class I, Division 1 or Class I, Zone 0 Locations. The interior of any open or closed container or vessel of a flammable liquid shall be considered Class I, Division 1, or Class I, Zone 0, as applicable:

Informational Note: For additional guidance, see Chapter 6 of NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*.

(C) Class I, Division 1; Class I, Zone 1; Class II, Division 1; or Zone 21 Locations. The following spaces shall be considered Class I, Division 1, or Class I, Zone 1, Class II, Division 1, or Zone 21 locations, as applicable:

- (1) The interior of spray booths and rooms except as specifically provided in 516.5(D).
- (2) The interior of exhaust ducts.
- (3) Any area in the direct path of spray operations.
- (4) Sumps, pits, or below grade channels within 7620 mm (25 ft) horizontally of a vapor source. If the sump, pit, or channel extends beyond 7620 mm (25 ft) from the vapor source, it shall be provided with a vapor stop or it shall be classified as Class I, Division 1 for its entire length. [34:6.4.1]
- (5) All space in all directions outside of but within 900 mm (3 ft) of open containers, supply containers, spray gun cleaners, and solvent distillation units containing flammable liquids.
- (6) For limited finishing workstations, the area inside the curtains or partitions. [See Figure 516.5(D)(5).]

(D) Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 Locations. The spaces listed in 516.5(D)(1) through (D)(5) shall be considered Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 as applicable.

(1) Unenclosed Spray Processes. Electrical wiring and utilization equipment located outside but within 6100 mm (20 ft) horizontally and 3050 mm (10 ft) vertically of an enclosed spray area and not separated from the spray area by partitions extending to the boundaries of the area designated as Division 2, Zone 2 or Zone 22 in Figure 516.5(D)(1) shall be suitable for Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations, whichever is applicable. [33:6.5.1] [See Figure 516.5(D)(1).]

(2) Closed-Top, Open-Face, and Open-Front Spray Booths and Spray Rooms. If spray application operations are conducted within a closed-top, open-face, or open-front booth or room, as shown in Figure 516.5(D)(2), any electrical wiring or utilization equipment located outside of the booth or room but within 915 mm (3 ft) of any opening shall be suitable for Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations, whichever is applicable. The Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations shown in Figure 516.5(D)(2) shall extend from the edges of the open face or open front of the booth or room.

(3) Open-Top Spray Booths. For spraying operations conducted within an open top spray booth, the space 915 mm (3 ft) vertically above the booth and within 915 mm (3 ft) of other booth openings shall be considered Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 whichever is applicable. [33:6.5.3]

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Article 516

Spray Application, Dipping, Coating, and Printing Processes Using Flammable or Combustible Materials

(4) Enclosed Spray Booths and Spray Rooms. For spray application operations confined to an enclosed spray booth or room, electrical area classification shall be as follows:

- (1) The area within 915 mm (3 ft) of any opening shall be classified as Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations, whichever is applicable, as shown in Figure 516.5(D)(4).
- (2) Where automated spray application equipment is used, the area outside the access doors shall be unclassified provided the door interlock prevents the spray application operations when the door is open.
- (3) Where exhaust air is permitted to be recirculated, both of the following shall apply:
 - a. The interior of any recirculation path from the secondary particulate filters up to and including the air supply plenum shall be classified as Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations, whichever is applicable.
 - b. The interior of fresh air supply ducts shall be unclassified.
- (4) Where exhaust air is not recirculated, the interior of fresh air supply ducts and fresh air supply plenums shall be unclassified. [33:6.5.4].

(5) Limited Finishing Workstations.

(a) For limited finishing workstations, the area inside the 915 mm (3 ft) space horizontally and vertically beyond the volume enclosed by the outside surface of the curtains or partitions shall be classified as Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22, as shown in Figure 516.5(D)(5).

(b) A limited finishing workstation shall be designed and constructed to have all of the following:

- (1) A dedicated make-up air supply
- (2) Curtains or partitions that are noncombustible or limited combustible
- (3) A dedicated mechanical exhaust and filtration system
- (4) An approved automatic extinguishing system [33:14.3.1]

Informational Note: For limited combustible curtains or partitions see NFPA 701-2019, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*.

(c) The amount of material sprayed in a limited finishing workstation shall not exceed 3.8 L (1 gal) in any 8-hour period. [33:14.3.2]

(d) Curtains or partitions shall be fully closed during any spray operations. [33:14.3.4]

(e) The equipment within the limited finishing workstation shall be interlocked such that the spray application equipment cannot be operated unless the exhaust ventilation system is operating and functioning properly and spray application is automatically stopped if the exhaust ventilation system fails.

(f) Any limited finishing workstation used for spray application operations shall not be used for any operation that is capable of producing sparks or particles of hot metal or for operations that involve open flames or electrical utilization equipment capable of producing sparks or particles of hot metal. [33:14.3.6]

(g) Where industrial air heaters are used to elevate the air temperature for drying, curing, or fusing operations, a high limit switch shall be provided to automatically shut off the drying apparatus if the air temperature in the limited finishing workstation exceeds the maximum discharge-air temperature allowed by the standard that the heater is listed to or 93°C (200°F), whichever is less. [33:14.3.7.1]

(h) A means shall be provided to show that the limited finishing workstation is in the drying or curing mode of operation and that the limited finishing workstation is to be unoccupied. [33:14.3.7.2]

(i) Any containers of flammable or combustible liquids shall be removed from the limited finishing workstation before the drying apparatus is energized. [33:14.3.7.3]

(j) Portable spot-drying, curing, or fusion apparatus shall be permitted to be used in a limited finishing workstation, provided that it is not located within the hazardous (classified) location defined in 14.3.5 of NFPA 33 when spray application operations are being conducted. [33:14.3.8]

(k) Recirculation of exhaust air shall be permitted when the provisions of 516.5(D)(4)(3) are both met. [33:14.3.9]

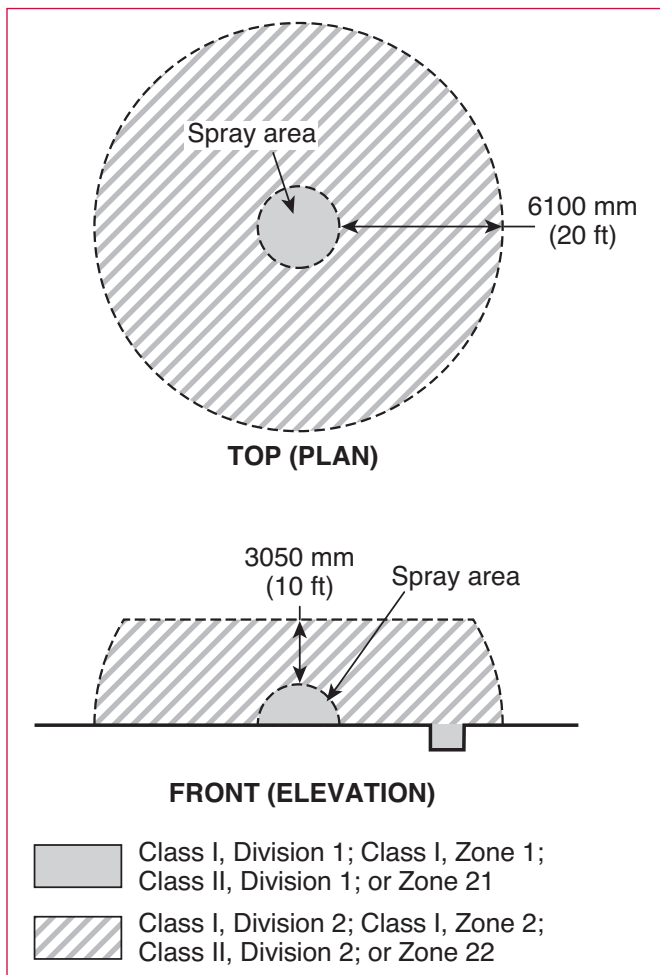
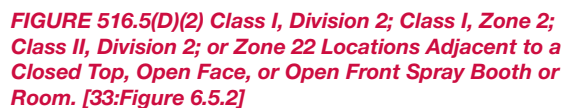


Figure 516.5(D)(1) Electrical Area Classification for Unenclosed Spray Areas. [33:Figure 6.5.1]

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(2) Luminaires, like that shown in Figure 516.6(C)(a), that are attached to the walls or ceiling of a spray area; that are separated from the spray area by glass panels and that are located within a Class I, Division 2; a Class I, Zone 2; a Class II, Division 2; or a Zone 22 location shall be suitable for such location. Such fixtures shall be serviced from outside the spray area. [33:6.6.2]

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(3) Luminaires, like that shown in Figure 516.6(C)(b), that are an integral part of the walls or ceiling of a spray area shall be permitted to be separated from the spray area by glass panels that are an integral part of the fixture. Such fixtures shall be listed for use in Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations, whichever is applicable, and also shall be listed for accumulations of deposits of combustible residues. Such fixtures shall be permitted to be serviced from inside the spray area. [33:6.6.3]

(4) Glass panels used to separate luminaires from the spray area or that are an integral part of the luminaire shall meet the following requirements.

- Panels for light fixtures or for observation shall be of heat-treated glass, laminated glass, wired glass, or hammered-wired glass and shall be sealed to confine vapors, mists, residues, dusts, and deposits to the spray area. [33:5.5.1]

Exception: Listed spray booth assemblies that have vision panels constructed of other materials shall be permitted.

- Panels for light fixtures shall be separated from the fixture to prevent the surface temperature of the panel from exceeding 93°C (200°F). [33:5.5.2]
- The panel frame and method of attachment shall be designed to not fail under fire exposure before the vision panel fails. [33:5.5.3]

(D) Portable Equipment. Portable electric luminaires or other utilization equipment shall not be used in a spray area during spray operations.

Exception No. 1: Where portable electric luminaires are required for operations in spaces not readily illuminated by fixed lighting within the spraying area, they shall be of the type identified for Class I, Division 1 or Class I, Zone 1 locations where readily ignitable residues may be present. [33:6.9 Exception]

Exception No. 2: Where portable electric drying apparatus is used in spray booths and the following requirements are met:

- The apparatus and its electrical connections are not located within the spray enclosure during spray operations.
- Electrical equipment within 450 mm (18 in.) of the floor is identified for Class I, Division 2 or Class I, Zone 2 locations.
- All metallic parts of the drying apparatus are electrically bonded and grounded.

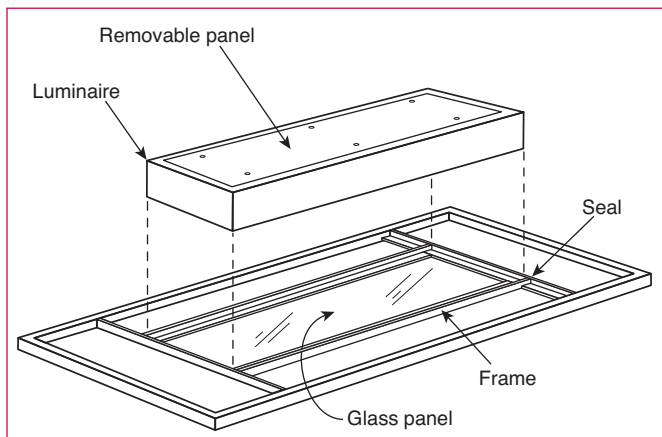


FIGURE 516.6(C)(a) Example of a Luminaire that is Mounted Outside of the Spray Area and is Serviced from Outside the Spray Area. [33:Figure 6.6.1]

(4) Interlocks are provided to prevent the operation of spray equipment while drying apparatus is within the spray enclosure, to allow for a 3-minute purge of the enclosure before energizing the drying apparatus and to shut off drying apparatus on failure of ventilation system.

(E) Electrostatic Equipment. Electrostatic spraying or detearing equipment shall be installed and used only as provided in 516.10.

Informational Note: For further information, see NFPA 33-2018 Standard for Spray Application Using Flammable or Combustible Materials.

(F) Static Electric Discharges. All persons and all electrically conductive objects, including any metal parts of the process equipment or apparatus, containers of material, exhaust ducts, and piping systems that convey flammable or combustible liquids, shall be electrically grounded. [34:6.8.1]

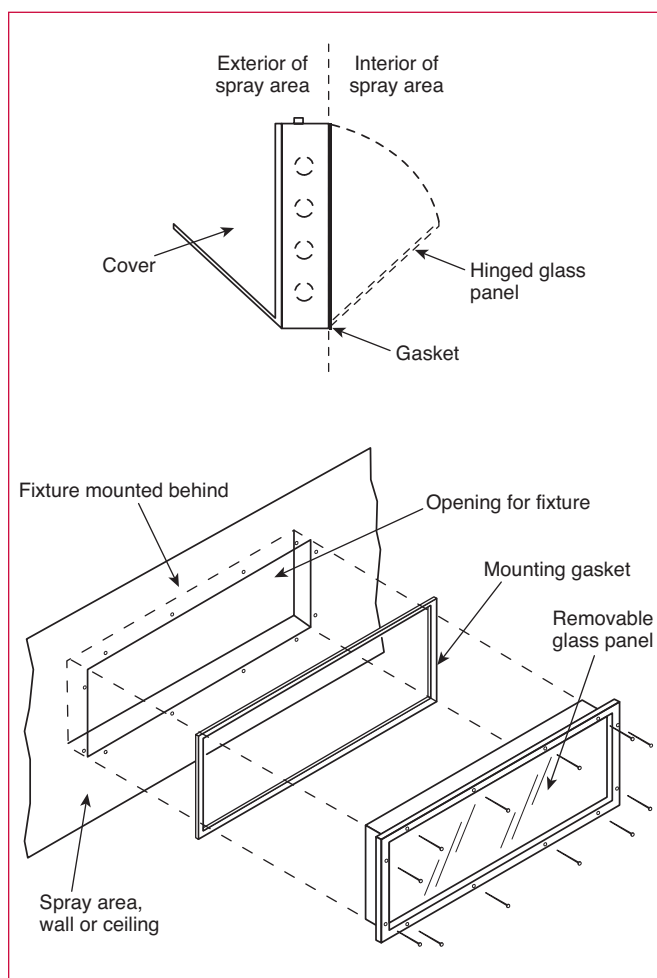


FIGURE 516.6(C)(b) Example of a Luminaire that is an Integral Part of the Spray Area and is Serviced from Inside the Spray Area. [33:Figure 6.6.3]

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516.7 Wiring and Equipment Not Within Classified Locations.

(A) Wiring. All fixed wiring above the Class I and II locations shall be in metal raceways, Type PVC conduit, Type RTRC conduit, or electrical nonmetallic tubing; where cables are used, they shall be Type MI, Type TC, or Type MC cable. Cellular metal floor raceways shall only be permitted to supply ceiling outlets or as extensions to the area below the floor of a Class I or II location. Where cellular metal raceways are used, they shall not have connections leading into or passing through the Class I or II location unless suitable seals are provided.

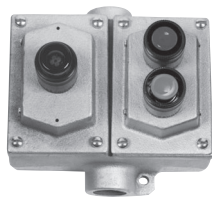
(B) Equipment. Equipment that could produce arcs, sparks, or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make-and-break or sliding contacts, where installed above a classified location or above a location where freshly finished goods are handled, shall be of the totally enclosed type or be constructed so as to prevent the escape of sparks or hot metal particles.



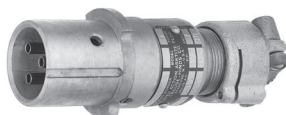
Pauluhn™ ZonePro
fluorescent luminaire



Hazard•Gard® XPLA series linear LED luminaire



EFS
pushbutton station and pilot light



CPH plug

516.10 Special Equipment.

(A) Fixed Electrostatic Equipment. This section shall apply to any equipment using electrostatically charged elements for the atomization, charging, and/or precipitation of hazardous materials for coatings on articles or for other similar purposes in which the charging or atomizing device is attached to a mechanical support or manipulator. This shall include robotic devices. This section shall not apply to devices that are held or manipulated by hand. Where robot or programming procedures involve manual manipulation of the robot arm while spraying with the high voltage on, the provisions of 516.10(B) shall apply. The installation of electrostatic spraying equipment shall comply with 516.10(A)(1) through (A)(10). Spray equipment shall be listed. All automatic electrostatic equipment systems shall comply with 516.6(A) through (F).

(1) Power and Control Equipment. Transformers, high-voltage supplies, control apparatus, and all other electrical portions of the equipment shall be installed outside of the Class I location or be of a type identified for the location.

Exception: High-voltage grids, electrodes, electrostatic atomizing heads, and their connections shall be permitted within the Class I location.

(2) Electrostatic Equipment. Electrodes and electrostatic atomizing heads shall be adequately supported in permanent locations and shall be effectively insulated from ground. Electrodes and electrostatic atomizing heads that are permanently attached to their bases, supports, reciprocators, or robots shall be deemed to comply with this section.

(3) High-Voltage Leads. High-voltage leads shall be properly insulated and protected from mechanical damage or exposure to destructive chemicals. Any exposed element at high voltage shall be effectively and permanently supported on suitable insulators and shall be effectively guarded against accidental contact or grounding.

(4) Support of Goods. Goods being coated using this process shall be supported on conveyors or hangers. The conveyors or hangers shall be arranged (1) to ensure that the parts being coated are electrically connected to ground with a resistance of 1 megohm or less and (2) to prevent parts from swinging.

(5) Automatic Controls. Electrostatic apparatus shall be equipped with automatic means that will rapidly de-energize the high-voltage elements under any of the following conditions:

- (1) Stoppage of ventilating fans or failure of ventilating equipment from any cause
- (2) Stoppage of the conveyor carrying goods through the high-voltage field unless stoppage is required by the spray process
- (3) Occurrence of excessive current leakage at any point in the high-voltage system
- (4) De-energizing the primary voltage input to the power supply

(6) Grounding. All electrically conductive objects in the spray area, except those objects required by the process to be at high voltage, shall be adequately grounded. This requirement shall apply to paint containers, wash cans, guards, hose connectors, brackets, and any other electrically conductive objects or devices in the area.

Informational Note: For more information on grounding and bonding for static electricity purposes, see NFPA 33-2018, Standard for Spray Application Using Flammable or Combustible Materials; NFPA 34-2018, Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids; and NFPA 77-2019, Recommended Practice on Static Electricity.

(7) Isolation. Safeguards such as adequate booths, fencing, railings, interlocks, or other means shall be placed about the equipment or incorporated therein so that they, either by their location, character, or both, ensure that a safe separation of the process is maintained.

(8) Signs. Signs shall be conspicuously posted to convey the following:

- (1) Designate the process zone as dangerous with regard to fire and accident
- (2) Identify the grounding requirements for all electrically conductive objects in the spray area
- (3) Restrict access to qualified personnel only

(9) Insulators. All insulators shall be kept clean and dry.

(10) Other Than Nonincendive Equipment. Spray equipment that cannot be classified as nonincendive shall comply with 516.10(A)(10)(a) and (A)(10)(b).

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(a) Conveyors, hangers, and application equipment shall be arranged so that a minimum separation of at least twice the sparking distance is maintained between the workpiece or material being sprayed and electrodes, electrostatic atomizing heads, or charged conductors. Warnings defining this safe distance shall be posted. [33:11.4.1]

(b) The equipment shall provide an automatic means of rapidly de-energizing the high-voltage elements in the event the distance between the goods being painted and the electrodes or electrostatic atomizing heads falls below that specified in 516.10(A)(10)(a). [33:11.3.8]

(B) Hand-Spraying Electrostatic Equipment. This section shall apply to any equipment using electrostatically charged elements for the atomization, charging, or precipitation of flammable and combustible materials for coatings on articles, or for other similar purposes in which the charging or atomizing device is hand-held and manipulated during the spraying operation. Electrostatic hand-spraying equipment and devices used in connection with paint-spraying operations shall be of listed types and shall comply with 516.10(B)(1) through (B)(5).

(1) General. The high-voltage circuits shall be designed so as not to produce a spark of sufficient intensity to ignite the most readily ignitable of those vapor-air mixtures likely to be encountered or result in appreciable shock hazard upon coming in contact with a grounded object under all normal operating conditions. The electrostatically charged exposed elements of the handgun shall be capable of being energized only by an actuator that also controls the coating material supply.

(2) Power Equipment. Transformers, power packs, control apparatus, and all other electrical portions of the equipment shall be located outside of the Class I location or be identified for the location.

Exception: The handgun itself and its connections to the power supply shall be permitted within the Class I location.

(3) Handle. The handle of the spraying gun shall be electrically connected to ground by a conductive material and be constructed so that the operator in normal operating position is in electrical contact with the grounded handle with a resistance of not more than 1 megohm to prevent buildup of a static charge on the operator's body. Signs indicating the necessity for grounding other persons entering the spray area shall be conspicuously posted.

(4) Electrostatic Equipment. All electrically conductive objects in the spraying area, except those objects required by the process to be at high voltage shall be electrically connected to ground with a resistance of not more than 1 megohm. This requirement shall apply to paint containers, wash cans, and any other electrical conductive objects or devices in the area. The equipment shall carry a prominent, permanently installed warning regarding the necessity for this grounding feature.

Informational Note: For more information on grounding and bonding for static electricity purposes, see NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*; NFPA 34-2018, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*; and NFPA 77-2019, *Recommended Practice on Static Electricity*.

(5) Support of Objects. Objects being painted shall be maintained in electrical contact with the conveyor or other grounded support. Hooks shall be regularly cleaned to ensure adequate grounding of 1 megohm or less. Areas of contact shall be sharp points or knife edges where possible. Points of support of the object shall be concealed from random spray where feasible, and, where the objects being sprayed are supported from a conveyor, the point of attachment to the conveyor shall be located so as to not collect spray material during normal operation.

(C) Powder Coating. This section shall apply to processes in which combustible dry powders are applied. The hazards associated with combustible dusts are present in such a process to a degree, depending on the chemical composition of the material, particle size, shape, and distribution.

(1) Electric Equipment and Sources of Ignition. Electrical equipment and other sources of ignition shall comply with the requirements of Article 502. Portable electric luminaires and other utilization equipment shall not be used within a Class II location during operation of the finishing processes. Where such luminaires or utilization equipment are used during cleaning or repairing operations, they shall be of a type identified for Class II, Division 1 locations, and all exposed metal parts shall be connected to an equipment grounding conductor.

Exception: Where portable electric luminaires are required for operations in spaces not readily illuminated by fixed lighting within the spraying area, they shall be of the type listed for Class II, Division 1 locations where readily ignitable residues may be present.

(2) Fixed Electrostatic Spraying Equipment. The provisions of 516.10(A) and 516.10(C)(1) shall apply to fixed electrostatic spraying equipment.

(3) Electrostatic Hand-Spraying Equipment. The provisions of 516.10(B) and 516.10(C)(1) shall apply to electrostatic hand-spraying equipment.

(4) Electrostatic Fluidized Beds. Electrostatic fluidized beds and associated equipment shall be of identified types. The high-voltage circuits shall be designed such that any discharge produced when the charging electrodes of the bed are approached or contacted by a grounded object shall not be of sufficient intensity to ignite any powder-air mixture likely to be encountered or to result in an appreciable shock hazard.

(a) Transformers, power packs, control apparatus, and all other electrical portions of the equipment shall be located outside the powder-coating area or shall otherwise comply with the requirements of 516.10(C)(1).

Exception: The charging electrodes and their connections to the power supply shall be permitted within the powder-coating area.

(b) All electrically conductive objects within the powder-coating area shall be adequately grounded. The powder-coating equipment shall carry a prominent, permanently installed warning regarding the necessity for grounding these objects.

Informational Note: For more information on grounding and bonding for static electricity purposes, see NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*; NFPA 34-2018, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*; and NFPA 77-2019, *Recommended Practice on Static Electricity*.

(c) Objects being coated shall be maintained in electrical contact (less than 1 megohm) with the conveyor or other support in order to ensure proper grounding. Hangers shall be regularly cleaned to ensure effective electrical contact. Areas of electrical contact shall be sharp points or knife edges where possible.

(d) The electrical equipment and compressed air supplies shall be interlocked with a ventilation system so that the equipment cannot be operated unless the ventilating fans are in operation. [33: Chapter 15]

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516.16 Grounding.

All metal raceways, the metal armors or metallic sheath on cables, and all non-current-carrying metal parts of fixed or portable electrical equipment, regardless of voltage, shall be grounded and bonded. Grounding and bonding shall comply with 501.30, 502.30, or 505.25, as applicable.

Part IV. Spray Application Operations in Membrane Enclosures

516.18 Area Classification for Temporary Membrane Enclosures.

Electrical area classification shall be as follows:

- (1) The area within the membrane enclosure shall be considered a Class I, Division 1 area, as shown in Figure 516.18.
- (2) A 1.5 m (5 ft) zone outside of the membrane enclosure shall be considered Class I, Division 2, as shown in Figure 516.18.

Informational Note No. 1: The risks to people and property are unique when spray painting within the confined spaces of temporary membrane enclosures. See NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*, for information on occupancy, ventilation, fire protection, and permitting for spray application operations in membrane enclosures. NFPA 33-2018 limits spray application operations within both outdoor and indoor temporary membrane enclosures, as well as use and time constraints.

Informational Note No. 2: Section 18.6 of NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*, limits material used in a vertical plane for membrane enclosures. See also NFPA 701-2019, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*, Test Method 2 for construction information.

Informational Note No. 3: See 18.3.2.1.1 of NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*, for membrane installation beneath sprinklers. See also 8.15.15 of NFPA 13-2019, *Standard for the Installation of Sprinkler Systems*, for protection of membrane structures.

516.23 Electrical and Other Sources of Ignition.

Electrical wiring and utilization equipment used within the classified areas inside and outside of membrane enclosures during spray painting shall be suitable for the location and shall comply with all of the following:

- (1) All power to the workpiece shall be removed during spray painting.
- (2) Workpieces shall be grounded.
- (3) Spray paint equipment shall be grounded.
- (4) Scaffolding shall be bonded to the workpiece and grounded by an approved method.

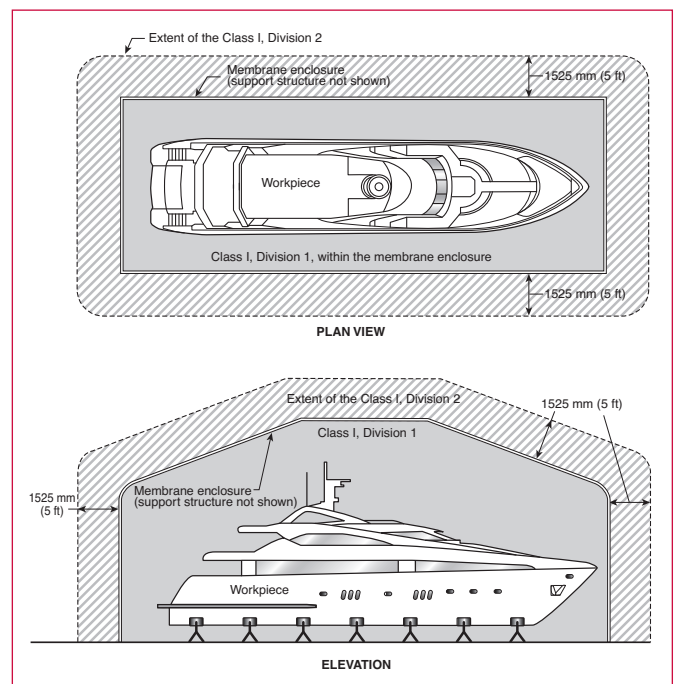


FIGURE 516.18 Electrical Classifications for Temporary Outdoor Membrane Enclosures. [33:Figure 18.7.1.1]

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Part V. Printing, Dipping, and Coating Processes

516.29 Classification of Locations.

Classification is based on quantities of flammable vapors, combustible mists, residues, dusts, or deposits that are present or might be present in quantities sufficient to produce ignitable or explosive mixtures with air. Electrical wiring and electrical utilization equipment located adjacent to open processes shall comply with the requirements as follows. Examples of these requirements are illustrated in Figure 516.29(a), Figure 516.29(b), Figure 516.29(c), and Figure 516.29(d).

Informational Note: For additional guidance, see Chapter 6 of NFPA 33-2018, *Standard for Spray Application Using Flammable or Combustible Materials*, and Chapter 6 of NFPA 34-2018, *Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*.

- (1) Electrical wiring and electrical utilization equipment located in any sump, pit, or below grade channel that is within 7620 mm (25 ft) horizontally of a vapor source, as defined by this standard, shall be suitable for Class I, Division 1 or Class I, Zone 1 locations. If the sump, pit, or channel extends beyond 7620 mm (25 ft) of the vapor source, it shall be provided with a vapor stop, or it shall be classified as Class I, Division 1 or Class I, Zone 1 for its entire length. [34:6.4.1]

- (2) Electrical wiring and electrical utilization equipment located within 1525 mm (5 ft) of a vapor source shall be suitable for Class I, Division 1 or Class I, Zone 1 locations. The space inside a dip tank, ink fountain, ink reservoir, or ink tank shall be classified as Class I, Division 1 or Class I, Zone 0, whichever is applicable.
- (3) Electrical wiring and electrical utilization equipment located within 915 mm (3 ft) of the Class I, Division 1 or Class I, Zone 1 location shall be suitable for Class I, Division 2 or Class I, Zone 2 locations, whichever is applicable.
- (4) The space 915 mm (3 ft) above the floor and extending 6100 mm (20 ft) horizontally in all directions from the Class I, Division 1 or Class I, Zone 1 location shall be classified as Class I, Division 2 or Class I, Zone 2, and electrical wiring and electrical utilization equipment located within this space shall be suitable for Class I, Division 2 or Class I, Zone 2 locations, whichever is applicable.
- (5) This space shall be permitted to be nonclassified for purposes of electrical installations if the surface area of the vapor source does not exceed 0.5 m² (5 ft²), the contents of the dip tank, ink fountain, ink reservoir, or ink tank do not exceed 19 L (5 gal), and the vapor concentration during operating and shutdown periods does not exceed 25 percent of the lower flammable limit.

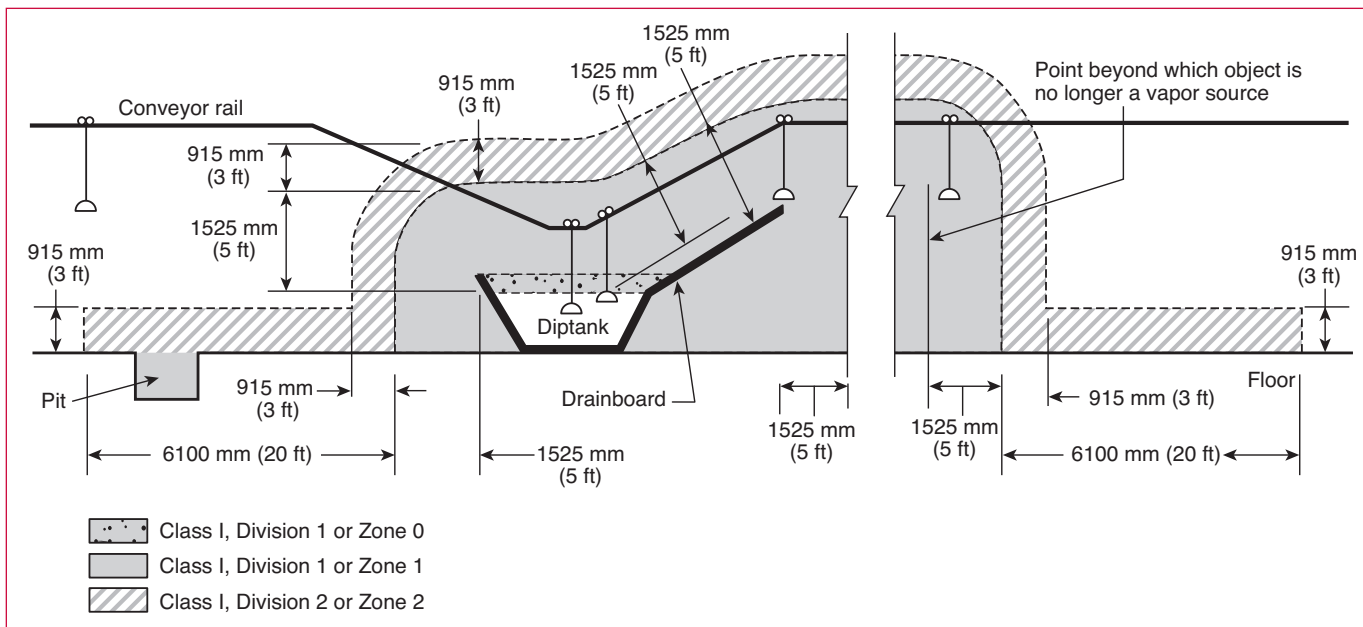


FIGURE 516.29(a) Electrical Area Classification for Open Dipping and Coating Processes Without Vapor Containment or Ventilation. [34:Figure 6.4(a)]

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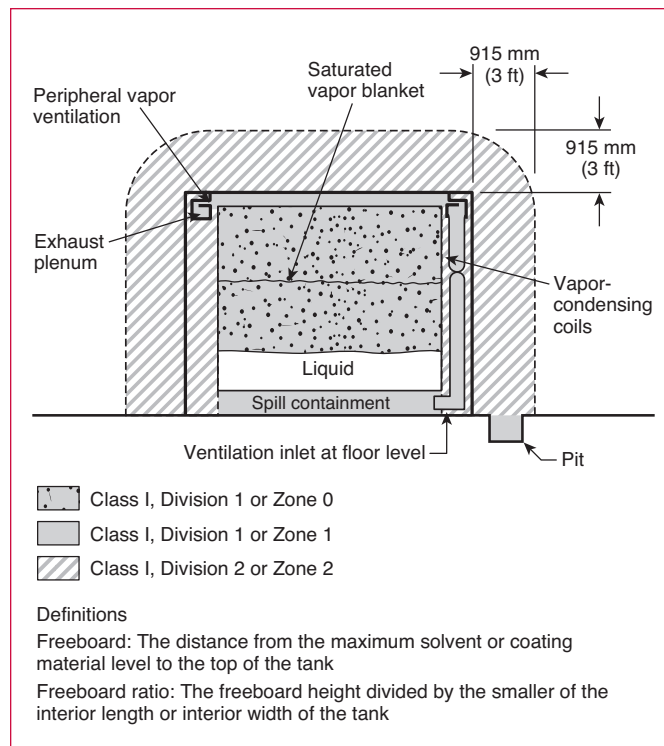


FIGURE 516.29(b) Electrical Area Classification for Open Dipping and Coating Processes with Peripheral Vapor Containment and Ventilation — Vapors Confined to Process Equipment. [34:Figure 6.4(b)]

516.35 Areas Adjacent to Enclosed Dipping and Coating Processes.

Areas adjacent to enclosed dipping and coating processes are illustrated by Figure 516.35 and shall be classified as follows:

- (1) The interior of any enclosed dipping or coating process or apparatus shall be a Class I, Division 1 or Class I, Zone 1 location, and electrical wiring and electrical utilization equipment located within this space shall be suitable for Class I, Division 1 or Class I, Zone 1 locations, whichever is applicable. The area inside the dip tank shall be classified as Class I, Division 1 or Class I, Zone 0, whichever is applicable.
- (2) The space within 915 mm (3 ft) in all directions from any opening in the enclosure and extending to the floor or grade level shall be classified as Class I, Division 2 or Class I, Zone 2, and electrical wiring and electrical utilization equipment located within this space shall be suitable for Class I, Division 2 locations or Class I, Zone 2 locations, whichever is applicable.
- (3) All other spaces adjacent to an enclosed dipping or coating process or apparatus shall be classified as nonhazardous for purposes of electrical installation.

516.36 Equipment and Containers in Ventilated Areas.

Open containers, supply containers, waste containers, and solvent distillation units that contain Class I liquids shall be located in areas ventilated in accordance with 516.4.

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516.37 Luminaires.

For printing, coating, and dipping equipment where the process area is enclosed by glass panels that are sealed to confine vapors and mists to the inside of the enclosure, luminaires that are attached to the walls or ceilings of a process enclosure and that are located outside of any classified area shall be permitted to be of general purpose construction. Such luminaires shall be serviced from outside the enclosure.

Luminaires that are attached to the walls or ceilings of a process enclosure, are located within the Class I, Division 2 or Class I, Zone 2 location, and are separated from the process area by glass panels that are sealed to confine vapors and mists shall be suitable for use in that location. Such fixtures shall be serviced from outside the enclosure.

516.38 Wiring and Equipment Not Within Classified Locations.

(A) Wiring. All fixed wiring above the Class I and II locations shall be in metal raceways, Type PVC conduit, Type RTRC conduit, or electrical nonmetallic tubing; where cables are used, they shall be Type MI, Type TC, or Type MC cable. Cellular metal floor raceways shall only be permitted to supply ceiling outlets or as extensions to the area below the floor of a Class I or II location. Where cellular metal raceways are used, they shall not have connections leading into or passing through the Class I or II location unless suitable seals are provided.

(B) Equipment. Equipment that is capable of producing arcs, sparks, or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make-and-break or sliding contacts, where installed above a classified location or above a location where freshly finished goods are handled, shall be of the totally enclosed type or be constructed so as to prevent the escape of sparks or hot metal particles.

516.40 Static Electric Discharges.

All persons and all electrically conductive objects, including any metal parts of the process equipment or apparatus, containers of material, exhaust ducts, and piping systems that convey flammable or combustible liquids, shall be electrically grounded.

Provision shall be made to dissipate static electric charges from all nonconductive substrates in printing processes.

Informational Note: For additional guidance on reducing the risk of ignition from electrostatic discharges, see NFPA 77-2019, *Recommended Practice on Static Electricity*.

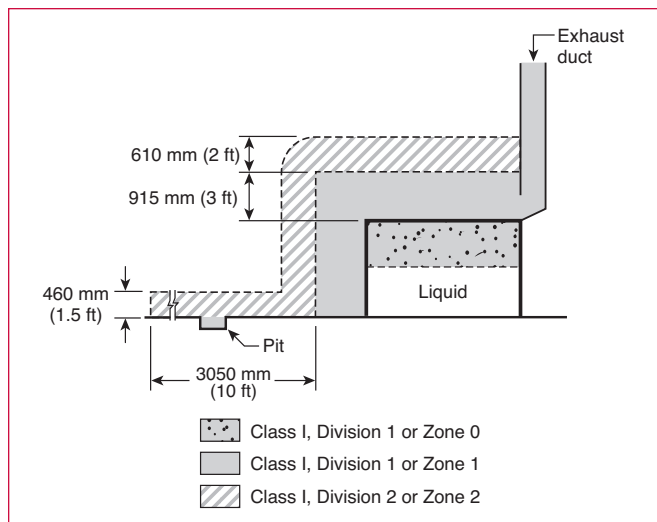


FIGURE 516.29(c) Electrical Area Classification for Open Dipping and Coating Processes with Partial Peripheral Vapor Containment and Ventilation – Vapors NOT Confined to Process Equipment. [34:Figure 6.4(c)]

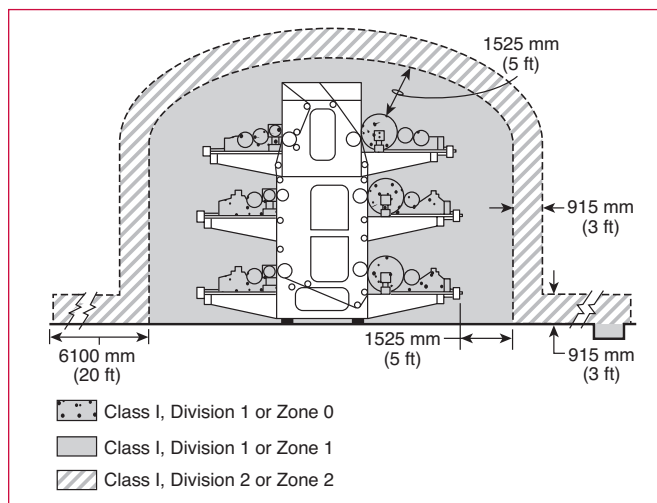


FIGURE 516.29(d) Electrical Area Classification for a Typical Printing Process. [34:Figure 6.4(d)]

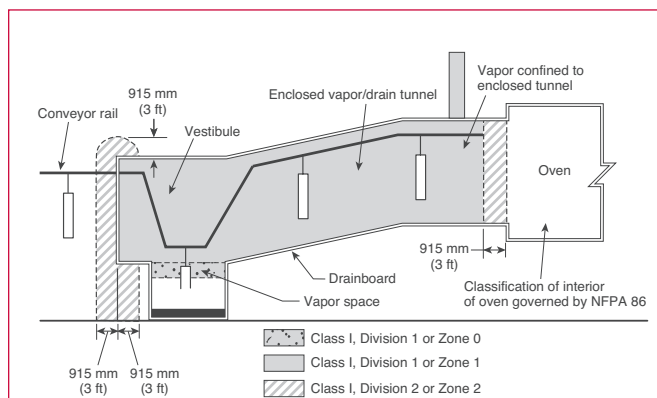


FIGURE 516.35 Electrical Area Classification Around Enclosed Dipping and Coating Processes. [34:Figure 6.5]

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Appendix I

Gases and Vapors Hazardous Substances Used in Business and Industry

Table I lists many compounds used in business and industry and shows the Class I groups, ignition temperatures, flash points, upper and lower flammable limits, and vapor densities. In order to determine the type of equipment needed for a particular location, it is first necessary to classify the gases and liquids used according to Article 500 or 505 of the *National Electrical Code*. The explosive atmospheres are divided into groups A, B, C, and D or IIC, IIB, and IIA according to the characteristics of the gas or vapor involved. In selecting a device, care should be used to make sure that it is suitable for the group or groups involved in the hazardous location. Substances not shown in this list should be discussed with inspection authorities before selecting equipment.

Devices suitable for use in Class I locations are not necessarily suitable for Classes II and III. Many of them are suitable, but if so, usually they are so listed. It is possible that a device suitable for Class I locations would, when blanketed by dust, overheat in a Class II location, or the presence of dust might interfere with safe operation in some other way. Devices listed for Class II have been investigated and found to be safe for use in atmospheres containing hazardous dusts. Care should be taken in selecting the correct equipment for each location.

The *Flash Point* of a liquid is the minimum temperature at which it gives off sufficient vapor to form an ignitable mixture with the air near the surface of the liquid or within the vessel used. *Ignitable mixture* means a mixture between the upper and lower flammable limits that is capable of the propagation of flame away from the source of ignition when ignited.

Propagation of Flame means the spread of flame from the source of ignition through a flammable mixture. A gas or vapor mixed with air in proportions below the lower flammable limit may burn at the source of ignition; that is, in the zone immediately surrounding the source of ignition, without propagating (spreading) away from the source of ignition. However, if the mixture is within the flammable range, the flame will spread through it when a source of ignition is supplied. The use of the term *flame propagation* is therefore convenient to distinguish between combustion which takes place only at the source of ignition and that which travels (propagates) through the mixture.

Some evaporation takes place below the flash point but not in sufficient quantities to form an ignitable mixture. This term applies mostly to flammable liquids, although there are certain solids, such as camphor and naphthalene, that slowly evaporate or volatilize at ordinary room temperature, or liquids such as benzene that freeze at relatively high temperatures and therefore have flash points while in the solid state.

The *Ignition Temperature* of a substance, whether solid, liquid, or gaseous, is the minimum temperature required to initiate or cause self-sustained combustion independently of the heating or heated element.

Ignition temperatures observed under one set of conditions may be changed substantially by a change of conditions. For this reason, ignition temperatures should be looked upon only as approximations. Some of the variables known to affect ignition temperatures are percentage composition of the vapor or gas-air mixture, shape and size of the space where the ignition occurs, rate and duration of heating, type and temperature of the ignition source, catalytic or other effect of materials that may be present, and oxygen concentration. As there are many differences in ignition temperature test methods, such as size and shape of containers, method of heating and ignition source, it is not surprising that ignition temperatures are affected by the test method.

The ignition temperature of a combustible solid is influenced by the rate of air flow, rate of heating, and size of the solid. Small sample tests have shown that as the rate of air flow or the rate of heating is increased, the ignition temperature of a solid drops to a minimum and then increases.

Flammable (Explosive) Limits. In the case of gases or vapors which form flammable mixtures with air or oxygen, there is a minimum concentration of vapor in air or oxygen below which propagation of flame does not occur on contact with a source of ignition. Gases and vapors may form flammable mixtures in atmospheres other than air or oxygen, as for example hydrogen in chlorine. There is also a maximum proportion of vapor or gas in air above which propagation of flame does not occur. These boundary-line mixtures of vapor or gas with air, which if ignited will just propagate flame, are known as the “lower and upper flammable limits,” and are usually expressed in terms of percentage by volume of gas or vapor in air.

In popular terms, a mixture below the lower flammable limit is too “lean” to burn or explode and a mixture above the upper flammable limit too “rich” to burn or explode.

The flammable limit figures given in the following Table I are based upon normal atmospheric temperatures and pressures, unless otherwise indicated. There may be considerable variation in flammable limits at pressures or temperatures above or below normal. The general effect of increase of temperature or pressure is to lower the lower limit and raise the upper limit. Decrease of temperature or pressure has the opposite effect.

Vapor Density. Vapor density is the weight of a volume of pure vapor or gas (with no air present) compared to the weight of an equal volume of dry air at the same temperature and pressure. It is calculated as the ratio of the molecular weight of the gas to the average molecular weight of air, 29. A vapor density figure less than 1 indicates that the vapor is lighter than air and will tend to rise in a relatively calm atmosphere. A figure greater than 1 indicates that the vapor is heavier than air and may travel at low levels for a considerable distance to a source of ignition and flash back (if the vapor is flammable).

Table II lists many of the combustible dusts commonly found in business and industry. The *NEC* subdivides these dusts into metal dusts which are Group E, carbonaceous dusts which are Group F, and other dusts which are Group G.

Note: For more information on the properties of flammable liquids and gases see *NFPA 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*. For more information on the properties of combustible dusts, see *NFPA 499, Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

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Appendix I

Gases and Vapors Hazardous Substances Used in Business and Industry

TABLE I

Class I* Group	Substance	Auto-Ignition Temp.*		Flash Point**		Flammable Limits** Percent by Volume		Vapor Density** (Air Equals 1.0)
		°F	°C	°F	°C	Lower	Upper	
C	Acetaldehyde	347	175	-38	-39	4.0	60	1.5
D	Acetic Acid	867	464	103	39	4.0	19.9 @ 200°F	2.1
D	Acetic Anhydride	600	316	120	49	2.7	10.3	3.5
D	Acetone	869	465	-4	-20	2.5	13	2.0
D	Acetone Cyanohydrin	1270	688	165	74	2.2	12.0	2.9
D	Acetonitrile	975	524	42	6	3.0	16.0	1.4
A	Acetylene	581	305	gas	gas	2.5	100	0.9
B(C)	Acrolein (inhibited) ¹	455	235	-15	-26	2.8	31.0	1.9
D	Acrylic Acid	820	438	122	50	2.4	8.0	2.5
D	Acrylonitrile	898	481	32	0	3.0	17	1.8
C	Adiponitrile	—	—	200	93	—	—	—
C	Allyl Alcohol	713	378	70	21	2.5	18.0	2.0
D	Allyl Chloride	905	485	-25	-32	2.9	11.1	2.6
B(C)	Allyl Glycidyl Ether ¹	—	—	—	—	—	—	—
D	Ammonia ²	928	498	gas	gas	15	28	0.6
D	n-Amyl Acetate	680	360	60	16	1.1	7.5	4.5
D	sec-Amyl Acetate	—	—	89	32	—	—	4.5
D	Aniline	1139	615	158	70	1.3	11	3.2
D	Benzene	928	498	12	-11	1.3	7.9	2.8
D	Benzyl Chloride	1085	585	153	67	1.1	—	4.4
B(D)	1,3-Butadiene ¹	788	420	gas	gas	2.0	12.0	1.9
D	Butane	550	288	-76	-60	1.6	8.4	2.0
D	1-Butanol	650	343	98	37	1.4	11.2	2.6
D	2-Butanol	761	405	75	24	1.7 @ 212°F	9.8 @ 212°F	2.6
D	n-Butyl Acetate	790	421	72	22	1.7	7.6	4.0
D	iso-Butyl Acetate	790	421	—	—	—	—	—
D	sec-Butyl Acetate	—	—	88	31	1.7	9.8	4.0
D	t-Butyl Acetate	—	—	—	—	—	—	—
D	n-Butyl Acrylate (inhibited)	559	293	118	48	1.5	9.9	4.4
C	n-Butyl Formal	—	—	—	—	—	—	—
B(C)	n-Butyl Glycidyl Ether ¹	—	—	—	—	—	—	—
C	Butyl Mercaptan	—	—	35	2	—	—	3.1
D	t-Butyl Toluene	—	—	—	—	—	—	—
D	Butylamine	594	312	10	-12	1.7	9.8	2.5
D	Butylene	725	385	gas	gas	1.6	10.0	1.9
C	n-Butyraldehyde	425	218	-8	-22	1.9	12.5	2.5
D	n-Butyric Acid	830	443	161	72	2.0	10.0	3.0
-3	Carbon Disulfide	194	90	-22	-30	1.3	50.0	2.6
C	Carbon Monoxide	1128	609	gas	gas	12.5	74.0	1.0
C	Chloroacetaldehyde	—	—	—	—	—	—	—
D	Chlorobenzene	1099	593	82	28	1.3	9.6	3.9
C	1-Chloro-1-Nitropropane	—	—	144	62	—	—	4.3
D	Chloroprene	—	—	-4	-20	4.0	20.0	3.0
D	Cresol	1038-1110	559-599	178-187	81-86	1.1-1.4	—	—
C	Crotonaldehyde	450	232	55	13	2.1	15.5	2.4
D	Cumene	795	424	96	36	0.9	6.5	4.1
D	Cyclohexane	473	245	-4	-20	1.3	8.0	2.9
D	Cyclohexanol	572	300	154	68	—	—	3.5
D	Cyclohexanone	473	245	111	44	1.1 @ 212°F	9.4	3.4
D	Cyclohexene	471	244	<20	<-7	—	—	2.8
D	Cyclopropane	938	503	gas	gas	2.4	10.4	1.5
D	p-Cymene	817	436	117	47	0.7 @ 212°F	5.6	4.6
C	n-Decaldehyde	—	—	—	—	—	—	—
D	n-Decanol	550	288	180	82	—	—	5.5
D	Decene	455	235	<131	<55	—	—	4.84
D	Diacetone Alcohol	1118	603	148	64	1.8	6.9	4.0
D	o-Dichlorobenzene	1198	647	151	66	2.2	9.2	5.1
D	1,1-Dichloroethane	820	438	22	-6	5.6	—	—
D	1,2-Dichloroethylene	860	460	36	2	5.6	12.8	3.4
C	1,1-Dichloro-1-Nitroethane	—	—	168	76	—	—	5.0
D	1,3-Dichloropropene	—	—	95	35	5.3	14.5	3.8
C	Dicyclopentadiene	937	503	90	32	—	—	—
D	Diethyl Benzene	743-842	395-450	133-135	56-57	—	—	4.6
C	Diethyl Ether	320	160	-49	-45	1.9	36.0	2.6
C	Diethylamine	594	312	-9	-23	1.8	10.1	2.5
C	Diethylaminoethanol	—	—	—	—	—	—	—
C	Diethylene Glycol Monobutyl Ether	442	228	172	78	0.85	24.6	5.6
C	Diethylene Glycol Monomethyl Ether	465	241	205	96	—	—	—
D	Di-isobutyl Ketone	745	396	120	49	0.8 @ 200°F	7.1 @ 200°F	4.9
D	Di-isobutylene	736	391	23	-5	0.8	4.8	3.9
C	Di-isopropylamine	600	316	30	-1	1.1	7.1	3.5
C	N-N-Dimethyl Aniline	700	371	145	63	—	—	4.2
D	Dimethyl Formamide	833	455	136	58	2.2 @ 212°F	15.2	2.5
D	Dimethyl Sulfate	370	188	182	83	—	—	4.4
C	Dimethylamine	752	400	gas	gas	2.8	14.4	1.6
C	1,4-Dioxane	356	180	54	12	2.0	22	3.0
D	Dipentene	458	237	113	45	0.7 @ 302°F	6.1 @ 302°F	4.7
C	Di-n-propylamine	570	299	63	17	—	—	3.5
C	Dipropylene Glycol Methyl Ether	—	—	186	86	—	—	5.11
D	Dodecene	491	255	—	—	—	—	—

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Gases and Vapors Hazardous Substances Used in Business and Industry

TABLE I

Class I* Group	Substance	Auto-Ignition Temp.*		Flash Point**		Flammable Limits** Percent by Volume		Vapor Density** (Air Equals 1.0)
		°F	°C	°F	°C	Lower	Upper	
C	Epichlorohydrin	772	411	88	31	3.8	21.0	3.2
D	Ethane	882	472	gas	gas	3.0	12.5	1.0
D	Ethanol	685	363	55	13	3.3	19	1.6
D	Ethyl Acetate	800	427	24	-4	2.0	11.5	3.0
D	Ethyl Acrylate (inhibited)	702	372	50	10	1.4	14	3.5
D	Ethyl sec-Amyl Ketone	—	—	—	—	—	—	—
D	Ethyl Benzene	810	432	70	21	0.8	6.7	3.7
D	Ethyl Butanol	—	—	—	—	—	—	—
D	Ethyl Butyl Ketone	—	—	115	46	—	—	4.0
D	Ethyl Chloride	966	519	-58	-50	3.8	15.4	2.2
D	Ethyl Formate	851	455	-4	-20	2.8	16.0	2.6
D	2-Ethyl Hexanol	448	231	164	73	0.88	9.7	4.5
D	2-Ethyl Hexyl Acrylate	485	252	180	82	—	—	—
C	Ethyl Mercaptan	572	300	<0	<-18	2.8	18.0	2.1
C	n-Ethyl Morpholine	—	—	—	—	—	—	—
C	2-Ethyl-3-Propyl Acrolein	—	—	155	68	—	—	4.4
D	Ethyl Silicate	—	—	125	52	—	—	7.2
D	Ethylamine	725	385	<0	<-18	3.5	14.0	1.6
C	Ethylene	842	450	gas	gas	2.7	36.0	1.0
D	Ethylene Chlorohydrin	797	425	140	60	4.9	15.9	2.8
D	Ethylene Dichloride	775	413	56	13	6.2	16	3.4
C	Ethylene Glycol Monobutyl Ether	460	238	143	62	1.1 @ 200°F	12.7 @ 275°F	4.1
C	Ethylene Glycol Monobutyl Ether Acetate	645	340	160	71	0.88 @ 200°F	8.54 @ 275°F	—
C	Ethylene Glycol Monoethyl Ether	455	235	110	43	1.7 @ 200°F	15.6 @ 200°F	3.0
C	Ethylene Glycol Monoethyl Ether Acetate	715	379	124	52	1.7	—	4.72
D	Ethylene Glycol Monomethyl ether	545	285	102	39	1.8 @ STP	14 @ STP	2.6
B(C)	Ethylene Oxide ¹	804	429	-20	-28	3.0	100	1.5
D	Ethylenediamine	725	385	104	40	2.5	12.0	2.1
C	Ethylenimine	608	320	12	-11	3.3	54.8	1.5
C	2-Ethylhexaldehyde	375	191	112	44	0.85 @ 200°F	7.2 @ 275°F	4.4
B	Formaldehyde (Gas)	795	429	gas	gas	7.0	73	1.0
D	Formic Acid (90%)	813	434	122	50	18	57	1.6
B	Fuel and Combustible Process Gas (containing more than 30 percent H ₂ by volume)	—	—	—	—	—	—	—
D	Fuel Oils	410-765	210-407	100-336	38-169	0.7	5	—
C	Furfural	600	316	140	60	2.1	19.3	3.3
C	Furfuryl Alcohol	915	490	167	75	1.8	16.3	3.4
D	Gasoline	536-880	280-471	-36 to -50	-38 to -46	1.2-1.5	7.1-7.6	3-4
D	Heptane	399	204	25	-4	1.05	6.7	3.5
D	Heptene	500	260	<32	<0	—	—	3.39
D	Hexane	437	225	-7	-22	1.1	7.5	3.0
D	Hexanol	—	—	145	63	—	—	3.5
D	2-Hexanone	795	424	77	25	—	8	3.5
D	Hexenes	473	245	<20	<-7	—	—	3.0
D	sec-Hexyl Acetate	—	—	—	—	—	—	—
C	Hydrazine	74-518	23-270	100	38	2.9	9.8	1.1
B	Hydrogen	968	520	gas	gas	4.0	75	0.1
C	Hydrogen Cyanide	1000	538	0	-18	5.6	40.0	0.9
C	Hydrogen Selenide	—	—	—	—	—	—	—
C	Hydrogen Sulfide	500	260	gas	gas	4.0	44.0	1.2
D	Isoamyl Acetate	680	360	77	25	1.0 @ 212°F	7.5	4.5
D	Isoamyl Alcohol	662	350	109	43	1.2	9.0 @ 212°F	3.0
D	Isobutyl Acrylate	800	427	86	30	—	—	4.42
C	Isobutyraldehyde	385	196	-1	-18	1.6	10.6	2.5
C	Isodecaldehyde	—	—	185	85	—	—	5.4
C	Iso-octyl Alcohol	—	—	180	82	—	—	—
C	Iso-octyl Aldehyde	387	197	—	—	—	—	—
D	Isophorone	860	460	184	84	0.8	3.8	—
D	Isoprene	428	220	-65	-54	1.5	8.9	2.4
D	Isopropyl Acetate	860	460	35	2	1.8 @ 100°F	8	3.5
D	Isopropyl Ether	830	443	-18	-28	1.4	7.9	3.5
C	Isopropyl Glycidyl Ether	—	—	—	—	—	—	—
D	Isopropylamine	756	402	-35	-37	—	—	2.0
D	Kerosene	410	210	110-162	43-72	0.7	5	—
D	Liquefied Petroleum Gas	761-842	405-450	—	—	—	—	—
	Manufactured Gas	—	—	—	—	—	—	—
	(see Fuel and Combustible Process Gas)	—	—	—	—	—	—	—
D	Mesityl Oxide	652	344	87	31	1.4	7.2	3.4
D	Methane	999	537	gas	gas	5.0	15.0	0.6
D	Methanol	725	385	52	11	6.0	36	1.1
D	Methyl Acetate	850	454	14	-10	3.1	16	2.8
D	Methyl Acrylate	875	468	27	-3	2.8	25	3.0
D	Methyl Amyl Alcohol	—	—	106	41	1.0	5.5	—
D	Methyl n-Amyl Ketone	740	393	102	39	1.1 @ 151°F	7.9 @ 250°F	3.9
C	Methyl Ether	662	350	gas	gas	3.4	27.0	1.6
D	Methyl Ethyl Ketone	759	404	16	-9	1.7 @ 200°F	11.4 @ 200°F	2.5
D	2-Methyl-5-Ethyl Pyridine	—	—	155	68	1.1	6.6	4.2
C	Methyl Formal	460	238	—	—	—	—	—
D	Methyl Formate	840	449	-2	-19	4.5	23	2.1
D	Methyl Isocyanate	994	534	19	-7	5.3	26	1.97
C	Methyl Mercaptan	—	—	—	—	3.9	21.8	1.7

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Gases and Vapors Hazardous Substances Used in Business and Industry

TABLE I

Class I* Group	Substance	Auto-Ignition Temp.*		Flash Point**		Flammable Limits** Percent by Volume		Vapor Density** (Air Equals 1.0)
		°F	°C	°F	°C	Lower	Upper	
D	Methyl Methacrylate	792	422	50	10	1.7	8.2	3.6
D	2-Methyl-1-Propanol	780	416	82	28	1.7 @ 123°F	10.6 @ 202°F	2.6
D	2-Methyl-2-Propanol	892	478	52	11	2.4	8.0	2.6
D	alpha-Methyl Styrene	1066	574	129	54	1.9	6.1	—
C	Methylacetylene	—	—	gas	gas	1.7	—	1.4
C	Methylacetylene-Propadiene (stabilized)	—	—	—	—	—	—	—
D	Methylamine	806	430	gas	gas	4.9	20.7	1.0
D	Methylcyclohexane	482	250	25	-4	1.2	6.7	3.4
D	Methylcyclohexanol	565	296	149	65	—	—	3.9
D	o-Methylcyclohexanone	—	—	118	48	—	—	3.9
D	Monoethanolamine	770	410	185	85	—	—	2.1
D	Monoisopropanolamine	705	374	171	77	—	—	2.6
C	Monomethyl Aniline	900	482	185	85	—	—	3.7
C	Monomethyl Hydrazine	382	194	17	-8	2.5	92	1.6
C	Morpholine	590	310	98	37	1.4	11.2	3.0
D	Naphtha (Coal Tar)	531	277	107	42	—	—	—
D	Naphtha (Petroleum) ⁴	550	288	<0	<-18	1.1	5.9	2.5
D	Nitrobenzene	900	482	190	88	1.8 @ 200°F	—	4.3
C	Nitroethane	778	414	82	28	3.4	—	2.6
C	Nitromethane	785	418	95	35	7.3	—	2.1
C	1-Nitropropane	789	421	96	36	2.2	—	3.1
C	2-Nitropropane	802	428	75	24	2.6	11.0	3.1
D	Nonane	401	205	88	31	0.8	2.9	4.4
D	Nonene	—	—	78	26	—	—	4.35
D	Nonyl Alcohol	—	—	165	74	0.8 @ 212°F	6.1 @ 212°F	5.0
D	Octane	403	206	56	13	1.0	6.5	3.9
D	Octene	446	230	70	21	—	—	3.9
D	n-Octyl Alcohol	—	—	178	81	—	—	4.5
D	Pentane	470	243	<-40	<-40	1.5	7.8	2.5
D	1-Pentanol	572	300	91	33	1.2	10.0 @ 212°F	3.0
D	2-Pentanone	846	452	45	7	1.5	8.2	3.0
D	1-Pentene	527	275	0	-18	1.5	8.7	2.4
D	Phenylhydrazine	—	—	190	88	—	—	—
D	Propane	842	450	gas	gas	2.1	9.5	1.6
D	1-Propanol	775	413	74	23	2.2	13.7	2.1
D	2-Propanol	750	399	53	12	2.0	12.7 @ 200°F	2.1
D	Propiolactone	—	—	165	74	2.9	—	2.5
C	Propionaldehyde	405	207	-22	-30	2.6	17	2.0
D	Propionic Acid	870	466	126	52	2.9	12.1	2.5
D	Propionic Anhydride	545	285	145	63	1.3	9.5	4.5
D	n-Propyl Acetate	842	450	55	13	1.7 @ 100°F	8	3.5
C	n-Propyl Ether	419	215	70	21	1.3	7.0	3.53
B	Propyl Nitrate	347	175	68	20	2	100	—
D	Propylene	851	455	gas	gas	2.0	11.1	1.5
D	Propylene Dichloride	1035	557	60	16	3.4	14.5	3.9
B(C)	Propylene Oxide ¹	840	449	-35	-37	2.3	36	2.0
D	Pyridine	900	482	68	20	1.8	12.4	2.7
D	Styrene	914	490	88	31	0.9	6.8	3.6
C	Tetrahydrofuran	610	321	6	-14	2.0	11.8	2.5
D	Tetrahydronaphthalene	725	385	160	71	0.8 @ 212°F	5.0 @ 302°F	4.6
C	Tetramethyl Lead	—	—	100	38	—	—	6.5
D	Toluene	896	480	40	4	1.1	7.1	3.1
D	Tridecene	—	—	—	—	—	—	—
C	Triethylamine	480**	249**	16	-9	1.2	8.0	3.5
D	Triethylbenzene	—	—	181	83	—	—	5.6
D	Tripropylamine	—	—	105	41	—	—	4.9
D	Turpentine	488	253	95	35	0.8	—	—
D	Undecene	—	—	—	—	—	—	—
C	Unsymmetrical Dimethyl Hydrazine (UDMH)	480	249	5	-15	2	95	2.0
C	Valeraldehyde	432	222	54	12	—	—	3.0
D	Vinyl Acetate	756	402	18	-8	2.6	13.4	3.0
D	Vinyl Chloride	882	472	-108.4	-78	3.6	33.0	2.2
D	Vinyl Toluene	921	494	127	53	0.8	11.0	4.1
D	Vinylidene Chloride	1058	570	-19	-28	6.5	15.5	3.4
D	Xylenes	867-984	464-529	81-90	27-32	1.0-1.1	7.0	3.7

¹If equipment is isolated by sealing all conduit 1/2 in. or larger, in accordance with Section 501.15(A) of NFPA 70, *National Electrical Code*, equipment for the group classification shown in parentheses is permitted.

²For classification of areas involving Ammonia, see *Safety Code for Mechanical Refrigeration*, ANSI/ASHRAE 15, and *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*, ANSI/CGA G2.1.

³Certain chemicals may have characteristics that require safeguards beyond those required for any of the above groups. Carbon disulfide is one of these chemicals because of its low autoignition temperature and the small joint clearance to arrest its flame propagation.

⁴Petroleum Naphtha is a saturated hydrocarbon mixture whose boiling range is 20° to 135°C. It is also known as benzine, ligroin, petroleum ether, and naphtha.

*Data from NFPA 497 - 2004, *Recommended Practice for the Classification of Flammable Liquids, Gases, Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

**Data from NFPA 325M-1991, *Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*.

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Appendix II

Dusts Hazardous Substances Used in Business and Industry

TABLE II

Class II, Group E

	Minimum Cloud or Layer Ignition Temp. ¹	
	°F	°C
Aluminum, atomized collector fines	1022	CI 550
Aluminum, A422 flake	608	320
Aluminum — cobalt alloy (60-40)	1058	570
Aluminum — copper alloy (50-50)	1526	830
Aluminum — lithium alloy (15% Li)	752	400
Aluminum — magnesium alloy (Dowmetal)	806	CI 430
Aluminum — nickel alloy (58-42)	1004	540
Aluminum — silicon alloy (12% Si)	1238	NL 670
Boron, commercial-amorphous (85% B)	752	400
Calcium Silicide	1004	540
Chromium, (97%) electrolytic, milled	752	400
Ferromanganese, medium carbon	554	290
Ferrosilicon (88%, 9% Fe)	1472	800
Ferrotitanium (19% Ti, 74.1% Fe, 0.06% C)	698	CI 370
Iron, 98%, H ₂ reduced	554	290
Iron, 99%, Carbonyl	590	310
Magnesium, Grade B, milled	806	430
Manganese	464	240
Silicon, 96%, milled	1436	CI 780
Tantalum	572	300
Thorium, 1.2%, O ₂	518	CI 270
Tin, 96%, atomized (2% Pb)	806	430
Titanium, 99%	626	CI 330
Titanium Hydride, (95% Ti, 3.8% H ₂)	896	CI 480
Vanadium, 86.4%	914	490
Zirconium Hydride, (93.6% Zr, 2.1% H ₂)	518	270

Class II, Group F

CARBONACEOUS DUSTS

Asphalt, (Blown Petroleum Resin)	950	CI 510
Charcoal	356	180
Coal, Kentucky Bituminous	356	180
Coal, Pittsburgh Experimental	338	170
Coal, Wyoming	—	—
Gilsonite	932	500
Lignite, California	356	180
Pitch, Coal Tar	1310	NL 710
Pitch, Petroleum	1166	NL 630
Shale, Oil	—	—

Class II, Group G

AGRICULTURAL DUSTS

Alfalfa Meal	392	200
Almond Shell	392	200
Apricot Pit	446	203
Cellulose	500	260
Cherry Pit	428	220
Cinnamon	446	230
Citrus Peel	518	270
Cocoa Bean Shell	698	370
Cocoa, natural, 19% fat	464	240
Coconut Shell	428	220
Corn	482	250
Corn cob Grit	464	240
Corn Dextrine	698	370
Cornstarch, commercial	626	330
Cornstarch, modified	392	200
Cork	410	210
Cottonseed Meal	392	200
Cube Root, South Amer.	446	230
Flax Shive	446	230
Garlic, dehydrated	680	NL 360
Guar Seed	932	NL 500
Gum, Arabic	500	260
Gum, Karaya	464	240
Gum, Manila (copal)	680	CI 360
Gum, Tragacanth	500	260
Hemp Hurd	428	220

TABLE II

Class II, Group G

	Minimum Cloud or Layer Ignition Temp. ¹	
	°F	°C
Lycopodium	590	310
Malt Barley	482	250
Milk, Skimmed	392	200
Pea Flour	500	260
Peach Pit Shell	410	210
Peanut Hull	410	210
Peat, Sphagnum	464	240
Pecan Nut Shell	410	210
Pectin	392	200
Potato Starch, Dextrinated	824	NL 440
Pyrethrum	410	210
Rauwolfia Vomitoria Root	446	230
Rice	428	220
Rice Bran	914	NL 490
Rice Hull	428	220
Safflower Meal	410	210
Soy Flour	374	190
Soy Protein	500	260
Sucrose	662	CI 350
Sugar, Powdered	698	CI 370
Tung, Kernels, Oil-Free	464	240
Walnut Shell, Black	428	220
Wheat	428	220
Wheat Flour	680	360
Wheat Gluten, gum	968	NL 520
Wheat Starch	716	NL 380
Wheat Straw	428	220
Woodbark, Ground	482	250
Wood Flour	500	260
Yeast, Torula	500	260

CHEMICALS

Acetoacetanilide	824	M 440
Acetoacet-p-phenetidine	1040	NL 506
Adipic Acid	1022	M 550
Anthranilic Acid	1076	M 580
Aryl-nitrosomethylamide	914	NL 490
Azelaic Acid	1130	M 610
2,2-Azo-bis-butyronitrile	662	350
Benzoic Acid	824	M 440
Benzotriazole	824	M 440
Bisphenol-A	1058	M 570
Chloroacetoacetanilide	1184	M 640
Diallyl Phthalate	896	M 480
Dicumyl Peroxide (suspended on CaCO ₃), 40-60	356	180
Dicyclopentadiene Dioxide	788	NL 420
Dihydroacetic Acid	806	NL 430
Dimethyl Isophthalate	1076	M 580
Dimethyl Terephthalate	1058	M 570
3,5 - Dinitrobenzoic Acid	860	NL 460
Dinitrotoluamide	932	NL 500
Diphenyl	1166	M 630
Ditertiary Butyl Paracresol	878	NL 470
Ethyl Hydroxyethyl Cellulose	734	NL 390
Fumaric Acid	968	M 520
Hexamethylene Tetramine	770	S 410
Hydroxyethyl Cellulose	770	NL 410
Isotoic Anhydride	1292	NL 700
Methionine	680	360
Nitrosoamine	518	NL 270
Para-oxy-benzaldehyde	716	CI 380
Paraphenylene Diamine	1148	M 620
Paratertiary Butyl Benzoic Acid	1040	M 560
Pentaerythritol	752	M 400
Phenylbetanaphthylamine	1256	NL 680
Phthalic Anhydride	1202	M 650
Phthalimide	1166	M 630
Salicylanilide	1130	M 610

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Appendix II

Dusts Hazardous Substances Used in Business and Industry

TABLE II

Class II, Group G

	°F	°C
Sorbic Acid	860	460
Stearic Acid, Aluminum Salt	572	300
Stearic Acid, Zinc Salt	950 M	510
Sulfur	428	220
Terephthalic Acid	1256 NL	680

DRUGS

2-Acetylaminio-5-nitrothiazole	842	450
2-Amino-5-nitrothiazole	860	460
Aspirin	1220 M	660
Gulasonic Acid, Diacetone	788 NL	420
Mannitol	860 M	460
Nitrotyridone	806 M	430
1-Sorbose	698 M	370
Vitamin B1, mononitrate	680 NL	360
Vitamin C (Ascorbic Acid)	536	280

DYES, PIGMENTS, INTERMEDIATES

Beta-naphthalene-azo-Dimethylaniline	347	175
Green Base Harmon Dye	347	175
Red Dye Intermediate	347	175
Violet 200 Dye	347	175

PESTICIDES

Benzethonium Chloride	716 CI	380
Bis(2-Hydroxy-5-chlorophenyl) methane	1058 NL	570
Crag No. 974	590 CI	310
Dieldrin (20%)	1022 NL	550
2, 6-Ditertiary-butyl-paracresol	788 NL	420
Dithane	356	180
Ferbam	302	150
Manganese Vancide	2448	120
Sevin	284	140
∞ ∞ - Trithiobis (N,N-Dimethylthio-formamide)	446	230

THERMOPLASTIC RESINS AND MOLDING COMPOUNDS

<u>Acetal Resins</u>		
Acetal, Linear (Polyformaldehyde)	824 NL	440
<u>Acrylic Resins</u>		
Acrylamide Polymer	464	240
Acrylonitrile Polymer	860	460
Acrylonitrile-Vinyl Pyridine Copolymer	464	240
Acrylonitrile-Vinyl Chloride-Vinylidene Chloride Copolymer (70-20-10)	410	210
Methyl Methacrylate Polymer	824 NL	440
Methyl Methacrylate-Ethyl Acrylate Copolymer	896 NL	408
Methyl Methacrylate-Ethyl Acrylate-Styrene Copolymer	824 NL	440
Methyl Methacrylate-Styrene-Butadiene-Acrylonitrile Copolymer	896 NL	480
Methacrylic Acid Polymer	554	290
<u>Cellulosic Resins</u>		
Cellulose Acetate	644	340
Cellulose Triacetate	806 NL	430
Cellulose Acetate Butyrate	698 NL	370
Cellulose Propionate	860 NL	460
Ethyl Cellulose	608 CI	320
Methyl Cellulose	644	340

¹Normally, the minimum ignition temperature of a layer of a specific dust is lower than the minimum ignition temperature of a cloud of that dust. Since this is not universally true, the lower of the two minimum ignition temperatures is listed. If no symbol appears between the two temperature columns, then the layer ignition temperature is shown. "CI" means the cloud ignition temperature is shown. "NL" means that no layer ignition temperature is available and the cloud ignition temperature is shown. "M" signifies that the dust layer melts before it ignites; the cloud ignition temperature is shown. "S" signifies that the dust layer sublimates before it ignites; the cloud ignition temperature is shown.

²Certain metal dusts may have characteristics that require safe-guards beyond those required for atmospheres containing the dusts of aluminum, magnesium, and their commercial alloys. For example, zirconium, thorium, and uranium dusts have extremely low ignition temperatures (as low as 20°C) and minimum ignition energies lower than any material classified in any of the Class I or Class II groups.

Data from NFPA 499 - 2004, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

TABLE II

Class II, Group G

	°F	°C
Carboxymethyl Cellulose	554	290
Hydroxyethyl Cellulose	644	340
<u>Chlorinated Polyether Resins</u>		
Chlorinated Polyether Alcohol	806	460
<u>Nylon (Polyamide) Resins</u>		
Nylon Polymer (Polyhexa-methylene Adipamide)	806	430
<u>Polycarbonate Resins</u>		
Polycarbonate	1310 NL	710
<u>Polyethylene Resins</u>		
Polyethylene, High Pressure Process	716	380
Polyethylene, Low Pressure Process	788 NL	420
Polyethylene Wax	752 NL	400
<u>Polymethylene Resins</u>		
Carboxypolymethylene	968 NL	520
<u>Polypropylene Resins</u>		
Polypropylene (No Antioxidant)	788 NL	420
<u>Rayon Resins</u>		
Rayon (Viscose) Flock	482	250
<u>Styrene Resins</u>		
Polystyrene Molding Compd.	1040 NL	560
Polystyrene Latex	932	500
Styrene-Acrylonitrile (70-30)	932 NL	500
Styrene-Butadiene Latex (>75% Styrene; Alum Coagulated)	824 NL	440
<u>Vinyl Resins</u>		
Polyvinyl Acetate	1022 NL	550
Polyvinyl Acetate/Alcohol	824	440
Polyvinyl Butyral	734 NL	390
Vinyl Chloride-Acrylonitrile Copolymer	878	470
Polyvinyl Chloride-Dioctyl Phthalate Mixture	608 NL	320
Vinyl Toluene-Acrylonitrile Butadiene Copolymer	936 NL	530

THERMOSETTING RESINS AND MOLDING COMPOUNDS

<u>Allyl Resins</u>		
Allyl Alcohol Derivative (CR-39)	932 NL	500
<u>Amino Resins</u>		
Urea Formaldehyde Molding Compound	860 NL	460
Urea Formaldehyde-Phenol Formaldehyde Molding Compound (Wood Flour Filler)	464	240
<u>Epoxy Resins</u>		
Epoxy	1004 NL	540
Epoxy - Bisphenol A	950 NL	510
Phenol Furfural	590	310
<u>Phenolic Resins</u>		
Phenol Formaldehyde	1076 NL	580
Phenol Formaldehyde Molding Compd. (Wood Flour Filler)	932 NL	500
Phenol Formaldehyde, Polyalkylene-Polyamine Modified	554	290
<u>Polyester Resins</u>		
Polyethylene Terephthalate	1076 NL	580
Styrene Modified Polyester-Glass Fiber Mixture	680	360
<u>Polyurethane Resins</u>		
Polyurethane Foam, No Fire Retardant	824	440
Polyurethane Foam, Fire Retardant	734	390

SPECIAL RESINS AND MOLDING COMPOUNDS

Alkyl Ketone Dimer Sizing Compound	320	160
Cashew Oil, Phenolic, Hard	356	180
Chlorinated Phenol	1058 NL	570
Coumarone-Indene, Hard	968 NL	520
Ethylene Oxide Polymer	662 NL	350
Ethylene-Maleic Anhydride Copolymer	1004 NL	540
Lignin, Hydrolyzed, Wood-Type, Fines	842 NL	450
Petrin Acrylate Monomer	428 NL	220
Petroleum Resin (Blown Asphalt)	932	500
Rosin, DK	734 NL	390
Rubber, Crude, Hard	662 NL	350
Rubber, Synthetic, Hard (33% S)	608 NL	320
Shellac	752 NL	400
Sodium Resinate	428	220
Styrene — Maleic Anhydride Copolymer	878 CI	470

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Appendix III

Selection of Seals and Drains

A. Need for Seals and Drains.

1. Seals

EYS and EZS sealing fittings:

- minimizes the passage of gases, vapors, or flames from one portion of the electrical installation to another at atmospheric pressure and normal ambient temperatures.
- limit explosions to the sealed-off enclosure.
- prevent precompression or “pressure piling” in conduit systems.

While not an *NEC* requirement, many engineers consider it good practice to sectionalize long conduit runs by inserting seals not more than 50 to 100 feet apart, depending on the conduit size, to minimize the effects of “pressure piling.”

Sealing fittings are required:

- at each entrance to an enclosure housing an arcing or sparking device when used in Class I, Division 1 and 2 hazardous locations. To be located as close as practicable and, in no case, more than 18" from such enclosures. The enclosure and the enclosure's installation instructions may specify a distance less than 18".
- at each entrance of 2" size or larger to an enclosure or fitting housing terminals, splices, or taps when used in Class I, Division 1 hazardous locations. To be located as close as practicable and, in no case, more than 18" from such enclosures.
- in conduit systems when leaving the Class I, Division 1 or Division 2 hazardous locations.
- where cables terminate at enclosures that are required to be explosionproof.
- where cables leave Class I, Division 1 locations and where they leave a Class I, Division 2 location if they are attached to process equipment that may cause a pressure of over 6 in. of water to be exerted on a cable end.

The *NEC* in Section 502.15 requires seals in Class II locations under certain conditions. Eaton's Crouse-Hinds sealing fittings can be used to meet this requirement, although there are other acceptable methods.

2. Drains

In humid atmospheres or in wet locations, where it is likely that water can gain entrance to the interiors of enclosures or raceways, the raceways should be inclined so that water will not collect in enclosures or on seals but will be led to low points where it may pass out through ECD drains.

Frequently the arrangement of raceway runs makes this method impractical if not impossible. In such instances Type EZD drain seal fittings should be used. These fittings prevent harmful accumulations of water above the seal. See Section 501.15(F).

In locations which usually are considered dry, surprising amounts of water frequently collect in conduit systems. No conduit system is airtight; therefore, it may “breathe.” Alternate increases and decreases in temperature and/or barometric pressure due to weather changes or due to the nature of the process carried on in the location where the conduit is installed will cause “breathing.”

Outside air is drawn into the conduit system when it “breathes” in. If this air carries sufficient moisture it will be condensed within the system when the temperature decreases and chills this air. The internal conditions being unfavorable to evaporation, the resultant water accumulation will remain and be added to by repetitions of the breathing cycle.

In view of this likelihood, it is good practice to insure against such water accumulations and probable subsequent insulation failures by

installing EZD with drain cover or EZD with inspection cover even though conditions prevailing at the time of planning or installing do not indicate their need.

B. Selection of Seals and Drains.

1. Primary Considerations

(a) Select the proper sealing fitting for the hazardous vapor involved; i.e., Class I, Groups A, B, C, or D.

(b) Select a sealing fitting for the proper use with respect to mounting position. This is particularly critical when the conduit runs between hazardous and nonhazardous areas. Improper positioning of a seal may permit hazardous gases or vapors to enter the system beyond the seal, and permit them to escape into another portion of the hazardous area, or to enter a nonhazardous area. Some seals are designed to be mounted in any position; others are restricted to horizontal or vertical mounting.

(c) Install the seals on the proper side of the partition or wall as recommended by the manufacturer. See “Installation Diagram for Sealing” in Appendix IV.

(d) Installation of seals should be made only by trained personnel in strict compliance with the instruction sheets furnished with the seals and sealing compound.

Therefore, it would be wise to incorporate precautionary notes on installation diagrams to stress the importance of following instructions. See “Sealing Compound and Dams” in this Appendix.

(e) It should be noted that Section 501.15(C)(4) prohibits splices or taps in sealing fittings.

(f) Eaton's Crouse-Hinds sealing fittings are listed by UL LLC for use in Class I hazardous locations with Eaton's Crouse-Hinds sealing compounds only, both CHICO A and CHICO Speedseal. These compounds, when properly mixed and poured, harden into a dense, strong mass which is insoluble in water, is not attacked by chemicals, and is not softened by heat. It will withstand with ample safety factor, pressure of the exploding trapped gases or vapor.

(g) Conductors sealed in the compound may be approved thermoplastic or rubber insulated type. Both may or may not be lead covered. (The lead need not be removed.) Caution: CHICO A and CHICO SpeedSeal are not electrically insulating compounds; therefore, they should not be so used.

2. Types of Sealing Fittings

The following sealing fittings meet the requirements of the *NEC* when properly installed.

(a) EYS Sealing Fittings

One style of EYS sealing fittings are for use with vertical or nearly vertical conduit in sizes from 1/2" through 1".

Other styles are available in sizes 1/2" through 6" for use in vertical or horizontal conduits. In horizontal runs, these are limited to face up openings.

Sizes from 1-1/4" through 6" have extra large work openings, and separate filling holes, so that CHICO X fiber dams are easy to make. Overall diameter of sizes 1-1/4" through 6" is scarcely greater than that of unions of corresponding sizes, permitting close conduit spacings.

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Appendix III

Selection of Seals and Drains

(b) EZS Sealing Fittings

EZS seals are for use with conduit running at any angle, from vertical through horizontal.

(c) EYD Drain Seal Fittings

EYD drain seals provide continuous draining and thereby prevent water accumulation. EYD seals are for vertical conduit runs and range in size from 1/2" to 4" inclusive.

They are provided with one opening for draining and one for filling, a rubber tube to form drain passage and an ECD drain fitting.

(d) EZD with Drain/Inspection Cover

EZD drain seals provide continuous draining and thereby prevent water accumulation.

The covers should be positioned so that the drain will be at the bottom. A set screw is provided for locking the cover in this position.

EZD fittings are suitable for sealing vertical conduit runs between hazardous and nonhazardous areas, but must be installed in the hazardous area when it is above the nonhazardous area. They must be installed in the nonhazardous area when it is above the hazardous area. Otherwise, the drain might communicate gases or vapors from the hazardous area into a portion of the conduit system in the nonhazardous area, a very unsafe situation. This applies to any drain seal.

EZD drain/inspection seals are designed so that the covers can be removed readily, permitting inspection during installation or at any time thereafter. After the fittings have been installed in the conduit run and conductors are in place, the cover and barrier are removed. After the dam has been made in lower hub opening with CHICO® X fiber the barrier must be replaced before the CHICO A sealing compound can be poured into the sealing chamber.

(e) EYSR Retrofit seals

Eaton's Crouse-Hinds EYSR Retrofit Sealing Fittings offer a low-cost solution to replacing installed Eaton's Crouse-Hinds EYS and EYD sealing fittings during the rewiring or expansion of an electrical system.

The EYSR allows rewiring or expanding an electrical system without disassembling the conduit system, reducing labor costs and downtime.

Made of Feraloy® iron alloy or optional copper-free aluminum, the EYSR is available in 3/4" to 4" NPT sizes, and is CSA certified for use in Class I, Division 2 hazardous (classified) locations.

C. Sealing Compound and Dams.

Conduit seals should be made *only* by trained personnel in strict compliance with the specific instruction sheets provided with each sealing fitting. Improperly made seals are worthless.

Eaton's Crouse-Hinds CHICO® A and CHICO SpeedSeal sealing compounds are the only sealing compounds approved for use with Eaton's Crouse-Hinds sealing fittings.

Following the procedures and precautions outlined below, and the specific instructions packed with each sealing fitting, "CHICO A" and CHICO SpeedSeal will provide seals that do their intended job: namely, restrict the passage of gases, vapors, or flames from one part of the electrical system to another at atmospheric pressure and normal ambient temperatures.

1. Dams

The first requirement for pouring a high quality CHICO A seal is a well made dam. Improperly packed or weak dams permit a loss of compound into conduit systems, which both wastes compound and makes an unsafe seal.

(a) When damming horizontal seals, prepare a dam in each conduit hub except the upper hub of vertical seals.

(b) Using the EYS-Tool-Kit, force the conductors towards the filling opening.*

Eaton's Crouse-Hinds recommends the use of the EYS-Tool-Kit when preparing a fiber dam. The EYS-Tool-Kit comes with five patented tools for wedging and lifting conductors, packing fiber and inspection of the fiber dam.

(c) Pack fiber (CHICO X) into each conduit hub in the sealing fitting, except for the upper hub of vertical seals.

(d) Push the conductors away from the filling opening and force them apart so that they do not lay in contact with each other along their length. If the conductors are in contact, the sealing compound will not form a closed path between them.

(e) Force the damming material (CHICO X fiber) between each conductor and between the conductors and the hubs and/or integral bushing. Remember that the dam has to be strong enough and tight enough to prevent a considerable weight of fluid sealing compound from seeping out.

(f) Push shreds of packing away from the conductors to prevent gas leakage paths. Care must be used so as not to damage the conductor insulation.

(g) The completed dam should be even with the integral bushing.

2. Sealing Compound

(a) Use of CHICO® A

CHICO A sealing compound is listed by UL for making seals in Eaton's Crouse-Hinds fittings. The insulation on the conductors sealed in the compound may be approved thermoplastic or rubber, with or without lead covering.

This is not an electrically insulating compound and should not be used for this purpose. CHICO A is not affected by gasoline, alcohol, acetone, ether, naphtha, petroleum, benzol, or lacquer solvent.

(b) Preparation of CHICO A

The following cautions are to be observed when preparing CHICO A sealing compound for pouring a seal:

(1) Use a clean mixing vessel for every batch. Particles of previous batches or dirt will spoil the seal.

(2) Recommended proportions are by volume – two parts of CHICO A to one part clean water. Slight deviations in these proportions will not affect the result.

(3) Do not mix more than can be poured in 15 minutes after water is added. Use cold water. Warm water increases setting speed. Stir immediately and thoroughly.

(4) If batch starts to set do not attempt to thin it by adding water or by stirring. Such a procedure will spoil seal. Discard partially set material and make fresh batch. After pouring, close opening immediately.

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(5) Do not pour compound in sub-freezing temperatures, or when these temperatures will occur during curing.

(6) See that compound level is in accordance with the instruction sheet for that specific fitting.

(c) Use of CHICO SpeedSeal Compound

With CHICO SpeedSeal, it is not necessary to prepare a dam for horizontal applications or separate the conductors in the sealing fitting, making for a much easier and faster job.

A few of the sealing fittings available from Crouse-Hinds.



EYD drain seal
1/2 – 1 inch



EYD drain seal
1 1/4 – 4 inch



EYS elbow seal
3/4-inch



EYSX expanded
all female HUB
1/2 – 4 inch



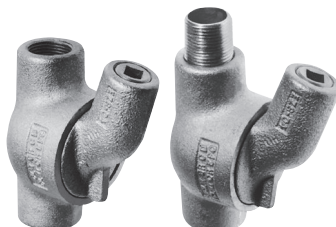
EYSX expanded
all female HUB
1/2 – 4 inch



EYSR
3/4- 4 inch
retrofit sealing fitting



EZD
with drain/inspection cover
1/2 – 2 inch



EYS
1/2 – 3 inch
for sealing at any angle

A few of the drains, breathers, and sealing fittings available from Eaton's Crouse-Hinds.



ECD 16
breather/drain
Cl. I, Gr. B, C, D
Cl. II, Gr. E, F, G
Cl. III



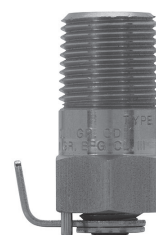
ECD 11 or 281
drain
Cl. I, Gr. C, D
Cl. II, Gr. E, F, G
Cl. III



ECD 13
breather
Cl. I, Gr. C, D
Cl. II, Gr. E, F, G
Cl. III



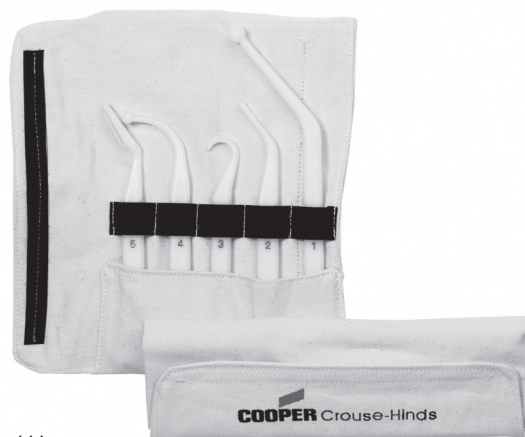
ECD 15
"universal" breather or drain
Cl. I, Gr. C, D
Cl. II, Gr. G
(Most effective for
these applications)



ECD 18
"combination"
breather and drain
Cl. I, Gr. C, D
Cl. II, Gr. F, G
Cl. III



DPE
breather drain
International
Ex approvals
IP66 Nema 4X



EYS tool kit

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Appendix III Selection of Seals and Drains

Eaton's Crouse-Hinds Sealing Compound products.



CHICO A-P INTRAPAK®
premeasured sealing
compound and water in
plastic mixing pouch



CHICO A
sealing compound

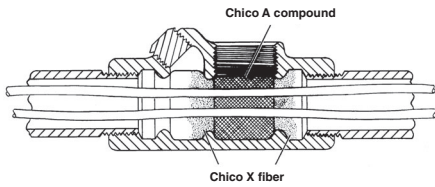


CHICO X fiber

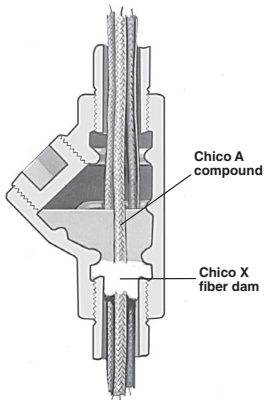


CHICO®
Speedseal™ compound

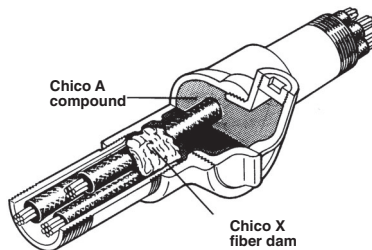
Seals made with CHICO A Sealing Compound and CHICO X Fiber.



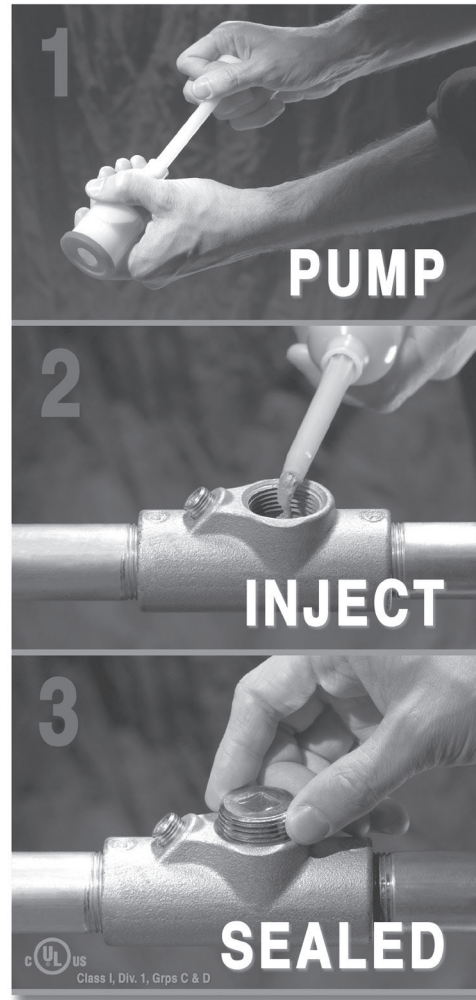
EYS – horizontal seal



EYS – vertical sealing



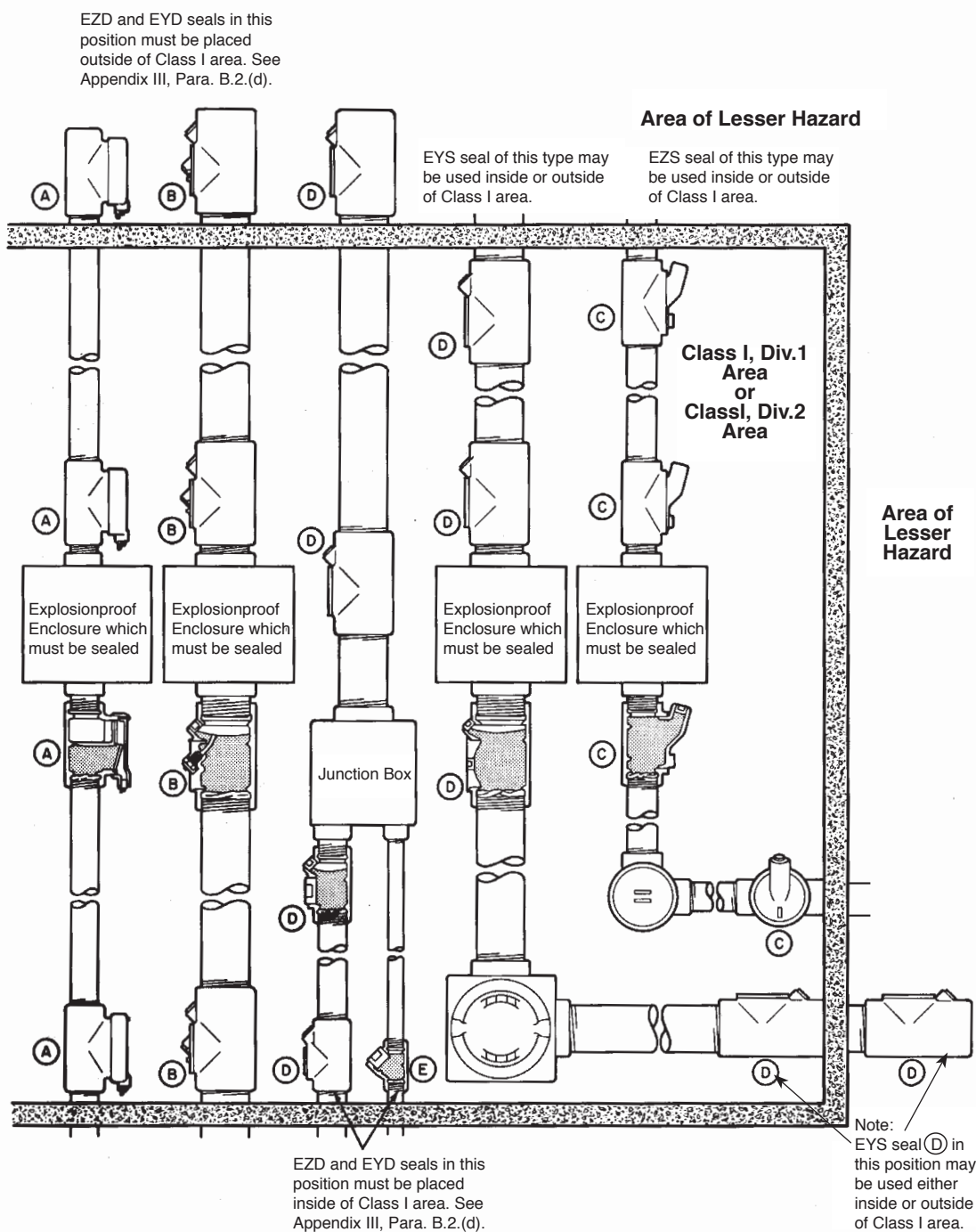
EVS – horizontal seal



CHICO® Speedseal™ compound lets you reliably install a complete explosionproof seal in less than five minutes. Just pump to mix, inject the pre-measured amount, replace the plug and the fitting is sealed.

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Appendix IV Installation Diagram for Sealing



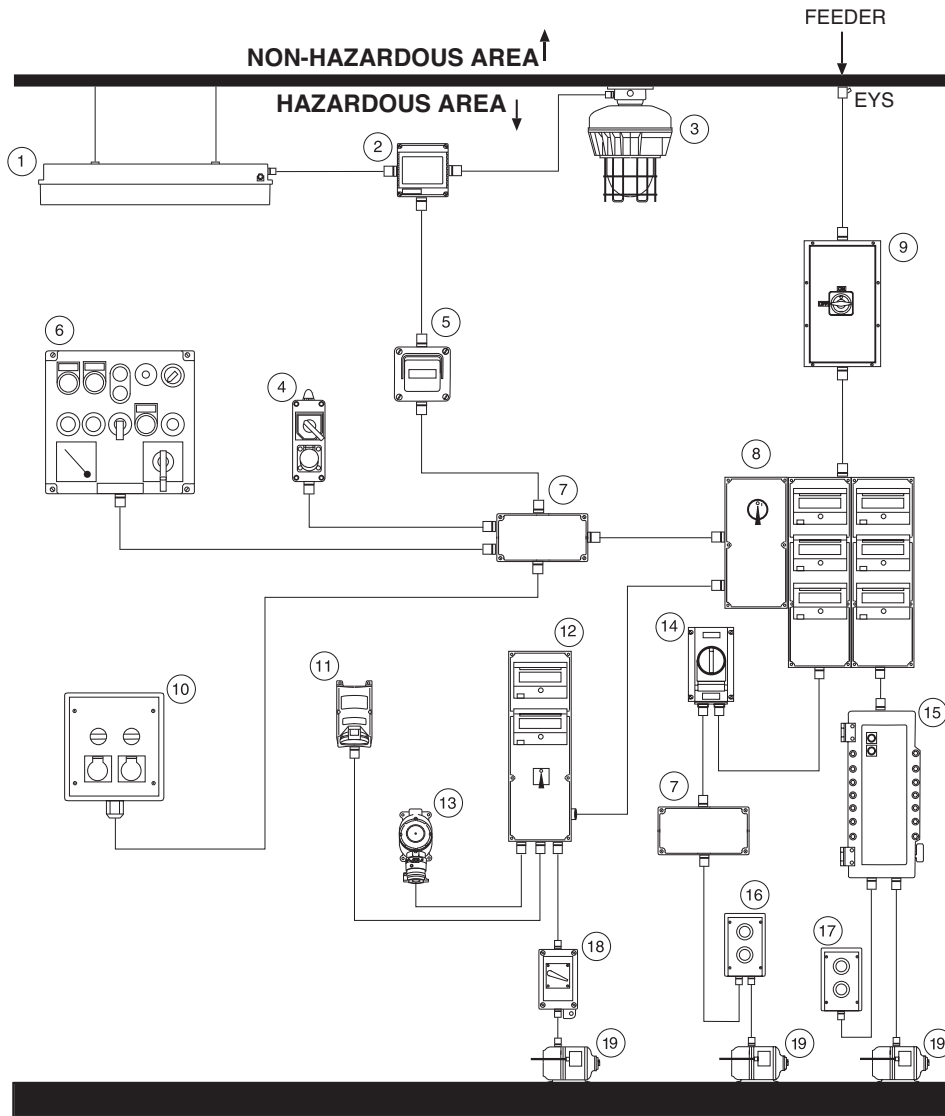
- (A) EZD drain seals are available in 1/2 – 2 inch conduit sizes for vertical conduits only.
- (B) EYD drain seals are available in 1/2 – 4 inch conduit sizes for vertical conduits only.
- (C) EZS seals of this form are available in 1/2 – 3 inch conduit sizes for vertical or horizontal conduits.

- (D) EYS seals of this form are available in 1/2 – 6 inch conduit sizes for vertical or horizontal conduits.
- (E) EYS seals of this form are available in 1/2 – 1 inch conduit sizes for vertical conduits.

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Appendix V

Diagram for Class I, Zone 1 Power & Lighting Installation



* North American wiring practices allow the use of MC-HL or MC cable or rigid conduit for Zone 1 hazardous areas. When entering a non-metallic enclosure, use a Zone 1 Myers hub. If the installation requires MC cable, use TMC/TMCX Terminator connectors.

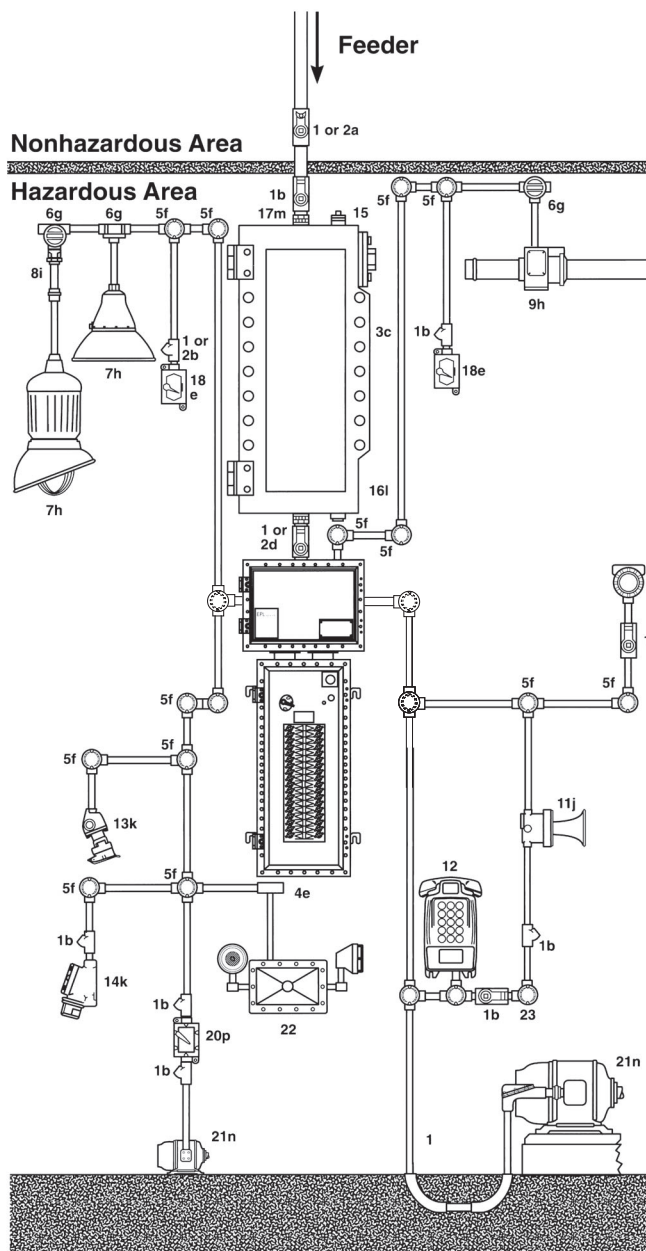
Key to Numerals*

- | | |
|--|--|
| <p>1. eLLK or FVS Fluorescent Luminaire with TMCX Terminator™ cable gland</p> <p>2. eAZK Lighting Junction Box with Zone 1 Myers® hubs</p> <p>3. EVLP or EVMA HID Luminaire with TMC Terminator cable gland</p> <p>4. GHG Switched IEC 309 Receptacle with Zone 1 Myers hubs</p> <p>5. GHG 273 Ex Push-Button Control Station with Zone 1 Myers hubs</p> <p>6. GHG 44 Control Panel with Zone 1 Myers hubs</p> <p>7. GHG 744 Terminal Box with Zone 1 Myers hubs</p> <p>8. EXKO Molded Plastic Distribution Panel with Zone 1 Myers hubs</p> <p>9. N2RS Control Switch with TMC Terminator cable gland</p> | <p>10. GHG 981 Socket Distribution Panel with Zone 1 Myers hubs</p> <p>11. GHG Interlocked IEC 309 Receptacle with Zone 1 Myers hubs</p> <p>12. EXKO Molded Plastic Distribution Panel with Zone 1 Myers hubs</p> <p>13. FSQC Arkrite Interlocked Receptacle with TMCX Terminator cable gland</p> <p>14. GHG 635 Manual Motor Starter with Zone 1 Myers hubs</p> <p>15. EBMS Magnetic Motor Starter with TMCX Terminator cable gland</p> <p>16. N2SCU SpecOne™ Control Station with Zone 1 Myers hubs</p> <p>17. GHG 43 SpecOne Control Station with Zone 1 Myers hubs</p> <p>18. EDS Motor Starter with TMCX Terminator cable gland</p> <p>19. Zone 1 Rated Motor with TMC or TMCX Terminator cable gland</p> |
|--|--|

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Appendix VI

Diagram for Class I, Div. 1* Lighting Installation



Key to Numerals

- 1 Sealing fitting. EYS for horizontal or vertical.
- 2 Sealing fitting. EZS for vertical or horizontal conduits.
- 3 Circuit breaker. Type EBM.
- 4 Panelboard. EXDC/EPL. Branch circuits are factory sealed. No seals required in mains or branches unless 2" or over in size.
- 5 Junction box. Series GUA, GUB, EAJ, EAB have threaded covers. Series CPS has ground flat surface covers.
- 6 Fixture hanger. EFHC, GUAC, or EFH.
- 7 Lighting Fixture. EV Series incandescent and EVM Series. H.I.D.
- 8 Flexible fixture support. ECHF.
- 9 Fluorescent fixture. EVFT.
- 11 Signal. ETH horns and sirens. ESR bells, Flex•Tone™ signals.
- 12 ETW explosionproof telephone.
- 13 Plug receptacle. CES delayed action.
- 14 Plug receptacle. FSQC. Interlocked with switch.
- 15 Breather. ECD.
- 16 Drain. ECD.
- 17 Union. UNY.
- 18 Switch. Series EFS.
- 19 Instrument enclosure. EIH.
- 20 Manual line starter. EMN.
- 21 Motors. Explosionproof.
- 22 Emergency lighting system. ELPS.
- 23 ETC Power Relay.

National Electrical Code References

- a Sec. 501.15(A)(4). Seal required where conduit passes from hazardous to nonhazardous area.
- b Sec. 501.15(A)(1)(1). Seals required within 18 inches of all arcing devices.
- c Sec. 408.36. Circuit breaker protection required ahead of panelboard.
- d Sec. 501.15(A)(1)(2). Seals required if conduit is 2 inches or larger.
- e Sec. 501.115(A). All arcing devices must be explosionproof.
- f Sec. 501.10(A). All boxes must be explosionproof and threaded for rigid or IMC conduit.
- g Sec. 501.130(A)(4). All boxes and fittings for support of luminaires must be approved for Class I locations.
- h Sec. 501.130(A)(1). All lighting fixtures, fixed or portable, must be explosionproof.
- i Sec. 501.130(A)(3). Pendant fixture stems must be threaded rigid or IMC conduit. Conduit stems if over 12 inches must have flexible connector, or must be braced.
- j Sec. 501.150(A). All signal and alarm equipment irrespective of voltage must be approved for Class I, Division 1 locations.
- k Sec. 501.145. Receptacles and plugs must be explosionproof and provide grounding connections for portable equipment.
- l Sec. 501.15(F)(1). Breathers and drains needed in all humid locations.
- m Sec. 501.10(A). All joints and fittings must be explosionproof.
- n Sec. 501.125(A). Motor must be suitable for Class I.
- p Art. 430. Motor overcurrent protection.

**Also applicable for Class I, Zone 1, see 505.15(B)*

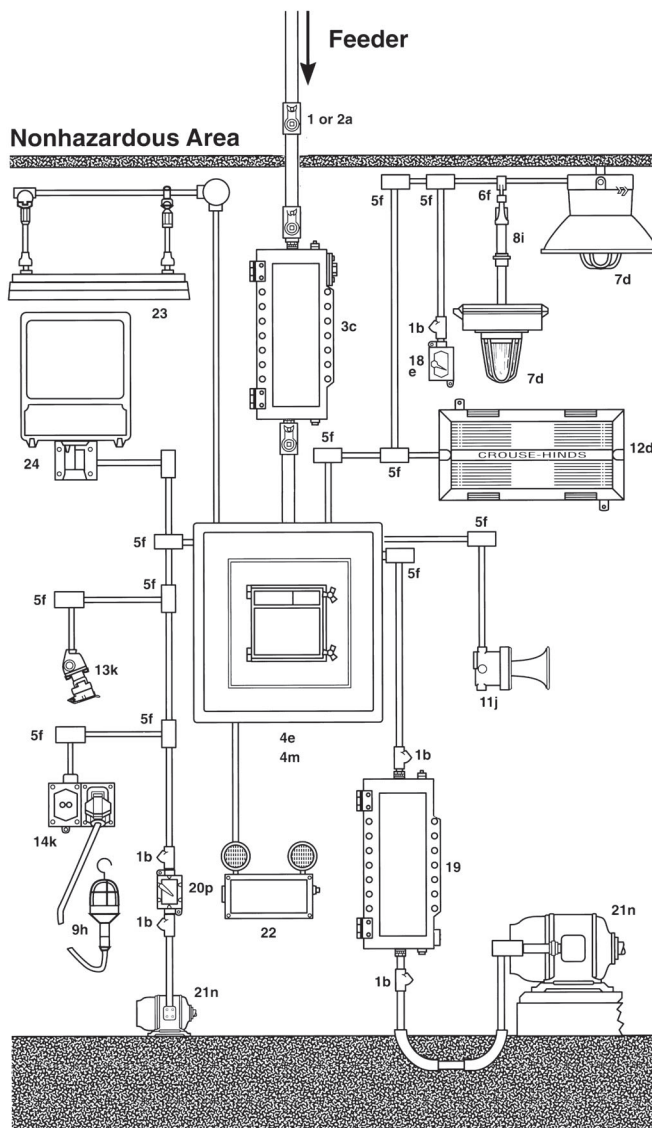
Diagram for Class I, Div. 1* Power Installation



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Appendix VIII

Diagram for Class I, Div. 2* Power & Lighting Installation



Key to Numerals

- 1 Sealing fitting. EYS for horizontal or vertical.
- 2 Sealing fitting. EZS for vertical or horizontal conduits.
- 3 Circuit breaker. Type EBM.
- 4 Panelboard. D2PB, N2PB. Branch circuits are factory sealed.
- 5 Junction box or conduit fitting. NJB, Condulet®.
- 6 Fixture hanger. AHG, GS, UNJ.
- 7 Lighting fixture. VMV, DMV, and LMV (CHAMP®).
- 8 Flexible fixture support. ECHF.
- 9 Handlamp. EVH.
- 11 Signal. ETH horns and sirens. ESR bells, Flex•Tone™, and W2H.
- 12 Compact fluorescent lighting fixture. FVS.
- 13 Plug receptacle. CES delayed action.
- 14 Plug receptacle. ENR or CPS delayed action with GFS-1 ground fault circuit interrupter.
- 15 Breather. ECD.
- 16 Drain. ECD.
- 17 Union. UNY.
- 18 Switch. Series EFS.
- 19 Magnetic line starter. EBMS.
- 20 Manual line starter. EMN.
- 21 Motors. Suitable for Class I, Division 2 locations.
- 22 Emergency lighting system. N2LPS.
- 23 Fluorescent fixture. FVN.
- 24 Floodlight. FMVA.

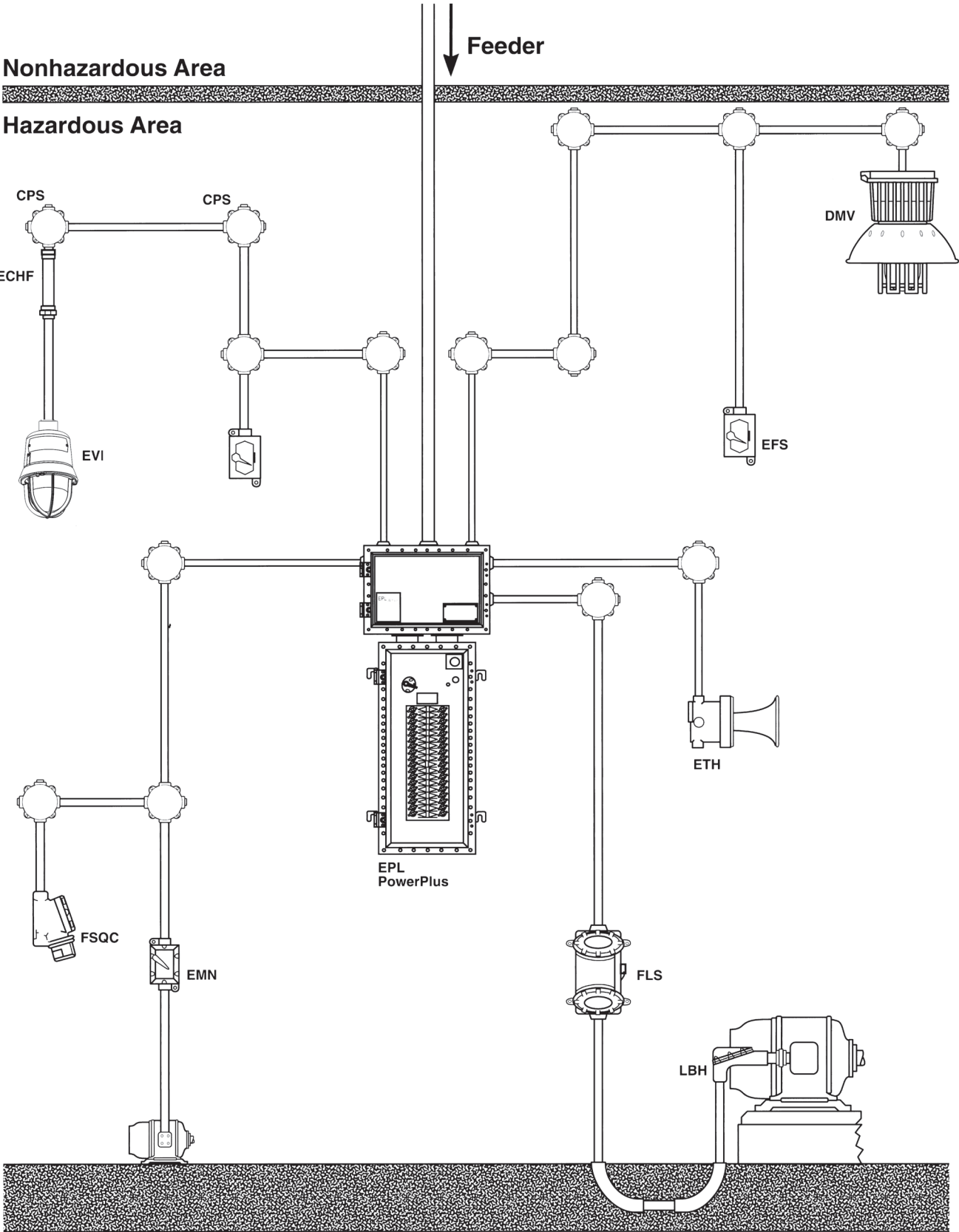
National Electrical Code References

- a Sec. 501.15(B)(2). Seal required where conduit passes from hazardous to non-hazardous area.
- b Sec. 501.15(B)(1). Seals required within 18 inches of all arcing devices.
- c Sec. 408.36. Circuit breaker protection required ahead of panelboard.
- d Sec. 501.130(B)(2). All fixed lighting fixtures shall be enclosed and gasketed and not exceed ignition temperature of the gas.
- e Sec. 501.115(B)(1). Most arcing devices must be explosionproof.
- f Sec. 501.10(B). All boxes must be threaded for rigid or IMC conduit.
- h Sec. 501.130(B)(1). All portable lighting fixtures must be explosion proof.
- i Sec. 501.130(B)(3). Pendant fixture stems must be threaded rigid conduit or IMC. Rigid stems if over 12 inches must have flexible connector, or must be braced.
- j Sec. 501.150(B). All signaling equipment must be approved for Class I location.
- k Sec. 501.145. Receptacles and plugs must be explosionproof and provide grounding connections for portable equipment.
- l Sec. 501.15(F)(1). Breathers and drains needed in all humid locations.
- m Sec. 501.10(B). Not all joints and fittings are required to be explosionproof.
- n Sec. 501.125(B). Motor shall be suitable for Division 2.
- p Art. 430. Motor overcurrent protection.

**Also applicable for Class I, Zone 2*

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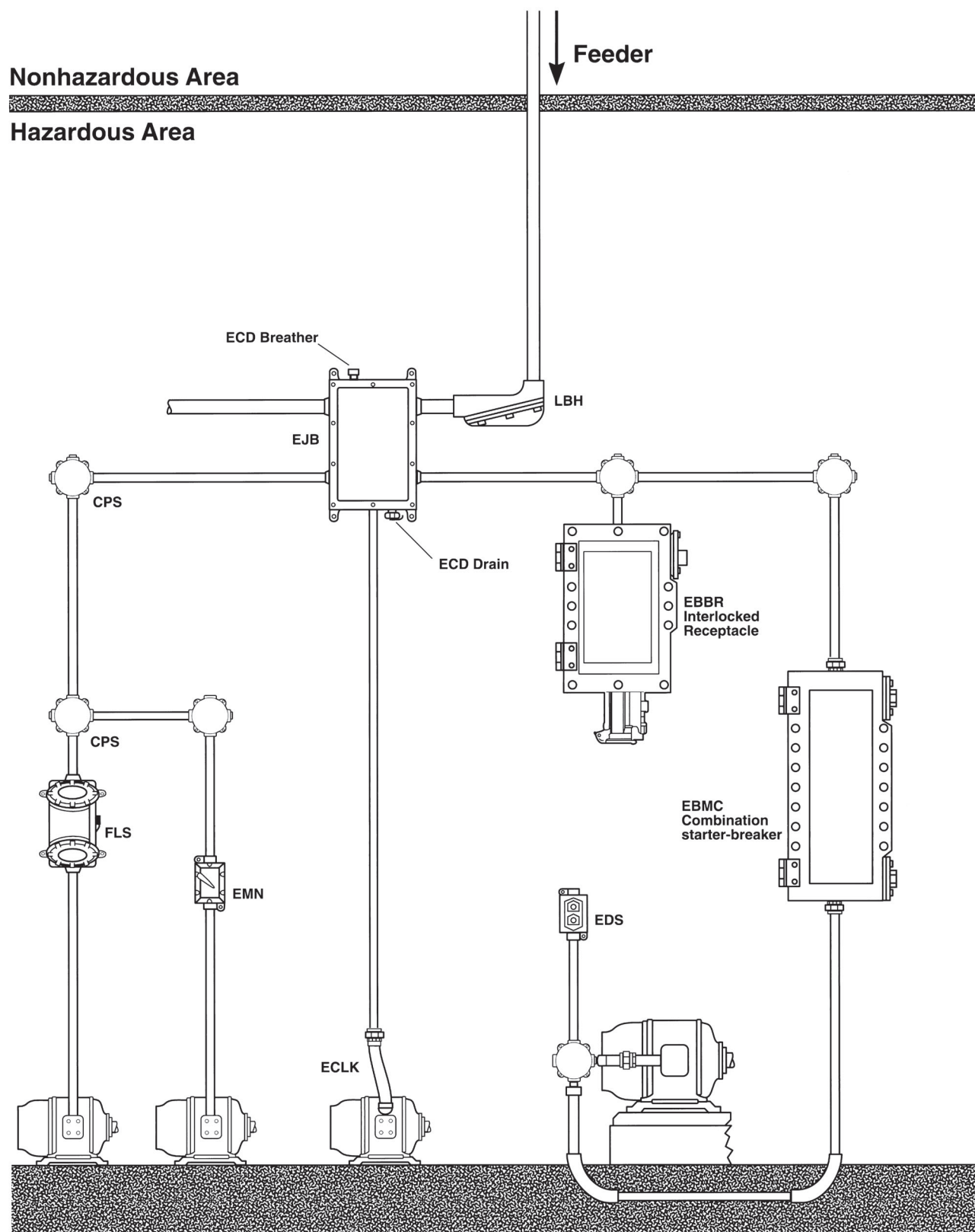
Appendix IX
Diagram for Class II Lighting Installation



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Appendix X

Diagram for Class II Power Installation



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Appendix XI

"Quick Selector" Electrical Equipment for Hazardous Locations

Note: Not all types listed are suitable for use in all four groups for Class I hazardous locations. Consult catalog listing pages for applicable classes and groups.

	Class I Div. 1*	Class I Div. 2†	Class II Div. 1	Class II Div. 2	Class III Div. 1	Class III Div. 2
			Groups E & F	Group G		
Conduit bodies and junction boxes	CPS, EC, ECP, EJB EJH, EKC, GUB EAB, EAJ UNF/UNY UNFL/UNYL	Form 7 Series, Form 8, Mark 9, Moguls, FS/ FD, W-Series, NJB and all products shown under Class I, Division 1	CPS, EC EJB, EJH EKC, GUB EAB, EAJ UNF/ UNY UNFL/ UNYL	Same if splices, taps, etc.		Dusttight fittings and all products shown under Class II, Division 1
Cable glands	TMCX II, TMCX, ADE 1FC, ADE 6FC, CGBS (C,D), EBY (B,C,D)	TMCX II, TMCX, (E,F,G) ADE 1FC, ADE 6FC, CGBS (E,F,G), EBY (F,G), TMC‡, CGB‡	TMCX II, TMCX, CGBS (C,D), EBY (B,C,D)			Dusttight fittings and all products shown under Class II, Division 1
Switches EBM Disconnects, EBMX, EDS, EFD, EFS, EHS, EID, FLS, GUSC, OAC, AF Series, GHG26 Disconnect Switch **						
Motor Control ACE, EBMC, EBMS, EBMX, FLS, EMN, EDS, EFD						
Panelboards	EPL, ESPBH, EWP EXD, GUSC	D2PB, D2D, D2L ESPBH, GUSC, SynergEX	EPL, ESPBH, EXD GUSC			All products shown under Class II, Division 1
Lighting fixtures	ELPS EVI EVF EVFDR EVH EVP HAZARD•GUARD® RCDE EVFT Commander FEPR Performer ZP EP Globe & Guard EPN Strobe EPB/EPC/EPP Beacon	FMVA CHAMP® DMV CHAMP® FVN LMV CHAMP® NDA Vaporgard™ VMV CHAMP® VSeries N2LPS FVS N2MV Apex Summit Radia Intrepid – SPA/SPP/SPS Optima HID Series Vulcan RBF Goliath Flood Light Series Pinnacle DP Quantumn RigPro Magna Achiever Dr 707/717/727 Exacta Globe & Guard Series 1158/1159 Marker Lights 7120/7121 Strobes 746D2 Spotlight Resista WP	EVFT EVP DMV CHAMP® EVI EVF EVFDR EXL FVN HAZARD•GUARD® LMV CHAMP® VMV CHAMP® ELPS FVS			
Fixture hangers	COUP CPS EAHC EC EFHC EFHX GUA UNR	AHG ALC ALT EC UNE UNH UNJ UNJC	CPS EC EAHC EFHC EFHX GUA UNR			
Plugs and receptacles	APJ, BHP, BHR, CES, CESD, CPH, CPP, CPS, DR, ENP, ENR, FP, FSQC, NPJ, SRD, SP		Groups F, G only APJ, BHP, BHR DR, ENP, ENR, FP, FSQC, NPJ, SRD, SP			
Interlocked plug receptacles	BHR, C2SR, EPC, FSQC, SRD		Groups F, G only BHR, DBR, EPC, FSQC, SRD, EBBR			
Control stations and pilot lights	EDS, EFD, EFS, EMP, GHG43 (Class I Div 2 and Class II Div 1), OAC, N2S (Class I, Division 2 only), FlexStation™, DSD-SR					
Industrial control	EDS, EFD, EFS, EMN, OAC, EBM, EBMX					
Circuit breakers	EDS, EFD, EIB, FLB, GUSC, EBMX		EDS, EFD, EIB, EPC, FLB, GUSC, EBM, EBMX			
Telephones, instruments and signals	EMH, ESR, ETW and D2TW Telephones, ETH, ETH Flex•Tone™ Device, EXSO Steady on beacons, EXR Rotating beacon, EXS strobe light, GUB (W2H for Class I, Division 2), EIH, EIHT					
Transformers	XDT Series					

*Also suitable for Class I, Zone 1, see 505.15(B) and 505.20 (B)

†Also suitable for Class I, Zone 2, see 505.15(C) and 505.20 (C)

‡May be permitted for use in Class I, Division 2 locations, provided there are no arcing and sparking risks see 501.10(B)

** Not suitable for Class I, Division 1

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NEC/CEC Global Reference Guide

Typical NEC/CEC marking of electrical apparatus in USA and Canada:

Marking according to NEC 500

Class I Division 1 Groups A, B, C & D T6

Class I Hazard category
 Division 1 Area classification
 Groups A, B, C & D Hazardous atmosphere category (gas or dust grouping)
 T6 Temperature classification

Marking according to NEC 505 / CEC 18

Class I Zone 1 AEx eb IIC T6 Gb*

Class I Hazard category (optional)
 Zone 1 Area classification
 AEx Explosion-protection standard
 e Method of explosion protection
 IIC Hazardous atmosphere category (gas or dust grouping)
 T6 Temperature classification
 Gb Equipment protection level

*Class I Zone equipment shall be permitted to omit the Class I marking. See NEC 505.9(C)(2).

Method of explosion protection

Type of protection	Description of protection		Permitted for use in Canada		Protection concept	
		Permitted for use in USA				
		NEC 500	NEC 505	CEC 18		CEC 18
		Division	Zone	Division		Zone
e	Increased safety	-	1, 2	-	1, 2	No arcs, sparks or hot surfaces
n	Non-incendive	2	2	2	2	
d	Flameproof	-	1, 2	-	1, 2	Contain the explosion prevent the flame propagation
-	Explosion-proof	1, 2	-	1, 2	-	
q	Powder filled	-	1, 2	-	1, 2	
ia	Intrinsic safety	1, 2	0, 1, 2	1, 2	0, 1, 2	Limit the energy of the spark and the surface temperature
ib	intrinsic safety	-	1, 2	-	1, 2	
p	Pressurized (purged)	1, 2	1, 2	1, 2	1, 2	Keep the flammable gas out
m	Encapsulation	-	1, 2	-	1, 2	
o	Oil immersion	2	1, 2	2	1, 2	

Area classification

	Continuous hazard	Intermittent hazard	Hazard under abnormal conditions
North America / NEC 500-503/CEC 18	Division 1	Division 1	Division 2
NEC 505-506/CEC 18	Zone 0 (Zone 20 dust)	Zone 1 (Zone 21 dust)	Zone 2 (Zone 22 dust)

Temperature classification according to NEC/CEC

Maximun surface temperature	Zone concept	Division concept
450 °C (842 °F)	T1	T1
300 °C (572 °F)	T2	T2
280 °C (536 °F)		T2A
260 °C (500 °F)		T2B
230 °C (446 °F)		T2C
215 °C (419 °F)		T2D
200 °C (392 °F)	T3	T3
180 °C (356 °F)		T3A
165 °C (329 °F)		T3B
160 °C (320 °F)		T3C
135 °C (275 °F)	T4	T4
120 °C (248 °F)		T4A
100 °C (212 °F)	T5	T5
85 °C (185 °F)	T6	T6

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NEC/CEC Global Reference Guide

Hazardous atmosphere category (gas or dust grouping)

Explosive atmosphere	Typical hazard material	North America NEC 500-503 / CEC 18		NEC 505 / CEC 18
		Hazard category	Grouping	Gas-grouping
Gases and vapours*	Acetylene	Class I	Group A	IIC
	Hydrogen	Class I	Group B	IIC or IIB+H2
	Ethylene/Formaldehyde	Class I	Group C	IIB
	Methane/Octane	Class I	Group D	IIA
Dust**	Metal dust	Class II	Group E	IIIC
	Coal dust	Class II	Group F	IIIB
	Grain dust	Class II	Group G	IIIB
Fibres & Flyings	Wood, paper or cotton processing	Class III	-	IIIA

* Equipment listed and marked in accordance with 505.9(C)(2) for use in Zone 0, 1, or 2 locations are permitted in Class I, Division 2 locations for the same gas and with a suitable temperature class, see article 501.5 of the National Electrical Code.

** Equipment listed and marked in accordance with 506.9(C)(2) for Zone 20, 21, or 22 locations are permitted in Class II, Division 2 locations for the same dust atmosphere and with a suitable temperature class, see article 502.6 of the National Electrical Code

NEMA enclosure types

Enclosure type	Intended use	Equivalent IP rating*
1	Indoor use, limited amounts of falling dirt	20
3	Outdoor use, rain, sleet, windblown dust, external formation of ice	55
3R	Outdoor use, rain, sleet, external formation of ice	24
3S	Outdoor use, rain, sleet, windblown dust, external mechanisms operable when ice laden	55
4	Indoor or outdoor use, windblown dust and rain, splashing water, hose directed water, external formation of ice	66
4X	Indoor or outdoor use, windblown dust and rain, splashing water, hose directed water, corrosion resistant, external formation of ice laden	66
5	Indoor use, settling airborne dust, falling dirt, non-corrosive liquids	53
6	Indoor or outdoor use, hose directed water, temporary submersion, external formation of ice	67
6P	Indoor or outdoor use, hose directed water, prolonged submersion, external formation of ice	68
7**	Indoor use, Class I, Division 1, Groups A, B, C, and D hazardous locations, air-break equipment	
8**	Indoor or outdoor use, Class I, Division 1 Groups A, B, C, and D hazardous locations, oil-immersed equipment	
9**	Indoor use, Class II, Division 1, Groups E, F, and G hazardous locations, air-break equipment	
10**	Mining applications	
12	Indoor use, circulating dust, falling dirt, dripping noncorrosive liquids	54
12K	Indoor use, circulating dust, falling dirt, dripping noncorrosive liquids, provided with knockouts	54
13	Indoor use, lint, dust, spraying of water, oil an noncorrosive coolant	54

* NEMA Enclosure Type can be converted to IP Code rating, but IP Codes cannot be converted to NEMA Enclosure Type (Ref. NEMA 250)

** Enclosure Types for U.S. only (Ref. NEMA 250)



Committees and directives

NEMA	(National Electrical Manufacturers Association) NEMA 250 series standards for enclosure types covers both hazardous areas (potentially explosive atmospheres) and non-hazardous areas.
NEC	– National Electrical Code (USA)
CEC	– Canadian Electrical Code (Canada)



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EU/ATEX/IECEX Global Reference Guide

Typical marking of electrical equipment for use in explosive gas atmospheres (EU / ATEX / IECEx):

Marking according to Directive 2014/34/EU (previously 94/9/EG) (ATEX)	Marking according to IEC/CENELEC standard 60079-0
  II 2 G	Ex db eb IIC T4 Gb
<p>CE... CE-marking and number of the notified (monitoring) body (0158 = DEKRA EXAM GmbH) (not for equipment category 3)</p> <p>D Explosion protection symbol</p> <p>II Equipment group (equipment for use in hazardous areas, other than mines susceptible to firedamp)</p> <p>2 Equipment category (category 2)</p> <p>G Explosive atmosphere (gas, vapour or mist)</p>	<p>Ex Explosion protection marking</p> <p>db Type of protection (flameproof enclosure, level of protection „db“)</p> <p>eb Type of protection (Increased safety, level of protection „eb“)</p> <p>IIC Equipment group (Electrical equipment group II, subgroup IIC (typical gas: hydrogen), intended for use in areas where an explosive gas atmosphere is to be expected, other than mines susceptible to firedamp)</p> <p>T4 Temperature class (max. surface temperature 135 °C)</p> <p>Gb Equipment protection level (EPL Gb; equipment with high protection level)</p>

Typical marking of electrical equipment for use in explosive dust atmospheres (EU / ATEX / IECEx):

Marking according to Directive 2014/34/EU (previously 94/9/EG) (ATEX)	Marking according to IEC/CENELEC standard 60079-0
  II 2 D	Ex tb IIIC T80 °C Db
<p>CE... CE-marking and number of the notified (monitoring) body (0158 = DEKRA EXAM GmbH) (not for equipment category 3)</p> <p>D Explosion protection symbol</p> <p>II Equipment group (equipment for use in hazardous areas, other than mines susceptible to firedamp)</p> <p>2 Equipment category (Category 2)</p> <p>D Explosive atmosphere (dust)</p>	<p>Ex Explosion protection marking</p> <p>tb Type of protection (protection by enclosure „tb“)</p> <p>IIIC Equipment group (Electrical apparatus group III, subgroup IIIC (conductive dust), intended for use in areas where an explosive dust atmosphere is to be expected, other than mines susceptible to firedamp)</p> <p>T80 °C Surface temperature (max. 80 °C)</p> <p>Db Equipment protection level (EPL Db; equipment with high protection level)</p>

Electrical types of protection for explosive atmospheres due to flammable gases, vapours and mists

Type	Pro-tection level	Type of protection	Group	Equipment category	Equipment pro-tection level (EPL)	CENELEC / IEC standard	Protection concept
d	da	Flameproof enclosure	II	1 G	Ga	EN 60079-1 / IEC 60079-1	Explosion containment, prevention of flame transmission
d	db	Flameproof enclosure	II	2 G	Gb	EN 60079-1 / IEC 60079-1	Explosion containment, prevention of flame transmission
d	dc	Flameproof enclosure	II	3 G	Gc	EN 60079-1 / IEC 60079-1	Explosion containment, prevention of flame transmission
p	pxb pyb	Pressurized enclosure	II	2 G	Gb	EN 60079-2 / IEC 60079-2	Exclusion of Ex-atmosphere
p	pzc	Pressurized enclosure	II	3 G	Gc	EN 60079-2 / IEC 60079-2	Exclusion of Ex-atmosphere
q		Powder filling	II	2 G	Gb	EN 60079-5 / IEC 60079-5	Prevention of explosion diffusion
o	ob	Liquid immersion	II	2 G	Gb	EN 60079-6 / IEC 60079-6	Exclusion of Ex-atmosphere
o	oc	Liquid immersion	II	3 G	Gc	EN 60079-6 / IEC 60079-6	Exclusion of Ex-atmosphere
e	eb	Increased safety	II	2 G	Gb	EN 60079-7 / IEC 60079-7	No arcs, sparks or hot surfaces
e	ec	Increased safety	II	3 G	Gc	EN 60079-7 / IEC 60079-7	No arcs, sparks or hot surfaces
i	ia	Intrinsic safety	II	1 G	Ga	EN 60079-11 / IEC 60079-11	Limitation of spark energy and surface temperature
i	ib	Intrinsic safety	II	2 G	Gb	EN 60079-11 / IEC 60079-11	Limitation of spark energy and surface temperature
i	ic	Intrinsic safety	II	3 G	Gc	EN 60079-11 / IEC 60079-11	Limitation of spark energy and surface temperature
p/v		Pressurized enclosure/ventilation	II	2 G	Gb	EN 50381 IEC 60079-13	Exclusion of Ex-atmosphere / dilution
nA		Non-sparking equipment	II	3 G	Gc	EN 60079-15 / IEC 60079-15	No arcs, sparks or hot surfaces
nC		Enclosed equipment	II	3 G	Gc	EN 60079-15 / IEC 60079-15	Explosion containment, prevention of flame transmission
nR		Restricted breathing enclosure	II	3 G	Gc	EN 60079-15 / IEC 60079-15	Exclusion of Ex-atmosphere for a limited period
m	ma	Encapsulation	II	1 G	Ga	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
m	mb	Encapsulation	II	2 G	Gb	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
m	mc	Encapsulation	II	3 G	Gc	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
i		Intrinsic system	II	2 G	Gb	EN 60079-25 / IEC 60079-25	Limitation of spark energy and surface temperature
		Equipment with protection level (EPL) Ga	II	1 G 1 G/2 G	Ga Ga/Gb	EN 60079-26 / IEC 60079-26	Double protection concept
op is		Inherent safe optical radiation	II	1 G	Ga	EN 60079-28 / IEC 60079-28	Limitation of optical radiation energy
op is		Inherent safe optical radiation	II	2 G	Gb	EN 60079-28 / IEC 60079-28	Limitation of optical radiation energy
op is		inherent safe optical radiation	II	3 G	Gc	EN 60079-28 / IEC 60079-28	Limitation of optical radiation energy
op pr op sh		Safe/interlocked optical radiation	II	2 G	Gb	EN 60079-28 / IEC 60079-28	Limitation or containment of optical radiation energy
op pr op sh		Safe/interlocked optical radiation	II	3 G	Gc	EN 60079-28 / IEC 60079-28	Limitation or containment of optical radiation energy
s	sa	Special protection	n.a.	n.a.	Ga	IEC 60079-33	Special measures
s	sb	Special protection	n.a.	n.a.	Gb	IEC 60079-33	Special measures
s	sc	Special protection	n.a.	n.a.	Gc	IEC 60079-33	Special measures

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EU/ATEX/IECEX Global Reference Guide

Example of classification of explosive gas atmospheres into zones
Ex gas atmosphere according to IEC/EN 60079-10-1

Explosion group

Explosive Atmosphere	Typical combustible material	Group
Gas, vapour or mist	Acetylene	IIC
	Hydrogen	IIC / IIB+H2
	Ethylene/Formaldehyde	IIB
	Methane/Octane	IIB
Dust	Metal dust	IIIC
	Coal dust	IIIB
	Grain dust	IIIB
Non-conductive	Wood, paper or cotton processing	IIIA
	Fibres & Flyings	IIIA

Temperature class

Maximum surface temperature	IEC/EN 60079-0
450 °C	T1
300 °C	T2
200 °C	T3
135 °C	T4
100 °C	T5
85 °C	T6

IP degree of protection to IEC 60529

First digit	Second digit
Protection against solid foreign objects	Protection against ingress of water with damaging effects
0 No protection	0 No protection
1 ≥ 50 mm diameter	1 Vertically dripping water
2 ≥ 12.5 mm diameter	2 15° angled dripping water
3 ≥ 2.5 mm diameter	3 Spraying water
4 ≥ 1.0 mm diameter	4 Splashing water
5 Dust protected	5 Water jets
6 Dust tight	6 Strong water jets
	7 Temporary submersion
	8 Permanent submersion
	9 High pressure, high temperature spray downs

Example of classification of explosive dust atmospheres into zones
Ex dust atmosphere according to IEC/EN 60079-10-2

Electrical types of protection for explosive atmospheres due to combustible dust

Type	Pro-tection level	Type of protection	Group		Equipment category	Equipment protection level (EPL)	CENELEC / IEC standard	Protection concept
			Directive	Standard				
p	pxb	Pressurized enclosure	II	III	2 D	Db	EN 60079-2 / IEC 60079-2	Exclusion of Ex-atmosphere
p	pzc	Pressurized enclosure	II	III	3 D	Dc	EN 60079-2 / IEC 60079-2	Exclusion of Ex-atmosphere
i	ia	Intrinsic safety	II	III	1 D	Da	EN 60079-11 / IEC 60079-11	Limitation of spark energy and surface temperature
i	ib	Intrinsic safety	II	III	2 D	Db	EN 60079-11 / IEC 60079-11	Limitation of spark energy and surface temperature
i	ic	Intrinsic safety	II	III	3 D	Dc	EN 60079-11 / IEC 60079-11	Limitation of spark energy and surface temperature
m	ma	Encapsulation	II	III	1 D	Da	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
m	mb	Encapsulation	II	III	2 D	Db	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
m	mc	Encapsulation	II	III	3 D	Dc	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
op is		Inherent safe optical radiation	II	III	1 D	Da	EN 60079-28 / IEC 60079-28	Limit of radiation energy
op is		Inherent safe optical radiation	II	III	2 D	Db	EN 60079-28 / IEC 60079-28	Limit of radiation energy
op is		Inherent safe optical radiation	II	III	3 D	Dc	EN 60079-28 / IEC 60079-28	Limit of radiation energy
op pr op sh		Safe/interlocked optical radiation	II	III	2 D	Db	EN 60079-28 / IEC 60079-28	Limitation or containment of radiation energy
op pr op sh		Safe/interlocked optical radiation	II	III	3 D	Dc	EN 60079-28 / IEC 60079-28	Limitation or containment of radiation energy
t	ta	Protection by enclosure	II	III	1 D	Da	EN 60079-31 / IEC 60079-31	Exclusion of dust
t	tb	Protection by enclosure	II	III	2 D	Db	EN 60079-31 / IEC 60079-31	Exclusion of dust
t	tc	Protection by enclosure	II	III	3 D	Dc	EN 60079-31 / IEC 60079-31	Exclusion of dust
s	sa	Special protection		III	n.a.	Da	IEC 60079-33	Special measures
s	sb	Special protection		III	n.a.	Db	IEC 60079-33	Special measures
s	sc	Special protection		III	n.a.	Dc	IEC 60079-33	Special measures

Zone classification / Equipment protection level

Substance	Period of presence of the combustible substances	Zone	Minimum requirements for equipment				Protection level
			Directive 2014/34/EU		Standard IEC/EN 60079-0		
			Equipment group	Equipment category	Group	Equipment protection level EPL	
Gas, mist, vapour	Continuously for long periods or frequently	Zone 0	II	1 G	II	Ga	very high
	Occasional occurrence	Zone 1	II	2 G	II	Gb	high
	Not likely, but if it occurs only rarely and for a short period	Zone 2	II	3 G	II	Gc	enhanced
Dust	Continuously for long periods or frequently	Zone 20	II	1 D	III	Da	very high
	Occasional occurrence	Zone 21	II	2 D	III	Db	high
	Not likely, but if it occurs only rarely and for a short period	Zone 22	II	3 D	III	Dc	enhanced
Methane, coal dust		Mining	I	M1	I	Ma	very high
		Mining	I	M2	I	Mb	high

2020 Code Digest

EU/ATEX/IECEX Global Reference Guide

Classification of explosion-protected equipment into equipment groups and categories in accordance with Directive 2014/34/EU

Equipment Group I for mines endangered by firedamp. The equipment Group I is subdivided into the Categories M1 and M2:

M1	The equipment in this category is intended for use in both underground parts of mines and those parts of surface installations of such mines that are endangered by firedamp and/or combustible dust. The equipment shall continue to remain functional even in the event of rare incidents relating to the equipment with an explosive atmosphere present, and feature such protective measures that in the event of failure of one means of protection, at least an independent second means provides the requisite level of protection, or the requisite level of protection is assured in the event of two faults occurring independently of each other.
M2	The equipment in this category is intended for use in both underground parts of mines and those parts of surface installations of such mines that are endangered by firedamp and/or combustible dust. If an explosive atmosphere occurs, it must be possible to switch off the equipment. The constructional explosion-protection measures ensure the required degree of safety during normal operation, even under severe operating conditions and, in particular, in cases of rough handling and changing environmental influences.

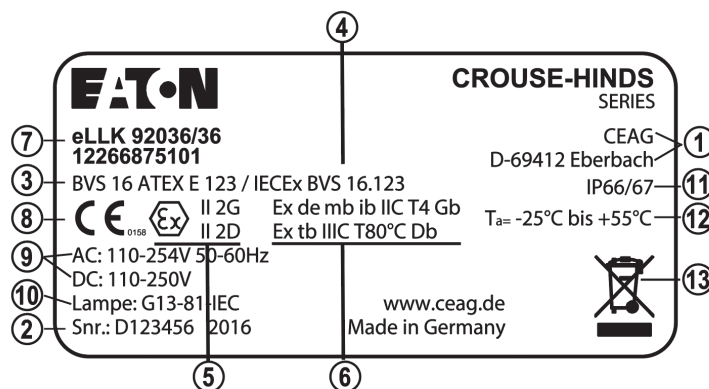
Equipment Group II for all other hazardous areas

The equipment Group II is subdivided into the Categories 1, 2 and 3:

1	The equipment in this category is intended for use in areas in which an explosive atmosphere is present continuously or for long periods or frequently. Even if equipment failures only occur infrequently, the equipment must ensure the required degree of safety and feature such explosion protection measures that — if one constructional protective measure fails, at least one other independent constructional protective measure ensures the required degree of safety, or — if two independent faults occur in combination, the required degree of safety is still ensured.
2	The equipment in this category is intended for use in areas in which an explosive atmosphere occurs occasionally. Even in the case of frequent equipment failures or faulty conditions that are normally to be expected, the constructional explosion-protection measures ensure the required degree of safety.
3	The equipment in this category is intended for use in areas in which no occurrence of an explosive atmosphere due to gases, vapours, mists or whirled-up dust is to be expected. If, however, it occurs, then in all probability only rarely or for a short period. During normal operation the equipment ensures the required degree of safety.

Example of type label

1. Name or registered trade mark (CEAG) and address of the manufacturer
2. Serial number including year of manufacture
3. Certificate number, may end with "X" or "U"
 - "X" indicates that special conditions for safe use apply
 - "U" is used for component certificates
4. Additional IECEx certification
5. Marking according to directive: Equipment group (II) and equipment category (2); type of explosive atmosphere G (Gas, vapour or mist) – D (dust)
6. Marking according to standard: IEC/EN
7. Equipment name/type
8. CE marking and number of the "notified body" responsible for monitoring the quality system (0158 = EXAM Germany)
9. Electrical parameters
10. Other essential information (depends on the standard, e.g. lamp)



11. Other optional information (e.g. degree of protection)
12. Permissible ambient temperature (-25°C to +55°C); no marking required for temperatures from -20°C to 40°C (standard values for all equipment)
13. Marking according to EU-directive 2002/96/EC (WEEE-directive: Waste of Electrical and Electronic Equipment)



Eaton's Crouse-Hinds 2020 Code Digest

This digest provides a compilation of key changes to the current regional code and covers the classification of hazardous atmospheres, explosion prevention techniques, equipment, wiring methods, and more.

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