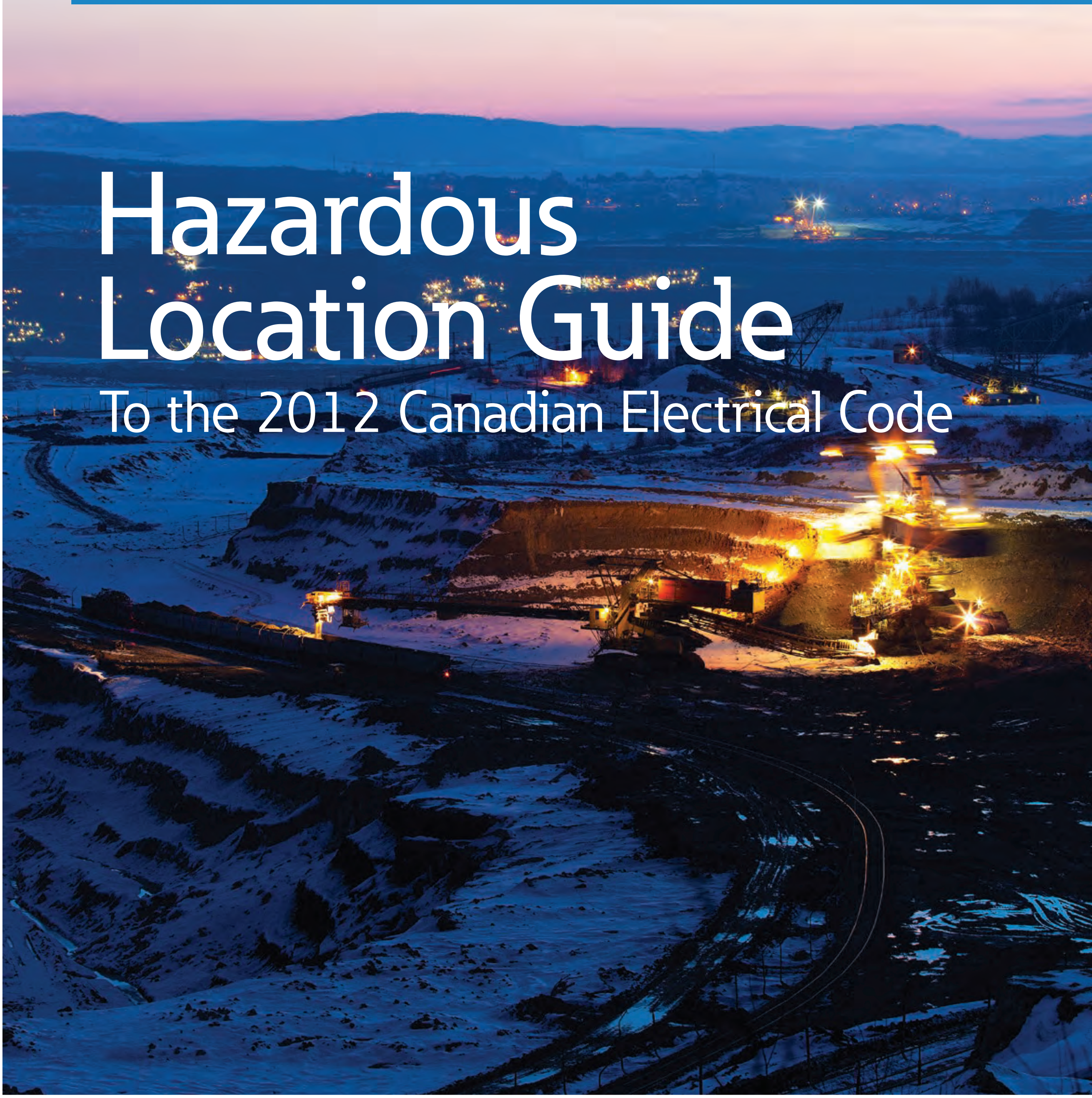
Section 18, 20 and 22 of the 2012 Canadian Electrical Code with product recommendations for use in hazardous locations

Hazardous Location Guide

To the 2012 Canadian Electrical Code



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This edition of the Hazardous Location Guide coincides with the 2012 edition of the CEC, effective through 2015, however may be superseded by new editions or amendments during that code cycle. Please consult CSA and authority having jurisdiction for latest Code updates and provincial applicability.

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Hazardous Location Guide

Finishing Processes

Aircraft Hangers

Section 22

Corrosive Liquids, Vapours or Moisture—Sewage Lift and Treatment Plants

Appendices

By adopting the Zone method of classifying Hazardous Areas, Canadian users have the ability to use the European (IEC) style equipment in addition to the existing North American products.

Prologue

There was a debate in Canada for many years about using the Zone system of classification. In 1992 members of the *Code* panel pointed out that it wasn't the Zone system of classification that Canadian users needed. It was the ability to use the European (IEC) equipment in addition to the existing North American equipment. The task force determined that the best system of area classification was to allow the use of both IEC and North American equipment in a three-Zone method. The 1998 *CEC* allowed full use of both types of equipment in Zone 0, 1 and 2, as well as in Divisions 1 and 2.

This *Cooper Crouse-Hinds Hazardous Location Guide to the 2012 Canadian Electrical Code* will explain and interpret Sections 18, 20 and 22 of the *Canadian Code*. The *Code* is printed in red. The Cooper Crouse-Hinds interpretation is printed in black. The print contained in the red boxes are notes from Appendix B or from tables located between section 84 and Appendix A. The beginning section provides valuable information on the principles of explosions, concepts of hazardous area classifications, and most widely used explosion-protected techniques.

We would welcome your suggestions for future issues. Please send your comments or suggestions to crouse.customerctr@cooperindustries.com

CHAPTER 1 THE ELECTRICAL CODE EVOLVES

The first electrical equipment used in the mines were motors to drive the elevators, ventilators and mining equipment.

1.1 The First Hazardous Areas

The first hazardous areas are reputed to have been recognized in coal mines. Methane gas, which is absorbed by coal, later escapes from the coal once it is mined. The methane gas, which is lighter than air, would occasionally be ignited by the miner's candles. This resulted in a double jeopardy of the ignition of methane gas and subsequent ignition of the coal dust itself. The first solution was to hire miners to ignite the gases each day with a very long pole with a burning ember at the end. This list of volunteers soon ran short so convicts from local prisons were recruited. Criminals yes, but fools they were not. Eventually, ponies were enlisted and outfitted with special saddles that carried a lighted candle. The ponies were doused with water and sent running through the mine shafts in hopes of creating only very small explosions.

Igniting small pockets of methane gas was one of the original methods to prevent ignition in coal mines.

Later in 1815 Sir Humphrey Davy invented the Davy lamp, which was a kerosene lantern with a fine brass mesh surrounding the burning wick. The mesh emitted some light but was fine enough to not let the flame propagate through the screen. Later, mechanical ventilation was introduced into the mines, which dispersed the methane to the point where there was not sufficient fuel left to ignite. The method of providing adequate ventilation is still in use today in reducing hazards.

The first electrical equipment used in the mines was motors to drive the elevators, ventilators and mining equipment. After the sparking motors resulted in some mine mishaps, they were totally enclosed, which contained the explosions. This marked the beginning of the metallic explosionproof enclosures with tight-fitting joints later called flame paths.

Reference: M Toney et. al., A History of Electrical Area Classification in the United States. In IEEE PCIC Conference Record 2000, pp. 273-279.

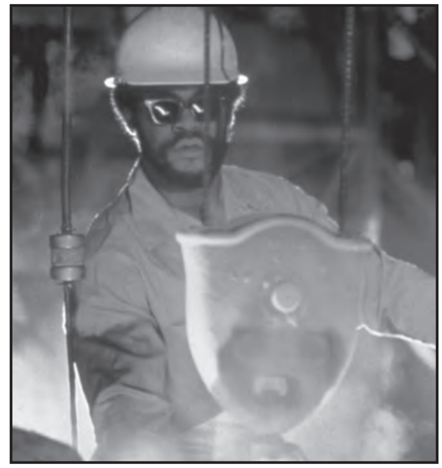
One of the first explosion-protected mining lanterns manufactured by Cooper Crouse-Hinds CEAG in Germany.

1.2 Electrical Code Evolution Described

In the early 1900s, when contractors were busy electrifying industrial buildings, electrical wires were run through existing gas pipes, resulting in today's conduit system of wiring. This was the basis for future North American codes and wiring practices. At the same time, the International Electrotechnical Commission (IEC) was founded in Switzerland. The IEC is the United Nations of the electrical industry. Its ultimate goal is to unify worldwide electrical codes and standards. Few IEC practices were incorporated into the NEC or CEC, mainly because North America operated on different voltages and frequencies than most of the rest of the world.

1.3 Division 1 Is Born

The advent of automobiles and airplanes in the early 1920s created a need to refine fuels. Because volatile vapours from gasoline and electrical sparks did not safely mix, the first Hazardous Area classification, called "Extra Hazardous Location," later referred to as Division 1, was inserted into the NEC. Division 1 described areas being normally hazardous. Thus, a new industry with the goal of protecting electrical equipment in hazardous areas was born. Explosionproof enclosures, intrinsic safety, oil immersion, and wire gauzed (meshed) enclosures for mining lanterns were the first types of protections developed.



Cooper Crouse-Hinds has manufactured electrical and explosion-protected equipment since 1897.

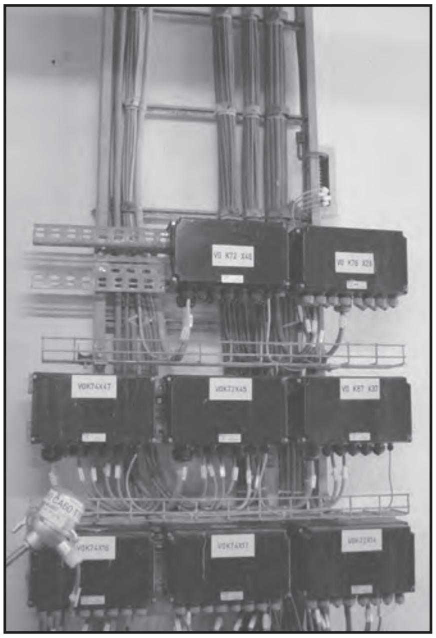
In 1931 Class I for gases and vapours, Class II for dusts and Class III for fibres were defined. The Class I areas were further subdivided in 1935 into the Groups A, B, C, & D (refer to section 2.4) based on the gases' main characteristics of:

- explosive pressure
- flame transmission
- ignition temperature

1.4 Division 2 Begins

Post-World War II brought many changes in Europe and North America. Metal shortages in Europe prompted more plastic use in electrical equipment, and the first construction standards for explosion-protected electrical equipment appeared in Germany. About the same time, North American industries determined that hazardous area classifications needed to be expanded. A Division 2 was needed to describe locations that were not normally hazardous to allow use of less expensive equipment and less restrictive wiring methods.

In 1956 the concept of intrinsic safety appeared in the North American Codes. In the 1960s, the European community was founded to establish a free trade zone in Europe. To reach this goal, technical standards needed to be harmonized. As a result the European Community for Electrotechnical Standardization (CENELEC) was established. The German chemical industry departed from the traditional conduit or pipe wiring system and migrated toward cable as a less expensive alternative. This wiring method change led to the Zone classification system later adopted in 1972 by most European countries in a publication known as IEC 79-10. This action led to the different methods of classifying hazardous areas, as well as protective, wiring, and installation techniques.



Cabling is becoming the preferred wiring method in Canadian Hazardous Locations.

1.5 Why Codes Changed in North America

North American industry has grown accustomed to the Division classification system. Plants in the U.S. and Canada are safe and operating efficiently. So why change to a new classification system? The business world continues to shrink and most companies are thinking globally. Many industrial end users and manufacturers wanted a harmonized international standard so a new plant built offshore would have the same equipment and installation standards as one built domestically. This would allow them to take advantage of a single source of materials and less expensive alternatives not always available elsewhere.

The U.S. and Canada debated the merits of classifying hazardous areas as zones instead of divisions for over 20 years. By adopting the Zone method of hazardous areas Canadian users now had the ability to use European (IEC) equipment in addition to the existing North American products. The subcommittee in charge of the Hazardous Locations section of the Canadian Electrical Code concluded that the best system of area classification to allow the use of both IEC and North American equipment was in fact the three-Zone method.

This led to many options and alternatives for materials and installation methods, all centered around different methods of protection. The purpose of this document is to explain the concepts of hazardous areas, the differences between Zones and Divisions, and the different explosion protection techniques. For more detailed information on the equipment available and the installation methods used, ask your Cooper Crouse-Hinds representative for a copy of the *Ex Digest*.

CHAPTER 2 BASICS OF EXPLOSION PROTECTION

The determination of the amount of time that an explosive mixture will be present in an area is the basis of "area classification."

2.1 Canadian Code Definitions

Section 0 of the *Canadian Electrical Code* defines Hazardous Locations as:

"premises, buildings, or parts thereof in which

(a) an explosive gas atmosphere is present, or may be present, in the air in quantities that require special precautions for the construction, installation , and use of electrical equipment;

(b) combustible dusts are present, or may be present, in the form of clouds or layers in quantities to require special precautions for the construction, installation, and operations of electrical equipment; or

(c) combustible fibres or flyings are manufactured, handled or stored in a manner that will require special precautions for the construction, installation, and operations of electrical equipment.

Section 18 of the *Canadian Electrical Code* contains the rules for classifying Hazardous Locations and for installing wiring and equipment in those locations. Rule 18-004, Classification, further defines what is required for an area to be considered a Hazardous Location. 18-004 reads as follows:

"Hazardous locations shall be classified according to the nature of the hazard, as follows:

"a) Class I locations are those in which flammable gases or vapours are or may be present in the air in quantities sufficient to produce explosive gas atmospheres;

"b) Class II locations are those that are hazardous because of the presence of combustible or electrically conductive combustible dusts;

"c) Class III locations are those that are hazardous because of the presence of easily ignitable fibres or flyings, but in which such fibres or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures."

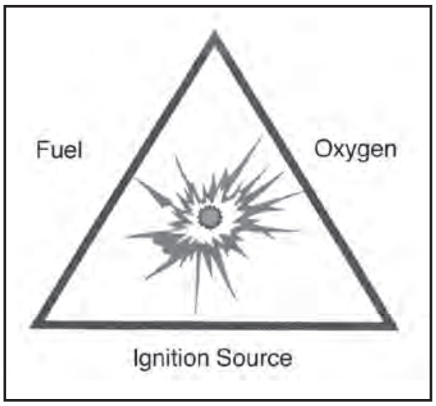
Worldwide there have been many spectacular examples of human failure when working in hazardous areas, which have resulted in explosions and fires causing the loss of life and destruction of installations. Two such examples are the Piper Alpha oil and gas production platform installed in the British Sector of the North Sea and Flixborough near Scunthorpe in Lincolnshire, England. In both examples, a massive release of flammable material was ignited by either electrical or mechanical energy.

Ignition of flammable materials causes catastrophic results.

A literal interpretation of the Hazardous Location definition might lead to classifying areas that are accepted as being unclassified and therefore the definitions must be applied with a degree of knowledge and experience. For example, part (a) of the Hazardous Location definition could lead to the conclusion that the fuel supply to gas furnaces in homes would require the area around the furnace to be classified. However, as the pressure of the gas is very low relative to the rating of the piping, and the installation of the piping can be done only by qualified persons, the possibility of a release of sufficient gas to create an "explosive gas atmosphere" is so low that the area is not classified. Rules in other codes such as the Building Codes or the Natural Gas and Propane Installation Codes contain additional information that may also affect whether an area should be considered a Hazardous Location. It is important that the decisions regarding the determination as to whether or not an area is a Hazardous Location are made only by individuals who are familiar with all the codes, standards and principles that apply.

2.2 The Hazard Triangle

For an area to be classified as a Hazardous Location there must be the possibility that the conditions for an explosion or fire may



All three elements must be present for an explosion to occur.

exist as the result of some abnormal occurrence. To better understand what these conditions may be, an understanding of the fire triangle is a fundamental requirement.

For an explosion to take place, all three sides of the triangle, satisfying the following conditions, must be present:

- There must be a supply of oxygen present. In most situations this is true as a result of the oxygen content in the air (21%).
- There must be sufficient fuel present in the air to form an ignitable mixture. The fuel may be in the form of a gas, vapour, mist or dust.
- There must be a source of ignition with sufficient energy to ignite the fuel-air mixture. For electrical equipment this may be from an arcing or sparking device or from a hot surface. There may be sources of ignition other than electrical equipment, such as hot exhaust surfaces from internal combustion engines. These devices do not fall within the scope of the *Canadian Electrical Code*, and are normally covered by other codes and standards such as Occupational Health and Safety Codes.

The basic approach to design in a Hazardous Location is to ensure that all three sides of the triangle do not exist simultaneously. If any one side of the triangle is not present, an explosion cannot occur. Protection against explosions will therefore require control or elimination of one or more sides of the triangle. Area classification deals with the fuel and oxygen sides of the triangle, whereas the installation Rules in the CEC deal with the types of equipment necessary to eliminate or reduce the occurrence of the ignition side to safe levels.

2.2.1 The Oxygen Side

In most situations there is sufficient oxygen present in the air (21%) to meet the conditions for an explosion. In some situations however, oxygen may be excluded by blanketing an enclosed area with another gas to ensure there will not be sufficient oxygen present. The blanket gas is normally an inert gas, such as nitrogen, or in some cases it may even be a flammable gas such as methane.

2.2.2 The Fuel Side

The fuel side of the triangle is removed by enclosing the gas or dust in piping, or vessels in the case of gas, vapours or flammable liquids, or in enclosed ducts in the case of dust. Of course there is always the possibility that flammable materials could be released in sufficient quantity to form an explosive mixture as a result of a malfunction of equipment. In some situations an explosive mixture may be present frequently or continuously as a result of normal operations such as the interior of vented fuel storage tanks or the interior of paint spray booths.

The determination of the amount of time that an explosive mixture will be present in an area is the basis of "area classification," which is discussed later in more detail.

2.2.3 The Ignition Side

The electrical equipment installed in Hazardous Locations forms the ignition side of the triangle. The various designs used for electrical equipment ensure there will not be a simultaneous occurrence of all three sides of the triangle. The specific design of an electrical device for use in a Hazardous Location will depend on the amount of time it will be exposed to flammable concentrations of flammable material. In other words the design must be suitable for the classification of the area in which it is installed.

Overall the design of equipment for the different "Zones" or "Divisions" is based on ensuring the probability of the simultaneous occurrence of a flammable gas (or vapour, mist or dust) concentration and an ignition source from equipment is so low that in practice it does not happen. It has been suggested in a number of industry papers that the probability of an ignition occurring once every hundred years is so low that in practice it will not happen. Probabilities at this level (approximately 1 in 10^6) are similar to those done for the catastrophic failure of piping or vessels. In basic terms as the probability of the occurrence of flammable mixtures increases, the probability of electrical equipment becoming an ignition source must correspondingly decrease. For example, in Class I, Zone 0 locations the probability of an explosive mixture being present is so high that the probability of electrical equipment creating a source of ignition must be reduced to near zero, hence the requirement for intrinsically safe equipment. On the other hand, in situations where the probability an explosive mixture being present is low, equipment that could create a momentary ignition source (such as a 3-phase motor) can be allowed.

2.3 Ignition Sources – Gases & Vapours

Ignition sources can occur by various mechanical means, but for the purpose of this publication we consider only electrical sources of potential ignition.

The most important characteristics in regard to ignition are:

- Upper Flammable Limit
- Lower Flammable Limit
- Flash Point of the Flammable Material
- Auto-Ignition Temperature
- Vapour Density

2.3.1 Upper & Lower Flammable Limits

There are a number of characteristics of gases and vapours that are important for the classification of a Hazardous Location and the application of equipment within the Hazardous Location.

- **Lower Explosive Limit (LEL) —** is the lowest percentage by volume of gas (or vapour) in a gas-air mixture that will form an ignitable concentration. Below that concentration there is insufficient gas or vapour in the mixture and the gas-air mixture is too lean to be ignited.

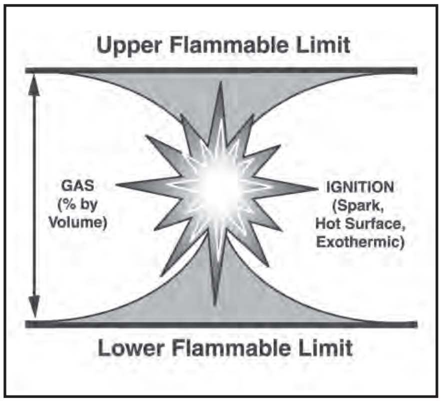
Class I Group	Substance	Flammable Limits Percent by Volume Lower	Upper
C IIB	Acetaldehyde	4.0	60
D IIA	Acetic Acid	4.0	19.9 @ 200°F
D IIA	Acetic Anhydride	2.7	10.3
D IIA	Acetone	2.5	13
D IIA	Acetone Cyanohydrin	2.2	12.0
D IIA	Acetonitrile	3.0	16.0
A IIC	Acetylene	2.5	100

Full table is contained in Appendix I.

- **Upper Explosive Limit (UEL) —** is the highest percentage by volume of gas or vapour in a gas-air mixture that will form an ignitable concentration. Above that concentration there is too much gas or vapour in the mixture and the gas-air mixture is too rich to ignite.

If the percentage of gas is below the lower limit, the mixture is too lean (insufficient fuel) to ignite. The mixture is too rich (insufficient oxygen) if the percentage is above the upper limit. Some gases, such as methane, are ignitable over a relatively narrow range of 5% to 15%. Methane is frequently used in the form of natural gas to provide a low-pressure gas blanket over liquid in a tank to ensure an ignitable mixture is not formed. The presence of the natural gas blanket ensures the mixture in the tank will always be above the UEL.

Other gases are ignitable over a relatively large range, such as acetylene (2.5 to 100%) and hydrogen, which is ignitable from 4% to 75%. As hydrogen is a very light gas it is often used in large turbine generators to reduce the friction loss of the rotor. Because of the extremely large explosive range of hydrogen, great care must be taken to ensure concentrations within the generator do not enter the explosive range as the result of the introduction of air. Refer to Appendix I of the *Cooper Crouse-Hinds Code Digest* or NFPA 325, *Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids,* for the complete listing of gases and vapours.



The mixture of gas and air must be between the Upper and Lower Flammable Limits for a fire or explosion to occur.

Liquids that are stored or used below their flash points will normally not require the area in which they are stored to be classified as a hazardous location.

2.3.2 Flash Point of the Flammable Materials

Flash point is the minimum temperature of a liquid at which sufficient vapour is given off to form an ignitable mixture with air, near the surface of a liquid. Liquids with a flash point below 37.8°C (100°F) are defined as flammable liquids whereas liquids with a flash point above 37.8°C are defined as combustible liquids. Liquids which are stored or used below their flash points will normally not require the area in which they are located to be classified as a hazardous location. However, liquids that are stored or processed under pressure, which may be released in the form of a mist, may be ignitable at temperatures below their flash points.

Flammable limits are normally given at 25°C; an increase in temperature widens the flammable limits.

As a general rule 12°C below flash point results in a flammable vapour concentration of 50% of the lower flammable limit. See Appendix I, "Gases & Vapours – Hazardous Substances Used in Business & Industry."

Class I Group	Substance	Flash Point °C	°F
C IIB	Acetaldehyde	-39	-38
D IIA	Acetic Acid	39	103
D IIA	Acetic Anhydride	49	120
D IIA	Acetone	-20	-4
D IIA	Acetone Cyanohydrin	74	165
D IIA	Acetonitrile	6	42
A IIC	Acetylene	gas	gas

Full table is contained in Appendix I.

2.3.3 Auto-Ignition Temperature

The ignition temperature of a gas, sometimes referred to as "auto-ignition" temperature, is the lowest surface temperature which will ignite the flammable atmosphere (independent of any externally heated element). This becomes important when determining the outside temperature rating, or T-rating, of an enclosure. Published values of ignition temperature are determined by injecting a gas sample into a heated flask to determine the minimum temperature at which ignition takes place.

Class I Group	Substance	Auto-Ignition Temp. °F	°C
C IIB	Acetaldehyde	347	75
D IIA	Acetic Acid	867	464
D IIA	Acetic Anhydride	600	316
D IIA	Acetone	869	465
D IIA	Acetone Cyanohydrin	1270	688
D IIA	Acetonitrile	975	524
A IIC	Acetylene	531	305

Full table is contained in Appendix I.

Actual ignition temperatures are affected by many variables such as the percentage of gas or vapour in the mixture, the size and shape of the heated surfaces, wind and convection currents, etc. The published ignition temperature values are generally accepted as being the minimum ignition temperatures. Further information regarding ignition temperatures can be found in the following documents:

- API Publication 2216 – *Ignition Risk of Hydrocarbon Vapours by Hot Surfaces in the Open Air*
- NFPA 325 – *Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*
- NFPA 497 – *Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*
- NFPA 499 – *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*
- *IEC – 60079-20-1*
- *CEC – Part I Appendix B*

2.3.4 Vapour Density

The vapour density of a gas, sometimes referred to as "relative vapour density," is the weight of a volume of a vapour or gas with no air present compared to the weight of an equal volume of dry air at the same normal atmospheric temperature and pressure. Vapour densities greater than 1.0 indicate the vapour or gas is heavier than air and will tend to settle towards the ground. Vapour densities less than 1.0 indicate the vapour or gas is lighter than air and will tend to rise.

Class I Group	Substance	Vapour Density (Air Equals 1.0)
C IIB	Acetaldehyde	1.5
D IIA	Acetic Acid	2.1
D IIA	Acetic Anhydride	3.5
D IIA	Acetone	2.0
D IIA	Acetone Cyanohydrin	2.9
D IIA	Acetonitrile	1.4
A IIC	Acetylene	0.9

Full table is contained in Appendix I.

When selecting hazardous area electrical apparatus, ensure that the gas grouping is appropriate to the area classification and that the temperature classification of the equipment is not higher than the auto ignition temperature of the surrounding gas or vapour.

2.4 Gas Grouping

Individual gases and vapours have distinct characteristics. One possible approach to equipment design would be to design equipment for each specific gas. That approach is not practical since it would greatly increase the cost of equipment and make the manufacturing process a virtual nightmare. In order to simplify the manufacturing and equipment selection processes, gases are divided into groups with similar characteristics based on two main factors:

- The requirements for constructing an "explosionproof" or "flameproof" enclosure to contain an explosion of the gas or vapour, and
- The minimum current (amperage) required to ignite the gas or vapour. This is the basis for gas grouping relative to intrinsically safe circuits.

Explosionproof or flameproof enclosures are constructed to withstand an internal gas explosion without damage to the enclosure and to cool the hot gases produced by the explosion as they exit the enclosure along the **flame paths.** The gases in the "higher" or more difficult gas groups require longer flame paths to cool the gas and thicker walls to contain the increased pressure of the internal explosion. The main factor in grouping gases for the design of explosionproof enclosures is the **Maximum Experimental Safe Gap (MESG).** MESG for a given gas is the maximum gap or opening (expressed in mm), for a 25 mm-wide flame path, which does not propagate an explosion of that gas.

Minimum Ignition Current (MIC) is determined in a laboratory test arrangement and is intended to give comparative values for the purposes of grouping only. Gases in the higher gas groups will ignite with lower currents, and as a result, intrinsically safe circuits for these groups will be restricted to lower currents than in the lower groups. It is important to understand that the MIC values apply only to the specified test apparatus. Actual ignition currents for given gas and circuit parameters must consider a number of factors such as voltage, capacitance and inductance in a circuit.

Most equipment that is explosion-protected to the IEC standards is rated IIC for the most severe gas groups. Most North American equipment is rated for Groups C and D, which account for 85 to 90% of hazardous area applications. In some cases enclosures are tested to meet the higher explosives pressures of hydrogen and are rated for Group B. It is extremely rare to find areas or equipment classified as Group A except for intrinsically safe apparatus certified for Group A.

It should be noted that some equipment approved for use in Class I, Zone 2 may not have a Gas Group marking. If the equipment does not produce sparks or arcs, such as terminal boxes or light fixtures, the equipment is suitable for all gas groups. The label on the product does not have to designate the gas group. However, if the product does generate heat,the T number code must be identified. Note that equipment operating at temperatures lower than 100°C may not be marked with a temperature code.

2.4.1 North American vs IEC Practices

The North American system groups gases into four groups while the IEC system groups the gases into only three groups. Table 2.4.1 shows a comparison of the two systems, a typical gas for each group and the MESG and MIC for each of the gases.

Typical Gas	MESG (mm)	MIC (mA)	North American Grouping	IEC Grouping
Acetylene	0.25	60	A	IIC
Hydrogen	0.28	75	B	IIC
Ethylene	0.65	108	C	IIB
Propane	0.97	146	D	IIA

Table 2.4.1
Comparison of North American and IEC Gas Groupings

The IEC gas groupings are divided into **Group I** for mining and **Group II** for surface industrial applications. Equipment approved for use in Group IIC is also safe to use with Groups IIB and IIA gases. Equipment approved for use in Group IIB is also safe to use with Group IIA gases. Under the North American system of gas grouping, there is not officially a hierarchy as in IEC. North American equipment is marked only in accordance with gas groups for which it has been tested. For example equipment tested with Group B, C and D gases would be marked "B, C, D." Equipment tested only with Group B gas would be marked "B" only. In practice however, the North American system is unofficially treated as if a hierarchy similar to IEC was in place.

2.5 Temperature Classification

The selection of electrical equipment for use in hazardous areas must ensure that the maximum surface temperature of **any part** of the apparatus **exposed to the potentially explosive atmosphere,** does not exceed its ignition temperature (i.e., the temperature at which the substance when heated will ignite spontaneously).

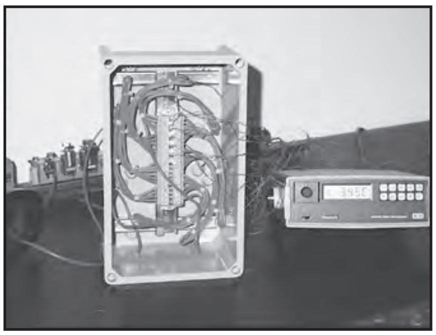
Temperature classifications according to the North American and IEC 79-0 standards are detailed in Table 2.5.

Temperature Classification	Maximum Surface Temperature	
	North America	IEC
T1	450°C	450°C
T2	300°C	300°C
T2A	280°C	-
T2B	260°C	-
T2C	230°C	-
T3	200°C	200°C
T3A	180°C	-
T3B	165°C	-
T3C	160°C	-
T4	135°C	135°C
T4A	20°C	-
T5	100°C	100°C
T6	85°C	85°C

Table 2.5
T-numbers for North America and IEC

The reference ambient temperature of 40°C will be assumed unless otherwise stated on the apparatus labeling. Normal test requirements also assume that the tested equipment is suitable for lower ambient temperatures of minus 25°C.

The **T-Classification** allocated to Certified Electrical Apparatus is based on normal temperature at the most difficult operating conditions. For example, the most onerous condition for an increased safety, Ex-e, terminal box would be an enclosure fitted with the maximum permitted number of terminals with every terminal carrying its maximum rated current and maximum cable lengths connected to each terminal.



An example of the temperature test for Increased Safety enclosures.

Increased Safety Ex-e terminal boxes are normally allocated a T6 Temperature Classification, i.e. 85°C maximum surface temperature on any exposed part of the apparatus at an ambient of 40°C. Apparatus with a T6 Classification has a very high degree of safety and flexibility, because there are no gases listed at T6 temperature. (The only listed gas with an ignition temperature of T5 (100°C) is Carbon Disulfide.)

It is important that the maximum operating temperature of cables connected to electrical equipment is considered, particularly if the cable is PVC insulated. They normally have a maximum operating temperature of 70°C. To make full use of the maximum operating temperature of T6 classified equipment, XLPE insulated cables with 90°C rated insulation should be used.

The minimum concentrations of dust that will explode are normally two or three orders of magnitude above acceptable concentrations for workers.

2.6 Ignition Sources – Dusts

Some dusts in suspension in the air will explode if ignited from a source with sufficient energy. Materials that can give dust explosions include:

- Natural organic materials (grain, linen, sugar)
- Synthetic organic materials (plastics, organic pigments, pesticides)
- Coal and peat
- Metals (aluminum, magnesium, iron, zinc)

2.6.1 Minimum Explosive Concentration – Dusts

For dust suspended in air to explode it must be present in quantities at or above the **Minimum Explosive Concentration (MEC)**. The MEC of dust is defined as:

- The minimum concentration of dust in air that will explode when ignited, expressed in grams per cubic centimeter (g/cm^3) or in ounces per cubic foot.

Typically the minimum concentrations of dust that will explode are normally two or three orders of magnitude above acceptable concentrations for workers and are normally present only inside process equipment such as coal pulverizers, enclosed conveyor transfer points, silos, grain elevators, etc. For example a glowing 25-watt incandescent bulb cannot be seen through a 2-metre dust cloud exceeding 40 g/cm^3, whereas the MEC for coal dust is in the range of 60 g/cm^3. While dust concentrations approaching these levels are not normally present in working areas, accumulations of dust, when disturbed, may result in temporary concentrations of dust above the MEC. The accumulation of layers of dust on heat-producing electrical equipment, such as motors, can prevent the release of heat from the equipment and may create temperatures hot enough to ignite the dust layer. The burning dust if disturbed can simultaneously create an ignitable dust cloud and an ignition source, resulting in a dust explosion.

2.6.2 Minimum Ignition Temperature – Dusts

The **Minimum Ignition Temperature (MIT)** for dust is defined as:

- The minimum temperature required, at normal atmospheric temperatures in the absence of spark or flame, to ignite a dust layer or a dust cloud.

For most dusts the "layer ignition temperature" is significantly lower than the cloud ignition temperature. Tables giving the ignition temperatures for dust will typically give the lower of the layer or cloud ignition temperatures.

	Minimum Cloud or Layer Ignition Temp.		
Class II, Group F	**°F**		**°C**
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	–		–

See Appendix II "Dusts – Hazardous Substances Used in Business & Industry"

Most sparks that occur from the operation of electrical equipment have sufficient energy to ignite most dust clouds.

2.6.3 Dust Explosions

Dust explosions are categorized as primary and secondary explosions. "Primary" explosions occur as the result of ignition of a dust cloud. The pressure wave from the explosion will throw accumulated dust into the air causing a series of "secondary" explosions that will travel until the source of accumulated dust is exhausted. Dust explosions that take place within a confined space can be very violent.

The **Ignition Sensitivity** of dusts is a measure of the amount of energy required to ignite the dust. Many dusts are capable of being ignited by relatively low energy sources, such as static electricity. As static electricity can be created by the relative motion of dust in enclosures, grounding and bonding of transport equipment is of critical importance where dust is transported.

The **Explosion Severity** of dusts (also referred to as explosion violence) is a measure of the maximum explosion pressure and the maximum rate of pressure rise and is equal to the maximum rate of pressure rise in a standard test volume. Dusts with high explosion severity include wheat grain, lignin, peat, milk powder, soybean, maize starch, rice starch, wheat starch, brown coal, charcoal, asphalt, cellulose, polyethylene, polyurethane, acetylsalicylic acid, dimethylaminophenazone, aluminum powder, magnesium, manganese, zinc, sulfur, fly ash, etc.

The **Minimum Ignition Energy (MIE)** of a dust cloud is a measure of the amount of spark energy to ignite it. In general most dust clouds require more energy to ignite than do gases and vapours, however most sparks that occur from the operation of electrical equipment have sufficient energy to ignite most dust clouds.

Other factors that influence the ease of ignition of dusts are:

- **Particle size** – Dust clouds composed of smaller particles will ignite more easily than dust clouds with larger particles.
- **Moisture content** – Increasing levels of moisture in dust will increase the ignition temperature of the dust.
- **Makeup of the dust cloud** – Where the dust cloud contains particles that are not combustible, such as rock dust, the presence of the rock dust can change the concentration of ignitable dust in the cloud to the point where the combination is not ignitable. This principle is often used in coal mines where noncombustible dust is spread over the coal dust to prevent the occurrence of dust explosions.

CHAPTER 3 CLASS I AREA CLASSIFICATION

North American facilities using the Zone concept classify most Hazardous Locations as Zone 2, which is equivalent to Division 2.

3.1 Comparison Between Divisions & Zones

Canada and the U.S. have changed their Electrical Installation Codes (CEC and NEC) to allow the use of Class I Hazardous Locations electrical equipment based on IEC standards, in addition to the “traditional” North American Class I Hazardous Locations electrical equipment. This allows users more flexibility in their choices of Hazardous Locations electrical equipment, particularly in Class I, Division 2/Zone 2 Hazardous Locations. At the same time designers have recognized that a majority of Class I Hazardous Locations that were previously classified as Class I, Division 1 Hazardous Locations actually meet the requirements for a Class I, Division 2/Zone 2. As a result, the majority of new Class I Hazardous Locations in Canada facilities are now classified as Class I, Zone 2 Hazardous Locations.

The change to Class I, Zone 2 classifications has resulted in:

- Decreased costs as the types of equipment now allowed in Class I, Zone 2 Hazardous Locations has significantly reduced the wiring costs over the equipment previously required in Class I, Division 1.
- Improved safety as the equipment used in Class I, Zone 2 Hazardous Locations is simpler to properly install and maintain than that equipment used in Class I, Division 1.

A comparison of the Division and Zone classification system is shown in Table 3.1. Division 2 is equivalent to Zone 2 while Division 1 is either Zone 0 or 1. Zone 0 is reserved for those areas continuously hazardous (e.g., inside a vented fuel tank), so other Division 1 areas would be classified as Zone 1.

There is a large opportunity for additional, lower cost Zone 2 equipment as companies classify more areas as Zone 2.

Class I	Division System	Description	Comments
Gases & Vapours	Division 1	Hazardous under normal operations	Division 1 is split into Zone 0 and 1. Zone 0 is a small percentage of locations usually confined to inside vented tanks.
	Division 2	Not normally hazardous	Zone 2 and Division 2 are essentially the same.

Table 3.1
Classification System Comparison

Classified Area		Time that hazardous gases are present in ignitable concentrations	Estimated % of Division areas in North America	Estimated % of Zone areas in Europe
Zone 0		Continuously		<2%
	Division 1	Normally present	<5%	
Zone 1		Occasionally in normal operations		>60%
Zone 2	Division 2	Not normally present	>95%	<40%

Table 3.2
Comparison of Zones and Divisions

3.2 Present Day Hazardous Area Classifications and Product Mix

It is estimated that less than 5% of Class I hazardous areas in new North America facilities are classified as Division 1. The split of hazardous areas in Europe is just the opposite, with over 60% of the areas classified as Zone 1. See Table 3.2. The reasons for the difference in the split between Zone 1/Division 1 and Zone 2/ Division 2 in Europe and North America appears to be the difference in the types of equipment available to European and North American users. Prior to the Canadian Electrical Code and the National Electric Code allowing the use of "European style" Hazardous Locations equipment, the cost differential between Zone 1 and Zone 2 wiring devices in Europe was much lower than the cost differential between Division 1 and Division 2 wiring devices in North America. As a result, there was no particular incentive for Europeans to develop products for Zone 2, instead users tended to choose similar wiring systems for Zone 2 as they used in Zone 1. Similarly there was no incentive to classify areas as Zone 2 even though they clearly met the Zone 2 definitions. In North America, on the other hand, the cost differential between Division 1 and Division 2 wiring systems was much greater. As a result, starting in the early 1990s North American users developed processes to classify more closely in accordance with the area classification definitions, thus resulting in a much higher percentage of Division 2/Zone 2 classified areas. This in turn has led to a focus on the development and use of more products for Division 2/ Zone 2 and a corresponding decrease in the use of Division 1 (explosionproof) products. However, if industry in Europe faces the same cost drivers as North America, Europeans will eventually use more Zone 2 products and will classify a higher percentage of their Hazardous Locations as Zone 2.

Area classification is the determination of the probable frequency and duration of the presence of gas, vapour or mist in excess of 100% of the LEL.

3.3 Area Classification – A Practical Approach

Area classification is the most important aspect of electrical design in Hazardous Locations. Historically the process of classifying Hazardous Locations has not been well understood by many designers. As a consequence, the approach to "over-classify" to err on the side of safety has been the industry norm.

Most Class I hazardous areas located indoors were classified as Class I Division 1. (Old-style motor starters have been replaced by EBMs.)

While it was common practice prior to the early 1990s to classify most indoor Class I Hazardous Locations as Class I, Division 1, many users now believe there are actually very few buildings that do not function in accordance with the *CEC* definition for Class I, Zone 2 (Division 2). It is important to remember that the Hazardous Location definitions in the *CEC* are the basic legal requirement. There are many other industry documents such as the *API Recommended Practice for Area Classification* which are only recommended means of meeting the *CEC* definitions and are not *Code* requirements. Any method that demonstrates compliance with the *CEC* area classification definitions meets the requirements of the *CEC*.

In most Class I buildings the area classification choice is between Zone 1 and Zone 2. In making that choice there are a number of tools that may be used. If it can be demonstrated that a building is "adequately ventilated," it meets one of the main requirements of a Zone 2 classification. An additional requirement for a Zone 2 classification is that in the event of an abnormal gas release approaching or exceeding explosive levels, action must be taken to correct the problem within a "short time." Many Canadian industrial users accept a 10-hour per year "rule of thumb" limit on exposure to "explosive gas atmospheres" for Class I Zone 2 Hazardous Locations. If the building is on a site that is continuously manned, or it is monitored by gas detection to shut down the process, or alarmed to allow operating personnel to correct the problem within a short time, the requirements for a Zone 2 classification are effectively met.

3.4 Adequate Ventilation for Zone 2

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* outlines a number of methods for demonstrating or meeting the requirement for "adequate ventilation." One method that has been used for many years is to provide a minimum of six continuous air changes per hour. Another method is to carry out a fugitive emissions study as outlined in Appendix B of the API standard. A third method for existing buildings that is not contained in API RP505 would be to measure the gas concentration in various areas of the building to determine if the requirement for "adequate ventilation" is actually being met. Records of permanently installed gas detection systems are often available to provide historical data. In recent years a combination of fugitive emission studies and/or field measurement have been used to demonstrate a building is adequately ventilated.

While past practices achieved Zone 2 (Division 2) area classification by providing six air changes per hour by mechanical means, recent experience has shown that in many Class I buildings "adequate ventilation" often requires ventilation rates in the order of one air change per hour. Frequently the ventilation requirements can be provided by the naturally occurring ventilation. In many cases, the reduced ventilation requirement eliminates the need for complicated and expensive ventilation systems and reduces the energy required to heat the building. However, there are many instances where buildings such as natural gas compressor buildings are remotely located and not manned or monitored on a 24 hour basis. The buildings are designed as Zone 1, as it is not possible to ensure that when explosive gas atmospheres occur, they will be present only for a "short time."

Remote Class I buildings that are not remotely monitored to ensure Zone 2 conditions can be met are classified Zone 1.

3.4.1 Who Classifies Hazardous Locations?

There is considerable debate around the world as to who is responsible for the classification of Hazardous Locations. In most Canadian companies Electrical Engineers lead the area classification process with input from Process Engineers.

If the North American Division method of area classification has been used on an existing plant then reference can be made to Appendix J of the *Canadian Code*, the *National Electric Code* Article 500-503 and the American Petroleum Institute Publication RP500. Section 18 of the *Canadian Code, API RP505 and* IEC Standard 79-10 provide guidance on classifying Hazardous Locations for the Zone system where the three-Zone system of classification has been used. Regardless of which system of area classification has been used, a thorough analysis should be undertaken by designers and engineers to determine the correct Hazardous Locations classification.

> *All Class I rules in Section 18 are based on the three-Zone system of area classification.*

3.5 Class I Hazardous Locations in Canada

Prior to the 1998 edition of the *Canadian Electrical Code*, Class I locations were divided into two Divisions — Divisions 1 & 2. The 1998 edition of the *Canadian Electrical Code* incorporated the IEC methods of protection into Class I locations. The task force writing the changes to the *Code* determined that the three-Zone system of area classification would best incorporate *both* the North American and IEC equipment and wiring methods in Section 18. For users wishing to continue the use of the two- Division system in existing facilities (or to add to existing facilities), the rules for a Class I, two-Division system were moved to Appendix J. All Class I rules in Section 18 are now based on the three-Zone system of area classification.

The classification of Hazardous Locations is a complex subject. Once a Hazardous Location is classified in accordance with the Canadian Electrical Code, the Rules in the Code outline the types of equipment that are suitable to use in the area. However, in most jurisdictions, Occupational Health and Safety Rules may impose restrictions on the type of non-electrical equipment that can be used in the area and on the work processes that can safely be followed in the area. Therefore, the classification of areas is an essential design consideration.

The process of classifying Class I Hazardous Locations requires a determination of the probable frequency *and* duration of the presence of an *explosive gas atmosphere* in a Hazardous Location.

The *Canadian Electrical Code* defines an explosive gas atmosphere as:

A mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, or mist in which, after ignition, combustion spreads throughout the unconsumed mixture.

In simpler terms, area classification is the determination of the probable frequency and duration of the presence of gas, vapour or mist in excess of 100% of the LEL. Areas where an explosive gas atmosphere is likely to be present more frequently or for longer periods will have "higher" area classification than areas where explosive gas atmospheres occur less frequently or for shorter periods.

3.6 Definition of Class I Zones

Class I Hazardous Locations are divided into three "Zones" in accordance with Rule 18-006, as follows:

Class I locations shall be further divided into three Zones based upon frequency of occurrence and duration of an explosive gas atmosphere as follows:

3.6.1 Zone 0

(a) Zone 0, comprising Class I locations in which explosive gas atmospheres are present continuously or are present for long periods;

Zone 0 locations are typically locations such as the vapour space above the liquid in a tank. In Zone 0 locations it is probable that the gas concentration will exceed 100% of LEL for very long periods. Table 3 in paragraph 6.5.8.3 of 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*, suggests Zone 0 locations are those where there is a flammable mixture more than 1,000 hours per year. Zone 0 locations typically do not exist outside of enclosed spaces except for the area immediately around vents which are venting from a Zone 0 location.*

Inside a vented storage tank containing flammable liquid is typically Zone 0.

3.6.2 Zone 1

(b) Zone 1, comprising Class I locations in which:

(i) Explosive gas atmospheres are likely to occur in normal operation;

*Table 3 in paragraph 6.5.8.3 of 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*, suggests Zone 1 locations are those where there is a flammable mixture more than 10 hours per year and less than 1,000 hours per year. Zone 1 locations normally occur around vents or in enclosed areas where there are intermittent or continuously open processes (for example, a paint spray booth). When classifying indoor locations it is common to treat them as Zone 1 if it cannot be demonstrated that the conditions for a Zone 2 location exist. An example of this situation would be a remote unattended gas compressor building where there is no gas monitoring. An abnormal leak resulting in gas concentration exceeding 100% of LEL could conceivably persist for well above the 10-hour threshold for Zone 1 locations.*

Process buildings may require permanently installed gas monitors to achieve Zone 2 classification.

(ii) The location is adjacent to a Class I, Zone 0 location, from which explosive gas atmospheres could be communicated.

Typically these areas would exist around a vent from a Zone 0 location. The size of the Zone 1 area around the Zone 0 area will depend upon the rate of release of the gas or vapour, the vapour density of the material released and the conditions in the area where it is released.

3.6.3 Zone 2

(c) Zone 2, comprising Class I locations in which:

(i) Explosive gas atmospheres are not likely to occur in normal operation and, if they do occur, they will exist for a short time only; or

Explosive gas atmospheres will not occur in the air except as the result of an abnormal situation such as a failed pump packing, flange leak, etc. Also when an abnormal situation does occur it will be corrected within a short time. 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 *suggests Zone 2 locations are those where explosive gas atmospheres will exist for less than 10 hours per year. Most Inspection Authorities require that indoor locations be classified as Zone 1 unless it can be demonstrated the conditions for Zone 2 exist. Indoor locations in remote unattended and unmonitored facilities most often cannot meet the 10-hour per year rule of thumb. The most common means of meeting the 10-hour rule of thumb in remote facilities is to install gas detection to shut down and depressurize the facility or to send an alarm to alert personnel to take corrective action.*

It is important that means to ensure the limited exposure time is met in Zone 2 locations as the design requirements for equipment acceptable in Zone 2 locations are based on limited exposure time.

(ii) The location is adjacent to a Class I, Zone 1 location from which explosive gas atmospheres 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.

Similar to (b)(ii) above, there will normally be a Zone 2 classified around a Zone 1 area surrounding a vent. It is also common for there to be a Zone 2 location around enclosed areas classified as Zone 1 unless there is a "vapour-tight barrier" around the Zone 1 area. For example, a process building with doors, windows, and other openings in the walls will typically have a Zone 2 area around all or portions of the building.

As outlined above, area classification is based on the probable frequency and duration of the occurrence of "explosive gas atmospheres at a location." It is done primarily to determine the type of equipment that is suitable for use in the area. The design of Hazardous Location equipment is based on the likely exposure time to "explosive gas atmospheres" as defined above.

In many other parts of the world, Zone Classification is the concept used.

3.6.4 Zone Classification Summary

The primary activity for Area Classification is to list the process equipment in the area under consideration and identify all potential sources of flammable material. An estimate must be made of the duration and frequency of each release in order to classify the emission as Continuous, Primary or Secondary and the rate of potentially explosive atmosphere into the surrounding area.

- Continuous Grade (>1000 hours/year) leads to a Zone 0.
- Primary Grade (10-1000 hours/year) leads to a Zone 1.
- Secondary Grade (<10 hour/year) leads to a Zone 2.

3.6.5 Examples of Hazardous Area Zone Classification

Zone 0

- Areas within process equipment developing flammable gas or vapours.
- Areas within enclosed pressure vessels or storage tanks.
- Areas around vent pipes which discharge continually or for long periods.
- Areas over or near the surface of flammable materials.

Zone 1

- Areas above roofs outside storage tanks.
- Areas above floating storage tanks.
- Areas within a specified radius around the outlet pipes and safety valves.
- Rooms without ventilation openings from a Zone 1 area.
- Areas around flexible pipelines and hoses.
- Areas around sample taking points.
- Areas around seals of pumps, compressors and similar primary sources.

Zone 2

- Areas around flanges and connecting valves.
- Areas outside Zone 1 around outlet pipes and safety valves.
- Areas around vent openings from Zone 2.

Changes to the Division of Class I, Hazardous Locations

Prior to the 1998 edition of the Canadian Electrical Code, Class I Hazardous Locations were required by the Code to be divided into two Divisions (Division 1 and Division 2) and the Rules in section 18 of the Canadian Electrical Code for Class I locations were based on the two-Division system. In the 1998 edition of the Code, the use of Hazardous Location equipment designed to IEC standards was added to section 18. The use of all previously allowed North American equipment was retained. However, in order to allow users the most effective means of applying all the equipment, it was determined that it could only be done under the three-Zone method of dividing Class I Hazardous Locations. Therefore, the 1998 edition and all subsequent editions of the CEC will use the three-Zone system of area classification and the Class I Rules have been written only for three Zones.

Recognizing that many existing facilities having Class I Hazardous Locations would not necessarily want to change the classification of those Class I Hazardous Locations to the three-Zone method, the continued use of the Division system was allowed for "additions, modifications, renovations to, or operation and maintenance of existing facilities employing the Division system of Classification for Class I locations". To facilitate the continued use of the two-Division system in these facilities, the definitions and the Rules for the two-Division system were moved to Appendix J18 and will be updated in parellel with Section 18 Rules. The Rules in Appendix J18, other than the area classification definitions, are similar in nature to section 18. Therefore, the Appendix J18 Rules are not covered in the following sections of this Guide. This is also true of section 20 and Appendix J20.

A useful table comparing the types of equipment allowed in the three-Zone and the two-Division is located in the Introduction to Appendix J and is repeated in Appendix III of the Guide.

General Arrangement of the Canadian Electrical Code

Sections 0 to 16 and section 26 of the Canadian Electrical Code are considered "general sections" and all other sections supplement or amend these general sections. In other words, the requirements in the general sections of the Code apply to Hazardous Locations in addition to the requirements in section 18 unless they are amended by the Rules of section 18. For example, the requirements for sizing conductors contained in Section 4 "Conductors" also applies to conductors in Hazardous Locations.

While the Rules in the various sections of the Canadian Electrical Code are mandatory, the notes and diagrams in Appendix B are informative (non-mandatory) and are intended to provide additional information and clarification of the Rules.

General Arrangement of the Code Sections of the Guide

- The specific Code Rules are presented in red text.
- Further explanation of the Code Rules by the writers of this guide are presented in black text.
- Appendix B items important to the understanding of the Code Rules are presented in red text inside "boxes". Note all Appendix B items in the Code are not necessarily repeated in this Guide.

SECTION 18

Scope and Introduction

Appendix B Notes

18-000

Through the exercise of ingenuity in the layout of electrical installations for hazardous locations, it is frequently possible to locate much of the equipment in less hazardous or in non-hazardous locations and thus to reduce the amount of special equipment required. It is recommended that the authority enforcing this Code be consulted before such layouts are prepared.

To assist users in the proper design and selection of equipment for electrical installations in hazardous locations, numerous reference documents are available. The following are three tables that list the documents most commonly referenced.

The Zone and Division systems of area classification are deemed to provide equivalent levels of safety; however, the Code has been written to give preference to the Zone system of area classification. It is important to understand that while the Code gives preference to the Zone system of area classification, it does not give preference to the IEC type of equipment. Equipment approved as Class I, or Class I, Division 1 will be acceptable in Zone 1 and Zone 2, and equipment marked Class I, Division 2 will be acceptable only in Zone 2. See

Rules 18-100, 18-150, and the Table in Appendix J, Section J1.2.

The Scope of this Section recognizes that there are cases where renovations or additions will occur on existing installations employing the Class/Division system of classification. It is expected that such installations will comply with the requirements for Class I installations as found in Appendix J.

Table A
Documents Generally Applicable to All Classes of Hazardous Locations

Publishing Organization	Reference Publication
CSA	CAN/CSA-C22.2 No. 130, *Requirements for Electrical Resistance Heating Cables and Heating Device Sets* C22.2 No. 137, *Electric Luminaires for Use in Hazardous Locations* C22.2 No. 145, *Motors and Generators for Use in Hazardous Locations* CAN/CSA-C22.2 No. 157, *Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations* C22.2 No. 159, *Attachment Plugs, Receptacles, and Similar Wiring Devices for Use in Hazardous Locations: Class I, Groups A, B, C, and D; Class II, Group G, in Coal or Coke Dust, and in Gaseous Mines* C22.2 No. 174, *Cables and Cable Glands for Use in Hazardous Locations* CAN/CSA-C22.2 No. 60529, *Degrees of protection provided by enclosures (IP Code)* ***(These standards are also listed in Appendix A.)***
ISA	RP 12.6.01, *Recommended Practice for Wiring Methods for Hazardous (Classified) Locations — Instrumentation — Part 1: Intrinsic Safety*
NFPA	70, *National Electrical Code* 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids* 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment* 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation*

Table B
Documents Applicable Specifically to Class I Hazardous Locations

Publishing Organization	Reference Publication
CSA	C22.2 No. 22, *Electrical Equipment for Flammable and Combustible Fuel Dispensers* C22.2 No. 30, *Explosion-Proof Enclosures for Use in Class I Hazardous Locations* C22.2 No. 152, *Combustible Gas Detection Instruments* C22.2 No. 213, *Non-incendive Electrical Equipment for Use in Class I, Division 2 Hazardous Locations* CAN/CSA-C22.2 No. 60079-0, *Explosive atmospheres — Part 0: Equipment - General Requirements* CAN/CSA-C22.2 No. 60079-1, *Explosive atmospheres — Part 1: Equipment protection by flameproof enclosures "d"* CAN/CSA-C22.2 No. 60079-2, *Explosive atmospheres — Part 2: Equipment protection by pressurized enclosure "p"* CAN/CSA-C22.2 No. 60079-5, *Explosive atmospheres — Part 5: Equipment protection by powder filling "q"* CAN/CSA-C22.2 No. 60079-6, *Explosive atmospheres — Part 6: Equipment protection by oil immersion "o"* CAN/CSA-C22.2 No.60079- 7, *Explosive atmospheres — Part 7: Equipment protection by increased safety "e"* CAN/CSA-C22.2 No. 60079-11, *Explosive atmospheres — Part 11: Equipment protection by intrinsic safety "i"* CAN/CSA-C22.2 No. 60079-15, *Electrical apparatus for explosive gas atmospheres — Part 15: Construction, test and marking of type of protection "n" electrical apparatus* CAN/CSA-C22.2 No. 60079-18, *Explosive Atmospheres — Part 18: Equipment Protection by Encapsulation "m"* CAN/CSA-C22.2 No. 60079-29-1, *Explosive Atmospheres — Part 29-1: Gas Detectors - Performance Requirements of Detectors for Flammable Gases* CAN/CSA-C22.2 No. 60079-31, *Explosive Atmospheres — Part 31: Equipment Dust Ignition Protection by Enclosure "t"* ***(These Standards are also listed in Appendix A.)***
API	RP 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2* RP 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*
IEC	60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres* 60079-10-2, *Explosive atmospheres — Part 10-2: Classification of areas — Combustible dust atmospheres* 60079-13, *Explosive atmospheres — Part 13: Equipment protection by pressurized room "p"* 60079-14, *Explosive atmospheres — Part 14: Electrical installations design, selection and erection* 60079-17, *Explosive atmospheres — Part 17: Electrical installations inspection and maintenance* 60079-19, *Explosive atmospheres — Part 19: Equipment repair, overhaul and reclamation* 60079-20-1, *Explosive atmospheres — Part 20-1: Material characteristics for gas and vapour classification — Test methods and data* 60079-25, *Explosive atmospheres — Part 25: Intrinsically safe electrical systems* 60079-26, *Explosive atmospheres — Part 26: Equipment with equipment protection level (EPL) Ga* 60079-30-2, *Explosive atmospheres — Part 30-2: Electrical resistance trace heating — Application guide for design, installation and maintenance*
NFPA	API 500 – Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2 API 505 – Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2

Table C
Documents Applicable Specifically to Class II Hazardous Locations

Publishing Organization	Reference Publication
CSA	C22.2 No. 25, *Enclosures for Use in Class II Groups E, F, and G Hazardous Locations* CAN/CSA-C22.2 No. 61241-4, *Electrical apparatus for use in the presence of combustible dust — Part 4: Type of protection "pD"* CAN/CSA-E61241-1-1, *Electrical apparatus for use in the presence of combustible dust — Part 1-1: Electrical apparatus protected by enclosures and surface temperature limitation — Specification for apparatus* ***(These Standards are also listed in Appendix A.)***
IEC	61241-2-1, *Electrical apparatus for use in the presence of combustible dust — Part 2 — Test methods — Section 1: Methods for determining the minimum ignition temperatures of dust* 61241-2-2, *Electrical apparatus for use in the presence of combustible dust — Part 2 — Test methods — Section 2: Method for determining the electrical resistivity of dust in layers* 61241-2-3, *Electrical apparatus for use in the presence of combustible dust — Part 2 — Test methods — Section 3: Method for determining minimum ignition energy of dust/air mixtures*

18-000 Scope (see Appendices B, F and J)

(1) This section applies to locations in which electrical equipment and wiring are subject to the conditions indicated by the following classifications.

(2) This section supplements or amends the general requirements of this Code.

Sections 0 to 16 and Section 26 are considered to be general sections of the CEC and apply to all other sections, including Sections 18 and 20, unless specifically amended within the section. Some requirements in other sections will also apply. For example, for electric heat tracing installed in Hazardous Locations, the Rules in Section 62 for electric heat tracing will also apply in addition to the requirements in Sections 18 and 20.

(3) For additions, modifications, renovations to, or operation and maintenance of existing facilities employing the Division system of classification for Class I locations, the continued use of the Division system of classification shall be permitted.

Section 18 is written to recognize only the Zone system of area classification. However, there is no requirement to change the area classification of facilities presently classified to the Division system. It is also permitted to make additions or renovations to these facilities without changing to the Zone system. Building a new facility to the Division system can only be done where "special permission" has been granted in accordance with Rule 2-030. This permission is normally granted by the engineer responsible for the facility.

(4) Where the Division system of classification is used for Class I locations, as permitted by Subrule (3), the Rules for Class I locations found in Annex J18 of Appendix J shall apply.

As Class I hazardous facilities classified to the Division system are not required to change to the Zone system, installation rules for those systems are contained in Appendix J.

18-002 Special Terminology (see Appendix B)

In this Section, the following definitions apply:

Cable gland – a device or combination of devices intended to provide a means of entry of a cable or flexible cord into an enclosure situated in a Hazardous Location and that also provides strain relief and shall be permitted to provide sealing characteristics where required, either by an integral means or when combined with a separate sealing fitting.

Conduit seal – a seal that is installed in a conduit to prevent the passage of an explosion from one portion of the conduit system to another and that minimizes the passage of gases or vapours at atmospheric pressure.

Appendix B Notes

Conduit seals — seals that are designed to prevent the passage of flames from one portion of the electrical installation to another through the conduit system and to minimize the passage of gases or vapours at atmospheric pressure. Unless specifically designed for the purpose, conduit seals are not intended to prevent the passage of fluids at a continuous pressure differential across the seal. Even at differences in pressure across the seal equivalent to a few centimetres of water, there may be passage of gas or vapour through the seal and/or through the conductors passing through the seal. Where conduit seals are exposed to continuous pressure, there may be a danger of transmission of flammable fluids to "safe areas", resulting in fire or explosions.

Cable seal – a seal that is installed at a cable termination to prevent the release of an explosion from an explosionproof enclosure and that minimizes the passage of gases or vapours at atmospheric pressure.

Appendix B Notes

Cable seals — seals that are designed to prevent the escape of flames from an explosion-proof enclosure. Because cables are not designed to withstand the pressures of an explosion, transmission of an explosion into a cable could result in ignition of gases or vapours in the area outside the enclosure.

Degree of protection – the measures applied to the enclosures of electrical apparatus to ensure:

(a) The protection of persons against contact with live or moving parts inside the enclosure and protection of apparatus against the ingress of solid foreign bodies; and

(b) The protection of apparatus against ingress of liquids.

The following table compares the various ingress protection (IP) ratings to NEMA enclosure ratings.

Conversion of "NEMA" Type to "IP" Code designations*

Type Number	IP Designation
1	IP10
2	IP11
3	IP54
3R	IP54
3S	IP54
4 and 4X	IP56
5	IP52
6 and 6P	IP67
12 and 12K	IP52
13	IP54

* Table cannot be used to convert "IP" Codes to "NEMA" Types. See NEMA 250 for additional details.

Explosive gas atmosphere – a mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, or mist in which, after ignition, combustion spreads throughout the unconsumed mixture.

For a gas-air mixture to be explosive the concentration of gas in the air must exceed the lower explosive limit and must be less than the upper explosive limit. For example methane is explosive in concentrations in air between 5% and 15%.

Refer to Appendix I of this document, "Gases and Vapours—Hazardous Substances Used in Business and Industry."

Explosive limits – the lower and upper percentage by volume of concentration of gas in a gas-air mixture that will form an ignitable mixture.

LEL: lower explosive limit

Gas detection systems are often scaled in percent of the LEL. For example, the LEL of methane is 5%. On most gas detectors this would result in a reading of 100%.

UEL: upper explosive limit

Fluid – a substance in the form of gas, vapour, or liquid

Hazardous Location – see **Location** in section 0

The definition of a Hazardous Location in section 0 has been updated in the 2009 edition of the Canadian Electrical Code and now reads as follows:

Hazardous location (see appendix B) — premises, buildings, or parts thereof in which

(a) an explosive gas atmosphere is present, or may be present in the air in quantities that require special precautions for the construction, installation and use of electrical equipment;

(b) combustible dusts are or may be present in the form of clouds or layers in quantities to require special precautions for the construction, installation and operation of electrical equipment; or

(c) combustible fibres or flyings are manufactured, handled or stored in a manner that will require special precautions for the construction, installation and operation of electrical equipment.

Appendix B Notes

Hazardous location

In this definition, "special precautions" refers to the features of electrical equipment design, installation, and use that are intended to prevent the equipment from igniting flammable vapours, dust, fibres or flyings. See Section 18 for more specific requirements on Hazardous Locations.

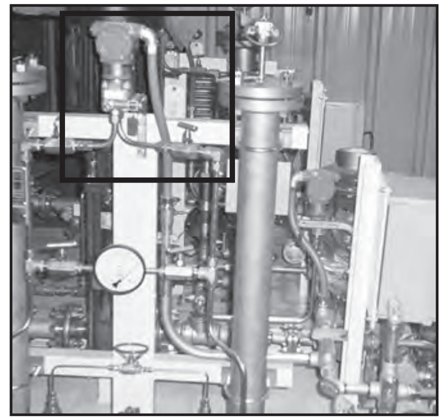
Methods of protection – defined methods to reduce the risk of ignition of explosive gas atmospheres.

A description of the various methods of protection can be found in Appendix B under rule 18-100.

Wellhead and gas detector.

Non-incendive circuit – a circuit in which any spark or thermal effect that may occur under normal operating conditions or due to opening, shorting, or grounding of field wiring is incapable of causing an ignition of the prescribed flammable gas or vapour.

A non-incendive circuit is similar to an intrinsically safe circuit in that it limits the amount of energy that could be produced due to shorting or opening a circuit. Unlike intrinsically safe circuits, non-incendive circuits do not have to consider the possibility of component faults. This is consistent with other equipment used in Class I, Zone 2 locations (e.g. motors) in that a component failure could result in an arc or spark until overcurrent protection operates. See Section 4.6 of the engineering digest.



Gas detectors are used to detect the presence of volatile vapours.

Normal operation – the situation when the plant or equipment is operating within its design parameters.

Normal operation is the operation when systems function in accordance with their design. A piece of equipment failing would not be considered normal operation.

Primary seal – a seal that isolates process fluids from an electrical system and has one side of the seal in contact with the process fluid.

Primary seals are the seals installed by a manufacturer in devices such as pressure switches, and transducers. They are not normally field installed.

Appendix B Notes

Primary seals — seals that are typically a part of electrical devices such as pressure-, temperature-, or flow-measuring devices and devices (such as canned pumps) in which the electrical connections are immersed in the process fluids.

Secondary seal – a seal that is designed to prevent the passage of process fluids at the pressure it will be subjected to upon failure of the primary seal.

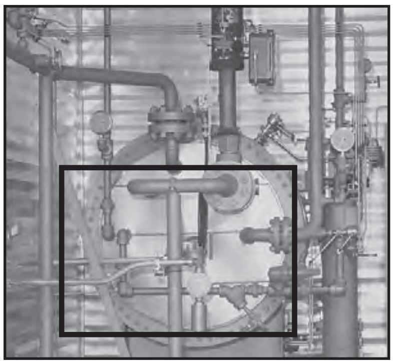
Secondary seals are seals designed to seal against the continuous pressure that would occur if a primary seal fails. Their purpose is to prevent gas from entering the conduit or cable system. Conduit and cable seals are not designed to seal against continuous pressure.

Appendix B Notes

Secondary seals —seals that are designed to prevent flammable process fluids from entering the electrical wiring system upon failure of a primary seal. These devices typically prevent passage of fluids at process pressure by a combination of sealing and pressure relief.

Protective gas – the gas used to maintain pressurization or to dilute a flammable gas or vapour.

In most situations, protective gases will be air without entrained flammable materials. It is also possible to use other inert gases such as nitrogen. Where air or an inert gas is used, safety is provided by eliminating the possibility of the fuel component of the "explosion triangle." Less common is the use of a combustible gas, such as natural gas, as a "protective gas." In these situations, the oxygen side of the explosion triangle is eliminated. Where this method is used, inert gas must be used when filling or emptying the enclosure to ensure air is not mixed with flammable gas or vapour.



Gas detector in process plant.

18-004 Classification (See Appendix B)

Hazardous locations shall be classified according to the nature of the hazard, as follows:

(a) Class I locations are those in which flammable gases or vapours are or may be present in the air in quantities sufficient to produce explosive gas atmospheres;

In certain situations where flammable gas or liquids are present in a location, the area may not require classification if they are contained in a manner that makes it unlikely they will be released into the air. This is typically the case where the flammable materials are stored or handled at such low pressures they are unlikely to escape in quantities sufficient to produce an explosive gas atmosphere. A common example is the low-pressure fuel gas used in home heating systems.

(b) Class II locations are those that are hazardous because of the presence of combustible or electrically conductive combustible dusts; and

(c) Class III locations are those that are hazardous because of the presence of easily ignitable fibres or flyings, but in which such fibres or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures.

18-006 Division of Class I Locations (see Appendices B and J)

Appendix B Notes

Rules 18-004, 18-006
Reference material for area classification can be found in the following documents:

(a) IEC 60079-10-1, Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres;

(b) IEC 60079-10-2, Explosive atmospheres — Part 10-2: Classification of areas — Combustible dust atmospheres;

(c) Energy Institute (British), Model Code of Safe Practice — Part 15: Area Classification Code for Installations Handling Flammable Fluids;

(d) API RP 505, Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2;

(e) API RP 500, Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2;

(f) 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

(g) see also the Note to Rule 18-064 in this Appendix.

Class I locations shall be further divided into three Zones based upon frequency of occurrence and duration of an explosive gas atmosphere as follows:

(a) Zone 0, consisting of Class I locations in which explosive gas atmospheres are present continuously or are present for long periods;

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* suggests Zone 0 locations are those in which flammable concentrations of gas or vapour are present more than 1,000 hours per year. Such locations normally occur in enclosed spaces such as storage tanks which are vented to atmosphere.

Appendix B Notes

Rule 18-006(a)

Typical situations leading to a Zone 0 area classification are

(a) the interiors of storage tanks that are vented to atmosphere and that contain flammable liquids stored above their flash point;

(b) enclosed sumps containing flammable liquids stored above their flash point continuously or for long periods; and

(c) the area immediately around atmospheric vents that are venting from a Zone 0 hazardous area.

(b) Zone 1, consisting of Class I locations in which:

(i) Explosive gas atmospheres are likely to occur in normal operation; or

(ii) The location is adjacent to a Class I, Zone 0 location, from which explosive gas atmospheres could be communicated; and

Typical Zone designation.
Zone 0 is inside the vented tank and near the vent. Zone 1 is a perimeter around the vent. Zone 2 is the area outside the tank.

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* suggests Zone 1 locations are those in which flammable concentrations of gas or vapour are present for more than 10 hours per year but less than 1,000 hours per year. Zone 1 locations are typically found around process vents, inside inadequately ventilated buildings or in below ground areas where heavier than air vapours are present.

Appendix B Notes

18-006(b)

Typical situations requiring a Class I, Zone 1 hazardous locations are:

(a) inadequately ventilated buildings or enclosures;

(b) adequately ventilated buildings or enclosures, such as remote unattended and unmonitored facilities, that have insufficient means of limiting the duration of explosive gas atmospheres when they do occur; and

(c) enclosed sumps containing flammable liquids stored above their flash point during normal operation.

(c) Zone 2, consisting of Class I locations in which:

(i) explosive gas atmospheres are not likely to occur in normal operation and, if they do occur, they will exist for a short time only; or

(ii) the location is adjacent to a Class I, Zone 1 location, from which explosive gas atmospheres 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.

To classify a building interior as Zone 2, in addition to demonstrating sufficient ventilation to reduce the normal emissions to safe levels (e.g. 5% LEL or lower), it is also necessary to ensure that explosive gas atmospheres that develop during abnormal operations exist only for short periods (see below). Equipment specifically designed for use in Zone 2 Hazardous Locations is designed so it is unlikely to present an ignition source during short-term explosive gas concentration events. Allowing explosive gas concentrations to exist for longer periods increases the probability of a coincident equipment failure. In an unmanned or unattended facility where there are no means to ensure the occurrence of explosive gas concentrations is limited to short periods, a Zone 1 classification may be required.

Today most Class I Hazardous Locations are classified as Class I, Zone 2. 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 suggests that Zone 2 locations are those in which flammable concentrations of gas or vapour may be present for less than 10 hours per year.

Appendix B Notes

18-006(c)

Typical situations leading to a Zone 2 area classification are:

(a) areas where flammable volatile liquids, flammable gases, or vapours are handled, processed, or used, but in which liquids, gases, or vapours are normally confined within closed containers or closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or systems or the abnormal operation of the equipment by which the liquids or gases are handled, processed, or used;

(b) adequately ventilated buildings that have means of ensuring that the length of time where abnormal operation resulting in the occurrence of explosive gas atmospheres exist will be limited to a "short time"; and

(c) most outdoor areas, except those around open vents, or open vessels or sumps containing flammable liquids.

API RP 505 defines "adequate ventilation" as "Ventilation (natural or artificial) that is sufficient to prevent the accumulation of significant quantities of vapour-air or gas-air mixtures in concentrations above 25% of their lower flammable (explosive) limit, LFL, (LEL)". Appendix B of API RP 505 outlines a method for calculating the ventilation requirements for enclosed areas based on fugitive emissions.

Industry documents such as API RP 505 provide guidance on how industry interprets a "short time".

18-008 Division of Class II Locations (see Appendix B)

Class II locations shall be further divided into two Divisions as follows:

(a) Division 1, consisting of Class II locations in which:

(i) combustible dust is or may be in suspension in air continuously, intermittently, or periodically under normal operating conditions in quantities sufficient to produce explosive or ignitable mixtures;

These conditions typically occur only in enclosed process equipment where materials are handled or processed. In explosive concentrations of dust, it is normally not possible to see more than a few feet.

(ii) the abnormal operation or failure of equipment or apparatus might:

(A) cause explosive or ignitable mixtures to be produced; and

(B) provide a source of ignition through simultaneous failure of electrical equipment, operation of protection devices, or from other causes; or

Where there is significant dust accumulation, it is possible that a mechanical malfunction could cause accumulated dust to be thrown into the air in sufficient quantity to provide an explosive concentration. If the dust cloud is ignited, it will disturb dust layers in the area, creating further dust clouds, and could result in a series of explosions.

(iii) combustible dusts having the property of conducting electricity may be present.

Coal handling areas are classified as Class II.

Conductive dusts impose the added hazard of electrical tracking. Therefore, where conductive dusts (Group E) are present there will only be Class II, Division 1. There will not be Class II, Division 2 area classification in those areas. As an example, conductive dusts would be present in munitions factories.

Appendix B Notes

18-008(a)

Class II, Division 1 locations usually include the working areas of grain-handling and storage plants; rooms containing grinders or pulverizers, cleaners, graders, scalpers, open conveyors or spouts, open bins or hoppers, mixers or blenders, automatic or hopper scales, packing machinery, elevator heads and boots, stock distributors, dust and stock collectors (except all-metal collectors vented to the outside), and all similar dust-producing machinery and equipment in grain processing plants, starch plants, sugar pulverizing plants, malting plants, hay grinding plants, and other occupancies of similar nature; coal pulverizing plants (except where the pulverizing equipment is essentially dust-tight); all working areas where metal dusts and powders are produced, processed, handled, packed, or stored (except in tight containers); and all other similar locations where combustible dust may, under normal operating conditions, be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Combustible dusts that are electrically non-conducting will include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and wood flour, oil meal from beans and seed, dried hay, and other organic materials that may produce combustible dusts when processed or handled. Only Group E dusts are considered electrically conductive for the purposes of classification. Metallic dusts of magnesium, aluminum, and aluminum bronze are particularly hazardous, and every precaution should be taken to avoid ignition and explosion.

(b) Division 2, consisting of Class II locations in which

(i) Combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment, but such dust would be present in quantities insufficient to:

(A) interfere with the normal operation of electrical or other equipment; and

(B) produce explosive or ignitable mixtures, except for short periods of time; or

(ii) combustible dust accumulations on, in, or in the vicinity of the electrical equipment, may be sufficient to interfere with the safe dissipation of heat from electrical equipment or may be ignitable by abnormal operation or failure of electrical equipment.

Class II, Division 2 locations are locations where dust concentrations in the air are normally well below the minimum ignitable levels. Class II, Division 2 locations may have sufficient dust accumulation present to create ignitable concentrations in air if they are disturbed. However, it is unlikely an electrical ignition source would also be present. Housekeeping practices in Class II locations may reduce the area classification from Class II, Division 1 to Class II, Division 2, and in some cases where the rate of dust accumulation is low, it may be reduced to nonhazardous by good housekeeping practices.

Appendix B Notes

18-008(b)

Class II, Division 2 locations include those in which dangerous concentrations of suspended dust are not likely, but where dust accumulation might form on, in, or in the vicinity of electrical equipment, and include rooms and areas containing only closed spouting and conveyors, closed bins or hoppers, or machines and equipment from which appreciable quantities of dust might escape only under abnormal conditions; rooms or areas adjacent to Class II, Division 1 locations and into which explosive or ignitable concentrations of suspended dust might be communicated only under abnormal operating conditions; rooms or areas where the formulation of explosive or ignitable concentrations of suspended dust is prevented by the operation of effective dust control equipment; warehouses and shipping rooms in which dust-producing materials are stored or handled only in bags or containers; and other similar locations.

There are many dusts, such as fine sulphur dust, that cannot be equated specifically to dusts mentioned above, and in a number of cases further information may be obtained by reference to Standards included in the NFPA National Fire Codes; for example, NFPA 655 gives information on prevention of sulphur fires and explosions and makes reference to electrical wiring and equipment.

18-010 Division of Class III Locations (see Appendix B)

Class III locations shall be further divided into two Divisions as follows:

(a) Division 1, consisting of Class III locations in which readily ignitable fibres or materials producing combustible flyings are handled, manufactured, or used; and

Typical application of Class III locations are textile plants. Fibres and flyings in Class III locations are not normally airborne for long distances, therefore the extent of Class III locations is often limited to the immediate area in which the ignitable fibres or combustible flyings are produced. In a large factory it is possible there may be a number of unconnected Class III, Division 1 locations. Where equipment producing fibres or flyings is enclosed, the hazardous area may not extend beyond the enclosure.

Appendix B Notes

18-010

Class III, Division 1 locations include parts of rayon, cotton, and other textile mills; combustible fibre 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.

Readily ignitable fibres and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fibre, oakum, baled waste, kapok, Spanish moss, excelsior, and other materials of similar nature.

(b) Division 2, consisting of Class III locations in which readily ignitable fibres other than those in process of manufacture are stored or handled.

The means by which ignitable fibres are stored may affect the area classification. If fibres are stored in containers from which they will not be released during storage, it is possible the storage area may not be classified as a Hazardous Location. If ignitable fibres are released allowing an accumulation of fibres in the area, the area should be classified Class III, Division 2.

18-012 Maintenance (see Appendix B)

Special precautions shall be observed as follows:

(a) repairs or alterations shall not be made to live equipment; and

(b) electrical equipment shall be maintained in its original safe condition.

Appendix B Note

18-012

Maintaining electrical installation safety in hazardous locations is dependent on a regimen of regular maintenance that will ensure that the electrical installation continues to provide safety throughout its life. Maintenance personnel are cautioned that modifications to original equipment or substitution of original components may void certification. To guide owners and operators of hazardous locations in developing appropriate maintenance procedures, the following documents in addition to the manufacturer's instructions may be used:

(a) IEC 60079-17, Explosive atmospheres — Part 17: Electrical installations inspection and maintenance;

(b) IEC 60300 series of Standards, Dependability management;

(c) IEEE 902, IEEE Guide for Maintenance, Operation, and Safety of Industrial and Commercial Power Systems; and

(d) NFPA 70B, Recommended Practice for Electrical Equipment Maintenance.

General

18-050 Electrical Equipment (see Appendix B)

(1) Where electrical equipment is required by this Section to be approved for use in hazardous locations, it shall also be approved for the specific gas, vapour, mist, or dust that will be present.

(2) For equipment approved with a method of protection permitted in a Class I location, such approval shall be permitted to be indicated by one or more of the following atmospheric group designations:

(a) Group IIC, consisting of atmospheres containing acetylene, carbon disulphide, or hydrogen, or other gases or vapours of equivalent hazard;

(b) Group IIB, consisting of atmospheres containing acrylonitrile, butadiene, diethyl ether, ethylene, ethylene oxide, hydrogen sulphide, propylene oxide, or unsymmetrical dimethyl hydrazine (UDMH), or other gases or vapours of equivalent hazard;

(c) Group IIA, consisting of atmospheres containing acetaldehyde, acetone, cyclopropane, alcohol, ammonia, benzine, benzol, butane, ethylene dichloride, gasoline, hexane, isoprene, lacquer solvent vapours, naphtha, natural gas, propane, propylene, styrene, vinyl acetate, vinyl chloride, xylenes, or other gases or vapours of equivalent hazard;

(d) Group II, consisting of all Group II gases;

(e) Group IIXXXXX, where XXXXX is a chemical formula or chemical name suitable for that specific gas only.

Most Zone-rated equipment is classified as Group IIC.

Equipment approved to IEC-based standards will use the IIA, IIB, and IIC gas grouping outlined above. This system has a hierarchy in that equipment approved for gas group IIC is also suitable for use with gases in groups IIB and IIA, and equipment approved for gas group IIB is also suitable for use in gases in group IIA. It would not be permissible to use equipment approved for a lower gas grouping in an area with gases from a higher grouping. For example, it would not be permissible to use equipment approved for gas group IIA in an area with gases from groups IIC or IIB. Most IEC-based equipment is approved to IIC. However, it is recommended to check the appropriate certificates and product labels.

While temperature and gas groups are shown in the same table, "Temperature and Gas Groups" in Appendix B, users are cautioned that ignition temperatures and gas groupings are not related. See "Basics of Explosion Protection," pg. 3-7.

Appendix B Notes

18-050

At present, the marking requirements of IEC-based Standards and North American-based Standards differ concerning the gas groups for which apparatus is approved.

With IEC-based Standards, apparatus marked IIB is also suitable for applications requiring Group IIA apparatus. Similarly, apparatus that is marked IIC is also suitable for applications requiring Group IIB or IIA apparatus.

With North American-based Standards, apparatus bears the mark of each Group for which it is certified, i.e., apparatus that is approved for Groups B, C, and D is marked to indicate such by including all three Groups.

NFPA 505 recognizes the use of electric trucks, Types EE and EX, in Class III hazardous locations.

(3) For equipment approved for Class I, Division 1 or 2, the specific gas shall be permitted to be indicated by one or more of the following atmospheric group designations:

(a) Group A, consisting of atmospheres containing acetylene;

(b) Group B, consisting of atmospheres containing butadiene, ethylene oxide, hydrogen (or gases or vapours equivalent in hazard to hydrogen, such as manufactured gas), or propylene oxide;

(c) Group C, consisting of atmospheres containing acetaldehyde, cyclopropane, diethyl ether, ethylene, hydrogen sulphide, or unsymmetrical dimethyl hydrazine (UDMH), or other gases or vapours of equivalent hazard;

(d) Group D, consisting of atmospheres containing acetone, acrylonitrile, alcohol, ammonia, benzine, benzol, butane, ethylene dichloride, gasoline, hexane, isoprene, lacquer solvent vapours, naphtha, natural gas, propane, propylene, styrene, vinyl acetate, vinyl chloride, xylenes, or other gases or vapours of equivalent hazard.

(4) Notwithstanding Subrule (3)(b), where the atmosphere contains:

(a) butadiene, Group D equipment shall be permitted to be used if such equipment is isolated in accordance with Rule 18-108(1) by sealing all conduit 16 trade size or larger; or

(b) ethylene oxide or propylene oxide, Group C equipment shall be permitted to be used if such equipment is isolated in accordance with Rule 18-108(1) by sealing all conduit 16 trade size or larger.

Equipment approved to CSA standards other than the IEC-based standards will use the A, B, C and D gas grouping method outlined above. The North American gas grouping does not have a hierarchy similar to the IEC grouping above. Under the North American system, equipment can only be marked with the gas groups for which it has been tested.

It is permissible to use mixtures of equipment using the two gas grouping methods in Class I Hazardous Locations. Class I Area Classification documents should therefore state the proper gas grouping for both systems.

(5) For equipment approved for Class II locations, approval for the specific dust shall be permitted to be indicated by one or more of the following atmospheric group designations:

(a) Group E, consisting of atmospheres containing combustible metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics;

For the purpose of complying with Rule 18-008(a)(iii), only group E dusts are considered to be conductive.

(b) Group F, consisting of atmospheres containing carbon black, coal, or coke dust; or

(c) Group G, consisting of atmospheres containing flour, starch, or grain dust, and other dusts of similarly hazardous characteristics.

18-052 Marking (see Appendix B)

Appendix B Notes

18-052, 18-090, 18-100, and 18-150

The 2011 edition of CAN/CSA-C22.2 No. 60079-0 [adopted IEC 60079-0 (fifth edition, 2007-10)] introduces "equipment protection levels" (EPLs) as a required marking on hazardous location electrical equipment certified to the IEC 60079 series of Standards. This marking will appear on new electrical equipment approved under the adopted 60079 series of Standards. For older equipment, in stock or in the field, that does not include the EPL marking, suitability for the intended zone will continue to be determined by the methods of protection. EPLs will enable users to identify the zone(s) in which the IEC 60079 type of hazardous location electrical equipment can be used, without having to identify the zone by the methods of protection used.

EPLs provide an indication of the suitability of electrical equipment for each zone. Further information on EPLs can be found in CAN/CSA-C22.2 No. 60079-0. The following table shows the acceptable EPLs for Zones 0, 1, and 2.

Zone	Acceptable protection level
Zone 0	Ga
Zone 1	Ga or Gb
Zone 2	Ga, Gb, or Gc

Rule 18-052

Equipment marked for Class I but not marked with a Division is suitable for both Zones 1 and 2.

Rule 18-052(1)

Some equipment permitted for use in Zone 2 hazardous locations is not marked to indicate the class and group because it is not specifically required to be approved for the location (e.g., motors and generators for Class I, Zone 2 that do not incorporate arcing, sparking, or heat-producing components — see Rule 18-150(2)(e).

(1) Electrical equipment intended for use in Class I Hazardous Locations shall be permitted to be marked with the following:

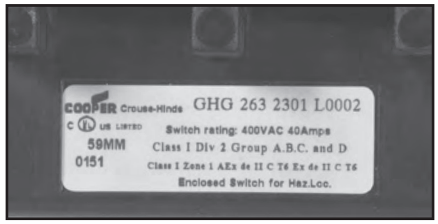
(a) the letters Ex;

(b) the symbol(s) to indicate a method(s) of protection used;

(c) the gas group as specified in Rule 18-050(2);

(d) the temperature rating in accordance with Subrule (4) for equipment of the heat-producing type; and

(e) the equipment protection level (EPL) Ga, Gb or Gc as appropriate.



Zone-rated equipment will have the Ex mark for the Canadian market.

This method of marking will be used for equipment approved to the IEC-based, CSA standards. A typical marking, such as on a pushbutton station, would be:

Ex de IIC T6

This marking would indicate the equipment is built to an IEC-based standard. It uses methods of protection d and e. It is suitable for use in Gas Group IIC, and its maximum surface operating temperature is less than T6 (85°C).

It is not uncommon in North America to also have equipment approved to CENELEC standards with a prefix of EEx or Ex or U.S. standards with a prefix of AEx.

(2) Notwithstanding Subrule (1), electrical equipment approved for:

(a) Class I or Class I, Division 1 or 2 locations shall be permitted to be marked with the class and the group described in Rule 18-050(3), or the specific gas or vapour for which it has been approved; and

(b) Class I, Division 2 only, shall be permitted to be so marked.

In Canada it is not uncommon for equipment to be marked with both marking systems outlined in 1 and above. It is also common for equipment to be marked with the Zone for which it is suitable, as that marking is required in the United States.

New equipment certified to the CAN/CSA 22.2 No 60079 series of standards will include EPL markings. EPLs are used to indicate the suitability of the equipment for each zone.

Zone	Acceptable EPL
Zone 0	Ga
Zone 1	Ga or Gb
Zone 2	Ga, Gb or

(3) Electrical equipment approved for Class II and III hazardous locations shall be permitted to be so marked and, for Class II locations, with the group or specific dust for which it has been approved.

Unlike Class I equipment, there is no hierarchy for Class II and Class III groups. Equipment must only be used in areas for which it has been tested and marked.

(4) Electrical equipment approved for use in Class I locations shall be permitted to be marked with:

(a) the maximum surface temperature; or

(b) one of the following temperature codes to indicate the maximum surface temperature:

Temperature code	Maximum surface temperature
T1	450°C
T2	300°C
T2A	280°C
T2B	260°C
T2C	230°C
T2D	215°C
T3	200°C
T3A	180°C
T3B	165°C
T3C	160°C
T4	135°C
T4A	120°C
T5	100°C
T6	85°C

(5) If no maximum surface temperature marking is shown on Class I equipment approved for the class and group, the equipment, if of the heat-producing type, shall be considered as having a maximum surface temperature of 100°C or less for the purposes of compliance with Rule 18-054.

(6) Electrical equipment approved for operation at ambient temperatures exceeding 40°C shall, in addition to the marking specified in Rule 18-052(3), be marked with the maximum ambient temperature for which the equipment is approved, and the maximum surface temperature of the equipment at that ambient temperature.

18-054 Temperature (see Appendix B)

Appendix B Notes

18-054, 18-150

Equipment of the heat-producing type is currently required by product standards to have a temperature code (T-Code) marking if its temperature exceeds 100°C. However, for equipment manufactured prior to the T-Code requirement and motors applied in accordance with Rule 18-150, there may be no such marking. Therefore, the suitability of older Hazardous Locations equipment of the heat-producing type and motors applied in accordance with Rule 18-150 should be reviewed prior to being installed in a Hazardous Location to ensure compliance with Rule 18-054. For the purpose of this Rule, equipment such as boxes, terminals, fittings, and RTDs are not considered to be heat-producing devices.

(1) In Class I Hazardous Locations, equipment shall not be installed in an area in which vapours or gases are present that have an ignition temperature less than the maximum external temperature of the equipment as referred to in Rules 18-052(4) and (5).

All electrical equipment installed in Class I Hazardous Locations must have a surface operating temperature below the ignition temperature of the gas. For some approved equipment, the surface temperature on the equipment may not be based on the external surface temperature of the equipment, it may be based on external temperature of components within the equipment. For explosionproof equipment, the external temperature will be measured on the external surface of the equipment. For equipment, such as Class I, Division 2 light fixtures, the maximum surface temperature is measured on the surface of internal components such as the bulb or the ballast.

The ignition temperature of a gas or a vapour from a hot surface will vary depending on a number of factors, such as the size and shape of the surface, the velocity of a gas-air mixture relative to the surface, turbulence, etc. The values for ignition temperatures given in Appendix B and in most other documents are referred to as "auto-ignition" temperatures (AIT's). They are based on a laboratory method that tests the gas in a heated vessel. API publication 2216, *Ignition Risk of Hydrocarbon Vapors by Hot Surfaces in the Open Air*, suggests that ignition from hot surfaces in the "open air" should not be assumed unless the temperature is about 200°C above the accepted minimum temperature.

It is clear that when using the ignition temperatures in Appendix B or similar tables, there is a very large safety factor. However, when higher temperatures than those listed in Appendix B are used, it is the responsibility of the designer to ensure an adequate safety factor is maintained.

(2) Where the equipment is not required to be approved for hazardous locations, the maximum external temperature referred to in Subrule (1) shall be the surface temperature at any point, internal or external, of the equipment.

This rule applies to equipment such as motors that are not required to be approved for Hazardous Locations when used in Class I, Zone 2 locations. The maximum external surface temperature will include the external surfaces of the rotor and stator as well as the external surfaces of the enclosure. It should be noted that this rule applies to all heat-producing equipment located in a Class I location regardless of whether or not it is required to be approved for the Hazardous Location.

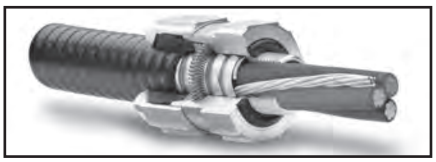
18-056 Non-essential Electrical Equipment

(1) No electrical equipment shall be used in a hazardous location, unless the equipment is essential to the processes being carried on therein.

Electrical equipment not associated with the processes in the Hazardous Location should not be located in the area. Wherever possible, equipment producing arcs or sparks in its normal operation, such as motor starters or switchgear, should be located outside the Hazardous Location.

(2) Service equipment, panelboards, switchboards, and similar electrical equipment shall, where practicable, be located in rooms or sections of the building in which hazardous conditions do not exist.

The use of cables with continuous jackets facilitates the remote location of the above equipment. Cables do not require sealing at the boundaries of Hazardous Locations as in a conduit system.



TECK cable has a continuous metal and PVC jacket.

18-058 Rooms, Sections, or Areas

Each room, section, or area, including motor- and generator-rooms and rooms for the enclosure of control equipment, shall be considered a separate location for the purpose of determining the classification of the hazard.

18-060 Equipment Rooms

(1) Where walls, partitions, floors, or ceilings are used to form hazard-free rooms or sections, they shall be:

(a) of substantial construction; and

(b) built of or lined with noncombustible material; and

(c) such as to ensure that the rooms or sections will remain free from hazards.

API-RP500—Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2 gives guidance for walls or partitions separating nonhazardous areas from Class I areas. RP500 refers to "vapour-tight" barriers and defines them as "a barrier that will not allow the passage of significant quantities of gas or vapour at atmospheric pressure." Section 6.7 of the API document also gives details for enclosed spaces overlapping Class I Hazardous Locations.

Areas where volatile liquids are stored are normally classified as Zone 2 or Division 2.

(2) Where a non-hazardous location within a building communicates with a Class I, Zone 2 location, a Class II location, or a Class III location, the locations shall be separated by close-fitting, self-closing, approved fire doors.

Such doors should be constructed to form a vapour-tight barrier when closed and should be equipped with devices to ensure they are closed when not in use. The use of signage to indicate the hazard of leaving such doors open is recommended.

(3) For communication from a Class I, Zone 1 location, the provisions of Rule 18-006(c)(ii) shall apply.

18-062 Metal-Covered Cable (see Appendix B)

(1) Where exposed overhead conductors supply mineral-insulated cable in a hazardous location, surge arresters shall be installed to limit the surge voltage level to 5 kV on the cable.

Appendix B Notes

18-062

For the purposes of this Rule, metal-covered cable includes a cable with a metal sheath or with a metal armour of the interlocking type, the wire type, or the flat tape type, or with metal shielding.

(2) Where single-conductor metal-covered cable is used in hazardous locations, it shall be installed in such a manner as to prevent sparking between cable sheaths or between cable sheaths and metal bonded to ground, and

(a) cables in the circuit shall be clipped or strapped together, in a manner that will ensure good electrical contact between metal coverings, at intervals of not more than 1.8 m, and the metal coverings shall be bonded to ground; or

(b) cables in the circuit shall have the metal coverings continuously covered with insulating material and the metal coverings shall be bonded to ground at the point of termination in the hazardous location only.

Single conductor power cables have magnetic fields surrounding them that can induce voltages in ferrous materials near the cables. These voltages may result in currents and arcing in equipment or structures near the cables. When single conductor power cables are located in Hazardous Locations all necessary design and installation measures should be taken to ensure that incendive sparking does not occur as the result of currents induced by the magnetic field around the cables.

Appendix B Notes

18-062(1)

Suitable lightning protective devices should include primary devices and also secondary devices if overhead secondary lines exceed 90 m in length or if the secondary is ungrounded.

Interconnection of all grounds should include grounds for primary and secondary lightning protective devices, secondary system grounds, if any, and grounds of conduit and equipment of the interior wiring system.

Appendix B Notes

18-062(2)(b)

Where single-conductor metal-covered or armoured cables with jackets are used in Hazardous Locations, the armour must be grounded in the Hazardous Location only to prevent circulating currents. As a result, there will be a standing voltage on the metal covering in the nonhazardous location area. There is, therefore, a need to properly isolate the armour in the nonhazardous area to ensure that circulating currents will not occur.

18-064 Pressurized Equipment or Rooms (see Appendix B)

Electrical equipment and associated wiring in Class I locations shall be permitted to be located in enclosures or rooms constructed and arranged so that a protective gas pressure is effectively maintained, in which case the provisions of Rules 18-100 to 18-162 need not apply.

It is the responsibility of the designer to ensure a safe installation result. References to assist the designer are outlined in Appendix B. The most commonly used reference in the past has been NFPA standard 496 "Purged and Pressurized Enclosures for Electrical Equipment."

Appendix B Notes

18-064

Suitable lightning protective devices should include primary devices and also secondary devices if overhead secondary lines exceed 90 m in length or if the secondary is ungrounded.

Interconnection of all grounds should include grounds for primary and secondary lightning protective devices, secondary system grounds, if any, and grounds of conduit and equipment of the interior wiring system.

18-066 Intrinsically Safe and Non-incendive Electrical Equipment and Wiring (see Appendices B and F)

Appendix B Notes

18-066(3)

Intrinsically safe wiring systems are not required to prevent the transmission of an explosion and therefore the only concern is the transmission of gases and vapours. Migration of gas and vapours can be prevented by the use of conduit and cable seals. Other alternatives for cables include the use of a compound such as silicone rubber applied around the end of the connector to prevent gas and vapours from entering the end of the cable. Where the flammable fluids could be operating at pressures above atmospheric pressure, the provisions of Rule 18-072 should be applied.

(1) Where electrical equipment is approved as intrinsically safe and associated circuits are designed and installed as intrinsically safe for the intended hazardous location, they shall be permitted and the provisions of Rules 18-100 to 18-376 need not apply.

Intrinsically safe systems limit the energy in Hazardous Locations to levels below that required to achieve ignition of gas or vapour in the area. Wiring systems are not required to meet Hazardous Location standards and simple end devices are not required to be contained in explosionproof enclosures. Simple devices, such as thermocouples, contacts, RTDs, potentiometers or LEDs, will neither generate nor store more than 1.2 volts, 0.1 amps, 25 nW or 20 µJ. When connected to an intrinsically safe associated apparatus (a barrier), the circuit is considered to be intrinsically safe. When using intrinsically safe systems, ordinary location wiring systems can be used on circuits in the Hazardous Location. If safety is to be maintained in a Hazardous Location, intrinsically safe systems in the Hazardous Location must be properly designed, installed and maintained. Designers applying intrinsically safe systems in Hazardous Locations should ensure that systems are in place for proper installation and maintenance of the systems. Users should consult Appendix F of the *Canadian Electrical Code* for basic requirements for intrinsically safe systems. Other sources of information are ISA standards and manufacturers' information.

(2) Where electrical equipment is approved as non-incendive and associated circuits are designed and installed as non-incendive, they shall be permitted in Class I, Zone 2 locations and the provisions of Rules 18-152 to 18-158 need not apply.

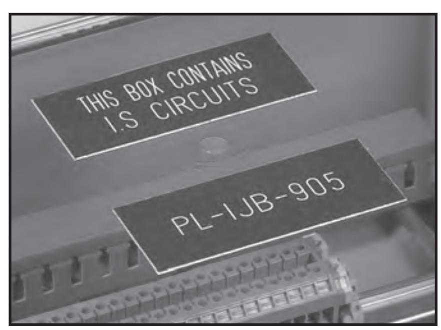
Non-incendive circuits are similar to intrinsically safe circuits in that they limit the energy in the circuit to levels below that required to achieve ignition of gas or vapour in the area. Non-incendive circuits differ from intrinsically safe circuits in that their design does not contain redundant components to ensure they will continue to function safely in the presence of component failure. Therefore, their use is restricted to Zone 2 locations.

(3) Raceways or cable systems for intrinsically safe and non-incendive wiring and equipment in Class I locations shall be installed to prevent migration of gas or vapour to other locations.

While intrinsically safe and non-incendive circuits may be exempted from other "sealing" rules in Section 18, measures must be taken to ensure that gas is not allowed to migrate from hazardous to nonhazardous locations within the intrinsically safe conduit or cable systems. While the method used is not specifically mandated by this *Code*, any system used must prevent gas under pressure from entering the cable or conduit system.

(4) The conductors in intrinsically safe and non-incendive circuits shall not be placed in any raceway, compartment, outlet, junction box, or similar fitting with the conductors of any other system, unless the conductors of the two systems are separated by a suitable mechanical barrier.

It is good practice to label the circuits which are intrinsically safe to prevent mixing with non-intrinsically safe wiring. Further information on intrinsically safe and non-incendive wiring systems can be found in Appendix F.



Intrinsically safe Ex-ia circuits must be labeled.

18-068 Cable Trays in Class II and Class III Locations

Cable trays in Class II and Class III locations shall be installed to minimize the buildup of dust or fibre on the cables.

18-070 Combustible Gas Detection (see Appendices B and H)

Electrical equipment suitable for non-hazardous locations shall be permitted to be installed in a Class I, Zone 2 hazardous location and electrical equipment suitable for Class I, Zone 2 hazardous locations shall be permitted to be installed in a Class I, Zone 1 hazardous location, provided that

(a) no specific equipment suitable for the purpose is available;

The Rule allows the use of Zone 2 equipment in Zone 1 where suitable Zone 1 equipment is not available provided other conditions are met.

(b) the equipment, during its normal operation, does not produce arcs, sparks, or hot surfaces, capable of igniting an explosive gas atmosphere; and

This rule has been modified to make it clear that it does not apply to equipment that produces arcs or sparks with sufficient energy to ignite gas or to equipment that operates at temperatures above the ignition temperature of the gas in the area.

(c) the location is continuously monitored by a combustible gas detection system that will

(i) activate an alarm when the gas concentration reaches 20% of the lower explosive limit;

When gas reaches the 20% LEL, protective means must be taken to attempt to prevent the gas concentration from continuing to rise to 100% of the LEL. This may consist of increased ventilation, action to eliminate the source of the gas or both.

(ii) activate ventilating equipment or other means designed to prevent the concentration of gas from reaching the lower explosive limit when the gas concentration reaches 20% of the lower explosive limit, where such ventilating equipment or other means is provided;

(iii) automatically de-energize the electrical equipment being protected when the gas concentration reaches 40% of the lower explosive limit, where the ventilating equipment or other means referred to in Item (ii) is provided;

If the gas concentration reaches 40% of the LEL, all equipment not rated for use in the Hazardous Location must be de-energised. If the device used to de-energise the equipment is located in the Hazardous Location, it must be rated for use in the Hazardous Location.

(iv) automatically de-energize the electrical equipment being protected when the gas concentration reaches 20% of the lower explosive limit, where the ventilating equipment or other means referred to in Item (ii) cannot be provided; and

(v) automatically de-energize the electrical equipment being protected upon failure of the gas detection instrument.

Failure of the gas detection equipment will result in the loss of monitoring for combustible gas. Under these conditions it will not be safe to continue to operate equipment not rated for the Hazardous Location so it must be de-energised.

Appendix B Notes

18-070

It is intended that this Rule be used only where suitable equipment, certified for use in the Hazardous Location, is not available. For example, Class I, Division 1 ignition systems for internal combustion engines are not available; only Class I, Division 2 ignition systems are available. Therefore, ignition systems rated for Class I, Division 2 are currently the only Hazardous Location ignition systems available and could possibly be used in Class I, Zone 1 locations.

In many situations, proper area classification will eliminate the need to use this Rule. Rule 18-070 should not be used to compensate for improper area classification.

When this Rule is used, the gas detection system should consist of an adequate number of sensors to ensure the sensing of flammable gases or vapours in all areas where they may accumulate.

Electrical equipment suitable for non-hazardous locations and that has unprotected arcing, sparking, or heat-producing components must not be installed in a Zone 2 location. Arcing, sparking, or heat-producing components may be protected by encapsulating, hermetically sealing, or sealing by other means such as restricted breathing.

Before applying this Rule, the user should fully understand the risks associated with such an installation. When applying this Rule, it remains the responsibility of the owner of the facility, or agents of the owner, to ensure that the resulting installation is safe. Simply complying with the requirements of Rule 18-070 may not ensure a safe installation in all situations.

18-072 Flammable Fluid Seals (See Appendix B)

(1) Electrical equipment with a primary seal in contact with flammable fluids shall

(a) be constructed or installed so as to prevent migration of flammable fluid through the wiring system; and

(b) be used at pressures lower than the marked maximum working pressure (MWP).

(2) Where Subrule (1) is met through the installation of secondary seals, the possibility of primary seal failure shall be indicated by

(a) design features that will make the occurrence of a primary seal failure obvious; or

(b) acceptable marking means indicating that the enclosure may contain flammable fluid under pressure.

The intent of this Rule is to ensure that flammable gases or vapours under pressure do not enter the wiring systems and migrate to a less hazardous or a non-hazardous area. It is not intended that a secondary seal be installed in every situation where a single primary seal is installed. Where devices containing primary seals have been tested to ANSI/ISA 12.27.01 (see below) or where experience has indicated suitable performance of a device with a single seal in similar applications, a secondary seal may not be required.

Appendix B Notes

18-072

ANSI/ISA 12.27.01, Requirements for Process Sealing between Electrical Systems and Flammable or Combustible Process Fluid, provides construction, performance, and marking requirements for the process seals incorporated into process-connected electrical equipment. Equipment containing a primary seal that complies with this Standard is eligible to include either the “Single Seal” or “Dual Seal” designation in the nameplate markings. These markings indicate that the electrical equipment is designed to prevent the migration of flammable fluid through the equipment into the wiring system when operated at or lower than the equipment rated pressure. Devices certified as conforming to ANSI/ISA 12.27.01 and marked either “Single Seal” or “Dual Seal” meet the intent of Subrule (1)(a).

Where devices containing primary seals are not marked to indicate conformance with ANSI/ISA 12.27.01, other means may be used to prevent fluid migration though the wiring system. This may include the use of suitable barriers located between the primary seal and the wiring system, such as secondary seals or short lengths of mineral-insulated (MI) cable. Where secondary seals are installed, examples of design features that make the occurrence of primary seal failure obvious are vents, drains, visible rupture or leakage, audible whistles, or electronic monitoring. The intent of making the primary seal failure obvious is to prevent continuous pressure on the secondary seal and the possibility of an eventual secondary seal failure, as well as to protect personnel working on the device. Alternatively, where means to relieve pressure on a secondary seal is not provided, a cautionary label should be provided to warn personnel that the enclosure may contain flammable fluid under pressure.

Engineering considerations may lead to the conclusion that the probability of leakage from a specific installation will be negligible. Acceptable factors such as an extensive history of safe operation with similar installations, or the use of a primary seal with a pressure rating well in excess of the maximum process operating pressure may be considered.

18-074 Bonding in Hazardous Locations

(1) Exposed non-current-carrying metal parts of electrical equipment, including the frames or metal exteriors of motors, fixed or portable lamps or other utilization equipment, luminaires, cabinets, cases, and conduit shall be bonded to ground using

(a) bonding conductors sized in accordance with Rule 10-814; or

(b) rigid metal conduit with threaded couplings and threaded bosses on enclosures with joints made up tight.

(2) Notwithstanding Subrule (1), where raceways or cable assemblies incorporate an internal bonding conductor, box connectors with standard locknuts shall be permitted to bond the metallic armour or raceway.

The bonding requirements of this Rule apply to all electrical equipment in Classes I, II and III, including intrinsically safe and non-incendive equipment.

CLASS I LOCATIONS

Installations in Class I, Zone 0 Locations

18-090 Equipment and Wiring (see Appendices B and F)

(1) Except as provided for in Subrules (2) and (3), electrical equipment and wiring shall not be installed in a Class I, Zone 0 hazardous location.

(2) Where required by other Rules of this Code, electrical equipment installed in a Class I, Zone 0 location shall be approved

(a) as providing equipment protection level Ga; or

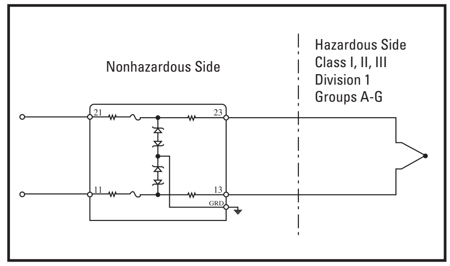
(b) as intrinsically safe type i or ia.

(3) Intrinsically safe circuits and wiring shall be designed for the application and shall be installed in accordance with the design.

In a Zone 0 location, only electrical equipment that is intrinsically safe type “i” or “ia” may be used. Intrinsically safe type “i” is the marking allowed for intrinsically safe equipment approved to CSA standard C22.2 No. 157 and “ia” is the marking for intrinsically safe equipment approved to CSA standard CAN/CSA-E60079-11. Both of these markings represent intrinsically safe equipment capable of supplying intrinsic safety in the presence of two component faults.

Ex-ia products may be approved to CSA standard E60079-11.

This rule requires intrinsically safe circuits and wiring to be properly designed and installed. While it does not specifically state the requirement, it is also important that intrinsically safe circuits and wiring are installed according to a control wiring diagram. Improper design, installation or maintenance of intrinsically safe circuits and wiring can render them unsafe for use. Part of any design should ensure that proper instructions are provided to the installer and maintenance personnel as to their requirements to properly install and maintain the systems.



Control wiring diagrams for Ex-ia circuit.

18-092 Sealing Class I, Zone 0

(1) Conduit seals shall be provided where the conduit leaves the Class I, Zone 0 location with no box, coupling, or fitting in the conduit run between the seal and the point at which the conduit leaves the location, except that a rigid unbroken conduit that passes completely through a Class I, Zone 0 area, with no fittings less than 300 mm beyond each boundary, need not be sealed provided that the termination points of the unbroken conduit are in non-hazardous areas.

(2) Cable seals shall be provided on cables at the first point of termination after entry into the Zone 0 location.

Installations in Class I, Zone 1 Locations

18-100 Equipment in Class I, Zone 1 Locations (see Appendix B and F)

Appendix B Notes

18-090, 18-100, 18-150

Equipment certified for hazardous locations is marked with the area classification where the equipment can be installed. For example, a piece of equipment marked with Class I may be installed in a Class I location.

This Code recognizes the IEC system of marking equipment as providing a specific method of protection. This equipment may only be installed in locations where this method of protection is recognized. For example, Rule 18-100 recognizes that equipment marked with the method of protection “d” is acceptable for installation in a Class I, Zone 1 location. Additional information related to methods of protection may be found in the CAN/CSA-E60079 Series of Standards listed in Appendix A.

The following table is provided to illustrate some of the equipment and methods of protection permitted in the three Zones. This table is not intended to be comprehensive. Other equipment may be permitted by specific rules (e.g., fuses in Rule 18-164).

Class I, Zone 0	**Class I, Zone 1**	**Class I, Zone 2**
i, ia*	Class I, Div. 1	Class I, Div. 1
	i, ia, and ib*	Class I, Div. 2
	d	i, ia, and ib*
	e	d
	o	e
	p	o
	q	p
	m	q
		m
		n
		Non-incendive
		Non-arcing, non-sparking, and non-heat-producing equipment.

*Equipment may be certified to CSA Standard CAN/CSA 22.2 No. 60079-11.

18-100, 18-150

For further information see the applicable Part II Standards.

(a) Intrinsically Safe (Intrinsic Safety) "i," "ia," or "ib": A method of protection based on the limitation of electrical energy to levels where any open spark or thermal effect occurring in equipment or interconnecting wiring that may occur in normal use, or under fault conditions likely to occur in practice, is incapable of causing an ignition. The use of intrinsically safe equipment in a Hazardous Location also requires that associated wiring and equipment, which is not necessarily located in a hazardous area, be assessed as part of any intrinsically safe system. The primary difference between equipment marked Ex-ia and Ex-ib is that equipment marked Ex-ia must continue to provide explosion protection after two faults have been applied, whereas equipment marked Ex ib must continue to provide explosion protection after one such fault has been applied (see CSA Standard CAN/CSA 22.2 No. 60079-11).

(b) Flameproof "d": A method of protection of electrical apparatus in which the enclosure will withstand an internal explosion of a flammable mixture that has penetrated into the interior, without suffering damage and without causing ignition, through any joints or structural openings in the enclosure, or an external explosive atmosphere consisting of one or more of the gases or vapours for which it is designed (see CSA Standard CAN/CSA 22.2 No. 60079-1).

(c) Increased Safety "e": A method of protection by which additional measures are applied to an electrical apparatus to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks during the service life of the apparatus. It applies only to an electrical apparatus, no parts of which produce arcs or sparks or exceed the limiting temperature in normal service (see CSA Standard CAN/CSA 22.2 No. 60079-1).

(d) Oil Immersed "o": A method of protection where electrical apparatus is made safe by oil immersion in the sense that an explosive atmosphere above the oil or outside the enclosure will not be ignited (see CSA Standard CAN/CSA-E60079-6).

(e) Pressurized "p": A method of protection using the pressure of a protective gas to prevent the ingress of an explosive atmosphere to a space that may contain a source of ignition and, where necessary, using continuous dilution of an atmosphere within a space that contains a source of emission of gas, which may form an explosive atmosphere (see CSA Standard CAN/CSA 22.2 No. 60079-2).

(f) Powder Filled (Sand Filled) "q": A method of protection where the enclosure of electrical apparatus is filled with a mass of granular material such that, if an arc occurs, the arc will not be liable to ignite the outer flammable atmosphere (see CSA Standard CAN/CSA 22.2 No. 60079-5).

(g) Encapsulation "m": A method of protection in which parts that could ignite an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that this explosive atmosphere cannot be ignited (see CSA Standard CAN/CSA 22.2 No. 60079-18).

(h) Non-sparking, Restricted Breathing, etc. "n": A method of protection applied to an electrical apparatus such that, in normal operation, it is not capable of igniting a surrounding explosive atmosphere, and a fault capable of causing ignition is not likely to occur (see CSA Standard CAN/CSA 22.2 No. 60079-15.)

Note: Method of Protection "n" includes a number of means of providing protection. In addition to non-sparking, component parts of apparatus that in normal operation arc, spark, or produce surface temperatures of 85°C or greater may be protected by one of the following:

(a) enclosed break device;

(b) non-incendive component;

(c) hermetically sealed device;

(d) sealed device;

(e) energy-limited apparatus and circuits; or

(f) restricted breathing enclosure.

Some of these methods are similar to methods previously allowed in Class I, Division 2 locations. To better understand the various methods allowed under Method of Protection "n," refer to CSA Standard CAN/CSA 22.2 No. 60079-7.

Where required by other Rules of this *Code*, electrical equipment installed in a Class I, Zone 1 location shall be approved:

(a) for Class I or Class I, Division 1 locations or;

Equipment approved to the original CSA Hazardous Location standards for Class I, Division 1 locations will be marked Class I, or Class I, Division 1. This rule accepts the use of this equipment, in addition to the equipment outlined in (b) in Class I, Zone 1 Hazardous Location.

(b) as providing equipment protection level Ga or Gb; or

(c) as providing one or more of the following methods of protection:

(i) intrinsically safe i, ia, or ib;

(ii) flame-proof d;

(iii) increased safety e;

(iv) oil immersed o;

(v) pressurized p;

(vi) powder-filled q; or

(vii) encapsulation m.

The IEC-based Hazardous Location equipment standards will be marked with the method(s) of protection used in their construction. All of the methods outlined below are acceptable for use in a Class I, Zone 1 Hazardous Location. Note that a more detailed description of the methods of protection are contained in Appendix B, and the CSA standards to which equipment is approved are listed in Appendix A.

It is important to be aware that equipment outlined in both (a) and (b) may be used in the same installation. Users may choose whatever mixture of the two types of equipment best meets their needs as long as the requirements of this rule are met.

18-102 Transformers and Capacitors, Class I, Zone 1

Transformers and electrical capacitors shall comply with the requirements of Rule 18-100 or shall be installed in electrical equipment vaults in accordance with Rules 26-350 to 26-356, and

Transformers meeting the requirements of the previous rule may be installed in a Class I, Zone 1 location. For example, small transformers or capacitors could be installed in explosionproof or flameproof enclosures. If larger transformers are located in the Class I, Zone 1 location they must be enclosed in equipment vaults meeting the requirements of (a) to (e). Essentially, this requires them to be located in a vault which is constructed and ventilated to make it a nonhazardous location. Most designers choose to locate transformers of any size outside the Class I, Zone 1 Hazardous Location.

Zone 1 switchracks.

(a) there shall be no door or other connecting opening between the vault and the hazardous area;

(b) the vault shall be provided with adequate ventilation;

(c) vent openings or vent ducts shall lead to a safe location outside the building containing the vault;

(d) vent openings and vent ducts shall be of sufficient area to relieve pressure caused by explosions within the vault; and

(e) every portion of a vent duct within the building shall be constructed of reinforced concrete.

18-104 Meters, Instruments, and Relays, Class I, Zone 1

(1) Where practicable, meters, instruments, and relays, including kilowatt-hour meters, instrument transformers and resistors, rectifiers, and thermionic tubes, shall be located outside the hazardous location.

(2) Where it is not practicable to install meters, instruments, and relays outside Class I, Zone 1 locations, they shall comply with the requirements of Rule 18-100.

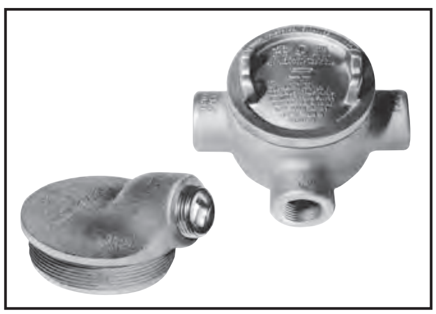
All electrical equipment located in a Class I, Zone 1 Hazardous Location must meet the requirements of Rule 18-100.

18-106 Wiring Methods, Class I, Zone 1 (see Appendix B)

(1) The wiring method shall be threaded rigid metal conduit or cables approved for hazardous locations with associated cable glands that comply with the requirements of Rule 18-100.

Cables in Class I, Zone 1 Hazardous Locations are required to be marked with an "HL" designation indicating it has passed the performance requirement outlined in CSA standard C22.2 No. 174 "Cables and Cable Glands for Use in Hazardous Locations." Cable glands meeting the requirements of standard C22.2 No. 174 are required to be marked Class I or Class I, Division 1. Exe glands may be used on cables entering Exe enclosures in Zone 1 locations.

TECK Terminator™ Connector.



GUAT Outlet Box and GUA Sealing Cover.

(2) Explosion-proof or flame-proof boxes, fittings, and joints shall be threaded for connection to conduit and cable glands.

Appendix B Notes

18-106, 18-108, 18-152(1)(b), 18-202(1)(b), 18-252(1)(b), 18-302(1)(b), 18-352(b)

Cables approved for hazardous locations are suitable for all locations, but the termination fittings must be suitable for the particular hazardous location.

For example, in a Class I, Zone 1 or 2 hazardous location, a termination fitting entering an enclosure required to be explosion-proof or flame-proof must be a sealing-type termination fitting, whereas a termination fitting entering an enclosure not required to be explosion-proof or flame-proof in a Class I, Zone 2 hazardous location is not required to be approved for Class I, Zone 2 hazardous areas. It is intended that termination fittings in all hazardous areas be compatible with the degree of protection and the explosion protection provided by the enclosure they enter. In general, the minimum requirement will be weatherproof termination fittings.

For the application of Section 18, rigid metal couplings are not considered fittings.

The CSA Standard for rigid metal conduit and couplings is C22.2 No. 45.1. This Standard does not require the markings for the conduit and couplings to indicate specific approval for hazardous locations. Certified rigid metal conduit and couplings are suitable for hazardous locations without specific area classification marking.

18-106(3)(a), 18-156(3)(a)

Where tapered threads are used, the requirement to have five fully engaged threads (i.e., threads done up tight) is critical for three reasons:

(a) When the threads are not fully engaged, the flame path is compromised, making it possible for an explosion occurring within the conduit system to be transmitted to the area outside the conduit.

(b) If there are not five fully engaged threads, the flame path may be too short to cool the gases resulting from an internal explosion to a temperature below that which could ignite gas in the surrounding area.

(c) As the conduit forms a bonding path to ground, not making the conduit tight will introduce resistance into the flame path and if a fault occurs, arcing at the interface may result.

While it may not always be possible to install certain fittings without backing off, it is important to ensure the connection is as tight as possible. Properly made conduit connections are critical to the safety of hazardous location wiring systems.

(3) Threaded joints that are required to be explosion-proof or flame-proof shall be permitted to be either tapered or straight and shall comply with the following:

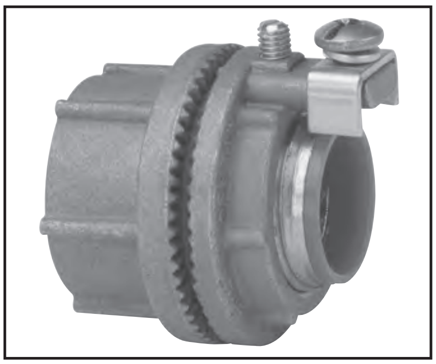
(a) tapered threads shall have at least five fully engaged threads, and running threads shall not be used;

(b) where straight threads are used in Groups IIA and IIB atmospheres, they shall have at least five fully engaged threads; and

(c) where straight threads are used in Groups IIC atmospheres, they shall have at least eight fully engaged threads.

Threaded joints that are required to be explosionproof or flameproof are flame paths and are required to cool gases exiting an explosionproof or flameproof enclosure (as the result of an internal explosion), to a temperature below the ignition temperature of the gases in the area. A minimum number of threads of engagement are required to ensure an adequate flame path. The rule also recognizes the use of tapered threads as used in traditional North American equipment and non-tapered or parallel (metric) threads as used in IEC or European equipment. The estimated NPT to metric equivalents are as follows:

NPT	Metric
3/8"	M16
1/2"	M20
3/4"	M25
1"	M32
1-1/2"	M40
2"	M63



Zone 1 Myers™ Hubs can be used for metric to NPT adapters.

(4) Where threadforms differ between the equipment and the wiring system, approved adapters shall be used.

Where tapered threads and parallel threads are used in a connection, an approved adapter is required to be used to ensure a proper flame path is maintained. It is not acceptable to mate a tapered thread with a parallel thread, as the connection will not make an adequate flame path.

(5) Conduit and cable entries into increased safety "e" enclosures shall be made in such a manner as to maintain the degree of protection provided by the enclosure.

Increased safety enclosures are weatherproof. Conduit and cable entries to the enclosures should also be weatherproof to ensure the degree of protection of the enclosure is not compromised. Increased safety connectors will meet the weatherproof requirements.

Appendix B Notes

18-106(4)
It is recognized that electrical equipment that has been certified to IEC-based Canadian Standards (IEC Standards adapted for Canadian Standards use) may have conduit or cable entries with threads that are either tapered or straight complying with ISO (International Organization for Standardization) Standards. Subrule (4) requires that approved adapters be used to ensure an effective connection to this equipment where threadforms differ between the equipment and the wiring method.

Two references for understanding ISO threads are ISO 965, Parts 1 and 3.

18-106(5)
The method of protection "increased safety" incorporates protection from ingress of water or foreign bodies. CSA Standard CAN/CSA-E60079-7 requires that enclosures containing bare conductive parts provide at least degree of protection IP54 (see following table) and that enclosures containing only insulated conductive parts provide at least degree of protection IP44. It is important that conduit and cable entries maintain at least the degree of protection provided by the enclosure by the use of devices such as gaskets and sealing lock nuts. Increased safety enclosures should restrict easy entry of gases or vapours in order to minimize the entry of gases or vapours from short-term releases.

Ingress protection (IP) describes the degree of protection an enclosure provides. The first number of the IP designation describes the degree of protection against physical contact (i.e., fingers, tools, dust, etc.) with internal parts; the second number designates the IP against liquids. For example, an IP54 rating will require an enclosure to be dust-protected and protected against water splashing from any direction. While the minimum requirement for an increased safety enclosure is IP44 or IP54 as stated above, typically most increased safety enclosures meet IP65 or IP66 rating.

For further information on the IEC "IP" designations, refer to IEC Standard 60529.

(6) Cables shall be installed and supported in a manner to avoid tensile stress at the cable glands.

Where a cable connection is under tensile stress, there is a danger the cable may pull out of the connector, thus compromising the integrity of the enclosure. A common method of ensuring there is no tensile stress on the cable connection is to support it in close proximity to the box. See Section 12, Rule 12-510(1), of the *Canadian Electrical Code* for more specific requirements.

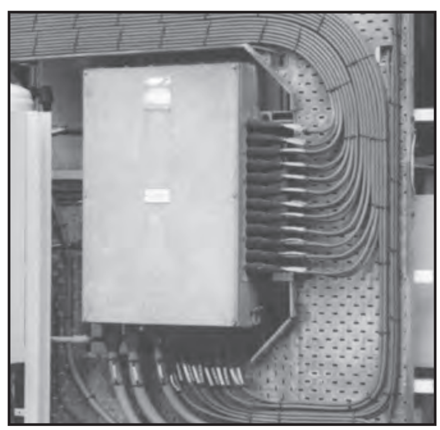
Ingress Protection

Protection against contact and solid objects

Number	Description
0	No Protection
1	Objects greater than 50 mm
2	Objects greater than 12 mm
3	Objects greater than 2.5 mm
4	Objects greater than 1 mm
5	Dust-protected
6	Dust-tight

Protection against liquids

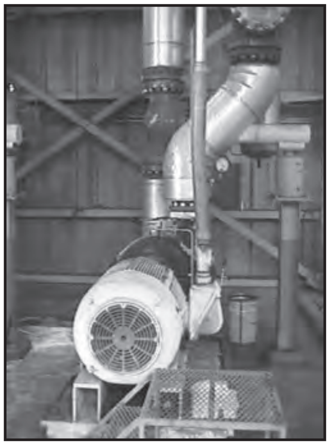
Number	Description
0	No Protection
1	Vertically dripping water
2	Dripping water when tilted up to 15°
3	Spraying water at an angle up to 60°
4	Splashing water from any direction
5	Low-pressure water jets
6	Strong jets of water
7	The effect of immersion to a depth of 1 m
8	Submersion



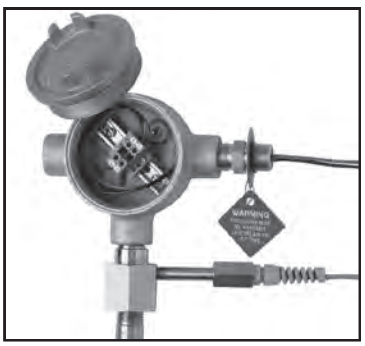
Cables should be secured when entering enclosures.

(7) Where flexible fittings are used for connection at motor terminals and similar places, they shall be of a type approved for the location.

Flexible connections may be made either by the use of cable or by an explosionproof flexible connection where conduit is used.



Flexible couplings are used for motor connectors in high-vibration applications.



Secondary Process Sealing Fittings. Cooper Crouse-Hinds has invented the first CSA approved, field installed, pressure rated process seal which stops both gases and liquids, under pressure, from migrating through conduit and individual conductors.

18-108 Sealing, Class I, Zone 1 (see Appendix B)

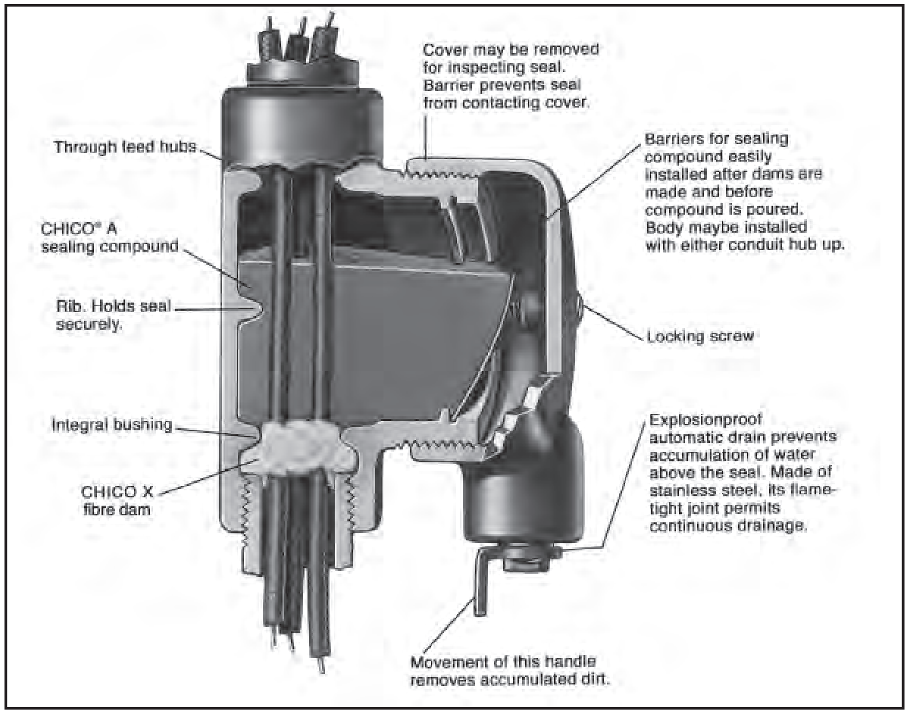
(1) Conduit seals shall be provided in conduit systems where:

(a) the conduit enters an explosion-proof or flame-proof enclosure containing devices that may produce arcs, sparks or high temperatures and shall be located as close as practicable to the enclosure, or as marked on the enclosure, but not further than 450 mm from the enclosure;

Seals are required to be located close to an explosionproof enclosure for two reasons:

1. To ensure an explosion within the enclosure will be contained within the enclosure; and

2. To keep the effective volume of the enclosure as small as possible. The pressure generated by an explosion is roughly proportional to the volume in which it takes place. If the effective volume of the enclosure is increased by additional devices prior to the seal, the pressure of an explosion within the combination may exceed the maximum pressure for which the enclosure was designed. Adding lengths of conduit to the enclosure, prior to the seal can create "pressure piling," which will further increase the pressure generated by an internal explosion.



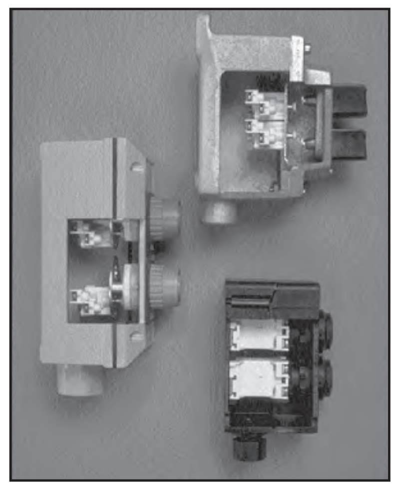
A properly poured seal will have all voids and spaces filled.

(b) the conduit is 53 trade size or larger and enters an explosion-proof or flame-proof enclosure housing terminals, splices, or taps, and shall be located no further than 450 mm from the enclosure;

See Table 9 of the *CEC,* "Cross-sectional Areas of Conduit and Tubing."

Explosionproof or flameproof enclosures containing devices such as terminals or other connections that do not produce arcs or sparks or operate at elevated temperatures during their normal operation, do not require sealing fittings where entries to the enclosures are smaller than 2 trade size.

(c) the conduit leaves the Class I, Zone 1 location with no box, coupling, or fitting in the conduit run between the seal and the point at which the conduit leaves the location, except that a rigid unbroken conduit that passes completely through a Class I, Zone 1 area with no fittings less than 300 mm beyond each boundary, need not be sealed provided that the termination points of the unbroken conduit are in non-hazardous areas; orconduit run between the seal



Factory-sealed switches, like the EDS or GHG control stations, utilize factory-sealed contact blocks that eliminate the need for additional seals.

and the point at which the conduit leaves the location, except that a rigid unbroken conduit which passes completely through a Class I, Zone 1 area with no fittings less than 300 mm beyond each boundary need not be sealed provided that the termination points of the unbroken conduit are in nonhazardous areas; or

Gas or vapour can enter a conduit system through any threaded connection. Therefore, it is assumed that the atmosphere existing within a Hazardous Location will also be present within the conduit system. Therefore, a seal is required after the last threaded connection where the conduit leaves the Class I, Zone 1 location. This is to prevent gas from the Zone 1 Hazardous Location from being transmitted to a less Hazardous Location.

Seals are required when conduit leaves a Zone 1 area.

Where a conduit passes through a Class I, Zone 1 location without having any connections within the Class I, Zone 1 area, gas from the Class I, Zone 1 location will not enter the conduit and a “boundary seal” is not required.

(d) the conduit enters an enclosure that is not required to be explosion-proof or flame-proof, except that a seal is not required where an unbroken and continuous run of conduit connects two enclosures that are not required to be explosion-proof or flame-proof.

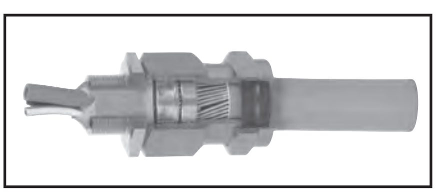
A conduit connecting an enclosure not required to be explosionproof or flameproof to an enclosure required to be explosionproof or flameproof will require a seal in the conduit between the two enclosures. Where two “increased safety” enclosures are connected together by an unbroken run of conduit, there are no connections where the gas can enter the conduit, therefore no seal is required. Note that Rule 18-106(5) will require the connection to the enclosure to maintain the degree of protection provided by the enclosure. Normally this requires a weatherproof connection.

(2) Only explosion-proof or flame-proof unions, couplings, reducers, and elbows that are not larger than the trade size of the conduit shall be permitted between the sealing fitting and an explosion-proof or flame-proof enclosure.

(3) Cable seals shall be provided in a cable system where

(a) the cable enters an enclosure required to be explosion-proof or flame-proof; or

In this situation, a sealing gland is required to ensure an explosion within the enclosure will be contained within the enclosure.



Ex-d flameproof (barrier) sealing gland.

(b) the cable first terminates after entering the Zone 1 area.

In Zone 1 areas, explosive concentrations of gas or vapour may be present for long periods (the industry Rule of Thumb suggests up to 1,000 hours per year) and therefore the end of a cable could be exposed to gas at atmospheric pressure for long periods. Sealing at point of first termination in the Zone 1 area is done to prevent migration of gas from the Zone 1 Hazardous Location to a less Hazardous Location

Appendix B Notes

18-108, 18-154

Seals are provided in conduit or cable systems to prevent the passage of gases, vapours, or flames from one portion of the electrical installation to another through the system.

Passage of gases, vapours, or flames through mineral-insulated cable is inherently prevented by construction of the cable, but sealing compound is used in cable glands to exclude moisture and other fluids from the cable insulation, and is required to be of a type approved for the conditions of use.

Cables and flexible cords are not tested to determine their ability to resist internal explosions. Therefore, regardless of size, each cable must be sealed at the point of entry into any enclosure that is required to be explosionproof.

Some designs of cable glands incorporate an integral seal, and these are marked “SL” to indicate that the seal is provided by the cable gland. Cable glands of this type are identified with the Class designation. Designs requiring a field- or factory-installed sealing fitting have the group designation marked on this component.

As the appropriate sealing characteristics may be achieved by different means, the manufacturer’s instructions should be followed.

Sealing of conductors in the conduit, or in most cables, requires that the sealing compound completely surround each individual insulated conductor to ensure that the seal performs its intended function. In certain constructions of cables, specifically those containing bundles of shielded pairs, triads, or quads, removal of the shielding or overall covering from the bundles negates the purpose for which the shielding was provided. Testing of this type of cable now includes testing for flame propagation along the length of the individual subassemblies of the cable.

The letters A, B, C, or D, or a combination thereof, may be added to signify the group(s) for which the cable has been tested, e.g.:

(a) “HL-CD” indicates the cable has been tested for flame propagation for gas groups C and D; and

(b) “TC-BCD” indicates the cable has been tested for flame propagation for gas groups B, C, and D.

See also the Table in the Note to Rule 18-050.

18-108(1)(d)

Seals are required on conduit systems where a conduit enters an enclosure not required to be explosionproof or flameproof (typically a type "e" enclosure) because the conduit system is required to be maintained as an explosionproof or flameproof wiring system in a Class I, Zone 1 Hazardous Location. Note that the conduit entry into a type "e" enclosure must also meet the ingress protection rating of the enclosure.

18-108(2)

Reducers may have one side larger than the trade size of the conduit where the entry to the explosionproof or flameproof enclosure is larger than the trade size of the conduit.

18-108(2) & 18-154(2)

Conduit fittings approved for Class I locations and similar to the “L,” “T,” or “Cross” type would not usually be classed as enclosures when not larger than the trade size of the conduit.

18-108(4)

It is important that the manufacturer’s instructions are closely adhered to or seals will not function properly to prevent the transmission of an explosion or to prevent the transmission of flammable fluids to nonhazardous areas where they will be exposed to unprotected ignition sources. Improper sealing has been the primary factor in a number of explosions, resulting in loss of life and/or major equipment damage. Users are reminded that only the sealing compound outlined with the instructions may be used in a seal. Use of other manufacturer’s compounds in a seal may compromise the integrity of the installation.

18-108(4)(a)

All motors and generators approved under the applicable Part II Standards for Class I locations are required to have a seal provided by the manufacturer between the main motor or generator enclosure and the enclosure for the conduit entry (connection box). A marking regarding the seal being provided is therefore not necessary on this particular class of product.

For cables, compliance with Subrule (4)(a)(i) and (ii) can be accomplished by

(a) a cable gland approved for Class I hazardous locations for appropriate cable type(s) and a field-installed sealing fitting;

(b) a cable gland approved for Class I hazardous locations for appropriate cable types with an integral seal; or

(c) a cable gland for approved cable types used with an approved enclosure provided with sealing as specified in Subrule (4)(a)(ii).

Cable glands with integral seals are marked "SL".

18-108(4)(a)(i)

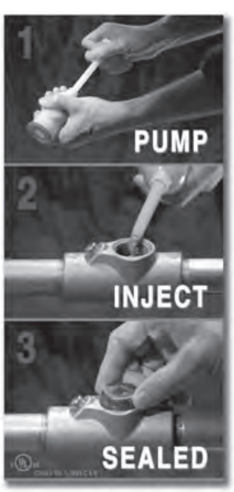
The term "accessible" as used in this Rule is in accordance with the Code definition in Section 0 for "Accessible as applied to wiring methods".

(4) Where secondary cable seals or conduit seals are required, they shall conform to the following:

(a) The seal shall be made:

(i) In a field-installed sealing fitting or cable gland that shall be accessible and shall comply with the requirements of Rule 18-100; or

Sealing fittings are required to be approved as outlined in Rules 18-100 and in 2-024. Sealing fittings are approved by a certification agency, to a CSA standard. Part of the approval will be instructions from the manufacturer on how to properly install the fittings. If they are not installed in accordance with the manufacturer's instructions, the installation will not meet the requirements of this *Code*.



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.

(ii) In a sealing fitting provided as part of an enclosure approved for the area and where the seal is factory-made, the enclosure shall be so marked to indicate that such a seal is provided;

Where seals are installed in the factory as a part of an enclosure, a seal is not required to be installed in the field. However, the enclosure must bear markings to indicate it is "factory sealed."

Factory sealed or Ex-de products do not require external seals.

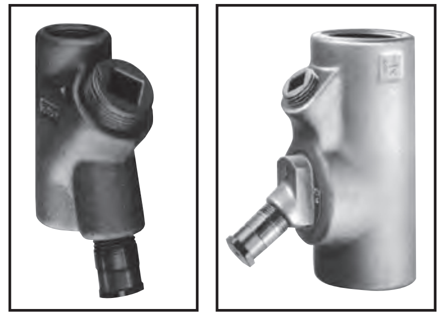
Sealing compound is generally supplied by the manufacturer for use with the manufacturer's sealing fittings. Use of compound other than that approved for the fitting will void the approval of the fitting. Compounds from different manufacturers may have different characteristics and may not provide a proper seal.

CHICO® sealing compound must be used with Cooper Crouse-Hinds fittings.

(b) 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;

(c) Where there is a probability that liquid or other condensed vapour 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 vapour; and

Where there is a possibility moisture may collect above a seal, seals with drains must be installed. This is of particular importance outdoors as accumulated moisture can freeze and fracture the fittings and/or the conduit.



EYD drain seals should be used where moisture may collect.

(d) Where there is a probability that liquid or condensed vapour may accumulate within motors or generators, joints and conduit systems shall be arranged to minimize entrance of liquid, but if means to prevent accumulation or to permit periodic draining are judged necessary, such means shall be provided at the time of manufacture, and shall be deemed an integral part of the machine.

(5) Runs of cables, each having a continuous sheath, either metal or nonmetal, shall be permitted to pass through a Class I, Zone 1 location without seals.

The continuous sheath of a cable will prevent the entry of gas or vapour into the cable. Therefore, there is no need to provide a seal at the boundary of a Hazardous Location. Seals are only required on cables with a continuous jacket or sheath at the point where they terminate in a Hazardous Location. Users must be aware that if jacket damage of a cable occurs within a Hazardous Location, it must be repaired to prevent the entry of gas or vapour into the cable.

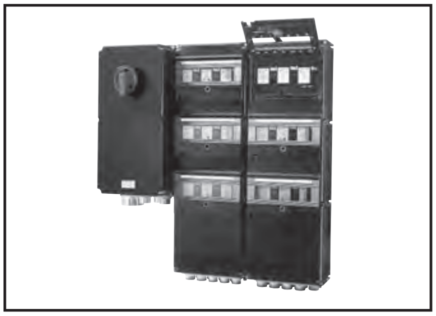
(6) Cables that do not have a continuous sheath, either metal or nonmetal, shall be sealed at the boundary of the Zone 1 location.

The use of cables without continuous jackets in hazardous areas is a rare occurrence and is not recommended.

18-110 Switches, Motor Controllers, Circuit Breakers, and Fuses, Class I, Zone 1

Switches, motor controllers, circuit breakers, and fuses, including push buttons, relays, and similar devices, shall be provided with enclosures, and the enclosure in each case together with the enclosed apparatus shall be approved as a complete assembly and shall comply with the requirements of Rule 18-100.

These devices may cause arcing or sparking as a result of their normal operation. Therefore, they must either be enclosed in an enclosure that is explosionproof or flameproof. Devices manufactured with method of protection "d" may be installed in enclosures providing method of protection "e."



The SpecOne™ D2Z nonmetallic panel uses Ex-de encapsulated breakers.

18-112 Control Transformers and Resistors, Class I, Zone 1

Transformers, impedance coils, and resistors used as or in conjunction with control equipment for motors, generators, and appliances and the switching mechanism, if any, associated with them, shall comply with the requirements of Rule 18-100.

These devices may become ignition sources as a result of high temperatures in normal operation or arcing and sparking in component failure. A Zone 1 location can have combustible concentrations of gas present as a result of "normal operation" of the process. Electrical equipment that may create arcs, sparks or high temperatures as a result of normal or abnormal operation must be protected by one or more of the means outlined in Rule 18-100.

18-114 Motors and Generators, Class I, Zone 1 (see Appendix B)

(1) Motors, generators, and other rotating electrical machines shall comply with the requirements of Rule 18-100.

Some motors and generators, such as single phase or direct current types, will create arcs or sparks as a result of their normal operation. Other motors (e.g. three phase) and generators may do so only during abnormal operation, such as a winding failure. However, as Class I, Zone 1 Hazardous Locations can have explosive gas atmospheres present during normal operation of plant processes, all motors and generators in Class I, Zone 1 Hazardous Locations must meet the requirements of Rule 18-100.

(2) Increased safety "e" motor installations shall meet the thermal protection requirement of Section 11.3 ("Cage induction motors — Thermal protection in operation") of IEC 60079-14, Explosive atmospheres — Part 14: Electrical installations design, selection and erection.

Increased safety motors are not constructed to contain an internal explosion, therefore should they fail they could become a source of ignition. In order to ensure they do not fail due to overloading, their application has certain restrictions in the IEC Installation Code 60079-14 Electrical Installations in Hazardous Locations (Other Than Mines). Increased safety motors installed in Class I, Zone 1 Hazardous Locations that are not installed in accordance with the requirements of Section 11.3 of IEC 60079-14 cannot be considered to meet the requirements for increased safety even though the motor may be narked as an increased safety motor.

Appendix B Notes

Rule 18-114(2)

Sections 7.2 and 11.3 of IEC 60079-14 (edition 4.0, 2007-12) are included here for the convenience of designers and users. For additional information on design and installation requirements of increased safety motors, consult the following:

(a) IEC 60079-14, *Electrical apparatus for explosive gas atmospheres — Part 14: Electrical installations in hazardous areas (other than mines);* and

(b) CAN/CSA-E60079-7, *Electrical Apparatus for Explosive Gas Atmospheres — Part 7: Increased Safety "e".*

The following extracts from IEC 60079-14, *Explosive atmospheres — Part 14: Electrical Installations design, selection and erection,* outline additional requirements for the application of method of protection "e" (Increased safety) motors in Class I, Zone 1 hazardous locations.

11.3 Cage induction motors

11.3.1 Mains-operated

In order to meet the requirements of item (a) of 7.2, inverse-time delay overload protective devices shall be such that not only is the motor current monitored, but the stalled motor will also be disconnected within the time tE stated on the marking plate. The current-time characteristic curves giving the delay time of the overload relay or release as a function of the ratio of the starting current to the rated current shall be held by the user.

The curves will indicate the value of the delay time from the cold state related to an ambient temperature of 20 °C and for a range of starting current ratios (IA /IN) of at least 3 to 8. The tripping time of the protective devices shall be equal to these values of delay ±20 %.

The properties of delta wound machines in the case of the loss of one phase should be specifically addressed. Unlike star wound machines, the loss of one phase may not be detected, particularly if it occurs during operation. The effect will be current imbalance in the lines feeding the machine and increased heating of the motor. A delta wound motor with a low torque load during start-up might also be able to start under this winding failure condition and therefore the fault may exist undetected for long periods. Therefore, for delta wound machines, phase imbalance protection shall be provided which will detect machine imbalances before they can give rise to excessive heating effects.

In general, motors designed for continuous operation, involving easy and infrequent starts which do not produce appreciable additional heating, are acceptable with inverse-time delay overload protection. Motors designed for arduous starting conditions or which are to be started frequently are acceptable only when suitable protective devices ensure that the limiting temperature is not exceeded.

Arduous starting conditions are considered to exist if an inverse-time delay overload protective device, correctly selected as above, disconnects the motor before it reaches its rated speed. Generally, this will happen if the total starting time exceeds 1.7 tE.

NOTE 1 Operation

Where the duty of the motor is not S1 (continuous operation at constant load), the user should obtain the appropriate parameters for the determination of suitability given a definition of operation.

NOTE 2 Starting

It is preferred that the direct on-line starting time for the motor is less than the tE time so that the motor protection device does not trip the motor during start-up. Where the starting time exceeds 80% of the tE time, the limitations associated with starting whilst maintaining operation within the machine instruction manual should be ascertained from the motor manufacturer.

As the voltage dips during a direct on-line start, the starting current decreases and the run-up time increases. Although these effects may tend to cancel out for small voltage dips, for voltages less than 85% of UN during startup, the motor manufacturer should declare the associated limitations on start-up.

Motors may be limited by the manufacturer to a fixed number of start attempts.

NOTE 3 Protection relay

The protection relay for machines in accordance with type of protection 'e' should, in addition to the requirements of Clause 7:

(a) monitor the current in each phase;

(b) provide close overload protection to the fully loaded condition of the motor.

Inverse-time delay overload protection relays may be acceptable for machines of duty type S1 which have easy and infrequent starts. Where the starting duty is arduous or starting is required frequently, the protection device should be selected so that it ensures limiting temperatures are not exceeded under the declared operational parameters of the machine. Where the starting time exceeds 1.7tE, an inverse-time relay would be expected to trip the machine during start-up.

Under some circumstances, e.g., for duty types other than S1, the motor may be certified with the temperature detection and protection. If this is the case, the tE time may not be identified.

11.3.2 Winding temperature sensors

In order to meet the requirements of 7.2(b), winding temperature sensors associated with protective devices shall be adequate for the thermal protection of the machine even when the machine is stalled. The use of embedded temperature sensors to control the limiting temperature of the machine is only permitted if such use is specified in the machine documentation.

NOTE The type of built-in temperature sensors and associated protective device will be identified on the machine.

11.3.3 Machines with rated voltage greater than 1 kV

Machines with a rated voltage exceeding 1 kV shall be selected taking into account the 'Potential stator winding discharge risk assessment — Ignition risk factors' (see Annex E). If the total sum of the risk factors is greater than 6, then anti-condensation space heaters shall be employed, and special measures shall be applied to ensure that the enclosure does not contain an explosive gas atmosphere at the time of starting.

NOTE 1 If the machine is intended to operate under 'special measures', the certificate will have the symbol 'X' in accordance with IEC 60079-0.

NOTE 2 Special measures may include pre-start ventilation, the application of fixed gas detection inside the machine or other methods specified in manufacturer's instructions.

NOTE 3 In the table in Annex E, the reference to 'Time between detailed inspections' is intended to reflect the interval between cleaning of the stator windings. It should read 'Time between major overhauls (disassembly and cleaning where necessary)' as a detailed inspection in accordance with IEC 60079-17 would not normally require the stator winding to be examined.

11.3.4 Motors with converter supply

Motors supplied at varying frequency and voltage by a converter shall have been type tested for this duty as a unit in association with the converter and the protective device.

11.3.5 Reduced-voltage starting (soft starting)

Motors with a soft start supply require either:

(a) the motor has been tested as a unit in association with the soft start device specified in the descriptive documents and with the protective device provided; or

(b) the motor has not been tested as a unit in association with the soft start device. In this case, means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation, other effective measures for limiting the temperature of the motor shall be provided or the speed control device ensures that the motor run up is such that the temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE 1 It is considered that soft starting is used for a short time period.

NOTE 2 When using a soft start device with high-frequency pulses in the output, care should be taken to ensure that any overvoltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

7.2 Rotating electrical machines

Rotating electrical machinery shall additionally be protected against overload unless it can withstand continuously the starting current at rated voltage and frequency or, in the case of generators, the short-circuit current, without inadmissible heating. The overload protective device shall be:

(a) a current-dependent, time lag protective device monitoring all three phases, set at not more than the rated current of the machine, which will operate in 2 h or less at 1.20 times the set current and will not operate within 2 h at 1.05 times the set current; or

(b) a device for direct temperature control by embedded temperature sensors; or

(c) another equivalent device.

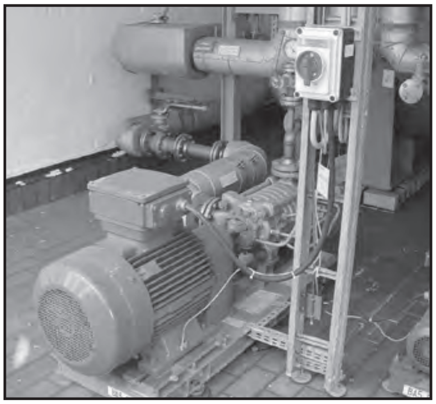
18-114, 28-314

Users are cautioned that combining a variable frequency drive (VFD) with a motor may increase the operating temperature of the motor as a result of the harmonics produced by the drive. This may cause the motor temperature to exceed its temperature code rating. This is of particular concern where the operating temperature of the motor is close to the ignition temperature of hazardous materials that may be in the area. Because of the generally lower ignition temperatures associated with Class II materials, it will be of particular concern in Class II areas. It remains the responsibility of the user to ensure that the operating temperature of the motor, in combination with the drive, is below the minimum ignition temperature of the hazardous material in the area. The motor manufacturer should be consulted where necessary. Some references that may assist the user in determining the suitability of an installation are:

CSA Technical Information Letter E-22, "Motors and Generators For Use in Class I, Division 2 and Class II, Division 2 Locations."

American Petroleum Industry Publication 2216, "Ignition Risk of Hydrocarbon Vapours by Hot Surfaces in the Open Air."

IEEE Paper No. PCIC-97-04, "Flammable Vapour Ignition Initiated by Hot Rotor Surfaces Within an Induction Motor—Reality or Not?"



Flameproof motor with nonmetallic disconnect switch for Zone 1 applications.

18-116 Ignition Systems for Gas Turbines, Class I, Zone 1 (see Appendix B)

Ignition systems for gas turbines shall comply with the requirements of Rule 18-100.

Ignition systems for gas turbines have similar potential to provide arcs and sparks as do motors in Rule 18-114. As a result, they must also meet the requirements of Rule 18-100.

Appendix B Notes

18-116

It should be recognized that gas turbines in hazardous locations also need safeguards against potential hazards from other than electrical ignition systems, such as exhaust and fuel systems. The complete engine assembly should, therefore, be investigated for its suitability in Class I, Zone 1 hazardous locations.

18-118 Luminaires, Class I, Zone 1

(1) Luminaires and portable lighting shall be approved as complete assemblies in accordance with the requirements of Rule 18-100 and shall be clearly marked to indicate the maximum wattage of lamps for which they are approved.

Luminaires in a Class I, Zone 1 Hazardous Location must be approved as complete assemblies and cannot be modified in the field. Luminaires will have a maximum surface temperature code based on the maximum wattage lamp for which the fixture is approved. Use of a luminaire with higher wattage lamps will cause the luminaire to run at higher temperatures and will void the approval. Luminaires will be tested for use in a 40°C ambient unless marked otherwise. Users should also be aware that using a luminaire in ambient temperatures higher than the ambient for which it is approved will require adjustment of the temperature code by the number of degrees the actual ambient temperature exceeds the temperature for which the luminaire was approved. For example, if a luminaire approved for use in a 40°C ambient is to be operated in a 60°C ambient, the maximum surface operating temperature or temperature code must be increased by 20°C.

The EVLS Hazard•Gard™ is a compact and rugged luminaire for explosionproof applications.

(2) Luminaires intended for portable use shall be specifically approved as complete assemblies for that use.

Similar requirements to Subrule (1) apply to portable luminaires. Users must also ensure that portable luminaires are not used in Hazardous Locations where the ignition temperature of the gas is lower than the maximum surface temperature of the luminaire.

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

(4) Pendant luminaires shall be:

(a) Suspended by and supplied through threaded rigid conduit stems, and threaded joints shall be provided with set screws or other effective means to prevent loosening; and

Zone 1 hand lamps.

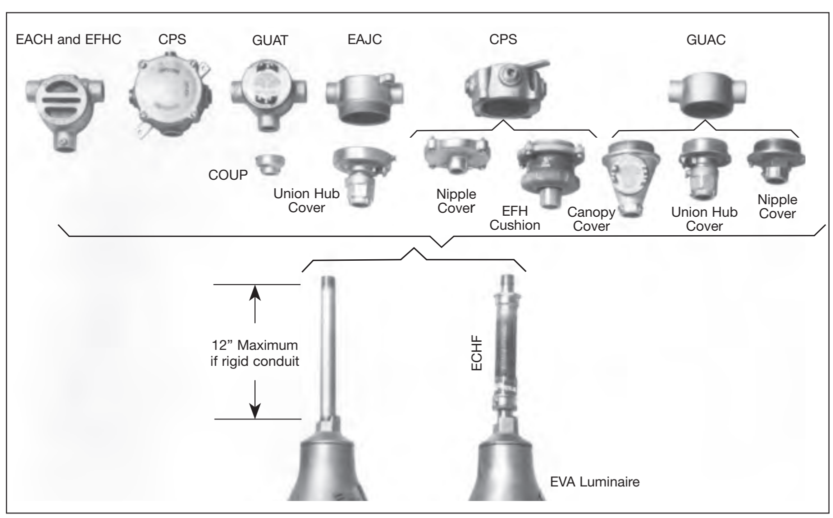
As it must be assumed combustible levels of gas will be present during normal operation in a Class I, Zone 1 Hazardous Location, a set screw is required to prevent the luminaire from unscrewing due to vibration or other means, thereby becoming a potential ignition source.

(b) for stems longer than 300 mm, provided with permanent and effective bracing against lateral displacement at a level not more than 300 mm above the lower end of the stem, or provided with flexibility in the form of a fitting or flexible connector approved for the purpose and for the location not more than 300 mm from the point of attachment to the supporting box or fitting.

(5) Boxes, box assemblies, or fittings used for the support of luminaires shall be approved for the purpose and shall comply with the requirements of Rule 18-100.

18-120 Utilization Equipment, Fixed and Portable, Class I, Zone 1

(1) Utilization equipment, fixed and portable, including electrically heated and motor-driven equipment, shall comply with the requirements of Rule 18-100.



Ordinary and hazardous area fixture hangers.

All electrical equipment used in a Class I, Zone 1 Hazardous Location must meet the requirements of Rule 18-100 to ensure it will not become a source of ignition within the Hazardous Location.

(2) Ground fault protection shall be provided to de-energize all normally ungrounded conductors of an electric heat tracing cable set with the ground fault trip setting adjusted to allow normal operation of the heater.

Arcing faults may occur in an electrical heat tracing cable without operating the overcurrent protection for the cable, depending on the location of the ground fault. To prevent a heat tracing cable from operating in these conditions, ground fault protection, which will de-energise all ungrounded conductors, must be provided for all electrical heat tracing in a Class I, Zone 1 Hazardous Location.

18-122 Flexible Cords, Class I, Zone 1

Flexible cords shall be permitted to be used only for connection between a portable lamp or other portable utilization equipment and the fixed portion of its supply circuit and, where used, shall

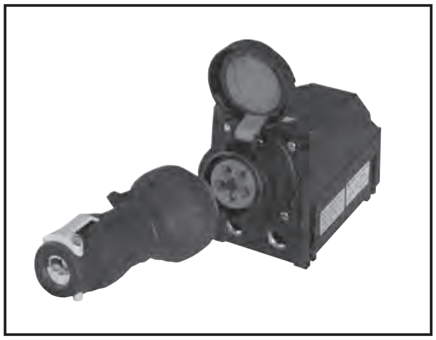
(a) be of a type approved for extra-hard usage;

(b) contain, in addition to the conductors of the circuit, a bonding conductor; and

(c) be provided with glands that comply with the requirements of Rule 18-100 where the flexible cord enters a box, fitting, or enclosure.

Flexible cords should only be used in a Class I, Zone 1 Hazardous Location to connect portable equipment to the fixed wiring system. Portable as applied to electrical equipment is defined in Section 0 of the *Canadian Electrical Code* as meaning “the equipment is specifically designed not to be used in a fixed position and receives current through the medium of a flexible cord or cable and usually an attachment plug.”

Portable cord used in a Class I, Zone 1 Hazardous Location must be an extra-hard usage type as defined in Table 11 of the *Canadian Electrical Code*. The cable must incorporate a bonding conductor and use a connector meeting the requirements of Rule 18-100. Users are reminded that the rules in other sections of the *Code* (for example the rules for conductors and cables in Section 12) also apply to the use of portable cords in a Class I, Zone 1, Hazardous Location.



Nonmetallic Zone 1 explosion-protected plug and receptacle.

18-124 Receptacles and Attachment Plugs, Class I, Zone 1

Receptacles and attachment plugs shall be of the type providing for connection to the bonding conductor of the flexible cord and shall comply with the requirements of Rule 18-100.

All electrical equipment used in a Class I, Zone 1 Hazardous Location must meet the requirements of Rule 18-100 to ensure it will not become a source of ignition within the Hazardous Location. Portable power is usually connected to interlocked receptacles within explosionproof enclosures or to receptacles containing explosion-protected, Ex-d, switches contained in Ex-e enclosures.

The FSQC interlocked product offering includes 30 A, 60 A and 100 A metallic receptacles for hazardous and ordinary locations.

18-126 Conductor Insulation, Class I, Zone 1

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

Insulation on conductors must either be suitable for use with liquids or vapours that may come in contact with them or must be protected with a sheath or jacket of material that will protect the insulation from the liquid or vapours. This is to prevent rapid degradation of insulation, resulting in an arcing failure of a conductor in the Class I, Zone 1, Hazardous Location.

18-128 Signal, Alarm, Remote-Control, and Communication Systems, Class I, Zone 1

Signal, alarm, remote control, and communication systems shall conform to the following:

(a) all apparatus and equipment shall comply with the requirements of Rule 18-100; and

(b) all wiring shall comply with Rules 18-106 and 18-108.

All electrical equipment used in a Class I, Zone 1 Hazardous Location must meet the requirements of Rule 18-100 to ensure it will not become a source of ignition within the Hazardous Location. Wiring systems must use wiring methods outlined in Rule 18-106 and seals must be provided as required in Rule 18-108.

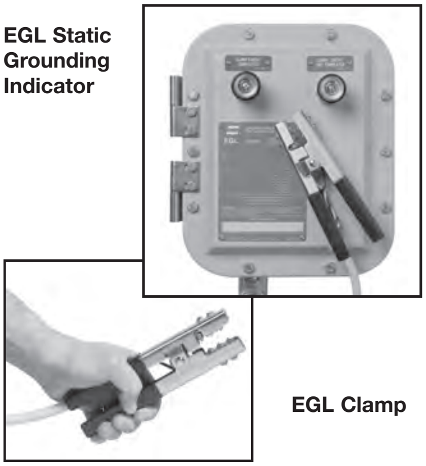
18-130 Live Parts, Class I, Zone 1

No live parts of electrical equipment or of an electrical installation shall be exposed.

If live parts of an electrical system in a Class I, Zone 1 Hazardous Location are exposed, there is potential for accidental contact that would create arcs or sparks capable of igniting gas or vapours in the area. This rule would not apply to intrinsically safe circuits.

Hazard•Gard™ EXS and EXDS Series Explosionproof Strobe Lights.

EGL Static Grounding Indicator



EGL Clamp

The EGL Static Grounding Indicator is suitable for Class I, Zone 1 locations.

Installations in Class I, Zone 2 Locations

18-150 Equipment in Class I, Zone 2 Locations (see Appendices B and F)

(1) Where required by other Rules of this Code, electrical equipment installed in a Class I, Zone 2 location shall be

(a) approved for Class I, Division 2 locations;

Equipment with Class I, Division 2 approval will normally be equipment that does not arc or spark in its normal operation. If this equipment has a surface operating temperature above 100°C, it will be marked with a maximum surface temperature or a temperature code or both. Typical types of equipment with Class I, Division 2 approval are electronic devices such as transmitters, luminaires, three phase motors, RTU's and other products that do not have exposed arcing or sparking components.

(b) approved as non-incendive;

Non-incendive equipment is not capable of producing arcs or sparks or operating at temperatures above 100°C during its normal operation. Non-incendive equipment is similar to intrinsically safe equipment in that it limits the current that can flow in a circuit in a hazardous area. It differs from intrinsically safe equipment in that it does not continue to provide protection in the presence of "component faults".

(c) approved as providing equipment protection level Ga, Gb, or Gc;

Method of protection "n" is a method of protection applied to electrical apparatus so that, in normal operation, it is not capable of igniting a surrounding explosive atmosphere, and a fault capable of causing ignition is not likely to occur. It is similar to Class I, Division 2 rated equipment in many respects but also includes additional features such as the "restricted breathing" concept for heat-producing equipment. The restricted breathing feature is most useful for luminaires used in locations where gases or vapours with low ignition temperatures are encountered. Restricted breathing is fully explained in the Cooper Crouse-Hinds video on HID lighting.

(d) approved as providing a method of protection "n"; or

(e) equipment permitted in Zone 1.

(2) Notwithstanding Subrule (1), the following shall be permitted:

(a) transformers, capacitors, solenoids, and other windings that do not incorporate sliding or make-and-break contacts, heat-producing resistance devices, and arcing or spark-producing components;

This equipment must still meet the temperature requirements of Rule 18-054. In many cases, it is possible to make this determination without having to have the maximum surface operating temperature of the equipment determined by test. For example, where the gas in an area is propane (AIT 470°C), it is reasonable to conclude that a motor with 155°C (Class F) insulation will not be capable of reaching a high enough temperature to ignite propane during normal operation.

(b) conduit and cables as outlined in Rule 18-152(1);

(c) non-explosion-proof or non-flameproof enclosures housing

(i) non-arcing connections and connecting devices such as joints, splices, terminals, and terminal blocks;

These types of devices do not create arcs or sparks or operate at high enough temperatures to ignite gas or vapour. Disconnecting type terminal blocks in incendive circuits would not qualify under this Rule.

(ii) switches, controllers, and circuit breakers meeting the requirements of Subrule (1);

(iii) unfused isolating switches that are interlocked with their associated current-interrupting devices such that they cannot be opened under load; or

Isolating switches will only produce arcing or sparking when opening or closing. If they are interlocked to ensure they will not be operated when energized, they will not be a source of ignition.

(iv) not more than

(A) ten sets of approved enclosed fuses; or

(B) ten circuit breakers that are not used as switches for the normal operation of the lamps for the protection of a branch circuit or a feeder circuit that supplies fixed lighting;

Where fuses or circuit breakers are protecting fixed lighting systems, a fuse is only likely to blow as a result of a fault within the lighting system or the wiring. These events happen infrequently and are unlikely to occur at the same time combustible levels of gas or vapour are present in the air at the location. The design of lighting fixtures for use in a Class I, Zone 2 Hazardous Location is based on the same principle. Use of weatherproof enclosures is highly recommended.

Where circuit breakers are used for the day to day switching of lamp circuits, general purpose enclosures are not permitted.

(d) for the protection of motors, appliances, and luminaires,

(i) a standard plug or cartridge fuse, provided that it is placed within an explosion-proof or flame-proof enclosure;

(ii) a fuse installed within a non-explosion-proof or non-flameproof enclosure, provided that the operating element of the fuse is

(A) immersed in oil or other suitable liquid; or

(B) enclosed within a hermetically sealed chamber; or

Where fuses are immersed in oil or sealed in an a manner that will prevent the entry of flammable gas or vapour, they may be enclosed in general purpose enclosures.

The elements in current limiting fuses are surrounded with a fine sand or powder and encased in a non-metallic cylinder. It is unlikely a spark during their operation could ignite gas outside as the spark would be quenched within the sand or powder that fills the fuse. Some indicating fuses have a hole in the fuse cylinder to provide indication and therefore are not acceptable. Some newer indicating fuses are constructed in a manner that does not cause the fuse body to be penetrated. This type of indicating fuse is permitted.

Use of weatherproof enclosures is highly recommended

(iii) a fuse installed within a non-explosion-proof or non-flame-proof enclosure, provided that the fuse is

(A) a non-indicating, filled, current-limiting type; or

(B) an indicating, filled, current-limiting type, constructed in a manner that the blown fuse indication does not cause the fuse body to be penetrated; or

(e) motors, generators, and other rotating electrical machines of the open or non-explosion-proof type

(i) that do not incorporate arcing, sparking, or heat-producing components; or

(ii) that incorporate arcing, sparking, or heat-producing components, provided that these components are provided with enclosures that comply with the requirements of Rule 18-100.

Appendix B Notes

18-150

Equipment marked Class I, Division 2 is suitable only for Zone 2. See the Note to Rule 18-100.

18-150(2)(c)(ii)

The equipment referred to in Rule 18-150(2)(c)(ii) includes service and branch circuit switches and circuit breakers; motor controllers, including push buttons, pilot switches, relays, and motor-overload protective devices; and switches and circuit breakers for the control of lighting and appliance circuits. Oil-immersed circuit breakers and controllers of the ordinary general-use type may not confine completely the arc produced in the interruption of heavy overloads, and specific approval for locations of this Class and Division is therefore necessary.

18-150(2)(c)(iv)

A group of three fuses protecting an ungrounded three-phase circuit and a single fuse protecting the ungrounded conductor of an identified 2-wire single-phase circuit would each be considered a set of fuses.

Motors or generators that incorporate unprotected arcing, sparking or heat producing components that do not meet the requirements of Rule 18-100 must be explosionproof or flameproof. This will include most single phase motors with starting switches or motors with temperature switches connected to incendive circuitry.

Champ® restricted breathing luminaires are rated Ex nR for Zone 2 areas.

18-152 Wiring Methods, Class I, Zone 2 (see Appendix B)

Refer to Table 19 for further information on cables.

(1) The wiring method shall be:

(a) threaded metal conduit;

(b) cables approved for hazardous locations;

Cables approved for Hazardous Locations will have a HL marking on the cable jacket. This indicates the cable has passed the additional tests in CSA Standard C22.2 No. 174 "Cables and Cable Glands for Use in Hazardous Locations." Most armoured cables will meet this requirement. It is not the intention of this subrule that cables used in Zone 2 locations must have an HL marking. It is only intended to point out that in addition to other cables listed in this section, HL rated cables are also acceptable for use in Zone 2 locations.

TECK cable for Hazardous Locations.

(c) Type TC cable installed in cable tray in accordance with Rule 12-2202;

Type TC (tray cable) is a non-armoured cable consisting of an inner core of insulated conductors or bundled subassemblies (twisted pairs, triads, etc.) covered by an overall outer jacket. Type TC cable must meet the requirements of CSA Standard C22.2 No. 230 "Tray Cables" (which is essentially a performance standard) and a construction standard, usually C22.2 No. 38 "Thermoset Insulated Wires and Cables," C22.2 No. 75 "Thermoplastic Insulated Wires and Cables," or C22.2 No. 239 "Control and Instrumentation Cables." Type TC cable is required to meet the FT-4 flame test as well as meeting other minimum mechanical strength requirements.

(d) armoured cable with overall non-metallic jacket, such as TECK90, ACWU90, copper-sheathed RC90, or aluminum-sheathed RA90;

(e) control and instrumentation cables with an interlocking metallic armour and a continuous jacket in control circuits (Type ACIC); or

Control and instrumentation cables with interlocked armour (type ACIC) must meet the requirements of CSA standard C22.2 No. 239 "Control and Instrumentation Cables." The cable can be supplied with a variety of inner core constructions, the common denominator being an interlocked armour with a continuous nonmetallic jacket, usually PVC.

(f) Type CIC cable (non-armoured control and instrumentation cable) installed in cable tray in accordance with the installation requirements of Rule 12-2202(2), where

(i) the voltage rating of the cable is not less than 300 V;

(ii) the circuit voltage is 150 V or less; and

(iii) the circuit current is 5 A or less.

Type CIC (non-armoured control and instrumentation cable) must meet the requirements of CSA standard C22.2 No. 239 "Control and Instrumentation Cables." Type CIC cable is similar to type ACIC cable except it does not have an interlocked armour. Type CIC cable is similar to type ITC cable in the NEC and is used under similar voltage and current restrictions. In order to be installed in cable trays, type CIC cable must also meet the requirements of standard C22.2 No 230 Tray Cables.

(2) Explosion-proof or flame-proof boxes, fittings, and joints shall be threaded for connection to conduit and cable glands.

(3) Threaded joints that are required to be explosion-proof or flame-proof shall be permitted to be either tapered or straight and shall comply with the following:

(a) tapered threads shall have at least five fully engaged threads, and running threads shall not be used;

(b) where straight threads are used in Groups IIA and IIB atmospheres, they shall have at least five fully engaged threads; and

(c) where straight threads are used in Group IIC atmospheres, they shall have at least eight fully engaged threads.

Threaded joints, which are required to be explosionproof or flameproof, are flame paths. They are required to cool gases exiting an explosionproof or flameproof enclosure (as the result of an internal explosion), to a temperature below the ignition temperature of the gases in the area. A minimum number of threads of engagement are required to ensure an adequate flame path. The generally accepted rule is 5 full threads for Group C & D or IIA & B areas and 7 full threads for Group B, IIC areas. The Rule also recognizes the use of tapered threads as used in traditional North American equipment and non-tapered or parallel threads as used in IEC or European equipment.

(4) Where thread forms differ between the equipment and the wiring system, approved adapters shall be used.

Where tapered threads and parallel threads are used in a connection, an approved adapter is required to be used to ensure a proper flame path is maintained. It is not acceptable to mate a tapered thread with a parallel thread, as the connection will not make an adequate flame path. Use metric to NPT adapters.

Appendix B Notes

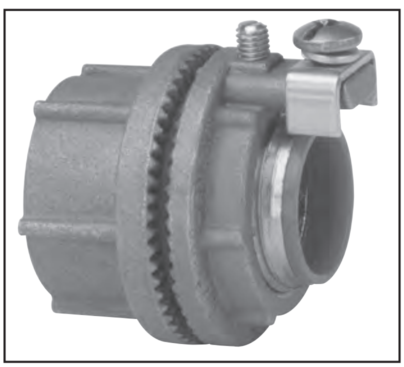
18-152(8)

Cable glands should be compatible with the degree of ingress protection and explosion protection provided by the enclosure on which they are installed.

For example, to maintain the protection of an enclosure required to be explosion-proof, a sealing-type gland approved for the location should be used. Where unarmoured cables must enter an enclosure required to be explosion-proof, a combination of an approved sealing fitting and a non-sealing cable gland may be used.

Where equipment normally considered suitable for use in ordinary locations is acceptable in Zone 2 locations, such as terminal boxes and motors, ordinary location cable glands that maintain the degree of protection of the enclosure may be used. Similarly where purged enclosures are used in Zone 1 and Zone 2, ordinary location cable glands that maintain the degree of protection of the enclosure may be used.

Where equipment is specifically designed for use in Zone 2 locations, such as “Ex nX”, ordinary location cable glands that maintain the degree of protection of the enclosure may be used. One means of achieving equivalent protection would be to use a cable gland with the same or better IP rating as the enclosure. [See the Ingress Protection table in the Note to Rule 18-106(5)]. If the gland does not have an IP rating, other ratings, such as weatherproof, may be matched to the enclosure rating.



Zone 1 Myers™ Hubs can be used for metric to NPT adapters.

(5) Cables shall be installed and supported in a manner to avoid tensile stress at the cable glands.

Where a cable connection is under tensile stress, there is a danger the cable may pull out of the connector, thus compromising the integrity of the enclosure. A common method of ensuring there is no tensile stress on the cable connection is to support it in close proximity to the box. See Section 12 of the *Canadian Electrical Code* for more specific requirements.

(6) Where it is necessary to use flexible connections at motor terminals and similar places, flexible metal conduit shall be permitted.

Flexible metal conduit (liquid-tight) may be used to provide flexible connections to devices in Class I, Zone 2 locations. When liquid-tight conduit is used, the requirements of Rules 12-1300 to 12-1306 must also be met.

(7) Boxes, fittings, and joints need not be explosionproof or flameproof except as required by the Rules in this Section.

In Class I, Zone 2 Hazardous Locations, devices that do not contain arcing, sparking or heat-producing resistance devices do not need to be contained in explosionproof or flameproof enclosures. As Class I, Zone 1 locations are characterized by short-term releases of gases or vapours, the use of weatherproof enclosures is recommended as it offers a further degree of safety by making it unlikely short-term releases of gases or vapours will penetrate enclosures in significant volumes.

(8) Cable glands shall be compatible with the degree of protection and explosion protection provided by the enclosure that the cable enters, where the area classification and environmental conditions require these degrees of protection.

18-154 Sealing, Class I, Zone 2 (see Appendix B)

(1) Conduit seals shall be provided in a conduit system where;

(a) the conduit enters an enclosure that is required to be explosion-proof or flame-proof and shall be located as close as practicable to the enclosure, or as marked on the enclosure, but not farther than 450 mm from the enclosure;

Seals are required to be located close to an enclosure required to be explosionproof for two reasons:

1. To ensure an explosion within the enclosure will be contained within the enclosure, and

2. To keep the effective volume of the enclosure as small as possible. The pressure generated by an explosion is roughly proportional to the volume in which it takes place. If the effective volume of the enclosure is increased by additional devices (enclosures) prior to the seal, the pressure of an explosion within the combination may exceed the maximum pressure for which the enclosure was designed. Adding lengths of conduit to the enclosure, prior to the seal, can create “pressure piling,” which will further increase the pressure generated by an internal explosion.

(b) the conduit leaves the Class I, Zone 2 location with no box, coupling, or fitting in the conduit run between the seal and the point at which the conduit leaves the location, except that a rigid unbroken conduit that passes completely through a Class I, Zone 2 area with no fittings less than 300 mm beyond each boundary need not be sealed, provided that the termination points of the unbroken conduit are in non-hazardous areas; or

Gas or vapour can enter a conduit system through any threaded connection. Therefore, it is assumed that the atmosphere existing within a Hazardous Location will also be present within the conduit system. Therefore, a seal is required after the last threaded connection where the conduit leaves the Class I, Zone 2 location. This is to prevent gas from the Class I, Zone 2 Hazardous Location from being transmitted to a nonhazardous location.

Where a conduit passes through a Class I, Zone 2 location without having any connections within the Class I, Zone 2 area, gas from the Class I, Zone 2 location will not enter the conduit and a “boundary seal” is not required.

(c) the conduit leaves a Class I, Zone 2 location outdoors; the seal may be located more than 300 mm beyond the Class I, Zone 2 boundary provided that it is located on the conduit prior to entering an enclosure or building.

(2) Only explosion-proof or flame-proof unions, couplings, reducers, and elbows that are not larger than the trade size of the conduit shall be permitted between the sealing fitting and an explosion-proof or flame-proof enclosure.

(3) Cable seals shall be provided in a cable system where

(a) the cable enters an enclosure required to be explosion-proof or flame-proof; or

In this situation, a sealing gland is required to ensure an explosion within the enclosure will be contained within the enclosure.

Ex-d cable glands require the cable to be sealed.

Appendix B Notes

18-154(1)(c)

This Rule allows the seal at the boundary between an outdoor Class I, Zone 2 location and an outdoor non-hazardous location to be located further than 300 mm from the boundary of the Class I, Zone 2 location, provided that it is located on the conduit prior to its entering an enclosure or a building. Because gas is present in Class I, Zone 2 locations only for short periods, it is unlikely that gas or vapour could be released through conduit couplings at sufficiently high rates to form an explosive mixture in outdoor areas. However, the seal must be located on the conduit before it enters an enclosure or a building because, depending on the ventilation rate, gas transmitted through the conduit may build up to flammable concentrations.

(b) the cable enters an enclosure not required to be explosion-proof or flame-proof and the other end of the cable terminates in a non-hazardous location in which a negative atmospheric pressure greater than 0.2 kPa exists.

This recognizes that gas at atmospheric pressure may migrate for short distances in a cable. If a cable is less than 10 Metres long and leaves the Class I, Zone 2 location, a seal is required to prevent gas migration to a less Hazardous Location.

Where a cable runs from a Class I, Zone 2 location to a nonhazardous location which operates at a negative pressure above 0.2 kPa, a seal is required to prevent the possibility gas may be drawn through the cable from the Class I, Zone 2 location into a nonhazardous location.

(4) Where a run of conduit enters an enclosure that is required to be explosion-proof or flame-proof, every part of the conduit from the seal to that enclosure shall comply with Rule 18-106.

(5) Runs of cables, each having a continuous sheath, either metal or non-metal, shall be permitted to pass through a Class I, Zone 2 location without seals.

The continuous sheath of a cable will prevent the entry of gas or vapour into the cable, therefore there is no need to provide a seal at the boundary of a Hazardous Location. Seals are only required on cables with a continuous jacket or sheath at the point where they terminate in a Hazardous Location. Users must be aware that if a jacket of a cable is damaged within a Hazardous Location, it must be repaired to prevent the entry of gas or vapour into the cable.

(6) Cables that do not have a continuous sheath, either metal or nonmetal, shall be sealed at the boundary of the Zone 2 location.

The use of cables without continuous jackets in hazardous areas is a rare occurrence and is not recommended.

(7) Where seals are required, Rule 18-108(6) shall apply.

Subrule 18-108(2) outlines the specific requirements to which seals must conform when they are installed.

The NH fuse holder is rated Ex-d for Zone 1 and 2 areas.

18-156 Luminaires and Portable Lamps, Class I, Zone 2

(1) Luminaires shall be protected from physical damage by suitable guards or by location.

(2) Pendant luminaires shall be

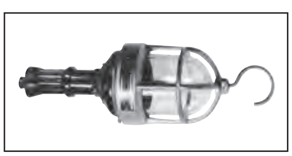
(a) suspended by threaded rigid conduit stems or by other approved means; and

(b) for stems longer than 300 mm, provided with permanent and effective bracing against lateral displacement at a level not more than 300 mm above the lower end of the stem, or flexibility in the form of a fitting or flexible connector approved for the purpose shall be provided not more than 300 mm from the point of attachment to the supporting box or fitting.

Fixtures with long pendants can put undue lateral stress on the mounting hardware that could cause failure of the hardware, possibly resulting in the assembly failing, causing the wires to arc by opening or shorting to ground. Therefore, pendant mounts longer than 300 mm require the use of a flexible fitting or connector intended for the purpose.

(3) Portable lamps shall comply with Rules 18-118(1) and (2).

Portable lamps are subject to damage and as a result often are an ignition source. Only portable lamps acceptable for use in Class I, Zone 1 Hazardous Locations are allowed in a Class I, Zone 2 location.



Portable hand lamps are suitable for Zone 1 or 2 areas.

18-158 Electrically Heated Utilization Equipment, Fixed and Portable, Class I, Zone 2

Electrically heated utilization equipment, whether fixed or portable, shall comply with the requirements of Rule 18-100

Electrically heated equipment has the potential of being a continuous ignition source and therefore must be protected by one of the methods outlined in Rule 18-100. Electric heat tracing must also meet the applicable requirements in section 62, “Fixed Electric Space and Surface Heating Systems."

18-160 Flexible Cords, Class I, Zone 2

Flexible cords shall be permitted to be used only for connection between permanently mounted luminaires, portable lamps, or other portable utilization equipment and the fixed portion of supply circuits and, where used, shall

(a) be of a type approved for extra-hard usage;

(b) contain, in addition to the circuit conductors, a bonding conductor; and

(c) be provided with a sealing gland where the flexible cord enters a box, fitting, or enclosure that is required to be explosion-proof or flame-proof.

Flexible cords should only be used in a Class I, Zone 2 Hazardous Location, to connect portable equipment to the fixed wiring system.

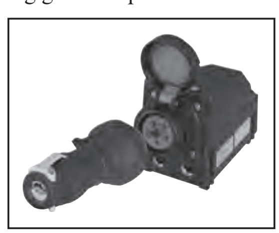
Portable as applied to electrical equipment is defined in Section 0 of the *Canadian Electrical Code* as meaning “the equipment is specifically designed not to be used in a fixed position and receives current through the medium of a flexible cord or cable and usually an attachment plug.”

Portable cord used in a Class I, Zone 2 Hazardous Location must be an extra-hard usage type as defined in Table 11 of the *Canadian Electrical Code*. The cable must incorporate a bonding conductor and use a connector meeting the requirements of Rule 18-100. Users are reminded that the Rules in other sections of the *Code* (for example the rules for conductors and cables in Section 12) also apply to the use of portable cords in a Class I, Zone 2, Hazardous Location.

18-180 Live Parts, Class I, Zone 2

No live parts of electrical equipment or of an electrical installation shall be exposed.

If live parts of an electrical system in a Class I, Zone 2 Hazardous Location are exposed, there is potential for accidental contact that would create arcs or sparks capable of igniting gas or vapours in the area.



SpecOne™ IEC 309 Plugs and Receptacles are available for Zone 1 and 2 Hazardous Locations.

CLASS II LOCATIONS

Installations in Class II, Division 1 Locations (see Appendix E)

Electrical equipment not rated for a Class II Hazardous Location can be installed within the location providing it is enclosed in a dust-free room. The specific requirements for dust-free rooms are outlined in Appendix E of the Canadian Electrical Code.

18-200 Transformers and Capacitors, Class II, Division 1

(1) Transformers and electrical capacitors that contain a liquid that will burn shall be installed in electrical equipment vaults in accordance with Rules 26-350 to 26-356, and

Where transformers are filled with a liquid that will burn, they must be located in vaults constructed to meet the requirements of Rules 26-350 to 26-356. This is similar to the requirement for dielectric-filled equipment located indoors. The vault is intended to contain a possible fire involving the transformer dielectric to prevent it from igniting dust in the Class II, Division 1 location.

(a) doors or other openings communicating with the hazardous area 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 weatherstripping) to minimize the entrance of dust into the vault;

All entries into the electrical equipment vault must be constructed to minimize the amount of dust entering the vault. Accumulations of dust within the electrical equipment vault must not be sufficient to cause the interior of the vault to require classification as a Class II location. Doors or other openings should be kept closed except during entry or exit, and housekeeping levels should keep dust accumulation to a safe level at all times.

(b) vent openings and ducts shall communicate only with the air outside the building; and

Vent openings should only link with a safe (nonhazardous) location. Normally the vault will be contained within a building. Any ventilating openings must be connected to a nonhazardous atmosphere outside the building.

(c) suitable pressure relief openings communicating only with the air outside the building shall be provided.

Pressure relief openings communicating with a nonhazardous area outside the building must be installed to relieve the pressure inside the vault in the event of a sudden pressure rise due to a fire or a transformer failure. This is to ensure the pressure rise will not cause the walls of the vault to fail. Refer to Appendix E.E6(b) (Dust-free Rooms) for more information.

(2) Transformers and electrical capacitors that do not contain a liquid that will burn shall be

(a) installed in electrical equipment vaults conforming to Subrule (1); or

(b) approved as a complete assembly including terminal connections for Class II locations.

Typically transformers approved for Class II locations will either be in dust-tight enclosures or will have encapsulated windings. It is more common to locate them outside the Class II Hazardous Location or to locate them in dust-free rooms.

(3) No transformer or capacitor shall be installed in a location where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present.

Transformers or capacitors should not be installed in locations where Group E dusts are present due to its conductive nature. This can cause tracking and subsequent failure of the transformer.

18-202 Wiring Methods, Class II, Division 1 (see Appendix B)

(1) The wiring method shall be

(a) threaded rigid metal conduit; or

(b) cables approved for hazardous locations.

Cables in Class II Division 1 Hazardous Locations are required to be marked with an “HL” designation indicating they have passed the performance requirement outlined in CSA standard C22.2 No. 174 “Cables and Cable Glands for Use in Hazardous Locations.”

Cooper Crouse-Hinds® TECK Connectors are CSA certified for use with TECK armoured cable.

(2) Boxes, fittings, and joints shall be threaded for connection to conduit or cable glands and boxes and fittings shall be approved for Class II locations.

Products tested to IEC standards for Zone 1 locations also meet CSA standards for Class II, Division 1, Group E, F, G locations.

Fittings or enclosures approved for Class II, Division 1 Hazardous Locations are required to have metal-to-metal joints, threaded joints or gasketed joints, meeting the specifications in CSA Standard C22.2 No. 25 “Enclosures for Use in Class II, Groups E, F and G Hazardous Locations.” Threaded joints are required to have at least three full threads of engagement when assembled. Meeting the requirements of this standard will ensure fittings and enclosures are essentially dust-tight.

Fittings and enclosures for Class II locations are not designed to contain explosions as are Class I enclosures. They are designed to prevent dust entry, thereby keeping electrical components separated from hazardous dust concentrations. Class I enclosures that are not also approved for use in Class II Hazardous Locations are not acceptable for use in Class II Hazardous Locations.

Enclosures containing electrical components not approved for Class II Hazardous Locations must also pass tests in Standard No. 25 for dust-tightness, temperature (dust blanketing), impact and flammability.

All SpecOne™ products are cUL certified for Class II, Division 1, Groups E, F and G.

(3) Cables shall be installed and supported in a manner to avoid tensile stress at the cable glands.

Where a cable connection is under tensile stress, there is a danger the cable may pull out of the connector, thus compromising the integrity of the enclosure. A common method of ensuring there is no tensile stress on the cable connection is to support it in close proximity to the box. See Section 12, Rule 12-510(1), of the *Canadian Electrical Code* for more specific requirements.

(4) Where flexible connections are necessary, they shall be provided by

(a) flexible connection fittings approved for the location;

(b) liquid-tight flexible conduit with fittings approved for the location; or

(c) extra-hard-usage flexible cord and cable glands approved for the location.

Where cables are used to feed electrical equipment, a flexible connection will also result.

(5) Where flexible connections are subject to oil or other corrosive conditions, the insulation of the conductors shall be of a type approved for the condition or shall be protected by means of a suitable sheath.

This is essentially a restatement of the requirements in Rule 22-202 "Wiring Methods in Category 2 Locations," which also applies to all Hazardous Locations.

18-204 Sealing, Class II, Division 1

Where a raceway provides communication between an enclosure that is required to be dust-tight and one that is not, the entrance of dust into the dust-tight enclosure through the raceway shall be prevented by

(a) a permanent and effective seal;

The seal in this rule is required to prevent the entry of dust into an enclosure containing electrical equipment. While the seal could be provided by a Class I seal, it could also be provided by other methods that would be effective in preventing the migration of dust through a raceway into an enclosure required to be dust-tight, such as the use of a silicone sealer.

(b) a horizontal section not less than 3 m long in the raceway; or

Over a distance of 3 metres it is assumed that dust will settle in the conduit and not migrate into an enclosure.

(c) a vertical section of raceway not less than 1.5 m long and extending downward from the dust-tight enclosure.

This is a similar approach to Subrule (b) in that it depends on gravity to settle any dust entering the raceway before reaching an enclosure.

18-206 Switches, Controllers, Circuit Breakers, and Fuses, Class II, Division 1

Switches, motor controllers, circuit breakers, Switches, motor controllers, circuit breakers, and fuses, including push buttons, relays, and similar devices, shall be provided with a dust-tight enclosure approved for Class II locations.

In Class II, Division 1 Hazardous Locations, electrical equipment enclosures must meet the requirements of Standard C22.2 "Enclosures for Use in Class II Groups E, F and G Hazardous Locations."

18-208 Control Transformers and Resistors, Class II, Division 1

Transformers, impedance coils, and resistors used as or in conjunction with control equipment for motors, generators, or electric appliances and the overcurrent devices or switching mechanisms, if any, associated with them shall be provided with a dust-tight enclosure approved for Class II locations.

In Class II, Division 1 Hazardous Locations, electrical equipment enclosures must meet the requirements of Standard C22.2 "Enclosures for Use in Class II Groups E, F and G Hazardous Locations."

18-210 Motors and Generators, Class II, Division 1

(see Appendix B)

Appendix B Notes

18-210, 18-212, 18-260, 18-262,

18-308, 18-310, 18-358, 18-360

As overheated windings of large pipe-ventilated motors (or fire therein) are not readily detected by odour or smoke, it is advisable, especially in the case of buildings not provided with automatic sprinklers, that the following precautions be taken:

(a) If ventilation air is supplied from a separate source, an air-pressure-operated switch should supervise the supply of air, and be arranged to shut down the pipe-ventilated motor in case of air failure;

(b) An automatic fire detector should be placed at the air discharge end of the pipe-ventilated motor and be arranged to shut down the motor on the occurrence of overheating or fire;

(c) A port with a self-closing shutter should be provided at the motor air intake end to facilitate discharge into the motor frame of a fire extinction medium;

(d) To complement Item (c), fire dampers fitted with fusible links should be provided for the air intake and discharge ends of the motor to confine fire and the fire extinction medium to the motor frame;

(e) Intake and discharge ducts should be carefully installed with respect to combustible construction or storage, and should not pierce fire walls, fire partitions, floors, or ceilings unless provided with automatic fire shutters or dampers where they pierce the fire section or division of the building (see NFPA Publication No. 91); and

(f) Intake and discharge ducts should be kept clear of accumulation of combustible lint or dust.

Motors, generators, and other rotating electrical machines shall be approved for Class II locations.

Motors approved for Class II locations are suitable for use in all Class II Hazardous Locations. These motors are required to be tested to CSA Standard C22.2 No. 25. This standard requires the motor pass dust penetration tests, abnormal external surface temperature tests with dust blanketing and accumulation of static electricity for motors with nonmetallic fans. Testing determines the maximum surface temperature under both running and stalled rotor conditions. The maximum surface temperature must not exceed 200°C for dust Groups E and F or 165°C for dust Group G. Overheating protective devices, such as temperature switches, thermistors or RTDs, are allowed to be used in meeting the maximum surface temperature limits. Where these devices are used, they (or their control devices) must be included in the motor control circuit or to de-energize the motor the Class II motor certification will be invalid.

18-212 Ventilating Pipes, Class II, Division 1 (see Appendix B)

(1) Every vent pipe for a motor, generator, or other rotating electrical machine or for enclosures for electrical apparatus or equipment shall

(a) be of metal not less than 0.52 mm (No. 24 MSG) thick or of an equally substantial non-combustible material;

(b) lead directly to a source of clean air outside a building;

(c) be screened at the outer end to prevent the entrance of small animals or birds; and

(d) be protected against mechanical damage and corrosion.

(2) Every vent pipe and its connection to a motor or to a dust-tight enclosure for other equipment or apparatus shall be dust-tight throughout its entire length.

(3) The seams and joints of every metal vent pipe shall be

(a) riveted and soldered;

(b) bolted and soldered;

(c) welded; or

(d) rendered dust-tight by some other equally effective means.

(4) No exhaust pipe shall discharge inside a building.

The above requirements for ventilating pipes for motors or electrical enclosures which are purged or pressurized with air must meet the requirements of this rule. Note that Subrule (1)(b) intends that the source of air be from a clean, nonhazardous location. Also note the Rule 18-210 Appendix B recommendations for the application of this rule to large motors.

18-214 Utilization Equipment, Fixed and Portable, Class II, Division 1

Utilization equipment, fixed and portable, including electrically heated and motor-driven equipment shall be approved for Class II locations.

This will generally require that the equipment be approved to Standard C22.2 No. 25 “Enclosures for Use in Class II Groups E, F and G Hazardous Locations” or Standard C22.2 No. 145 “Motors and Generators for Use in Hazardous Locations,” or both. 18-216 Luminaires, Class II, Division 1.

18-216 Luminaires, Class II, Division 1

Luminaires must comply with dust-tightness standards and temperature tests where the luminaires are covered with dust materials. The luminaires are operated at the rated voltage until all temperatures become constant. Based on an ambient temperature of 40ºC, no external surface of the enclosure shall attain a temperature in excess of 165ºC.

(1) Luminaires and portable lighting shall be approved as complete assemblies for Class II locations and shall be clearly marked to indicate the maximum wattage of lamps for which they are approved.

Class II luminaires are tested to ensure they are dust-tight. To arrive at a maximum surface temperature code, the maximum temperature on the outside of the luminaire is measured. In general, the maximum surface temperature code for a Class II luminaire will be approximately 100°C higher than that of a similar Class I, Division 2 lighting luminaire.

(2) Luminaires intended for portable use shall be specifically approved as complete assemblies for that use.

Similar requirements to Subrule (1) apply to portable fixtures. It is not acceptable to field assemble portable lighting luminaires from components that are not part of an assembly approved for Class II locations.

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

(4) Pendant luminaires shall be

(a) suspended by threaded rigid conduit stems or chains with approved fittings or by other approved means, which shall not include a flexible cord as the supporting medium, and threaded joints shall be provided with set screws or other effective means to prevent loosening;

As it must be assumed combustible levels of dust will be present during normal operation in a Class II, Division 1 Hazardous Location, a set screw is required to prevent the luminaire from unscrewing due to vibration or other means, thereby becoming a potential ignition source.

(b) for rigid stems longer than 300 mm, provided with permanent and effective bracing against lateral displacement at a level not more than 300 mm above the lower end of the stem, or provided with flexibility in the form of a fitting or flexible connector approved for the purpose and for the location not more than 300 mm from the point of attachment to the supporting box or fitting;

(c) where wiring between an outlet box or fitting and the luminaire is not enclosed in conduit, provided with a flexible cord approved for extra-hard usage and suitable seals where the cord enters the luminaire and the outlet box or fitting.

Extra-hard usage cord may be used to connect the fixture to an outlet box or fitting provided it is not used to suspend the fixture.

(5) Boxes, box assemblies, or fittings used for the support of luminaires shall be approved for the purpose and Class II locations.

18-218 Flexible Cords, Class II, Division 1

Flexible cords used shall:

(a) be of a type approved for extra-hard usage; and

(b) contain a bonding conductor in addition to the conductors of the circuit; and

(c) be provided with glands approved for the class and group to prevent the entrance of dust at the point where the cord enters a box or fitting that is required by this Section to be dust-tight.

Portable cord used in a Class II, Division 1 Hazardous Location must be an extra-hard usage type as defined in Table 11 of the *Canadian Electrical Code*. The cable must incorporate a bonding conductor and use a connector approved for use in a Class II, Division 1 Hazardous Location. Users are reminded that the Rules in other sections of the *Code* (for example the rules for conductors and cables in Section 12) also apply to the use of portable cords in a Class II, Division 1, Hazardous Location.

18-220 Receptacles and Attachment Plugs, Class II, Division 1

Receptacles and attachment plugs shall be approved for Class II locations.

All electrical equipment used in a Class II, Division 1 Hazardous Location must be approved for use in Class II, Division 1 Hazardous Locations to ensure it will not become a source of ignition within the Hazardous Location.

The 100 A FSQC Interlocked Receptacle is approved for use in Class II, Divisions 1 and 2, Group F and G locations.

18-222 Signal, Alarm, Remote-Control, and Communication Systems, Meters, Instruments, and Relays, Class II, Division 1

Signal, alarm, remote control, and communication systems, and meters, instruments, and relays shall conform to the following:

(a) all apparatus and equipment shall be provided with enclosures approved for Class II locations, except that

(i) devices that carry or interrupt only a voice current shall not be required to be provided with such enclosures; and

Devices that carry or interrupt only voice current operate at energy levels below those required to ignite dust. Therefore, their enclosures are not required to be approved for Class II locations. It is recommended that dust-tight enclosures be used for these applications.

(ii) current-breaking contacts that are immersed in oil or enclosed in a chamber sealed against the entrance of dust shall be permitted to be provided with a general-purpose enclosure if the prevailing dust is electrically non-conductive; and

This rule cannot be used with Group E (metallic) dusts. It is recommended that dust-tight enclosures be used for these applications.

(b) all wiring shall comply with Rules 18-202 and 18-204.

While the end devices may be installed in enclosures that are not approved for Class II locations, the wiring systems to the enclosures must meet the requirements for Class II, Division 1 Hazardous Locations and must be sealed in accordance with Rule 18-204.

18-224 Live Parts, Class II, Division 1

No live parts of electrical equipment or of an electrical installation shall be exposed.

If live parts of an electrical system in a Class II, Division 2 Hazardous Location are exposed, there is potential for accidental contact that would create arcs or sparks capable of igniting dust in the area.

Installations in Class II, Division 2 Locations (see Appendix E)

Electrical equipment not rated for a Class II Hazardous Location can be installed within the location providing it is enclosed in a dust-free room. The specific requirements for dust-free rooms are outlined in Appendix E of the *Canadian Electrical Code*.

18-250 Transformers and Capacitors, Class II, Division 2

(1) Transformers and electrical capacitors that contain a liquid that will burn shall be installed in electrical equipment vaults in accordance with Rules 26-350 to 26-356.

As in any enclosed area, transformers or capacitors containing liquid that will burn must be installed in a vault meeting the requirements of Rules 26-350 to 26-356. This is to prevent the spread of fire to other areas of the building in the event of a fire involving the combustible liquid equipment.

(2) Transformers and electrical capacitors that contain a liquid that will not burn shall be

(a) installed in electrical equipment vaults in accordance with Rules 26-350 to 26-356; or

(b) approved for Class II locations.

Transformers or capacitors containing non-combustible liquid may either be installed in vaults meeting the requirements of Rules 26-350 to 26-356 or be approved for use in Class II locations. Approval for Class II locations would require the equipment to be dust-tight and to meet the maximum surface temperature requirements of CSA Standard C22.2 No. 25 “Enclosures for Use in Class II Groups E, F and G Hazardous Locations.”

(3) Dry core transformers installed in Class II, Division 2 locations shall

(a) be installed in electrical equipment vaults in accordance with Rules 26-350 to 26-356; or

(b) have their windings and terminal connections enclosed in tight housings without ventilating or other openings and operate at not more than 750 V.

Transformers with encapsulated windings and with dust-tight terminal housings would also meet the requirements of this rule.

18-252 Wiring Methods, Class II, Division 2 (see Appendix B)

(1) The wiring method shall be:

(a) threaded metal conduit; or

(b) cables approved for hazardous locations;

Cables approved for Hazardous Locations will have an “HL” marking on the cable jacket. This indicates the cable has passed the additional tests in CSA Standard C22.2 No. 174 “Cables and Cable Glands for Use in Hazardous Locations.” Most armoured cables will meet this requirement.

(c) Type TC cable installed in cable tray in accordance with Rule 12-2202, enclosed in rigid conduit or another acceptable wiring method wherever it leaves the cable tray;

Type TC (Tray Cable) is a non-armoured cable consisting of an inner core of insulated conductors or bundled subassemblies (twisted pairs, triads, etc.) covered by an overall outer jacket. Type TC cable must meet the requirements of CSA Standard C22.2 No. 230 “Tray Cables” (which is essentially a performance standard) and a construction standard, usually C22.2 No. 38 “Thermoset Insulated Wires and Cables,” C22.2 No. 75 “Thermoplastic Insulated Wires and Cables,” or C22.2 No. 239 “Control and Instrumentation Cables.” Type TC cable is required to meet the FT-4 flame test as well as meeting other minimum mechanical strength requirements.

(d) armoured cable with overall non-metallic jacket, such as TECK90, ACWU90, copper-sheathed RC90, or aluminum-sheathed RA90;

Type ACWU cable is an armoured cable consisting of an inner core of insulated conductors covered by an interlocked armour and an overall nonmetallic jacket. Conductors may be either copper or aluminum. Type ACWU cables must meet the requirements of CSA Standard C22.2 No. 51. While type ACWU cable is available with either copper or aluminum conductor, in Canada it is most often used with aluminum conductors.

(e) control and instrumentation cables with an interlocking metallic armour and a continuous jacket in control circuits (Type ACIC); or

(f) Type CIC cable (non-armoured control and instrumentation cable) installed in cable tray in accordance with the installation requirements of Rule 12-2202(2), where

(i) the voltage rating of the cable is not less than 300 V;

(i) the circuit voltage is 150 V or less; and

(i) the circuit current is 5 A or less.

Control and instrumentation cables with interlocked armour (type ACIC) must meet the requirements of CSA standard C22.2 No. 239 “Control and Instrumentation Cables.” The cable can be supplied with a variety of inner core constructions, the common denominator being an interlocked armour with a continuous nonmetallic jacket, usually PVC.

(2) Boxes and fittings in which taps, joints, or terminal connections are made shall be either an Enclosure Type 4 or 5, or

(a) be provided with telescoping or close-fitting covers, or other effective means to prevent the escape of sparks or burning material; and

(b) have no openings, such as holes for attachment screws, through which, after installation, sparks or burning material might escape, or through which exterior accumulations of dust or adjacent combustible material might be ignited.

Boxes or fittings may either be CSA enclosure type 4 or 5 or be of a type meeting Subrules (a) and (b). The intent is to ensure dust does not enter the enclosure and to ensure that sparks or burning material that could be produced inside the enclosure will not escape into the Hazardous Location outside the enclosure.

(3) Cables shall be installed and supported in a manner to avoid tensile stress at the cable glands.

Where a cable connection is under tensile stress, there is a danger the cable may pull out of the connector, thus compromising the integrity of the enclosure. A common method of ensuring there is no tensile stress on the cable connection is to support it in close proximity to the box. See Section 12, Rule 12-510(1), of the *Canadian Electrical Code* for more specific requirements.

(4) Where it is necessary to use flexible connections, the provisions of Rule 18-202(4) and (5) shall apply.

Flexible metal conduit (liquid-tight) may be used to provide flexible connections to devices in Class I, Zone 2 locations. When liquid-tight conduit is used, the requirements of Rules 12-1300 to 12-1306 must also be met.

18-254 Sealing, Class II, Division 2

Sealing of raceways shall conform to Rule 18-204.

Sealing of raceways to prevent dust entry to enclosures has the same requirement in Class II, Division 2 as in Class II, Division 1.

18-256 Switches, Controllers, Circuit Breakers, and Fuses, Class II, Division 2

Enclosures for switches, motor controllers, circuit breakers, and fuses, including push buttons, relays, and similar devices, shall be either an Enclosure Type 4 or 5, or

(a) be equipped with telescoping or close-fitting covers, or with other effective means to prevent the escape of sparks or burning material; and

(b) have no openings, such as holes for attachment screws, through which, after installation, sparks or burning material might escape, or through which exterior accumulations of dust or adjacent combustible material might be ignited.

Enclosures for switches, motor controllers, circuit breakers, fuses, push buttons, relays and similar devices may either be CSA enclosure type 4 or 5 or be of a type meeting Subrules (a) and (b). The intent is to ensure dust does not enter the enclosure and to ensure that sparks or burning material that could be produced inside the enclosure will not escape into the Hazardous Location outside the enclosure.

18-258 Control Transformers and Resistors, Class II, Division 2

(1) Switching mechanisms, including overcurrent devices, used in conjunction with control transformers, impedance coils, and resistors shall be provided with enclosures conforming to Rule 18-256.

(2) Where not located in the same enclosure with switching mechanisms, control transformers and impedance coils shall be provided with tight housings without ventilating openings.

(3) Resistors and resistance devices shall have dust-tight enclosures approved for Class II locations, except that where the maximum normal operating temperature of the resistor will not exceed 120 °C, non-adjustable resistors and resistors that are part of an automatically timed starting sequence may have enclosures conforming to Subrule (2).

Where resistors or resistance devices operate at 120°C or lower, they may be in an enclosure meeting the requirements of Subrule 2. Where they operate above 120°C, they must be in a dust-tight enclosure approved for Class II locations. Meeting the CSA Standard requirements for Class II enclosures will ensure the temperature of the exterior of the housing will not exceed the maximum allowable for Class II enclosures.

18-260 Motors and Generators, Class II, Division 2 (see Appendix B)

(1) Except as provided in Subrule (2), motors, generators, and other rotating electrical machinery shall be

(a) approved for Class II, or Class II, Division 2 locations; or

Motors approved for Class II locations are suitable for use in Class II, Division 1 and Division 2 locations. These motors are required to be tested to CSA Standard C22.2 No. 145. This standard requires the motor pass dust penetration tests, abnormal external surface temperature tests with dust blanketing and accumulation of static electricity for motors with nonmetallic fans. Testing determines the maximum surface temperature under both running and locked rotor conditions. The maximum surface temperature must not exceed 200°C for dust Groups E and F or 165°C for dust Group G. Overheating protective devices, such as temperature switches, thermistors or RTDs, are allowed to be used in meeting the maximum surface temperature limits. Where these devices are used, they (or their control devices) must be included in the motor control circuit or the Class II motor certification will be invalid.

Motors marked as approved for Class II, Division 2 locations are tested in accordance with CSA Technical Information Letter (TIL) E-22, as there is currently no CSA Standard for Class II, Division 2 motors. This TIL requires the motor pass dust penetration tests and accumulation of static electricity tests for motors with nonmetallic fans. Motors must also be tested to ensure their maximum external surface temperature does not exceed 200°C (Groups E and F) or 165°C (Group G) when operated at full load in a 40°C ambient temperature. The TIL does not require dust blanketing tests.

(b) ordinary totally enclosed pipe-ventilated or totally enclosed fan-cooled, subject to the following:

(i) equipped with integral overheating protection in accordance with Rule 28-314; and

The overheating protection must be connected to shut down the motor.

(ii) if drain holes or other openings are provided, they shall be closed with threaded plugs.

This requirement ensures dust will not enter the motor through the drain hole. Motors for use in Class II locations must not allow dust to enter the inside of the motor, as a winding failure could create an explosion. Motors for Class II locations are not constructed to contain an internal explosion.

(2) Where accumulations of non-conductive, non-abrasive combustible dust are or will be moderate and if machines can be easily reached for routine cleaning and maintenance, the following shall be permitted to be installed:

(a) standard open-type machines without sliding contacts, centrifugal or other types of switching mechanisms (including motor overcurrent, overload, and overtemperature devices), or integral resistance devices;

(b) standard open-type machines with such contacts, switching mechanisms, or resistance devices enclosed within dust-tight housings without ventilating or other openings; and

(c) self-cleaning textile motors of the squirrel-cage type.

Moderate accumulations of dust will be insufficient to create explosive dust concentrations. These types of motors should be used with caution in Class II, Division 2 locations. The Appendix B note to this rule offers the following additional information:

Appendix B Notes

18-260(2)

It is the responsibility of the owner of the facility to demonstrate to the authority having jurisdiction that the conditions outlined in the Rule will exist.

Accumulations of the dust can be considered to be moderate if the colour of a surface is visible through the dust layer.

18-262 Ventilation Pipes, Class II, Division 2 (see Appendix B)

(1) Vent pipes for motors, generators, or other rotating electrical machinery, or for enclosures for electrical apparatus or equipment, shall conform to Rule 18-212(1).

(2) Vent 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 accumulations of dust or combustible material in the vicinity.

(3) Where metal vent pipes are used, lock seams and riveted or welded joints shall be permitted to be used and, where some flexibility is necessary, for example at connections to motors, tight-fitting slip joints shall be permitted to be used.

18-264 Utilization Equipment, Fixed and Portable, Class II, Division 2

(1) Electrically heated utilization equipment, whether fixed or portable, shall be approved for Class II locations.

The requirements for electrically heated utilization equipment in Class II, Division 2 locations is the same as in Class II, Division 1 locations. This is to ensure the equipment operates below temperatures that would ignite dust in the area. Electrically heated equipment operating above the minimum ignition temperature of the dust in the area has special requirements for Class II, Division 2 locations.

(2) Motors of motor-driven utilization equipment shall conform to Rule 18-260.

(3) The enclosure for switches, circuit breakers, and fuses shall conform to Rule 18-256.

(4) Transformers, impedance coils, and resistors forming part of or used in connection with utilization equipment shall conform to Rule 18-258(2) and (3).

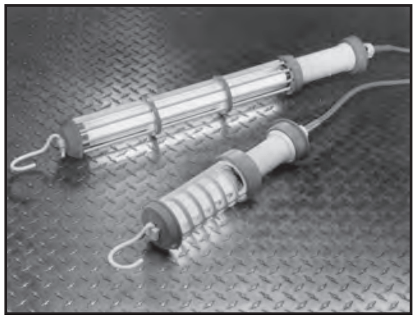
(5) Where portable utilization equipment is permitted to be used in Class II, Division 1 locations and in Class II, Division 2 locations, it shall conform to Rule 18-214.

18-266 Luminaires, Class II, Division 2

(1) Lighting equipment shall conform to the following:

(a) portable lamps shall be approved as complete assemblies for Class II locations and shall be clearly marked to indicate the maximum wattage of lamps for which they are approved; and

Portable luminaires are often exposed to mechanical damage that could potentially cause the bulb to burst, creating an arcing source. Therefore the requirements for portable lamps in Class II, Division 2 are the same as in Class II, Division 1 to ensure the lamp in the fixture is adequately guarded against breakage.



The EVH is certified for use in Class I, Div. 1 & 2, Groups C, D and Class II, Div. 1, Groups E, F, G locations.

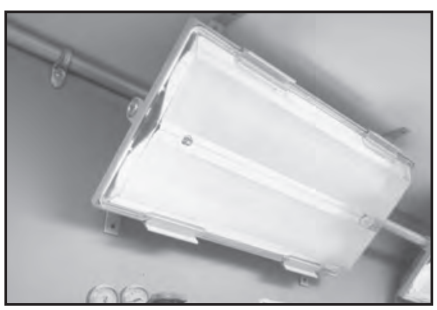
(b) luminaires shall

(i) be protected from physical damage by suitable guards or by location;

(ii) provide enclosures for lamps and lampholders that shall be designed to minimize the deposit of dust on lamps and to prevent the escape of sparks, burning material, or hot metal; and

(iii) be clearly marked to indicate the maximum wattage of lamps for which they are permitted to be used without exceeding a maximum exposed surface temperature of 165 °C under normal conditions of use.

The requirements of Subrule (b) are most easily met by the use of luminaires with a Class II approval. Basically, luminaires for use in Class II locations are industrial vapour-tight fixtures that have been tested to demonstrate they are dust-tight and that their maximum exposed surface temperature is below the required temperature.



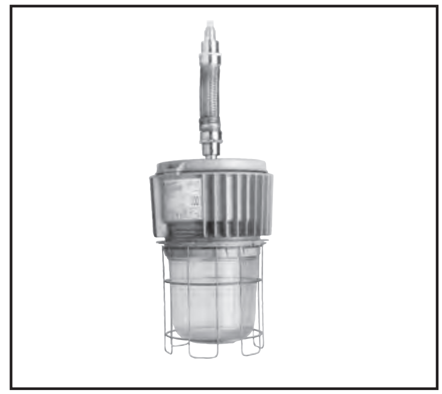
The FVS is rated for Zone 1 and Simultaneous Presence.

(2) Pendant luminaires shall be

(a) suspended by threaded rigid conduit stems or chains with approved fittings, or by other approved means, which shall not include flexible cord as the supporting medium;

(b) for rigid stems longer than 300 mm, provided with permanent and effective bracing against lateral displacement at a level not more than 300 mm above the lower end of the stem, or provided with flexibility in the form of a fitting or flexible connector approved for the purpose not more than 300 mm from the point of attachment to the supporting box or fitting; and

Luminaires with long pendants can put undue lateral stress on the mounting hardware that could cause failure of the hardware, possibly resulting in the assembly failing, causing the wires to arc by opening or shorting to ground. Therefore, pendant mounts longer than 300 mm require the use of a flexible fitting or connector intended for the purpose.



The ECHF is specifically designed as a flexible support for pendant-mounted fixtures in Hazardous Locations.

(c) where wiring between an outlet box or fitting and the luminaire is not enclosed in conduit, provided with a flexible cord approved for extra-hard usage.

(3) Boxes, box assemblies, or fittings used for the support of luminaires shall be approved for that purpose.

The weight of some luminaires can overstress the mounting supports unless they are designed for the purpose.

COOPER CROUSE-HINDS LUXICON

The Cooper Crouse-Hinds Luxicon® software provides users with fast, economical lighting layouts.

(4) Starting and control equipment for mercury vapour and fluorescent lamps shall conform to Rule 18-258.

This requirement is normally met by enclosing these devices in dust-tight enclosures, either integral to or separate from the enclosure. The use of lighting fixtures approved for Class II locations is recommended as the simplest and generally most cost-effective means of meeting the overall requirements of Rule 18-266.

18-268 Flexible Cords, Class II, Division 2

Flexible cords shall conform to Rule 18-218.

The requirements for flexible cords in a Class II, Division 2 Hazardous Location are the same as for flexible cords in a Class II, Division 1, Hazardous Location. See the notes to Rule 18-218.

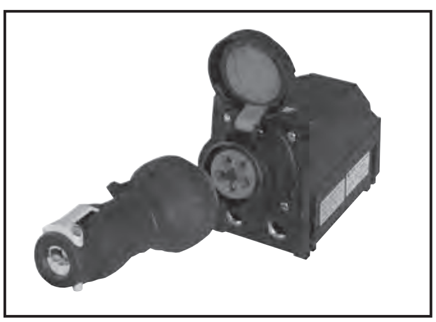
18-270 Receptacles and Attachment Plugs, Class II, Division 2

Receptacles and attachment plugs shall be

(a) of a polarized type that affords automatic connection to the bonding conductor of the flexible supply cord; and

(b) designed so that the connection to the supply circuit cannot be made or broken while live parts are exposed.

These requirements ensure that Cord-connected equipment is properly bonded to ground and that bare live parts will not be exposed while being connected or disconnected. It is important to ensure proper bonding at all times in Hazardous Locations to ensure exposed arcing will not develop as the result of equipment failure. It is also important to ensure that bare live parts that could potentially create an arc are not exposed to the Hazardous Location environment.



Cooper Crouse-Hinds Zone 1 and 2 plugs and receptacles are suitable for Class II, Division 2 dust areas.

18-272 Signal, Alarm, Remote-Control, and Communication Systems, Meters, Instruments, and Relays, Class II, Division 2

Signal, alarm, remote control, and communications systems, and meters, instruments, and relays shall conform to the following:

(a) contacts that interrupt other than voice currents shall be enclosed in conformity with Rule 18-256;

(b) the windings and terminal connections of transformers and choke coils that may carry other than voice currents shall be provided with tight enclosures without ventilating openings; and

(c) resistors, resistance devices, thermionic tubes, and rectifiers that may carry other than voice currents shall be provided with dust-tight enclosures approved for Class II locations, except that where the maximum normal operating temperature of thermionic tubes, non-adjustable resistors, or rectifiers will not exceed 120 °C, such devices shall be permitted to have tight enclosures without ventilating openings.

Enclosures for switches, motor controllers, circuit breakers, fuses, push buttons, relays and similar devices may either be CSA enclosure type 4 or 5 or be of a type meeting Subrules (a) and (b) of Rule 18-256. The intent is to ensure dust does not enter the enclosures and to ensure that sparks or burning material that could be produced inside the enclosures will not escape into the Hazardous Location outside the enclosure.

18-274 Live Parts, Class II, Division 2

No live parts of electrical equipment or of an electrical installation shall be exposed.

If live parts of an electrical system in a Class II, Division 2 Hazardous Location are exposed, there is potential for accidental contact that would create arcs or sparks capable of igniting dust in the area.

CLASS III LOCATIONS

Installations in Class III, Division 1 Locations (see Appendix E)

Electrical equipment not rated for a Class III Hazardous Location can be installed within the location providing it is enclosed in a dust-free room. The specific requirements for dust-free rooms are outlined in Appendix E of the *Canadian Electrical Code*.

18-300 Transformers and Capacitors, Class III, Division 1

Transformers and electrical capacitors shall conform to Rule 18-250.

The requirements for the installation of transformers in a Class III, Division 1 location are the same as in Class II, Division 2 (see notes to Rule 18-250). Essentially the intent is to isolate these devices from exposure to the fibres or flyings in the Class III, Division 1 Hazardous Location.

18-302 Wiring Methods, Class III, Division 1 (see Appendix B)

(1) The wiring method shall be

(a) threaded rigid metal conduit;

(b) cables approved for hazardous locations;

(c) electrical metallic tubing;

(d) armoured cable with overall non-metalli-jacket, such as TECK90, ACWU90, copper-sheathed RC90, or aluminum-sheathed RA90; or

(e) control and instrumentation cables with an interlocking metallic armour and a continuous jacket in control circuits (Type ACIC).

The requirements for wiring in Class III, Division 1 are similar to those in Class II, Division 1 except that in Class III, Division 1, electrical metallic tubing (EMT) is permitted. EMT is permitted because the particle size of fibres and flyings is sufficiently large that it will not readily enter EMT. See additional comments to Rule 18-202.

(2) Boxes and fittings in which taps, joints, or terminal connections are made shall be either an Enclosure Type 5 or shall

(a) be provided with telescoping or close fitting covers, or other effective means to prevent the escape of sparks or burning material; and

(b) have no openings, such as holes for attachment screws, through which, after installation, sparks or burning material might escape, or through which adjacent combustible material might be ignited.

nclosures used in a Class III, Division 1, Hazardous Location will not allow the entry of fibres and flyings and will not allow sparks or burning material, capable of igniting fibres or flyings, to exit the enclosures.

(3) Cables shall be installed and supported in a manner to avoid tensile stress at the cable glands.

Where a cable connection is under tensile stress, there is a danger the cable may pull out of the connector, thus compromising the integrity of the enclosure. A common method of ensuring there is no tensile stress on the cable connection is to support it in close proximity to the box. See Section 12, Rule 12-510(1) of the *Canadian Electrical Code* for more specific requirements.

(4) Where it is necessary to use flexible connections, the provisions of Rule 18-202(4) and (5) shall apply.

Flexible connections suitable for use under Rule 18-202(4) and (5) for use in Class II, Division 1 Hazardous Locations are also acceptable in Class III, Division 1 locations. Essentially this allows the use of liquid-tight conduit and extra-hard usage cord and, where exposed to oil or other corrosive, the insulation of the conductors must be of a type approved for the use or protected by a suitable sheath.

18-304 Switches, Controllers, Circuit Breakers, and Fuses, Class III, Division 1

Enclosures for switches, motor controllers, circuit breakers, and fuses, including push buttons, relays, and similar devices, shall be either an Enclosure Type 5 or shall be provided with tight enclosures designed to minimize entrance of fibres and flyings, and shall

(a) be equipped with telescoping or close-fitting covers, or with other effective means to prevent the escape of sparks or burning material; and

(b) have no openings, such as holes for attachment screws, through which, after installation, sparks or burning material might escape, or through which exterior accumulations of fibres or flyings or adjacent combustible material might be ignited.

Devices that arc or spark during their normal operation must be contained in enclosures that will prevent the entry of fibres or flyings or the exit of sparks or burning material which could ignite fibres outside the enclosures.

18-306 Control Transformers and Resistors, Class III, Division 1

Transformers, impedance coils, and resistors used as or in conjunction with control equipment for motors, generators, and appliances shall conform to Rule 18-258, with the exception that, when these devices are in the same enclosure with switching devices of such control equipment, and are used only for starting or short-time duty, the enclosure shall conform to the requirements of Rule 18-304.

Transformers, coils and resistors used for controlling motors, generators and appliances must meet the same requirements as in Class II, Division 1 (see Rule 18-258) except, when they are in the same enclosure with the switching device and are used for short-time duty, they may be in enclosures meeting Rule 18-304. One example would be a transformer or reactor used for reduced-voltage motor starting.

18-308 Motors and Generators, Class III, Division 1 (see Appendix B)

(1) Except as provided in Subrule (2), motors, generators, and other rotating electrical machinery shall be

(a) totally enclosed non-ventilated;

(b) totally enclosed pipe-ventilated; or

(c) totally enclosed fan-cooled.

Motors which do not circulate air from outside the motor enclosure through the windings are acceptable in all Class III, Division 1 Hazardous Locations.

(2) Where only moderate accumulations of lint and flyings are likely to collect on, or in the vicinity of, a rotating electrical machine and the machine is readily accessible for routine cleaning and maintenance, it shall be permissible to install in the location:

(a) standard open-type machines without sliding contacts, centrifugal, or other types of switching mechanisms, including motor overload devices;

(b) standard open-type machines that have contacts, switching mechanisms, or resistance devices enclosed within tight housings without ventilating or other openings; or

(c) self-cleaning textile motors of the squirrel-cage type.

(3) Motors, generators, or other rotating electrical machinery of the partially enclosed or splash-proof type shall not be installed in Class III locations.

Where only moderate accumulations of lint and flyings are likely to collect on or near the motor, standard open-type motors that do not incorporate unenclosed contacts, switching mechanisms or resistance devices may be used providing the motors are readily accessible for routine cleaning. The use of these motors will also require that cleaning be done frequently to ensure only moderate accumulation of lint or flyings. Motors or generators with enclosures that are only partially enclosed or are only rated as splash-proof may not be used.

18-310 Ventilating Pipes, Class III, Division 1 (see Appendix B)

(1) Vent pipes for motors, generators, or other rotating electrical machinery or for enclosures for electrical apparatus or equipment shall conform to Rule 18-212(1).

(2) Vent pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of fibres or flyings into the ventilated equipment or enclosure, and to prevent the escape of sparks, flame, or burning material that might ignite accumulations of fibres or flyings or combustible material in the vicinity.

(3) Where metal vent pipes are used, lock seams and riveted or welded joints shall be permitted to be used and, where some flexibility is necessary, tight-fitting slip joints shall be permitted to be used.

This Rule outlines the minimum requirements for ventilating pipes used to convey clean air to pipe-ventilated rotating electrical machinery or enclosures for electrical apparatus. These requirements are intended to ensure the piping system is sufficiently tight and robust to prevent fibres or flyings from entering the piping and being deposited in the motors. Deposits of flyings in the motors could be ignited from a hot rotor or winding.

18-312 Utilization Equipment, Fixed and Portable, Class III, Division 1

(1) Electrically heated utilization equipment, whether fixed or portable, shall be approved for Class III locations.

Products approved for Class II, Division 1 locations for Groups E, F, G are normally suitable for use in Class III, Division 1 areas.

(2) Motors of motor-driven utilization equipment shall conform to Rule 18-308.

(3) The enclosures for switches, motor controllers, circuit breakers, and fuses shall conform to Rule 18-304.

18-314 Luminaires, Class III, Division 1

(1) Lighting equipment shall conform to the following:

(a) portable lamps shall

(i) be equipped with handles;

(ii) be protected with substantial guards;

(iii) have lampholders of the unswitched type with no exposed metal parts and without provision for receiving attachment plugs; and

(iv) in all other aspects comply with Item (b);

Due to the potential for physical abuse in normal use, portable lamps must meet these additional requirements. Lampholders cannot have switches or plug-ins, as they would be sources of arcing.

(b) luminaires shall

(i) provide enclosures for lamps and lampholders that shall be designed to minimize entrance of fibres and flyings and to prevent the escape of sparks, burning material, or hot metal;

(ii) be clearly marked to indicate the maximum wattage lamp that is permitted to be used without exceeding a maximum exposed surface temperature of 165 °C under normal conditions of use.

(2) Luminaires that may be exposed to physical damage shall be protected by a suitable guard.

(3) Pendant luminaires shall comply with Rule 18-266(2).

(4) Boxes, box assemblies, or fittings used for the support of luminaires shall be approved for that purpose.

(5) Starting and control equipment for mercury vapour and fluorescent lamps shall comply with Rule 18-306.

Class III, Division 1 lighting fixtures must prevent the ingress of fibres and flyings, prevent the egress of sparks or burning materials and operate with a maximum exposed surface temperature of 165°C. Class II and Class III lighting fixtures are similar in design. Some fixtures are rated for Class II and Class III Hazardous Locations.

18-316 Flexible Cords, Class III, Division 1

Flexible cords shall comply with Rule 18-218.

Rule 18-218 requires the use of extra-hard usage cords containing a bonding conductor and must be provided with a gland which prevents entry of fibres or flyings into boxes or fittings.

18-318 Receptacles and Attachment Plugs, Class III, Division 1

Receptacles and attachment plugs shall comply with Rule 18-270.

Receptacles and attachment plugs in Class III, Division 1 locations must meet the same requirements as in Class II, Division 2. (See notes to Rule 18-270.)

18-320 Signal, Alarm, Remote-Control, and Communication Systems, Class III, Division 1

Signal, alarm, remote-control, and communication systems shall comply with Rule 18-272.

Signal, alarm, remote control and communication systems in Class III, Division 1 locations must meet the same requirements as in Class II, Division 2. (See notes to Rule 18-272.)

18-322 Electric Cranes, Hoists, and Similar Equipment, Class III, Division 1

Where installed for operation over combustible fibres or accumulations of flyings, travelling cranes and hoists for material handling, travelling cleaners for textile machinery, and similar equipment shall conform to the following:

(a) the power supply to contact conductors shall be isolated from all other systems, ungrounded, and equipped with recording ground detection that will give an alarm and will automatically de-energize the contact conductors in case of a fault to ground, or with ground fault detection that will give a visual and audible alarm and maintain the alarm as long as power is supplied to the system and the ground fault remains;

(b) 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;

The power supply to electric cranes and similar equipment travelling over combustible fibres or flyings or handling combustible fibres or flyings must be from an ungrounded system, which is isolated from all other systems. The use of ungrounded systems will prevent flashovers to ground in the Class III, Division 1 Hazardous Location when a ground fault occurs. The ground fault detection system must either operate to disconnect the power from the contact conductors or must operate an audible and visual alarm that will continue both the audible and visual alarm functions as long as the ground fault remains. It is intended that the ground fault be removed as soon as possible, as the occurrence of a second ground fault could result in the production of arcs or sparks in the Hazardous Location.

The most common means of achieving an isolated system would be the use of a dedicated transformer with an ungrounded secondary.

(c) current collectors shall conform to the following:

(i) they shall be arranged or guarded to confine normal sparking and to prevent escape of sparks or hot particles;

(ii) to reduce sparking, two or more separate surfaces of contact shall be provided for each contact conductor; and

(iii) reliable means shall be provided to keep contact conductors and current collectors free of accumulations of lint or flyings; and

The contact conductors and current collectors shall be constructed to confine normal sparking and to prevent the escape of any products of the sparking that could ignite fibres or flyings. The contact conductors and current collectors must be designed to prevent the accumulation of fibres or flyings on their surfaces. Housekeeping practices should be such that any accumulations are regularly removed.

(d) Control equipment shall comply with Rules 18-304 and 18-306.

18-324 Storage-Battery Charging Equipment, Class III, Division 1

Storage-battery charging equipment shall be located in separate rooms built or lined with substantial non-combustible materials constructed so as to adequately exclude flyings or lint and shall be well ventilated.

Storage battery charging equipment located within the Hazardous Location must be located in separate rooms constructed or lined with noncombustible materials to prevent the ingress of flyings or lint. The rooms should be sufficiently well ventilated to remove any hydrogen generated by the battery-charging operations. If the battery charging equipment is located in a nonhazardous location, these rules would not apply.

18-326 Live Parts, Class III, Division 1

No live parts of electrical equipment or of an electrical installation shall be exposed, except as provided in Rule 18-322.

If live parts of an electrical system in a Class III, Division 1 Hazardous Location are exposed, there is potential for accidental contact that would create arcs or sparks capable of igniting fibres or flyings in the area.

Installations in Class III, Division 2 Locations (see Appendix E)

18-350 Transformers and Capacitors, Class III, Division 2

Transformers and capacitors shall conform to Rule 18-250.

Rules for installation of transformers and capacitors in Class III, Division 2 Hazardous Locations are the same as for Class II, Division 2 Hazardous Locations. See notes to Rule 18-250.

18-352 Wiring Methods, Class III, Division 2

The wiring method shall be

(a) threaded rigid metal conduit;

(b) cables approved for hazardous locations;

(c) electrical metallic tubing;

(d) armoured cable with overall non-metallic jacket, such as TECK90, ACWU90, copper-sheathed RC90, or aluminum-sheathed RA90;

(e) control and instrumentation cables with an interlocking metallic armour and a continuous jacket in control circuits (Type ACIC);

(f) Type TC cable, installed in cable tray in accordance with Rule 12-2202; or

(g) Typed CIC cable (non-armoured control and instrumentation cable) installed in cable tray in accordance with the installation requirements of Rule 12-2202(2), where

(i) the voltage rating of the cable is not less than 300 V;

(ii) the circuit voltage is 150 V or less; and

(iii) the circuit current is 5 A or less.

Wiring methods allowed in Class III, Division 2 Hazardous Locations are the same as allowed in Class III, Division 1 Hazardous Locations. See Rule 18-302. An exception is the use of open wiring on insulators in the areas listed above, providing the requirements of Rules 12-202 to 12-224 are met. Open wiring on insulators therefore must be insulated conductors or cables.

18-354 Switches, Controllers, Circuit Breakers, and Fuses, Class III, Division 2

Enclosures for switches, motor controllers, circuit breakers, and fuses shall conform to Rule 18-304.

The rules for switches, motor controllers, circuit breakers and fuses in Class III, Division 1 locations also apply in Class III, Division 2 locations.

18-356 Control Transformers and Resistors, Class III, Division 2

Transformers, impedance coils, and resistors used as or in conjunction with control equipment for motors, generators, and appliances shall conform to Rule 18-306.

The rules for control transformers and resistors in Class III, Division 1 locations also apply in Class III, Division 2 locations.

18-358 Motors and Generators, Class III, Division 2 (see Appendix B)

Motors, generators, and other rotating machinery shall conform to Rule 18-308.

The rules for motors and generators in Class III, Division 1 locations also apply in Class III, Division 2 locations.

18-360 Ventilating Pipes, Class III, Division 2 (see Appendix B)

Ventilating pipes shall conform to Rule 18-212(1).

The requirements for ventilating pipes in Class III, Division 2 locations are the same as in Class II, Division 1 locations. See Rule 18-212.

18-362 Utilization Equipment, Fixed and Portable, Class III, Division 2

Fixed or portable utilization equipment shall conform to Rule 18-312.

The rules for fixed and portable utilization equipment in Class III, Division 1 locations also apply in Class III, Division 2 locations.

18-364 Luminaires, Class III, Division 2

Luminaires shall conform to Rule 18-314.

The rules for lighting fixtures in Class III, Division 1 locations also apply in Class III, Division 2 locations.

18-366 Flexible Cords, Class III, Division 2

Flexible cords shall conform to Rule 18-218.

The requirements for flexible cords in Class III, Division 2 locations are the same as in Class II, Division 1 locations. See Rule 18-218.

18-368 Receptacles and Attachment Plugs, Class III, Division 2

Receptacles and attachment plugs shall conform to Rule 18-270.

The requirements for receptacles and attachment plugs in Class III, Division 2 locations are the same as in Class II, Division 2 locations. See Rule 18-270.

18-370 Signal, Alarm, Remote-Control, and Communication Systems, Class III, Division 2

Signal, alarm, remote-control, and communication systems shall conform to Rule 18-272.

The requirements for signal, alarm, remote control, and communication systems in Class III, Division 2 locations are the same as in Class II, Division 2 locations. See Rule 18-272.

18-372 Electric Cranes, Hoists, and Similar Equipment, Class III, Division 2

Electric cranes, hoists, and similar equipment shall be installed as prescribed by Rule 18-322.

The rules for electric cranes, hoists and similar equipment in Class III, Division 1 locations also apply in Class III, Division 2 locations. See Rule 18-322.

18-374 Storage-Battery Charging Equipment, Class III, Division 2

Storage-battery charging equipment shall be located in rooms conforming to Rule 18-324.

The rules for rooms containing storage battery charging equipment in Class III, Division 1 Hazardous Locations also apply in Class III, Division 2 Hazardous Locations. See Rule 18-324.

18-376 Live Parts, Class III, Division 2

No live parts of electrical equipment or of an electrical installation shall be exposed, except as provided in Rule 18-322.

If live parts of an electrical system in a Class III, Division 2 Hazardous Location are exposed, there is potential for accidental contact that would create arcs or sparks capable of igniting fibres or flyings in the area.

SECTION 20

Scope and Introduction

20-000 Scope (see Appendix J)

(1) This Section supplements or amends the general requirements of this Code and applies to installations as follows:

(a) gasoline dispensing and service stations — Rules 20-002 to 20-014;

(b) propane dispensing, container filling, and storage — Rules 20-030 to 20-042;

(c) compressed natural gas refuelling stations, compressors, and storage facilities — Rules 20-060 to 20-070;

(d) commercial garages — repairs and storage — Rules 20-100 to 20-114;

(e) residential storage garages — Rules 20-200 to 20-206;

(f) bulk storage plants — Rules 20-300 to 20-312;

(g) finishing processes — Rules 20-400 to 20-414; and

(h) aircraft hangars — Rules 20-500 to 20-522.

Section 20 outlines specific requirements for those facilities above. While Section 18 contains the definitions for the classification of Hazardous Locations and the requirements for wiring and equipment to be used in those locations, it does not give the user guidance in applying those definitions. For industrial sites at petroleum and chemical facilities there are a number of "Recommended Practices" (see item 18-006 Appendix B) available to the designer to assist in achieving a proper area classification. In effect, Section 20 defines the area classification of the Hazardous Locations outlined in Rule 20-000(1). It also outlines certain specific requirements for equipment and wiring in those Hazardous Locations. As these Hazardous Locations also fall within the scope of Section 18, the requirements in Section 18 will apply except where amended by rules in this section. As in Section 18, the general sections of the *CEC* (Sections 0 to 16 and 26) also apply to installations covered under this section.

The facilities covered in this section are those meeting the definition of Class I locations as defined in Rule 18-004(a), which reads:

"Class I locations are those in which flammable gases or vapours are or may be present in the air in quantities sufficient to produce explosive gas atmospheres."

(2) For additions, modifications, or renovations to, or operation and maintenance of existing facilities employing the Division system of classification for Class I locations, the continued use of the Division system of classification shall be permitted.

Section 20 is written to recognize only the Zone system of area classification, however there is no requirement to change the area classification of facilities presently classified to the Division system. It is also permitted to make additions or renovations to these facilities without changing to the Zone system. Building a new facility to the Division system can only be done where "special permission" has been granted in accordance with Rule 2-030.

(3) Where the Division system of classification is used for Class I locations, as permitted by Subrule (2), the Rules for Class I locations found in Annex J20 of Appendix J shall apply.

As Class I hazardous facilities classified to the Division system are not required to change to the Zone system, installation rules for those systems are contained in Appendix J, Annex J20.

(4) The definitions stated in Rule 18-002 shall also apply to Section 20.

All methods of protection allowed in Class I, Zone 2 locations are not shown in Appendix J. This rule modifies Appendix J to allow all equipment acceptable for use in Class I, Zone 2 to also be used in Class I, Division 2 locations in Appendix J.

Rule 18-002 outlines definitions of terms used in the body of Section 18. These definitions also apply to Section 20.

Gasoline Dispensing and Service Stations

20-002 General

(1) Rules 20-004 to 20-014 apply to electrical apparatus and wiring installed in gasoline dispensing and service stations and other locations where gasoline or other similar volatile flammable liquids are dispensed or transferred to the fuel tanks of self-propelled vehicles.

Rule 20-002 states that Rules 20-004 to 20-014 apply to facilities dispensing gasoline and "other similar volatile flammable liquids." A volatile flammable liquid is defined in API RP 505 and API RP 500 as: "a flammable liquid whose temperature is above its flash point, or a Class II combustible liquid having a vapour pressure not exceeding 276 kPa (40 psia) at 37.8ºC (100°F) whose temperature is above its flash point." These are liquids which at ambient temperature will flash sufficient vapours to create an ignitable mixture with air near their surface. However, the rate at which they give off vapours is much lower than highly volatile liquids such as propane or liquefied natural gas. Highly volatile liquids when released to atmosphere are at temperatures above their boiling point and will rapidly boil off large volumes of vapours. For this reason propane and compressed natural gas have separate rules from gasoline and similar flammable liquids.

(2) Other areas used as lubritoriums, service rooms and repair rooms, and offices, salesrooms, compressor rooms, and similar locations shall conform to Rules 20-100 to 20-114 with respect to electrical wiring and equipment.

20-004 Hazardous Areas (see Appendix B)

(1) Except as provided for in Subrule (3), the space within a dispenser enclosure up to 1.2 m vertically above its base, including the space below the dispenser that may contain electrical wiring and equipment, shall be considered a Class I, Zone 1 location.

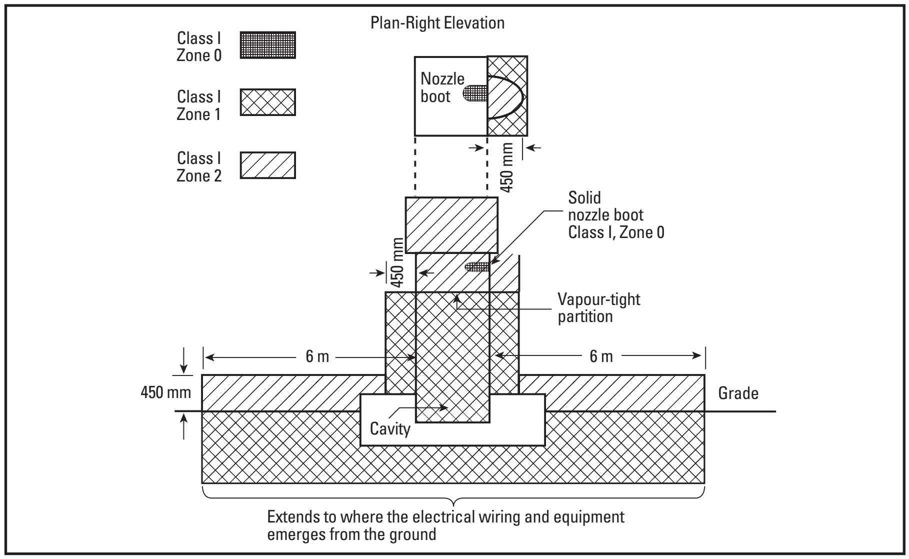
Gasoline vapours are typically 3 to 4 times heavier than air and when released will fall to grade or to the bottom of their containment. Due to the possibility of leakage within the dispenser enclosure, the area near the bottom of the enclosure where vapours would collect is classified as a Zone 1 location. Leakage within the enclosure could result in ignitable concentrations of vapours being present during the normal operation of the pump.

(2) The space within a nozzle boot of a dispenser shall be considered a Class I, Zone 0 location.

Each time the nozzle is replaced in the nozzle boot there are vapours released. As these vapours will be present for long periods of time, the area within the nozzle boot is classified as a Zone 0 location. Only intrinsically safe (type "ia") electrical equipment would be suitable for use in the boot.

(3) The space within a dispenser enclosure above the Class I, Zone 1 location as specified in Subrule (1) or spaces within a dispenser enclosure isolated from the Zone 1 location by a solid vapour-tight partition or by a solid nozzle boot but not completely surrounded by a Zone 1 location shall be considered a Class I, Zone 2 location.

Areas within the dispenser above the 1.2 m Zone 1 location or isolated by a vapour-tight partition from the Zone 1 location are to be classified as Class I, Zone 2. However, if the area surrounding the dispenser is Zone 1, the interior of the dispenser will also be Zone 1.



Cross-sectional view of dispenser with vapour-tight partition.

(4) The space within 450 mm horizontally from the Zone 1 location within the dispenser enclosure as specified in Subrule (1) shall be considered a Class I, Zone 1 location.

The space for 450 mm horizontally outside the dispenser, up to the top of the Zone 1 area specified in Subrule 1 will also be classified as a Class I, Zone 1 Hazardous Location.

(5) The space outside the dispenser within 450 mm horizontally from the opening of a solid nozzle boot located above the vapour-tight partition shall be considered a Class I, Zone 2 location, except that the classified area need not extend beyond the plane in which the boot is located.

(6) In an outside location, any area beyond the Class I, Zone 1 area (and in buildings not suitably cut off) within 6 m horizontally from the exterior enclosure of any dispenser shall be considered a Class I, Zone 2 location that extends to a level 450 mm above driveway or ground level.

The area for 6 metres horizontally outside the Zone 1 area in Subrule 4, to a height of 450 mm above grade, will be Class I, Zone 2. If a portion of a building is inside the Zone 2 location, the interior of the building will also be Zone 2 unless the walls of the building within the Zone 2 area are vapour-tight.

Clearly the 6 meter (20 foot) hazardous area outside the pump extends into the area where vehicles will be located when their fuel tanks are being filled. As some OH&S Codes consider operation of a vehicle in a Class I Hazardous Location to be “hot work” (running internal combustion engines have been known to ignite flammable vapors), it is reasonable to question how it is possible to drive vehicles in and out of these hazardous areas. One possible explanation is that while the hazardous area applies to fixed wiring systems at all times, it applies only to vehicles during the filling of fuel tanks. During the filling process the liquid fuel entering fuel tanks pushes out the vapors within the tanks, thus forming an explosive mixture around the filling point. Thus it is important not to leave a vehicle running, or to operate devices that would create an incendive spark, during the filling process.

Appendix B Notes

20-004

For the purposes of Subrules (6) and (7), buildings such as kiosks in which electrical equipment such as cash registers and/or self-service console controls are located are considered to be buildings not suitably cut off.

(7) In an outside location, any area beyond the Class I, Zone 1 location (and in buildings not suitably cut off) within 3 m horizontally from any tank fill-pipe shall be considered a Class I, Zone 2 location that extends upward to a level 450 mm above driveway or ground level.

The space for 3 metres horizontally around any tank fill pipe, to a height of 450 mm, will be a Class I, Zone 2 location. If a portion of a building is inside the Zone 2 location, the interior of the building will also be Zone 2 unless the walls of the building within the Zone 2 area are vapour-tight.

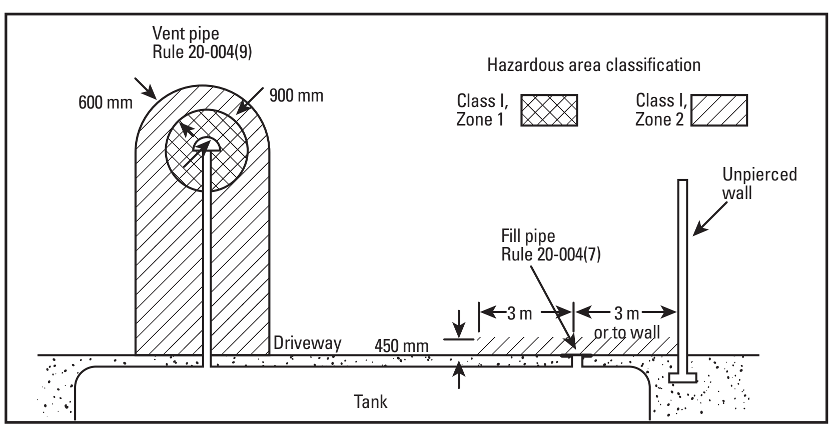
(8) Electrical wiring and equipment, any portion of which is below the surface of areas defined as Class I, Zone 1 or Zone 2 in Subrule (1), (4), (6), or (7), shall be considered within a Class I, Zone 1 location that extends at least to the point of emergence above grade.

Wiring below the surface of areas classified as Class I, Zone 1 or Zone 2 will be considered to be in a Zone 1 location at least to the point where it emerges above grade. It will require the wiring systems and equipment to meet Zone 1 requirements. This is due to the possibility that flammable liquids may be present in the ground under the hazardous area and could seep into electrical equipment or wiring systems.

(9) Areas within the vicinity of tank vent-pipes shall be classified as follows:

(a) the spherical volume within a 900 mm radius from the point of discharge of any tank vent-pipe shall be considered a Class I, Zone 1 location and the volume between the 900 mm to 1.5 m radius from the point of discharge of a vent shall be considered a Class I, Zone 2 location;

There will be a 900 mm Class I, Zone 1 area around the vent pipe opening and a further 600 mm Class I, Zone 2 area surrounding the Zone 1 area. As the gasoline vapours within the tank are heavier than air, there will not normally be significant vapours being discharged around the vent. However, when the tank is being filled, relatively large amounts of vapours will be forced out of the tank by the incoming liquids.



Gasoline storage tank installation.

(b) for any vent that does not discharge upward, the cylindrical volume below both the Zone 1 and Zone 2 locations extending to the ground shall be considered a Class I, Zone 2 location; and

For these vents there will be a Class I, Zone 2 circular area with a 1.5 m radius extending to ground level, below the hazardous are surrounding the vent.

(c) The hazardous area shall not be considered to extend beyond an unpierced wall.

Where the wall of a building extends into the hazardous area, the hazardous area does not extend beyond the wall if the wall is unpierced. Other standards refer to such walls as vapour-tight when they will not allow the passage of gas or vapour at atmospheric pressure. If the wall is not vapour-tight (i.e., it has openings such as doors, windows, unsealed pipe penetrations, etc., within the hazardous area), the hazardous area will extend beyond the wall and include the whole of the enclosed space beyond the wall.

(10) Areas within lubrication rooms shall be classified as follows:

(a) the area within any pit or space below grade or floor level in a lubrication room shall be considered a Class I, Zone 1 location, unless the pit or space below grade is beyond the hazardous areas specified in Subrules (6), (7), and (9), in which case the pit or space below grade shall be considered a Class I, Zone 2 location;

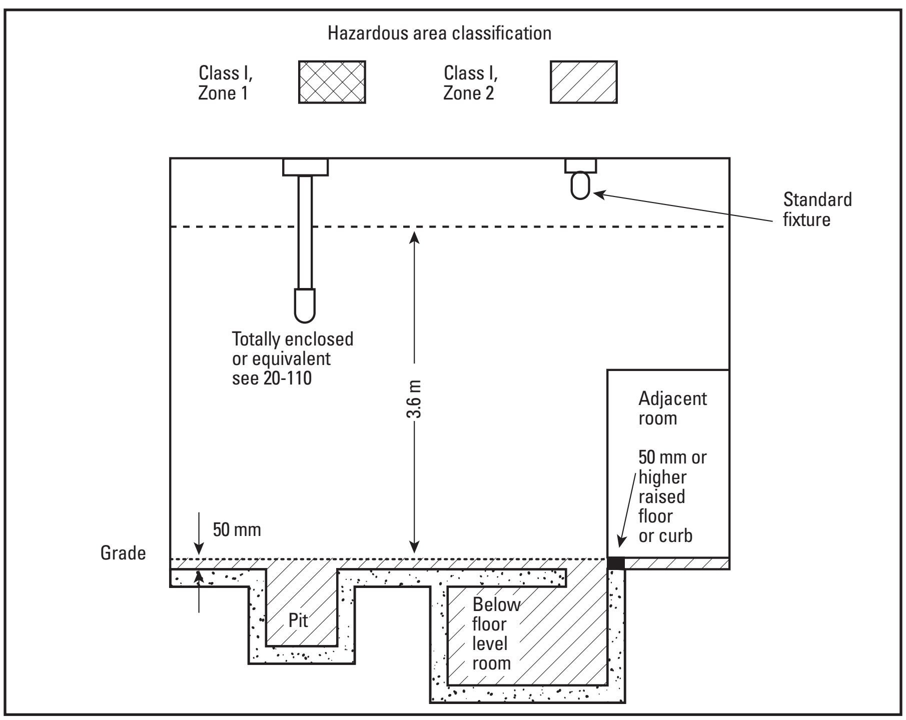
Areas (pits or spaces) below grade in lubrication rooms will be Class I, Zone 2 unless the Class I, Zone 1 area in Subrules 6, 7 or 9 overlaps a portion of them. If the Class I, Zone 1 hazardous area overlaps them, the below grade areas will also be Class I, Zone 1.

(b) notwithstanding Item (a), for each floor below grade that is located beyond the hazardous area specified in Subrules (6), (7), and (9) and where adequate ventilation is provided, a Class I, Zone 2 location shall extend up to a level of only 50 mm above each such floor; and

Where "adequate ventilation" is provided in the below grade areas overlapped by Class I, Zone 1 areas, they will be classified as Class I, Zone 2 locations. NFPA 30 (Flammable and Combustible Liquids Code) considers ventilation to be "adequate" if it is sufficient to prevent accumulation of significant quantities of vapor-air mixtures in concentrations one fourth (25%) of the lower flammable limit.

(c) the area within the entire lubrication room up to 50 mm above the floor or grade, whichever is higher, and the area within 900 mm measured in any direction from the dispensing point of a hand-operated unit dispensing volatile flammable liquids shall be considered a Class I, Zone 2 location.

The area above the floor or grade (whichever is higher) in the entire lubrication room will be Class I, Zone 2 for 50 mm above the floor or grade. In addition, the area for 900 mm around the dispensing point of a hand-operated unit dispensing "volatile flammable liquids" will be considered a Class I, Zone 2 Hazardous Location. Volatile flammable liquids are "flammable liquids whose temperatures are above their flash points, or Class II combustible liquids having vapour pressures not exceeding 276 kPa (40 psia) at 37°C (100°F), whose temperatures are above their flash points." Therefore, in determining whether dispensed liquids require area classification, the important factors are their flash point and the temperature at which they are dispensed. For example, a solvent with a flash point of 50°C dispensed at a room temperature of 20°C would not be volatile and would not require classification. On the other hand, a solvent having a flash point of 15°C would be volatile at room temperature and would require classification in accordance with this rule. In cases where materials are heated prior to dispensing, they will be volatile and require area classification if they are heated to or above their flash points.



Typical lubricating section of commercial service station.

20-006 Wiring and Equipment Within Hazardous Areas

(1) Electrical wiring and equipment within the hazardous areas defined in Rule 20-004 shall conform to Section 18 requirements.

Unless modified by other rules in this section the wiring and equipment requirements in Section 18 will apply to Hazardous Locations in gasoline dispensing and service stations.

(2) Where dispensers are supplied by rigid metal conduit, a union and a flexible fitting shall be installed between the conduit and the dispenser junction box in addition to any sealing fittings required by Section 18.

A union and a flexible fitting (flexible explosionproof conduit) must be used to prevent damage to the conduit or conductors as a result of vibration or movement of the dispenser relative to the rigid conduit. A union is required to allow replacement of the dispenser without damage to components of the wiring system.

Unions have serrated joint construction.

(3) The flexible metal fitting required by Subrule (2) shall be installed in a manner that allows relative movement of the conduit and the dispenser.

(4) Where dispensers are supplied by a cable approved for hazardous locations, provisions shall be made to separate the cable from the dispenser junction box without rendering ineffective the explosion-proof cable seal.

Where the dispenser is supplied by a cable rated for use in Hazardous Locations (HL marked), the connection method must allow the cable to be disconnected from the dispenser without damaging the cable or the seal. Most “sealing type” connectors are constructed in such a manner that they can be disconnected from the connection box without the need of a union.

20-008 Wiring and Equipment Above Hazardous Areas

Wiring and equipment above hazardous areas shall conform to Rules 20-106 and 20-110.

As gasoline vapours are heavier than air and will remain near floor level, the area above the hazardous areas can be classified as nonhazardous and wiring requirements in Section 12 can be applied. This rule also requires those wiring systems meet the additional requirements outlined in Rules 20-106 and 20-110. The requirements in Rules 20-106 and 20-110 are intended to prevent equipment located above the hazardous area creating arcs, sparks of flaming material that could fall into the hazardous area.

20-010 Circuit Disconnects

Each circuit leading to or through a dispensing pump shall be provided with a switching means that will disconnect simultaneously all ungrounded conductors of the circuit from the source of supply.

A single point of disconnection is required to ensure the risk of electric shock or ignition of flammable vapours can be removed with a single operation.

Cooper Crouse-Hinds Zone 1 Disconnect Switches, 10 to 180 amps.

20-012 Sealing

(1) Seals as required by Section 18 shall be provided in each conduit run entering or leaving a dispenser or any cavities or enclosures in direct communication with a dispenser.

(2) Additional seals shall be provided in conformance with Rules 18-108 and 18-154, and the requirements of Rules 18-108(1)(c) and 18-154(1)(b) shall include horizontal and vertical boundaries.

Seals are required on each conduit entering or leaving a dispenser. In addition, seals may be required as outlined in Rules 18-108(1)(a)(iii) or 18-158(1)(a)(ii). As it is possible for gasoline vapours that may be present in the soil to enter underground conduits, a seal is required where the conduit exits the ground in the nonhazardous area to prevent the migration of gasoline vapours into the area. Where cables are used, seals are not required at the boundaries of Hazardous Locations.

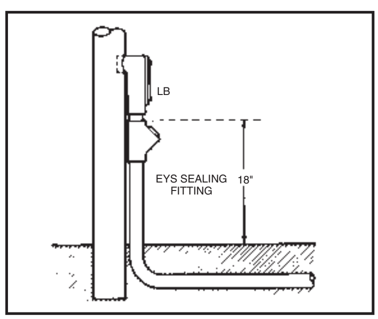


Illustration of seal at gas station.

20-014 Bonding

All non-current-carrying metal parts of dispensing pumps, metal raceways, and other electrical equipment shall be bonded to ground in accordance with Section 10.

Section 10 requires that all noncurrent-carrying parts of the electrical system are bonded to ground with a properly sized bonding conductor. This is to prevent shock or ignition hazard by ensuring a conductive path of low enough impedance to properly operate protective over-current devices.

Propane Dispensing, Container Filling, and Storage

20-030 Scope (see Appendix B)

Rules 20-032 to 20-042 apply to locations in which propane is dispensed or transferred to the fuel tanks of self-propelled vehicles or to portable containers and to locations in which propane is stored or transferred from rail cars or tanker vehicles to storage containers.

Propane is a highly volatile liquid that when released will quickly vapourize and form large volumes of flammable propane/air mixture. As propane is heavier than air (1.6 times heavier) it will tend to sink to ground level and may collect in unventilated areas.

20-032 Special Terminology

In this Subsection the following definitions apply:

Container refill centre — a facility such as a propane service station that is open to the public and at which propane is dispensed into containers or the fuel tanks of motor vehicles and that consists of propane storage containers, piping, and pertinent equipment including pumps and dispensing devices.

Filling plant — a facility such as a bulk propane plant, the primary purpose of which is the distribution of propane, that receives propane in tank car or truck transport for storage and/or distribution in portable containers or tank trucks, that has bulk storage, and that usually has container filling and truck loading facilities on the premises.

Propane — any material that is composed predominantly of the following hydrocarbons either by themselves or as mixtures: propane, propylene, butane (normal butane or iso-butane), and butylene.

Table 63 (See Rule 20-034)

Hazardous Areas for Propane Dispensing, Container Filling, and Storage

Part	Location	Extent of Hazardous Locations*	Zone of Class I, Group IIA Hazardous Location
A	Storage containers other than TC/CTC/DOT cylinders and ASME vertical containers of less than 454 kg water capacity	Within 4.5 m in all directions from connections, except connections otherwise covered in the Table	Zone 2
B	Tank vehicle and tank car loading and unloading†	Within 3 m in all directions from connections regularly made or disconnected from product transfer	Zone 1
		Beyond 3 m but within 7.5 m in all directions from a point where connections are regularly made or disconnected and within the cylindrical volume between the horizontal equator of the sphere and grade (see Diagram 7)	Zone 2
C	Gauge vent openings other than those on TC/CTC/DOT cylinders and ASME vertical containers of less than 454 kg water capacity	Within 1.5 m in all directions from point of discharge	Zone 1
		Beyond 1.5 m but within 4.5 m in all directions from point of discharge	Zone 2
D	Relief device discharge other than those on CTC/DOT cylinders and ASME vertical containers of less than 454 kg water capacity	Within direct path of discharge‡	Zone 1
		Within 1.5 m in all directions from point of discharge	Zone 1
		Beyond 1.5 m but within 4.5 m in all directions from point of discharge except within the direct path of discharge	Zone 2
E	Pumps, vapour compressors, gas-air mixers, and vapourizers (other than direct-fired or indirect-fired with an attached or adjacent gas-fired heat source)	—	—
	Indoors without ventilation	Entire room and any adjacent room not separated by a gas-tight partition	Zone 1
		Within 4.5 m of the exterior side of any exterior wall or roof that is not vapour-tight or within 4.5 of any exterior opening	Zone 2
	Indoors with adequate ventilation	Entire room and any adjacent room not separated by a gas-tight partition	Zone 2
	Outdoors in open air at or above grade	Within 4.5 m in all directions from this equipment and within the cylindrical volume between the horizontal equator of the sphere and grade (see Diagram 8)	Zone 2
F	Service Station Dispensing Units	Entire space within dispenser's enclosure, or up to a solid partition within the enclosure at any height above the base. The space within 450 mm horizontally from the dispenser enclosure up to 1.2 m above the base or to the height of a solid partition within the enclosure. Entire pit or open space beneath the dispenser.	Zone 1
		The space above a solid partition within the dispenser enclosure. The space up to 450 mm above grade within 6 m horizontally from any edge of the dispenser enclosure§	Zone 2

(Continued)

Table 63
(Continued)

Part	Location	Extent of Hazardous Locations*	Zone of Class I, Group IIA Hazardous Location
G	Pits or trenches containing or located beneath propane gas valves, pumps, vapour compressors, regulators, and similar equipment	—	—
	Without mechanical ventilation	Entire pit or trench	Zone 1
		Entire room and any adjacent room not separated by a gas-tight partition	Zone 2
		Within 4.5 m in all directions from pit or trench when located outdoors	Zone 2
	With adequate mechanical ventilation	Entire pit or trench	Zone 2
		Entire room and any adjacent room not separated by a gas-tight partition	Zone 2
		Within 4.5 m in all directions from pit or trench when located outdoors	Zone 2
H	Special buildings or rooms for storage of portable containers	Entire room	Zone 2
I	Pipelines and connections containing operational bleeds, drips, vents, or drains	Within 1.5 m in all directions from point of discharge	Zone 1
		Beyond 1.5 m from point of discharge, same as Part E of this Table	—
J	Container Filling	—	—
	Indoors with adequate ventilation	Within 1.5 m in all directions from the dispensing hose inlet connections for product transfer	Zone 1
		Beyond 1.5 m and entire room	Zone 2
	Outdoors in open air	Within 1.5 m in all directions from the dispensing hose inlet connections for product transfer	Zone 1
		Beyond 1.5 but within 4.5 m in all directions from the dispensing hose inlet connections and within the cylindrical volume between the horizontal equator of the sphere and grade (see Diagram 9)	Zone 2
K	Outdoor storage area for portable cylinders or containers	—	—
	Aggregate storage up to and including 454 kg water capacity	Within 1.5 m in all directions from connections	Zone 2
	Aggregate storage over 454 kg water capacity	Within 4.5 m in all directions from connections	Zone 2

* The classified area shall not extend beyond an unpierced wall, roof, or solid vapour-tight partition.
† When classifying extent of hazardous area, consideration shall be given to possible variations in the locating of tank cars and tank vehicles at the unloading points and the effect these variations of location may have on the point of connection.
‡ Fixed electrical equipment should not be installed in this space.
§ For pits within this area, see Part G of this Table.

20-034 Hazardous Areas

In container refill centres and in filling plants the hazardous areas shall be classified as listed in Table 63.

Table 63 "Hazardous Areas for Propane Dispensing, Container Filling, and Storage," outlines the required area classification for the types of operations that take place at facilities handling propane. Note that for indoor facilities, adequate ventilation may be used to achieve a Zone 2 classification. It is also important to be aware that Zone 2 locations are those where flammable concentrations of gas or vapour will exist only for short periods. API RP 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2* suggests that is less than 10 hours per year. Equipment certified for use in Zone 2 Hazardous Locations may be unsafe to use in facilities where explosive concentrations of gas can go undetected for longer periods. In these facilities, combustible gas detectors can be used to detect the presence of abnormal gas concentrations to allow corrective action to be taken within a short period.

20-036 Wiring and Equipment in Hazardous Areas

(1) All electrical wiring and equipment in the hazardous areas referred to in Rule 20-034 shall conform to the requirements of Section 18.

Unless modified by other rules in this section the wiring and equipment requirements in Section 18 will apply to Hazardous Locations in gasoline dispensing and service stations.

(2) Where dispensing devices are supplied by rigid metal conduit, the requirements of Rule 20-006(2) and (3) shall be met.

This requires the use of a flexible conduit or fitting and a union. See note to Rule 20-006 for more detail.

20-038 Sealing

(1) Seals shall be installed as required by Section 18 and the requirements shall be applied to horizontal as well as vertical boundaries of the defined hazardous locations.

Section 18 requires the use of seals in conduit at the boundaries of the different Hazardous Locations to prevent the transmission of gas through the conduit to a less or nonhazardous location. It is important to note that conduit seals are not intended to prevent the passage of liquids, gases or vapours at a continuous pressure differential across the seal. Where this is possible, other means should be used to ensure propane does not migrate past seals. See Rule 18-072 Flammable fluid seals. Note that cables with a continuous outer jacket are not required to be sealed at Hazardous Location boundaries.

(2) Seals for dispensing devices shall be provided as required by Rule 20-012.

Seals for dispensing devices for propane dispensers follow the same rules as for gasoline dispensers as outlined in Rule 20-012.

20-040 Circuit Disconnects

Each circuit leading to or through a propane dispensing device or pump shall be provided with a switching means that will disconnect simultaneously all ungrounded conductors of the circuit from the source of supply.

A single point of disconnection is required to ensure the risk of electric shock or ignition of flammable vapours can be removed with a single operation.

20-042 Bonding

All non-current-carrying metal parts of equipment and raceways shall be bonded to ground in accordance with Section 10.

Section 10 requires that all noncurrent-carrying parts of the electrical system are bonded to ground with a properly sized bonding conductor. This is to prevent shock or ignition hazard by ensuring a conductive path of low enough impedance to properly operate protective over-current devices.

Compressed Natural Gas Refueling Stations, Compressors and Storage Facilities

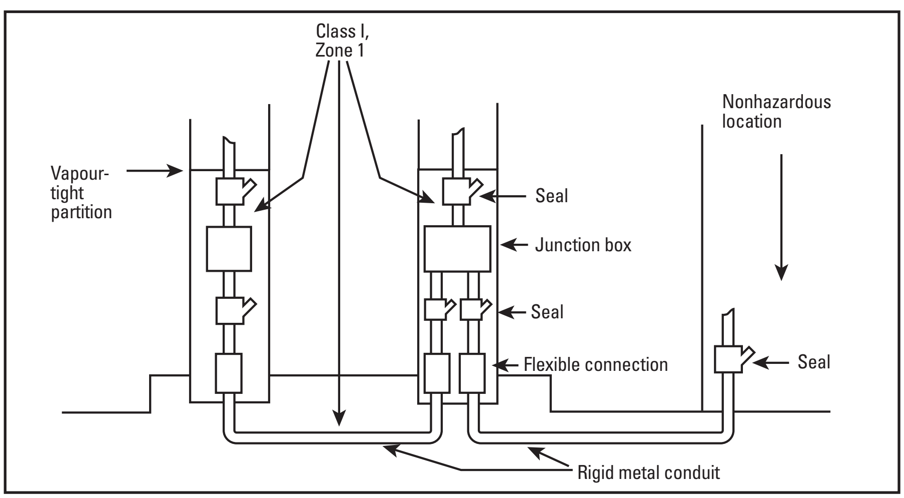
20-060 Scope (see Appendix B)

(1) Rules 20-062 to 20-070 apply to locations in which compressed natural gas is dispensed to the fuel tanks of self-propelled vehicles and to associated compressors and storage facilities.

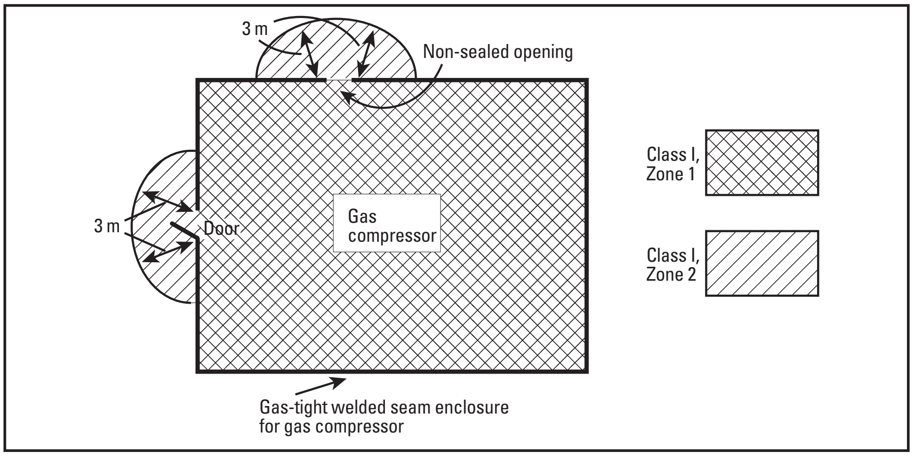
At atmospheric pressure, natural gas is lighter than air (approximately 0.6 x air). In order to store sufficient natural gas into a small enough container to power vehicles, the gas is compressed to high pressures. As compressed natural gas (CNG) is stored at a much higher pressure than either gasoline or propane, it may be released at a much higher rate. However, as CNG is lighter than air, it will rise and disperse in the air. When released in an enclosed space, it will expand rapidly to all areas within the space. Therefore, the Hazardous Location boundaries around CNG facilities will differ from those surrounding heavier than air gasoline or propane facilities.

(2) The Rules in this Section do not apply to vehicle refuelling appliances installed in accordance with CSA B149.1 that do not have storage facilities.

Facilities that connect directly to a natural gas supply, without storage facilities, are covered by CAN/CGA-B149.1 *Natural Gas Installation Code*.



Locations for sealing fittings for gasoline dispensers.



Hazardous Location around a gas compressor enclosure.

20-062 Hazardous Areas

Compressed natural gas refuelling stations, compressors, and storage facilities shall be classified as shown in Table 64.

20-064 Wiring and Equipment in Hazardous Areas

(1) All electrical wiring and equipment in the hazardous areas defined in Rule 20-062 shall comply with the requirements of Section 18.

(2) Where dispensing devices are supplied with rigid metal conduit, the requirements of Rule 20-006(2) and (3) shall be met.

A union and flexible fitting need to be installed between the conduit and the junction box in addition to any seal fitting s that may be required.

20-066 Sealing

(1) Seals shall be installed as required by Section 18, and the requirements shall be applied to horizontal as well as vertical boundaries of the defined hazardous locations.

Section 18 requires the use of seals in conduit at the boundaries of the different Hazardous Locations to prevent the transmission of gas through the conduit to a less or nonhazardous location. It is important to note that conduit seals are not intended to prevent the passage of liquids, gases or vapours at a continuous pressure differential across the seal. Section 18 now requires the use of a secondary seal where these possibilities exist.

Note that cables with a continuous outer jacket are not required to be sealed at Hazardous Location boundaries.

(2) Seals for dispensing devices shall be provided as required by Rule 20-012.

Seals for dispensing devices for propane dispensers follow the same rules as for gasoline dispensers as outlined in Rule 20-012.

20-068 Circuit disconnects

Each circuit leading to a compressor or a dispensing device shall be provided with a switching means that will disconnect simultaneously all ungrounded conductors of the circuit from the source of supply.

20-070 Bonding

All non-current-carrying metal parts of equipment and raceways shall be bonded to ground in accordance with Section 10.

Section 10 requires that all noncurrent-carrying parts of the electrical system are bonded to ground with a properly sized bonding conductor. This is to prevent shock or ignition hazard by ensuring a conductive path of low enough impedance to properly operate protective over-current devices. Also see Rule 18-074 Bonding in Hazardous Locations.

Commercial Garages—Repairs and Storage

20-100 Scope

Rules 20-102 to 20-114 apply to locations used for service and repair operations in connection with self-propelled vehicles in which volatile flammable liquids or flammable gases are used for fuel or power, and locations in which more than three such vehicles are, or may be, stored at one time.

The scope of this section states that it applies to facilities in which vehicles using volatile flammable liquids or flammable gases for fuel are serviced or repaired. However, the area classifications outlined herein are suitable for vehicles fueled by gasoline. If vehicles using highly volatile liquids such as propane, or lighter than air gas such as compressed natural gas, are serviced or repaired, it may be appropriate to extend the area classification above grade to include the area up to the ceiling.

While the following rules outline the area classification for various areas, it will also be necessary to specify the gas Group and the maximum permissible surface temperature for electrical equipment used in the Hazardous Locations. If propane and gasoline or natural gas fueled vehicles are used, the gas Group will be Group D. Ignition temperatures for these gases can be found in 18-052.

Table 64
(See Rule 20-064)
Class I, Zone 1 Space Surrounding Compressed Natural Gas (CNG) Storage Facilities

Storage Volume Water Capacity (L)	Distance Measured from Containers in Metres*
Up to and including 4000	2.5
Over 4000, up to and including 10 000	4
Over 10 000	10

*When a wall with a 4-hour fire resistance rating is located within these distances, the distances shall be measured either around the end of or over the wall, but not through it. This wall shall not be located closer than 1 m from a fuel container up to 10 000 L in storage volume, and 1.5 m from a fuel container with a storage volume greater that 10 000 L.

Where the wall of an adjacent building other than a compressor enclosure is within the specified distance and serves as the 4-hour fire resistance rated wall, it shall have no doors, windows, or openings in it unless the building is also classified as a Class I, Zone 1 location.

20-102 Hazardous Areas

(1) For each floor at or above grade, the entire area up to a level 50 mm above the floor shall be considered a Class I, Zone 2 location except that showrooms shall not be classified as hazardous locations, provided that they are

(a) elevated from a service and repair area by at least 50 mm; or

(b) separated from a service and repair area by tight-fitting barriers such as curbs, ramps, or partitions at least 50 mm high.

There is potential for gasoline to leak from the vehicles in these types of operations. As gasoline vapours are heavier than air and the volume of material released would be limited, the area for 50 mm above the floor level is classified as a Class I, Zone 2 Hazardous Location. Showrooms sufficiently above (50mm) or separate from the service and repair areas where potential leaks would occur are exempt from being classified as hazardous locations.

(2) For each floor below grade, the entire area up to a level 50 mm above the bottom of outside doors or other openings that are at, or above, grade level shall be considered a Class I, Zone 2 location except that, where adequate ventilation is provided, the hazardous location shall extend up to a level of only 50 mm above each such floor.

It is assumed that any heavier than air vapours will exit the building through the entry doors. Below the door level the vapours will tend to build up until they reach the bottom of the outside door. Therefore, it is necessary to classify the area up to 50 mm above the bottom of the door level. If “adequate ventilation” is provided to continuously remove the vapours, the hazardous area extends only to 50 mm above floor level. NFPA 30 (Flammable and Combustible Liquids Code) considers ventilation to be “adequate” if it is sufficient to prevent accumulation of significant quantities of vapor-air mixtures in concentrations one fourth (25%) of the lower flammable limit.

(3) Notwithstanding Subrule (2), in storage garages only the area up to a level of 50 mm above each floor that is below grade shall be considered a Class I, Zone 2 location.

As the risk of leakage in a storage garage (where no work is being done) is much lower than in a repair facility, the area classification will extend to 50 mm above the garage floor when the floor is below grade.

(4) Any pit or depression below floor level shall be considered a Class I, Zone 2 location that extends up to the floor level.

Heavier than air vapours may collect in the pit or depression up to the floor level.

(5) Adjacent areas in which hazardous vapours are not likely to be released, such as stockrooms, switchboard rooms, and other similar locations having floors elevated at least 50 mm above the adjacent garage floor, or separated from the garage floor by tight-fitting barriers such as curbs, ramps, or partitions at least 50 mm high, shall not be classed as hazardous.

The area classification above the floor level will extend into adjacent rooms or areas unless the hazardous vapours are blocked by a raised curb or floor extending to the top of the Hazardous Location. The curb or elevated floor will block vapours from entering the adjacent rooms or areas.

20-104 Wiring and Equipment in Hazardous Areas

Within hazardous areas as defined in Rule 20-102, wiring and equipment shall conform to the applicable requirements of Section 18.

Unless modified by other rules in this section the wiring and equipment requirements in Section 18 will apply to Hazardous Locations in gasoline dispensing and service stations.

20-106 Wiring Above Hazardous Areas

As gasoline vapours are heavier than air and will remain near floor level, the area above the hazardous areas can be classified as nonhazardous and wiring requirements in Section 12 can be applied. Where vehicles with lighter than air fuel (natural gas and, in the future, hydrogen), it may be necessary to classify the building up to the ceiling, in which case this rule would not apply.

(1) All fixed wiring above hazardous areas shall be in accordance with Section 12 and suitable for the type of building and occupancy.

(2) For pendants, flexible cord of the hard-usage type shall be used.

(3) For connection of portable luminaires, portable motors, or other portable utilization equipment, flexible cord of the hard-usage type shall be used.

Extra-hard usage cord would also be acceptable.

20-108 Sealing

(1) Seals shall be installed as required by Section 18, and the requirements of Rule 18-154(1)(b) shall include horizontal and vertical boundaries.

Section 18 requires the use of seals in conduit at the boundaries of the different Hazardous Locations to prevent the transmission of gas through the conduit to a less or nonhazardous location. It is important to note that conduit seals are not intended to prevent the passage of liquids, gases or vapours at a continuous pressure differential across the seal. Where this is possible, other means should be used to ensure propane does not migrate past seals. These means will typically involve some method of relieving the pressure buildup.

Note that cables with a continuous outer jacket are not required to be sealed at Hazardous Location boundaries.

(2) Raceways embedded in a floor or buried beneath a floor shall be considered to be within the hazardous area above the floor if any connections or extensions lead into or through such an area.

Conduits with fittings or couplings in the hazardous area will be considered to be within the hazardous area and will require a sealing fitting be installed in the conduit. The requirements for cables are somewhat different. If the termination on the cable is within the hazardous area, a sealing connector will only be required if the cable is less than 10 metres in length. (See rule 18-158(1)(b).)

20-110 Equipment Above Hazardous Areas (see Appendix I)

(1) Fixed equipment that is less than 3.6 m above the floor level and that may produce arcs, sparks, or particles of hot metal, such as cut-outs, switches, charging panels, generators, motors, or other equipment (excluding receptacles and luminaires) having make-and-break or sliding contacts, shall be of the totally enclosed type or constructed to prevent escape of sparks or hot metal particles.

Equipment that may produce arcs or sparks or that may expel particles of hot metal must be enclosed to ensure that materials that may ignite vapours below will not be released.

(2) Permanently installed luminaires that are located over lanes through which vehicles are commonly driven shall be permitted to be suitable for non-hazardous locations and shall be

(a) located not less than 3.6 m above floor level; or

(b) protected from mechanical injury by a guard or by location.

Luminaires above lanes where vehicles are driven must be located a minimum of 3.6 m above floor level. Where high vehicles such as large trucks or recreation vehicles will travel through these areas, higher mounting levels may be required.

(3) Portable luminaires shall

(a) be of the totally enclosed gasketted type, equipped with handle, lampholder, hook, and substantial guard attached to the lampholder or handle, and all exterior surfaces that may come in contact with battery terminals, wiring terminals, or other objects shall be of non-conducting materials or shall be effectively protected with an insulating jacket;

Portable luminaires may be used in the hazardous area and therefore must be enclosed and gasketed and must have guards to prevent damage to the glass enclosure. This is to ensure there is no exposed arcing should the lamp be dropped or otherwise damaged. There is also a requirement to ensure that exposed parts that could come in contact with battery terminals are made of nonconducting material so they will not be capable of shorting the battery terminals and creating an arc.

The explosionproof and dust-ignition-proof EVH portable lights are suitable for Class I, II & III, Division 1 & 2 Hazardous Locations.

(b) be unswitched type; and

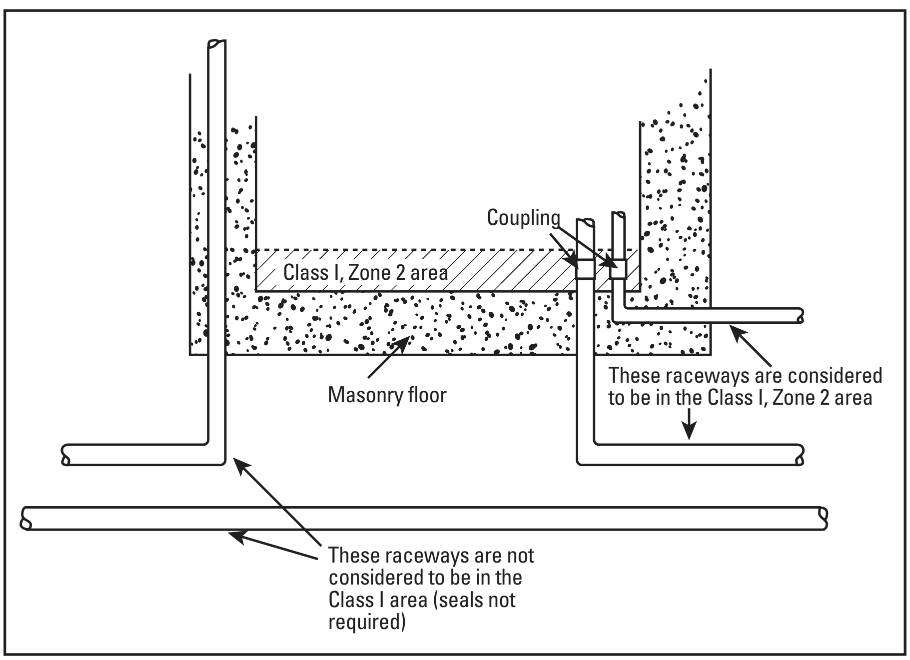
The lampholders must be unswitched as the switch would be an arcing device capable of igniting flammable vapours.

(c) not be provided with receptacles for attachment plugs.

Receptacles for attachment plugs are not allowed as the arc produced when the plug is inserted or removed could ignite flammable vapours when used in Hazardous Locations.

20-112 Battery-Charging Equipment

Battery chargers and their control equipment, and batteries being charged, shall not be located within the hazardous areas classified in Rule 20-102.



Classification for raceways passing through or buried under service station floors.

Attaching and removing clips to the battery terminals from the charger will cause arcs capable of igniting flammable vapours. Therefore, the chargers and their controls must be located outside Hazardous Locations.

20-114 Electric Vehicle Charging

(1) Flexible cords used for charging shall be of extra-hard-usage type.

The flexible cords used to connect the chargers to the batteries are subject to rough physical use and could become ignition sources if damaged. Therefore, the use of extra-hard usage cord is mandated. If damaged, cords should be immediately replaced.

(2) Connectors shall have a rating not less than the ampacity of the cord and in no case less than 50 A.

Connectors that are overloaded will overheat and could possibly become hot enough to ignite flammable vapours. Therefore, they must have an ampacity rating equal to or greater than the cord rating, but a minimum of 50 amps.

(3) Connectors shall be designed and installed so that they will break apart readily at any position of the charging cable, and live parts shall be guarded from accidental contact.

(4) No connector shall be located within the hazardous area defined in Rule 20-102.

When connectors are plugged in or removed they may create a spark capable of igniting flammable vapours. Therefore, they are not allowed to be located in a hazardous area.

(5) Where plugs are provided for direct connection to vehicles, the point of connection shall not be within a hazardous area as defined in Rule 20-102.

Inserting and removing a plug to charge a vehicle will create a spark capable of igniting flammable vapours. Therefore, the point of connection must not be located in a Hazardous Location.

(6) Where a cord is suspended from overhead, it shall be arranged so that the lowest point of sag is at least 150 mm above the floor.

(7) Where the vehicle is equipped with a plug that will readily pull apart, and where an automatic arrangement is provided to pull both cord and plug beyond the range of mechanical damage, no additional connector shall be required in the cable or outlet.

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Residential Storage Garages

20-200 Scope

Rules 20-202 to 20-206 apply to a building or part of a building in which not more than three vehicles of the type described in Rule 20-100 are, or may be, stored, but that will not normally be used for service or repair operations on stored vehicles.

Residential storage garages are only those where no more than three vehicles are stored. These locations are intended for vehicle storage only and should not normally be used to service vehicles.

20-202 Nonhazardous Location

Where the lowest floor is at or above adjacent grade or driveway level, and where there is at least one outside door at or below floor level, the garage area shall not be classed as a hazardous location.

The risk of the release of large volumes of vapours from the limited number of vehicles is very small. Providing there is at least one door at or below floor level that will allow heavier than air vapours to escape, the garage will not be classified as a Hazardous Location.

20-204 Hazardous Location

Where the lowest floor is below adjacent grade or driveway level, the following shall apply:

(a) the entire area of the garage or of any enclosed space that includes the garage shall be classified as a Class I, Zone 2 location up to a level 50 mm above the garage floor; and

(b) adjacent areas in which hazardous vapours or gases are not likely to be released, and where floors are elevated at least 50 mm above the garage floor or separated from the garage floor by tight curbs or partitions at least 50 mm high, shall not be classed as hazardous.

Where the lowest area of the garage floor is below the adjacent grade or driveway level, the entire garage or any enclosed space which includes the garage, will be classified as a Class I, Zone 2 location for a height of 50 mm above the floor. This is because the heavier than air vapours are trapped below grade level. Adjacent areas with barriers or floors a minimum of 50 mm above the level of the garage floor will not require classification as the vapours are blocked from entering them.

20-206 Wiring

(1) Wiring above the hazardous locations shall conform to Section 12.

(2) Wiring in the hazardous locations shall conform to Section 18.

Bulk Storage Plants

20-300 Scope

Rules 20-302 to 20-312 apply to locations where gasoline or other similar volatile flammable liquids are stored in tanks having an aggregate capacity of one carload or more, and from which such products are distributed (usually by tank truck).

20-302 Hazardous Areas

(1) Areas containing pumps, bleeders, withdrawal fittings, meters, and similar devices that are located in pipelines handling flammable liquids under pressure shall be classified as follows and meet the following requirements:

(a) indoor areas having adequate ventilation shall be considered Class I, Zone 2 locations within a 1.5 m distance extending in all directions from the exterior surface of such devices, as well as 7.5 m horizontally from any surface of these devices, and extending upwards to 900 mm above floor or grade level, provided that the following conditions are met:

The extended Hazardous Location 900 mm above floor level is intended to respond to the fact that the vapours are heavier than air and will extend outward from the source near ground level.

Often, in indoor facilities housing pipeline components containing volatile flammable liquids, the entire interior of the building is classified. This is based on the possibility of release of large volumes of flammable liquid, which will give off large volumes of vapours that may spread to all areas of the building. As well, the Hazardous Location will normally extend beyond the confines of the building to include areas outside that may be exposed to explosive vapour atmospheres as the flammable gas or vapour leaks out of the building.

Adequate ventilation deals with the ventilation required to dilute or sweep out the normal or "fugitive emissions" that are continuously occurring. The ventilation will not be sufficient to ensure explosive gas atmospheres do not occur in large areas of the building as a result of a large "abnormal" release of volatile liquid. NFPA 30 (Flammable and Combustible Liquids Code) considers ventilation to be "adequate" if it is sufficient to prevent accumulation of significant quantities of vapor-air mixtures in concentrations one fourth (25%) of the lower flammable limit. Note that the definition for Zone 2 locations in Section 18 requires that when abnormal situations resulting in ignitable concentrations of gas or vapour occur, they will exist for a short time only. API RP 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*, suggests as a "rule of thumb" the maximum time ignitable concentrations of gas should be present in a Zone 2 location is 10 hours per year. Equipment designed for use in Zone 2 locations is not suitable for use in areas where it will be exposed to ignitable concentrations of gas or vapour for longer periods.

For unattended facilities, it is recommended that users review the Zone 2 area classification Rule 18-006(c) and the Appendix B item to that rule.

(i) design of the ventilation systems takes into account the relatively high relative density of the vapours;

The ventilation system must be designed to ensure dilution of the heavier than air vapours that collect near floor level.

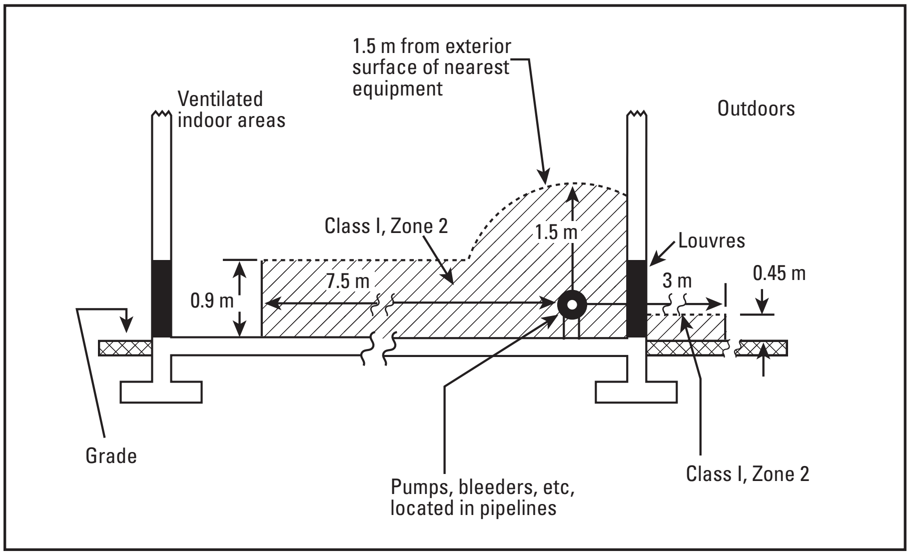
(ii) where openings are used in outside walls, they are of adequate size and located at floor level unobstructed except by louvres or coarse screens; and

Ventilation openings should not be blocked off unless it can be demonstrated they are not required to achieve "adequate ventilation."

(iii) where natural ventilation is inadequate, mechanical ventilation is provided;

Adequate ventilation refers not only to the rate of ventilation but also requires that all areas of the building are adequately ventilated. As the vapours in Bulk Storage Plants are normally heavier than air, it will be important to ensure that the areas near floor level are ventilated in a manner that will ensure there are no "dead spots" where vapours can collect.

(b) indoor areas not having adequate ventilation in accordance with Subrule (1)(a) shall be considered Class I, Zone 1 locations within a 1.5 m distance extending in all directions from the exterior surface of such devices as well as 7.5 m horizontally from any surface of the device and extending upward 900 mm above floor or grade level; and



Ventilated indoor bulk flammable liquid storage area.

It is normal in most indoor facilities housing pipeline components containing volatile flammable liquids, to classify the entire interior of the building. This is based on the possibility of release of large volumes of flammable liquid, that will in turn give off large volumes of vapours that may spread to areas well above floor level. As well the Hazardous Location will normally extend beyond the confines of the building to include areas outside that may be exposed to explosive vapour atmospheres as the result of an abnormal release inside the building.

(c) outdoor areas shall be considered Class I, Zone 2 locations within a 900 mm distance extending in all directions from the exterior surface of such devices as well as up to 450 mm above grade level within 3 m horizontally from any surface of the devices.

The extended Hazardous Location is intended to respond to the fact that the vapours are heavier than air and will expand near ground level.

(2) Areas where flammable liquids are transferred shall be classified as follows:

(a) in outdoor areas or where adequate ventilation is provided in indoor areas in which flammable liquids are transferred to individual containers, such areas shall be considered a Class I, Zone 1 location within 900 mm of the vent or fill opening extending in all directions and a Class I, Zone 2 location within the area extending between a 900 mm and 1.5 m radius from the vent or fill opening extending in all directions, and including the area within a horizontal radius of 3 m from the vent or fill opening and extending to a height of 450 mm above floor or grade levels; or

Where large amounts of volatile flammable liquids are transferred, large volumes of vapours may be produced that will extend beyond the Zone 1 boundary. Where possible, vapours from containers should be vented outside the building during transfer operations.

(b) where adequate ventilation is not provided in indoor areas in which flammable liquids are transferred to individual containers, such areas shall be considered a Class I, Zone 1 location.

This will often include the entire indoor area.

(3) Areas in outside locations where loading and unloading of tank vehicles and tank cars takes place shall be classified as follows:

(a) the area extending 900 mm in all directions from the dome when loading through an open dome or from the vent when loading through a closed dome with atmospheric venting shall be considered a Class I, Zone 1 location;

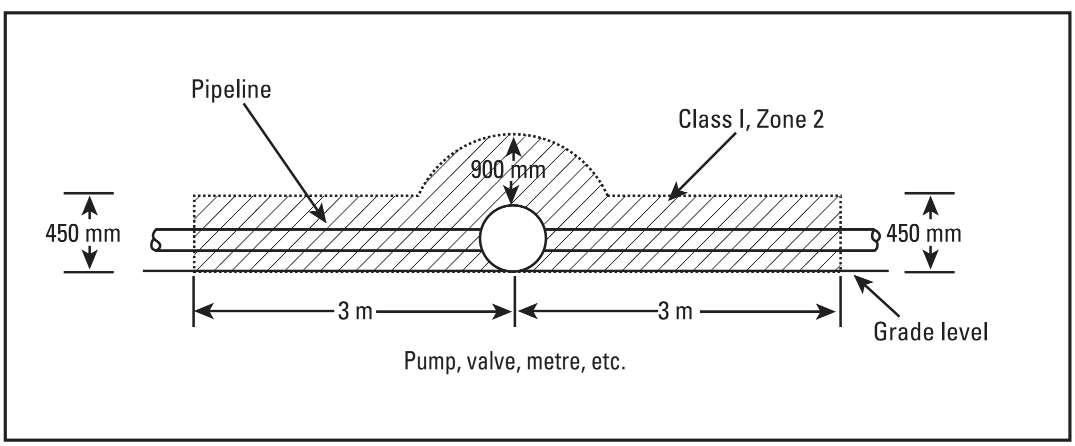
(b) the area extending between a 900 mm and a 1.5 m radius from the dome when loading through an open dome or from the vent when loading through a closed dome with atmospheric venting shall be considered a Class I, Zone 2 location;

(c) the area extending within 900 mm in all directions from a fixed connection used in bottom loading or unloading, loading through a closed dome with atmospheric venting, or loading through a closed dome with a vapour recovery system shall be considered a Class I, Zone 2 location, except that in the case of bottom loading or unloading this classification shall also be applied to the area within a 3 m radius from the point of connection and extending 450 mm above grade; and

(d) the internal space of tank vehicles and tank cars shall be a Zone 0 location.

(4) Areas within the vicinity of above-ground tanks shall be classified as follows:

(a) the area above the roof and within the shell of a floating roof type tank shall be considered a Class I, Zone 1 location;



Outdoor bulk flammable liquid storage area.

The vapours from the liquids contained in floating roof tanks will be heavier than air. As a result, they will tend to collect in the space between the floating roof and the top of the tank. As this is a normal operating condition, the area classification will be Class I, Zone 1.

(b) for all types of above-ground tanks:

(i) the area within 3 m from the shell, ends, and roof of other than a floating roof shall be considered a Class I, Zone 2 location; and

When tanks are being filled, heavier than air vapours are forced out the vents and will migrate over the surface of the tank towards ground level. Therefore, it is necessary to classify an area around the shell of the tank.

(ii) where dikes are provided, the area inside the dike and extending upwards to the top of the dike shall be considered a Class I, Zone 2 location;

(c) the area within 1.5 m of a vent opening and extending in all directions shall be considered a Class I, Zone 1 location;

(d) the area between 1.5 m and 3 m of a vent opening and extending in all directions shall be considered a Class I, Zone 2 location; and

(e) the vapour space above a liquid in a storage tank shall be considered a Zone 0 location.

The vapours in the vapour space above the liquid in a vented tank can be within the explosive range for long periods of time. Therefore, that space will be classified as a Class I, Zone 0 Hazardous Location and electrical equipment used in that area must be intrinsically safe type Ex-ia.

(5) Pits and depressions shall be classified as follows:

(a) any pit or depression, any part of which lies within a Zone 1 or Zone 2 location unless provided with adequate ventilation, shall be considered a Class I, Zone 1 location;

As the vapours associated with Bulk Storage areas are heavier than air, they will tend to accumulate in below grade areas.

As a result those areas may contain ignitable concentrations of vapours for relatively long periods of time, and will therefore meet the definition for Class I, Zone 1 Hazardous Locations.

(b) any such areas, when provided with adequate ventilation, shall be considered a Class I, Zone 2 location; and

When these below grade areas are ventilated, any collected vapours will be removed and the below grade areas will assume the same area classification as the surrounding Class I, Zone 2 area.

(c) any pit or depression not within a Zone 1 or Zone 2 location as defined in this Section but that contains piping, valves, or fittings shall be considered a Class I, Zone 2 location.

Leakage from the valves could release sufficient vapours to create an explosive atmosphere in the below grade area. Therefore, the area will require classification, not as a result of the surrounding area, but as a result of the sources in the below grade area.

(6) Garages in which tank vehicles are stored or repaired shall be considered a Class I, Zone 2 location up to 450 mm above floor or grade level, unless conditions warrant more severe classification or a greater extent of the hazardous area.

This classification is more rigorous than that specified for commercial repair or service garages (i.e. the Zone 2 location extends to 450 mm above the floor as opposed to 50 mm in commercial garages). This is due to the fact that the type of vehicles typically stored in garages at bulk storage plants may carry considerably larger volumes of volatile flammable liquids. A condition that could warrant a more severe classification would be the use of a garage for housing vehicles carrying compressed natural gas or propane. This is not to suggest this is the only condition that could lead to a more severe classification.

(7) Buildings such as office buildings, boiler rooms, etc., that are outside the limits of hazardous areas as defined in this Section and that are not used for handling or storage of volatile flammable liquids or containers for such liquids shall not be considered hazardous locations.

20-304 Wiring and Equipment in Hazardous Areas

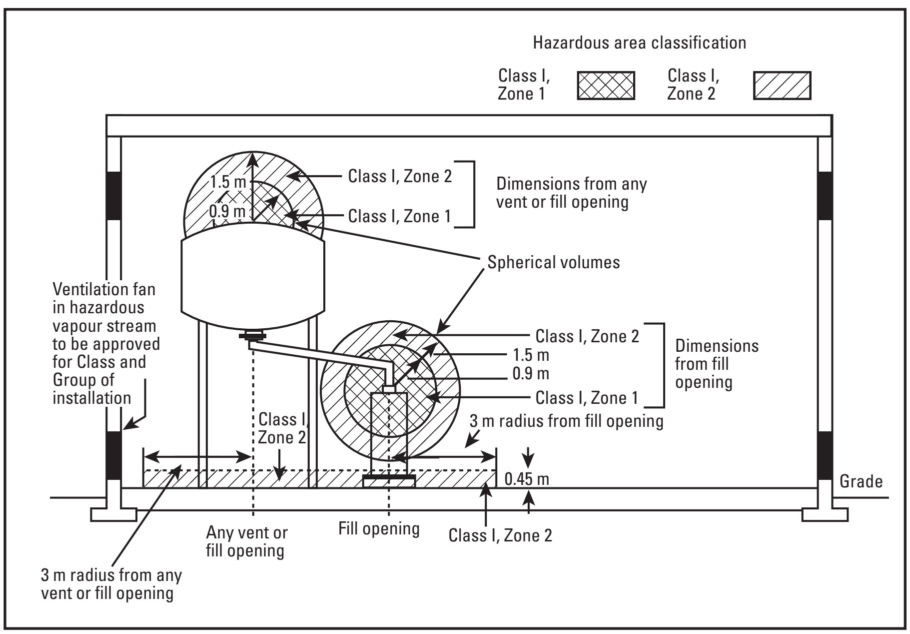
All electrical wiring and equipment in hazardous areas defined in Rule 20-302 shall conform to the requirements of Section 18.

20-306 Wiring and Equipment Above Hazardous Areas

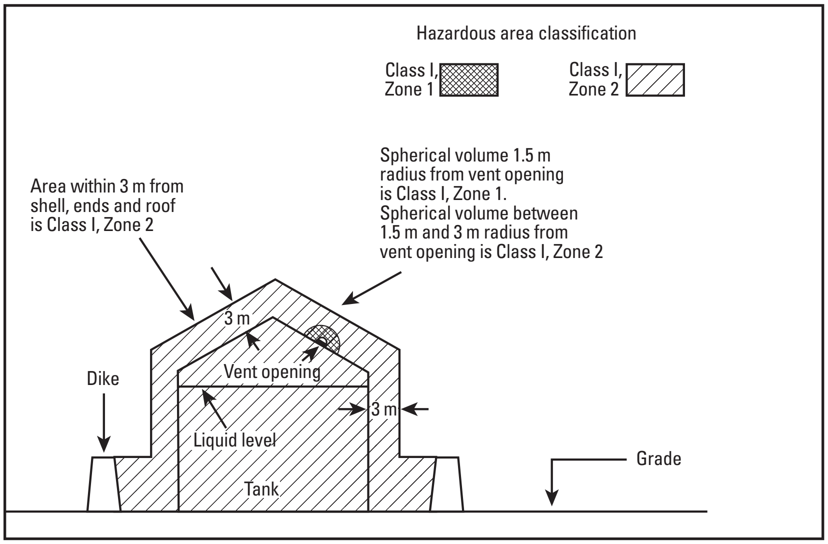
(1) Wiring installed above a hazardous location shall conform to the requirements of Section 12 and be suitable for the type of building and the occupancy.

As wiring installed above Hazardous Locations is not actually in the Hazardous Locations, it will not be required to meet the wiring rules in Section 18. It will however be required to meet the requirements in Section 12.

(2) Fixed equipment that may produce arcs, sparks, or particles of hot metal, such as lamps and lampholders, cut-outs, switches, receptacles, motors, or other equipment having make-and-break or sliding contacts, shall be of the totally enclosed type or constructed to prevent the escape of sparks or hot metal particles.



Ventilated indoor transfer of flammable liquids to individual containers.

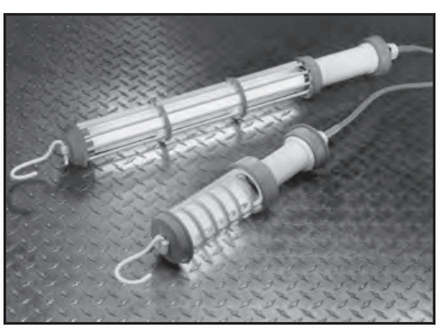


Area classification around vent in bulk flammable liquid storage tank.

Equipment that may produce arcs or sparks or that may expel particles of hot metal must be suitably enclosed to ensure that materials that may ignite heavier than air vapours in the hazardous area near grade will not be released.

(3) Portable lamps or utilization equipment and the flexible cords supplying them shall conform to the requirements of Section 18 for the class of location above which they are connected or used.

Portable lamps are often subject to physical damage. Portable lamps for use in Hazardous Locations are constructed in a manner that will ensure the lamps are not likely to create an exposed arcing source during their normal use. During periods of maintenance or construction, care should be taken to ensure that portable lamps that are not rated for Hazardous Locations are not inadvertently used in a Hazardous Location. A common misconception when using portable lamps in hazardous areas is that it is acceptable to use a general purpose portable lamp as long as it is plugged into a receptacle in a nonhazardous area. No part of a general purpose portable lamp should be used in a hazardous area.



The EVH is certified for use in Class I, Div. 1 & 2, Groups C, D and Class II, Div. 1, Groups E, F, G locations.

20-308 Sealing

(1) Seals shall be installed in accordance with Section 18 and shall be applied to horizontal as well as vertical boundaries of the defined hazardous locations.

Section 18 requires the use of seals in conduit at the boundaries of the different Hazardous Locations to prevent the transmission of gas through the conduit to a less or nonhazardous location. It is important to note that conduit seals are not intended to prevent the passage of liquids, gases or vapours at a continuous pressure differential across the seal. Where this is possible, other means should be used to ensure liquids, gas or vapours do not migrate past seals. These means will typically involve some method of relieving the pressure buildup.

Note that cables with a continuous outer jacket are not required to be sealed at Hazardous Location boundaries.

(2) Buried raceways under defined hazardous areas shall be considered within such areas.

Due to the possibility that the ground under the hazardous areas may contain spilled hydrocarbons, there is a possibility that the buried conduit or cable will also be exposed to the hydrocarbons. Therefore, the raceways are considered to be in the same hazardous area as the surface and must use wiring methods and sealing as required for that area classification as outlined in Section 18.

20-310 Gasoline Dispensing

Where gasoline dispensing is carried on in conjunction with bulk station operations, the applicable provisions of Rules 20-002 to 20-014 inclusive shall apply.

The same area classification as in the “Gasoline and Service Stations” section will apply in the area of the dispensers. The remainder of the rules in that section will also apply to the wiring and electrical equipment in the area.

20-312 Bonding

All noncurrent-carrying metal parts of equipment and raceways shall be bonded to ground in accordance with Section 10.

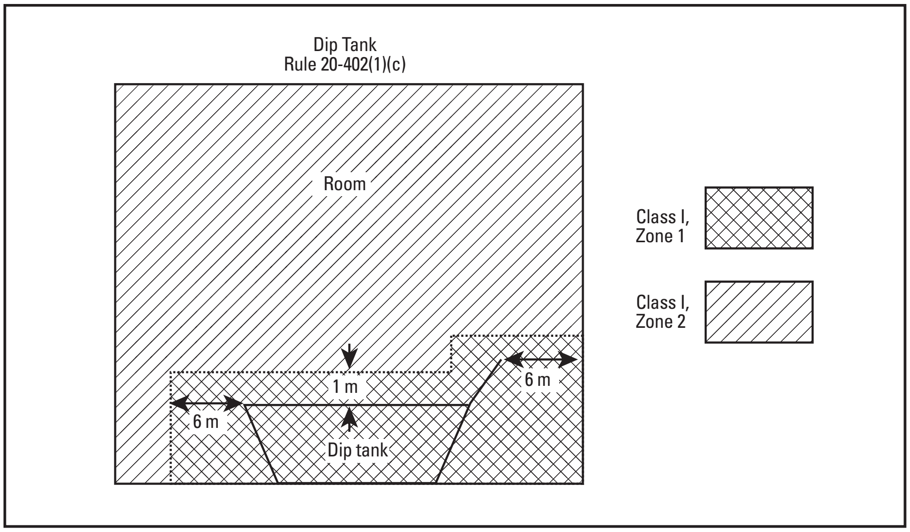
Section 10 requires that all noncurrent-carrying parts of the electrical system are bonded to ground with a properly sized bonding conductor. This is to prevent shock or ignition hazard by ensuring a conductive path of low enough impedance to properly operate protective over-current devices. Also see Rule 18-074 Bonding in hazardous locations.

Finishing Processes

20-400 Scope

Rules 20-402 to 20-414 apply where paints, lacquers, or other flammable finishes are regularly or frequently applied by spraying, dipping, brushing, or by other means, and where volatile flammable solvents or thinners are used or where readily ignitable deposits or residues from such paints, lacquers, or finishes may occur.

This section applies to finishing processes using flammable finishes. Finishing processes using nonflammable finishes, such as water-based paints, are outside the scope of this section.



Classification of areas surrounding dip tank and drain board.

20-402 Hazardous Locations

(1) The following areas shall be considered Class I, Zone 1 locations:

(a) where adequate ventilation is provided, the interiors of spray booths and their exhaust ducts;

The interior of paint spray booths and the exhaust ducts are classified as Zone 1 locations as it will be normal to have ignitable concentrations of vapour or mist during the painting operation. This is consistent with the definition for Zone 1 in Rule 18-006.

(b) all space within 6 m horizontally in any direction, extending to a height of 1 m above the goods to be painted, from spraying operations more extensive than touch-up spraying and not conducted within the spray booth, and as otherwise shown in Diagram 5;

Where paint spraying is not conducted within a spray booth, the Zone 1 hazardous area will extend 6 metres horizontally to a height of 1 metre above the goods to be painted. The remainder of the room will be classified as a Zone 2 hazardous area.

(c) all space within 6 m horizontally in any direction from dip tanks and their drain boards with the space extending to a height of 1 m above the dip tank and drain board; and

In addition to the Zone 1 hazardous area outlined in (c) above, Subrule 4 requires the remainder of the room to be classified as a Class I, Zone 2 Hazardous Location.

(d) all other spaces where hazardous concentrations of flammable vapours are likely to occur.

(2) For spraying operations within an open-faced spray booth, the extent of the Class I, Zone 2 location shall extend not less than 1.5 m from the open face of the spray booth, and as otherwise shown in Diagram 4.

When the spray booth has an open side, the hazardous vapours from the painting operation will extend outside the open face. A Class I, Zone 2 Hazardous Location must extend a minimum of 1.5 metres horizontally from the open face. The Zone 2 area will extend to floor level and 1 metre above the booth. Note that these are minimum dimensions. Where heavy spraying may create ignitable concentrations of flammable vapour beyond the dimensions given, these dimensions must be extended to cover the whole area where ignitable concentrations can occur. It is the responsibility of the owner to ensure the area around a spray booth is properly classified.

(3) For spraying operations confined within a closed spray booth or room or for rooms where hazardous concentrations of flammable vapours are likely to occur, such as paint mixing rooms, and as otherwise shown in Diagram 10, the space within 1 m in all directions from any openings in the booth or room shall be considered a Class I, Zone 2 location.

This is intended to classify an area outside these rooms around openings where ignitable concentrations of vapours may occur as a result of leakage from the rooms. Note that the openings referred to here would normally be closed when the spraying operation is in progress.

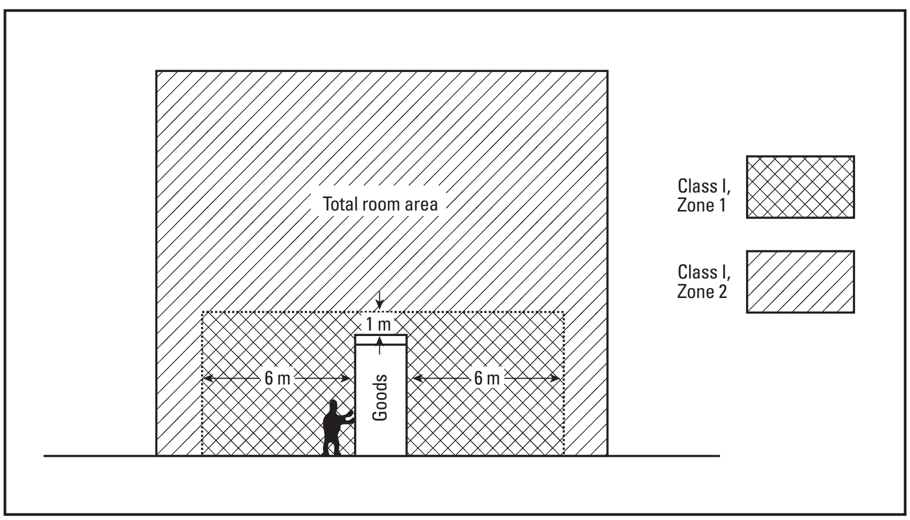
(4) All space within the room but beyond the limits for Class I, Zone 1 as classified in Subrule (1) for extensive open spraying, and as otherwise shown in Diagram 5 for dip tanks and drain boards and for other hazardous operations, shall be considered to be Class I, Zone 2 locations.

For rooms where open spraying or other open operations take place, it is assumed that the vapours may spread beyond the Zone 1 area from time to time. Therefore, the remainder of the room is classified Class I, Zone 2.

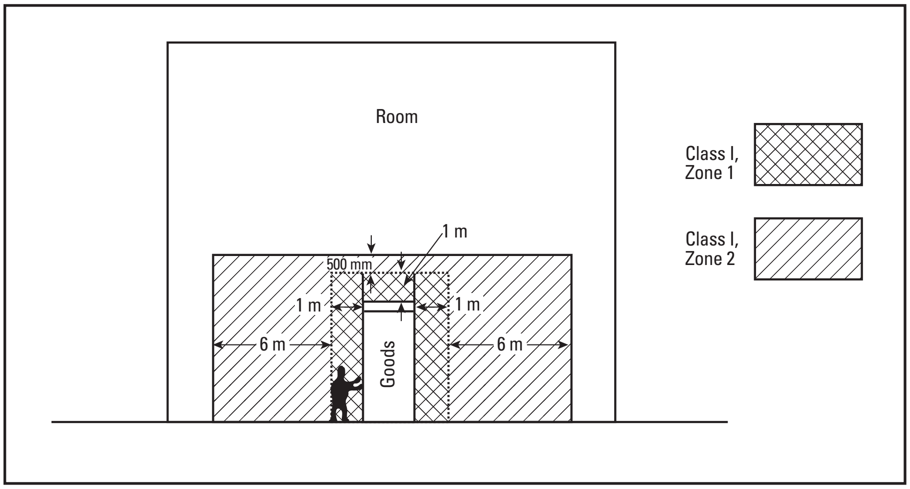
(5) Adjacent areas that are cut off from the defined hazardous area by tight partitions without communicating openings, and within which hazardous vapours are not likely to be released, shall be permitted to be classed as non-hazardous.

Walls that will prevent the passage of vapours at atmospheric pressure, will limit the extent of the hazardous area.

(6) Drying and baking areas provided with adequate ventilation and effective interlocks to de-energize all electrical equipment not approved for Class I locations in case the ventilating equipment is inoperative shall be permitted to be classed as non-hazardous.



Classification of areas where extensive open spraying is carried out without floor-level ventilation.



Classification of area with floor-level ventilation interlocked with spraying equipment.

During the drying and baking operation the volume of vapours being released is small in comparison to the volumes given off during the spraying operation. If sufficient ventilation is provided to continuously dilute those vapours to concentrations below 25% of their lower explosive limit, the area may be unclassified.

(7) Notwithstanding the requirements of Subrule (1)(b), where adequate ventilation with effective interlocks is provided at floor level, and as otherwise shown in Diagram 6:

(a) the space within 1 m horizontally in any direction from the goods to be painted and such space extending to a height of 1 m above the goods to be painted shall be considered a Class I, Zone 1 location; and

(b) all space between a 1 m and a 1.5 m distance above the goods to be painted and all space within 6 m horizontally in any direction beyond the limits for the Class I, Zone 1 location shall be considered a Class I, Zone 2 location.

Where adequate ventilation interlocked with the spraying operation is provided, the hazardous area outlined in (1)(b) is reduced to the dimensions above.

(8) Notwithstanding the requirements of Subrule (2), where a baffle of sheet metal of not less than No. 18 MSG is installed vertically above the front face of an open-face spray booth to a height of 1 m or to the ceiling, whichever is less, and extending back on the side edges for a distance of 1.5 m, the space behind this baffle shall be considered a non-hazardous location.

When a baffle is provided to prevent vapours from the open booth from traveling back over the top of the booth, the Class I, Zone 2 area classification on top of the booth is eliminated.

(9) Notwithstanding the requirements of Subrule (3), where a baffle of sheet metal of not less than No. 18 MSG is installed vertically above an opening in a closed spray booth or room to a height of 1 m or to the ceiling, whichever is less, and extends horizontally a distance of 1 m beyond each side of the opening, the space behind the baffle shall be considered a non-hazardous location.

Similar to Subrule 8, where a baffle is installed covering a Zone 2 location outside the openings referred to in Subrule 3, the Class I, Zone 2 Hazardous Location will not extend above the baffle.

20-404 Ventilation and Spraying Equipment Interlock

The spraying equipment for a spray booth shall be interlocked with the spray booth ventilation system so that the spraying equipment is made inoperable when the ventilation system is not in operation.

Interlocking shall be provided to prevent or shut down the spraying operation if the ventilation system is not running.

20-406 Wiring and Equipment in Hazardous Areas

(1) All electrical wiring and equipment within the hazardous areas as defined in Rule 20-402 shall conform to the requirements of Section 18.

Wiring in the hazardous areas defined in Rule 20-402 must meet the requirements for Class I wiring outlined in Rules 18-000 to 18-162.

(2) Unless specifically approved for both readily ignitable deposits and the flammable vapour location, no electrical equipment shall be installed or used where it may be subject to a hazardous accumulation of readily ignitable deposits or residue.

Electrical equipment suitable in Class I, Zone 1 and Zone 2 Hazardous Locations is outlined in Rules 18-100 and 18-150. In addition to meeting the requirements outlined in these rules, it is necessary the equipment is approved for the gas group corresponding to the vapours encountered, and that the equipment operating temperature is not high enough to ignite vapours or deposits.

(3) Illumination of readily ignitable areas through panels of glass or other transparent or translucent materials is permissible only where

(a) fixed lighting units are used as the source of illumination;

(b) the panel is non-combustible and effectively isolates the hazardous area from the area in which the lighting unit is located;

(c) the panel is of a material or is protected so that breakage is unlikely; and

(d) the arrangement is such that normal accumulations of hazardous residue on the surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination.

Indirect lighting systems from lighting sources located outside the spraying area are permitted providing the conditions outlined above are met. Indirect lighting systems are often preferable to locating fixtures within the booth.

(4) Portable electric lamps or other utilization equipment shall

(a) not be used within a hazardous area during operation of the finishing process;

(b) be of a type specifically approved for Class I locations when used during cleaning or repairing operations.

Portable electrical equipment or other utilization equipment such as electric tools, heaters, etc. shall not be used during spraying operations. Electrical equipment used during cleaning or repairing operations must be of a type approved for use in the hazardous area or approved as having a method of protection acceptable in the area. (See Rules 18-100 and 18-150.)

(5) Notwithstanding Subrule (2),

(a) totally enclosed and gasketted lighting shall be permitted to be used on the ceiling of a spray room where adequate ventilation is provided; and

Totally enclosed and gasketed lighting may be used on the ceiling of adequately ventilated spray booths. This rule was added to the *Code* prior to the development of cost-effective Hazardous Location lighting fixtures for use in Zone 2 locations. The use of fixtures rated for use in the area is recommended.

The VMV series is enclosed, gasketed and suitable for Zone 2 areas.

(b) infrared paint drying units shall be permitted to be used in a spray room if the controls are interlocked with those of the spraying equipment so that both operations cannot be performed simultaneously, and if portable, the paint drying unit shall not be brought into the spray room until spraying operations have ceased.

Infrared drying systems may be located in the spray booth if they are interlocked to ensure they cannot be used while the spraying operation is in progress. Portable infrared drying systems must not be brought into a spray booth until spraying operations have ceased. Use of the infrared heaters during the spraying operations creates a possible ignition hazard.

20-408 Fixed Electrostatic Equipment

Electrostatic spraying and detearing equipment shall conform to the following:

(a) no transformers, power packs, control apparatus, or other electrical portions of the equipment except high-voltage grids and their connections shall be installed in any of the hazardous areas defined in Rule 20-402, unless they are of a type specifically approved for the location;

All electrical equipment, other than electrostatic spraying and detearing equipment, shall not be installed in any of the Hazardous Locations defined in Rule 20-402 unless they are approved as a type suitable for use in the Hazardous Location.

(b) high-voltage grids or electrodes shall be

(i) located in suitable non-combustible booths or enclosures provided with adequate ventilation;

(ii) rigidly supported and of substantial construction; and

(iii) effectively insulated from ground by means of non-porous, non-combustible insulators;

(c) high-voltage leads shall be

(i) effectively and permanently supported on suitable insulators;

(ii) effectively guarded against accidental contact or grounding; and

(iii) provided with automatic means for discharging any residual charge to ground when the supply voltage is interrupted;

The high voltage leads must be supported and guarded to prevent personnel from accidentally coming in contact with them and to prevent them from contacting grounded parts, thus creating an ignition source.

(d) where goods are being processed,

(i) they shall be supported on conveyors in such a manner that minimum clearance between goods and high-voltage grids or conductors cannot be less than twice the sparking distance; and

(ii) a conspicuous sign indicating the sparking distance shall be permanently posted near the equipment;

The sparking distance is the distance at which a flashover can occur between the high voltage grids and the articles being painted (which are grounded).

(e) automatic controls shall be provided that will operate without time delay to disconnect the power supply and to signal the operator in the event of

(i) stoppage of ventilating fans;

(ii) failure of ventilating equipment;

(iii) stoppage of the conveyor carrying goods through the high-voltage field;

(iv) occurrence of a ground or of an imminent ground at any point on the high-voltage system; or

(v) reduction of clearance below that specified in Item (d); and

Automatic controls must immediately shut down the power supply to the high voltage components, and to provide an alarm, if any of the conditions outlined above occurs.

(f) adequate fencing, railings, or guards that are electrically conducting and effectively bonded to ground shall be provided for safe isolation of the process, and signs shall be permanently posted designating the process area as dangerous because of high voltage.

Fencing, railings or guards, which are bonded to ground, are required to protect personnel from coming in contact with high voltages. Proper signs alerting personnel of the potential hazards are also required.

20-410 Electrostatic Hand Spraying Equipment

Electrostatic hand spray apparatus and devices used with such apparatus shall conform to the following:

(a) the high-voltage circuits shall be intrinsically safe and not produce a spark of sufficient intensity to ignite any vapour-air mixtures, nor result in an appreciable shock hazard to anyone coming in contact with a grounded object;

Intrinsically safe circuits will limit the current in the circuit to a value lower than that required to ignite the paint vapours. The current in intrinsically safe circuits may be well above the "let go" current for humans (15 to 20 ma), therefore it cannot be assumed coming in contact with an intrinsically safe high voltage circuit will not constitute a shock hazard. Equipment is designed to prevent the operator from contacting live circuits.

(b) the electrostatically charged exposed elements of the hand gun shall be capable of being energized only by a switch that also controls the paint supply;

The switch on the hand gun must simultaneously energise the electrostatic element and turn on the paint spray.

(c) transformers, power packs, control apparatus, and all other electrical portions of the equipment, with the exception of the hand gun itself and its connections to the power supply, shall be located outside the hazardous area;

Electrical power and control equipment associated with the spraying operation and not required to be located in the hazardous area, must be located outside the hazardous area.

(d) the handle of the spray gun shall be bonded to ground by a metallic connection and be constructed such that the operator in normal operating position is in intimate electrical contact with the handle in order to prevent buildup of a static charge on the operator's body;

The handle of the spray gun must be solidly bonded to ground by a metallic connection to ensure it remains at ground potential. The handle must be constructed in a manner that insures the operator's hand is in contact with it while spraying. This will ensure the operator does not develop a charge relative to ground.

(e) all electrically conductive objects in the spraying area shall be bonded to ground and the equipment shall carry a prominent permanently installed warning regarding the necessity for this bonding feature;

All electrically conductive (noncurrent-carrying) parts or objects in the spraying area must be bonded to ground to ensure they do not develop a charge relative to ground. Warning signage must be installed to explain the requirement.

(f) precautions shall be taken to ensure that objects being painted are maintained in metallic contact with the conveyor or other grounded support, and they shall include the following:

(i) hooks shall be regularly cleaned;

(ii) areas of contact shall be sharp points or knife edges; and

(iii) 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; and

It is important that all objects being painted maintain metallic contact (i.e. low resistance) with the grounded conveyor to ensure they do not develop a charge relative to ground. Equipment must be designed and maintained to ensure low resistance contact is maintained at all times.

(g) the spraying operation shall take place within a spray area that is adequately ventilated to remove solvent vapours released from the operation, and the electrical equipment shall be interlocked with the ventilation of the spraying area so that the equipment cannot be operated unless the ventilation system is in operation.

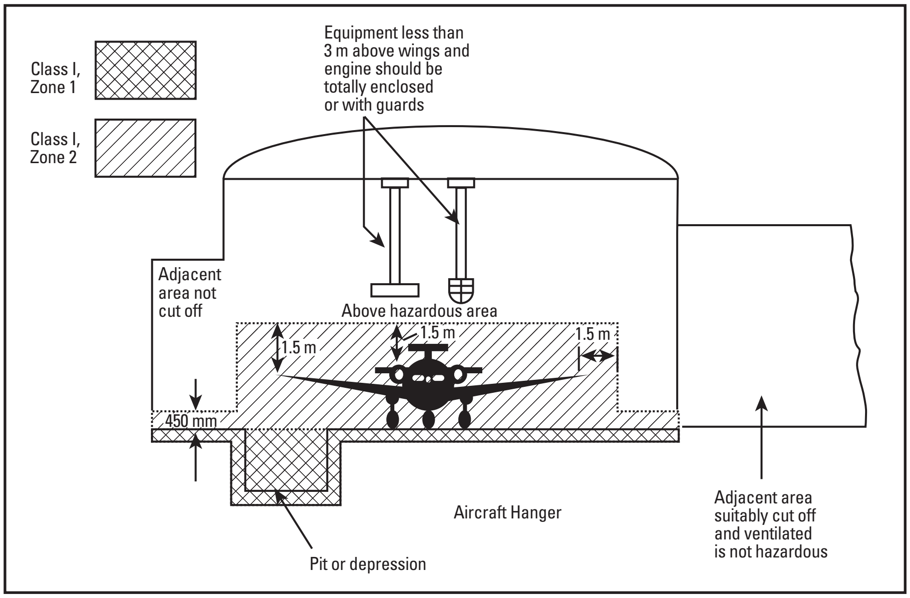
The area in which the spraying takes place must have sufficient ventilation to ensure the solvent vapours from the paint do not build up to ignitable levels. The spraying operation must be interlocked to prevent spraying if the ventilation is not running.

20-412 Wiring and Equipment Above Hazardous Areas

(1) All fixed wiring above hazardous areas shall conform to Section 12.

As wiring installed above Hazardous Locations is not actually in the Hazardous Locations, it will not be required to meet the wiring rules in Section 18. It will however be required to meet the requirements in Section 12.

(2) Equipment that may produce arcs, sparks, or particles of hot metal, such as lamps and lampholders for fixed lighting, cut-outs, switches, receptacles, motors, or other equipment having make-and-break or sliding contacts, where installed above a hazardous area or above an area where freshly finished goods are handled, shall be of the totally enclosed type or constructed to prevent the escape of sparks or hot metal particles.



Classification of areas in aircraft hangars.

Equipment that may produce arcs or sparks or that may expel particles of hot metal must be suitably enclosed to ensure that materials that may ignite heavier than air vapours in the hazardous area near grade will not be released.

20-414 Bonding

All metal raceways and all non-current-carrying metal portions of fixed or portable equipment, regardless of voltage, shall be bonded to ground in accordance with Section 10.

Section 10 requires that all noncurrent-carrying parts of the electrical system are bonded to ground with a properly sized bonding conductor. This is to prevent shock or ignition hazard by ensuring a conductive path of low enough impedance to properly operate protective over-current devices.

Aircraft Hangers

20-500 Scope

Rules 20-502 to 20-522 apply to locations used for storage or servicing of aircraft in which gasoline, jet fuels or other volatile flammable liquids, or flammable gases are used, but shall not include those locations used exclusively for aircraft that have never contained such liquids or gases, or that have been drained and properly purged.

Rules 20-502 to 20-522 apply to hangers where aircraft are stored or serviced. Aircraft stored or undergoing service normally contain fuel, which may be above its flash point. There is the possibility of flammable vapours being released from fuel tanks or the possibility of liquid fuel leaking from aircraft and producing flammable vapours. Therefore, it is necessary to classify areas of the hanger where explosive concentrations may occur and to ensure that electrical equipment located in those areas will not ignite the flammable vapours.

Hangers used only for aircraft, which have never contained fuel or from which the fuel has been drained and properly purged, are not considered to be Hazardous Locations and are not subject to the rules of this section.

20-502 Hazardous Areas

(1) Any pit or depression below the level of the hangar floor shall be considered a Class I, Zone 1 location that shall extend up to the floor level.

The vapours from aircraft fuel are heavier than air and may collect in pits or depressions below the hanger floor. As the vapours in these areas may persist for long periods, the pits or depressions must be classified as Class I, Zone 1 Hazardous Locations.

(2) The entire area of the hangar including any adjacent and communicating areas not suitably cut off from the hangar shall be considered a Class I, Zone 2 location up to a level 450 mm above the floor.

While it is not normal to have explosive concentrations of fuel vapours present in a hanger, they can occur as the result of a fuel spill. As the vapours are heavier than air they will remain near floor level. The area for 450 mm above floor level is therefore classified Class I, Zone 2.

(3) The area within 1.5 m horizontally from aircraft power plants, aircraft fuel tanks, or aircraft structures containing fuel shall be considered a Class I, Zone 2 location that extends upward from the floor to a level 1.5 m above the upper surface of wings and of engine enclosures.

In addition to the hazardous area in (2), the area outlined in (3) is also classified a Class I, Zone 2 Hazardous Location. As the hanger may contain a variety of aircraft, power plants, fuel tanks, or other fuel containing structures, it is important that in classifying the hanger for the purpose of installing permanent wiring systems, the classified area should include the area required to be classified for all possible aircraft to be stored or serviced. When servicing aircraft, it is important that staff are aware of the hazardous area around each aircraft.

(4) Adjacent areas in which hazardous vapours are not likely to be released, such as stock rooms, electrical control rooms, and other similar locations, shall be permitted to be classed as non-hazardous when adequately ventilated and when effectively cut off from the hangar itself in accordance with Rule 18-060.

This will include rooms in which the ventilation system will ensure that any vapours entering from the hanger will be diluted by a ventilation system providing "adequate ventilation." Rooms that are effectively cut off from the hanger are also are permitted to be classified as nonhazardous. Typically this requirement can be met by a wall which will not permit the passage of vapours at atmospheric pressure.

20-504 Wiring and Equipment in Hazardous Areas

(1) All fixed and portable wiring and equipment that is or may be installed or operated within any of the hazardous locations defined in Rule 20-502 shall conform to the requirements of Section 18.

Wiring in the hazardous areas defined in Rule 20-402 must meet the requirements for Class I wiring outlined in Rules 18-000 to 18-182.

(2) All wiring installed in or under the hangar floor shall conform to the requirements for Class I, Zone 1 locations.

Fuel leaking onto the floor may enter wiring systems installed in or under the hanger floor. Therefore, the wiring will be required to meet Class I, Zone 1 requirements.

(3) Wiring systems installed in pits, or other spaces in or under the hangar floor shall be provided with adequate drainage and shall not be placed in the same compartment with any other service except piped compressed air.

Where the wiring method is wire in conduit, sloping the conduit and providing drain fittings can meet the requirements in this Rule. The need is to ensure that any liquids entering the conduit system will be drained. Where cable with a continuous jacket is used, fuel will not enter the cable. It will be important to ensure the cable jacket is resistant to damage from the fuel.

(4) Attachment plugs and receptacles in hazardous locations shall be explosion-proof, or shall be designed so that they cannot be energized while the connections are being made or broken.

In addition to explosionproof attachment plugs and receptacles, attachment plugs and receptacles that will not release or admit a plug when energised may also be used.

20-506 Wiring Not Within Hazardous Areas

(1) All fixed wiring in a hangar not within a hazardous area as defined in Rule 20-502 shall be installed in metal raceways or shall be armoured cable, Type MI cable, aluminum-sheathed cable, or copper-sheathed cable, except that wiring in a non-hazardous location as set out in Rule 20-502(4) shall be permitted to be of any type recognized in Section 12 as suitable for the type of building and the occupancy.

Armoured cable used should have a continuous nonmetallic outer jacket. Common cables used for this purpose are TECK and ACWU for power and ACIC for control and instrumentation.

(2) For pendants, flexible cord of the hard-usage type and containing a separate bonding conductor shall be used.

Table 11 in the Canadian Electrical Code outlines cable types suitable for hard and extra-hard usage.

(3) For portable utilization equipment and lamps, flexible cord approved for hard usage and containing a separate bonding conductor shall be used.

(4) Suitable means shall be provided for maintaining continuity and adequacy of the bonding between the fixed wiring system and the non-current-carrying metal portions of pendant luminaires, portable lamps, and other portable utilization equipment.

Connectors, plugs, etc., used for terminating flexible cord in (2) and (3) above must be a type that will insure the noncurrent-carrying devices are adequately bonded to ground.

20-508 Equipment Not Within Hazardous Areas

(1) In locations other than those described in Rule 20-502, equipment that is less than 3 m 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, cut-outs, 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 to prevent the escape of sparks or hot metal particles, except that equipment in areas described in Rule 20-502(4) shall be permitted to be of the general-purpose type.

Equipment that could produce arcs or sparks or expel hot metal particles is required to be totally enclosed to ensure that material capable of igniting flammable vapours will not be released and drop into hazardous areas below.

(2) Lampholders of metal shell, fibre lined type shall not be used for fixed lighting.

Fibre in lampholders is subject to deterioration and failure due to the heat produced in lighting fixtures. Most industrial fixtures will use porcelain to insulate the metal shell.

(3) Portable lamps that are used within a hangar shall comply with Rule 18-118.

This requires portable lamps to be approved as complete assemblies and meeting the requirements for equipment suitable for use in a Zone 1 Hazardous Location.

(4) Portable utilization equipment that is, or may be, used within a hangar shall be of a type suitable for use in Class I, Zone 2 locations.

Portable utilization equipment, other than lamps, shall meet the requirements in Rules 18-150 to 18-162.

20-510 Stanchions, Rostrums, and Docks

(1) Electric wiring, outlets, and equipment including lamps on, or attached to, stanchions, rostrums, or docks that are located, or likely to be located, in a hazardous area as defined in Rule 20-502(3) shall conform to the requirements for Class I, Zone 2 locations.

This requires electrical equipment installed on stanchions, rostrums and docks that is used within the hazardous area surrounding airplanes to meet the requirements in Rules 18-150 to 18-162.

(2) Where stanchions, rostrums, and docks are not located, or are not likely to be located, in a hazardous area as defined in Rule 20-502(3), wiring and equipment shall conform to Rules 20-506 and 20-508, except for the following:

(a) receptacles and attachment plugs shall be of the locking type that will not break apart readily; and

(b) wiring and equipment, not more than 450 mm above the floor in any position, shall conform to Subrule (1).

Wiring and equipment within 450 mm of the floor will be in a Class I, Zone 2 Hazardous Location and will need to meet the requirements for Class I, Zone 2 contained in Rules 18-150 to 18-162.

(3) Mobile stanchions with electrical equipment conforming to Subrule (2) shall carry at least one permanently affixed warning sign, to the effect that the stanchions be kept 1.5 m clear of aircraft engines and fuel tank areas.

Mobile stanchions with electrical equipment not suitable for use in Hazardous Locations shall have a minimum of one warning sign informing staff that they are not suitable for use in the hazardous areas around airplanes.

20-512 Sealing

(1) Seals shall be installed in accordance with Section 18 and shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas.

Section 18 requires the use of seals in conduit at the boundaries of the different Hazardous Locations to prevent the transmission of gas through the conduit to a less or nonhazardous location. It is important to note that conduit seals are not intended to prevent the passage of liquids, gases or vapours at a continuous pressure differential across the seal. Where this is possible other means should be used to ensure propane does not migrate past seals. These means will typically involve some method of relieving the pressure buildup.

Note that cables with a continuous outer jacket are not required to be sealed at Hazardous Location boundaries.

(2) Raceways embedded in a masonry floor or buried beneath a floor shall be considered within the hazardous area above the floor when any connections or extensions lead into or through the hazardous area.

There is a possibility that fuel leaking onto the floor may enter raceways below or embedded in the floor. Therefore, the raceways are considered to be in the same hazardous area as the surface and must use wiring methods and sealing as required for that area classification as outlined in Section 18.

20-514 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.

Electrical systems could inadvertently create an ignition source while fuel vapours are present.

20-516 Aircraft Battery-Charging and Equipment

(1) Aircraft batteries shall not be charged when installed in an aircraft located inside or partially inside a hangar.

Sparks capable of igniting fuel are often produced while connecting clips to batteries. Charging of the batteries may also produce hydrogen vapors that could be ignited.

(2) Battery chargers and their control equipment shall not be located or operated within any of the hazardous areas defined in Rule 20-502 but shall be permitted to be located or operated in a separate building or in an area complying with Rule 20-502(4).

(3) Mobile chargers shall carry at least one permanently affixed warning sign stating that the chargers are to be kept 1.5 m clear of aircraft engines and fuel tank areas.

(4) Tables, racks, trays, and wiring shall not be located within a hazardous area, and shall conform to the provisions of Section 26 pertaining to storage batteries.

Rules 26-540 to 26-554 are the applicable Rules.

20-518 External Power Sources for Energizing Aircraft

(1) Aircraft energizers shall be designed and mounted so that all electrical equipment and fixed wiring are at least 450 mm above floor level, and they shall not be operated in a hazardous area as defined in Rule 20-502(3).

Energisers must be designed so that their electrical equipment and fixed wiring will be above the 450 mm Class I, Zone 2 area above floor level. They must not be operated within the hazardous area surrounding aircraft.

(2) Mobile energizers shall carry at least one permanently affixed sign stating that the energizers are to be kept 1.5 m clear of aircraft engines and fuel tank areas.

(3) Aircraft energizers shall be equipped with polarized external power plugs and with automatic controls to isolate the ground power unit electrically from the aircraft in case excessive voltage is generated by the ground power unit.

(4) Flexible cords for aircraft energizers and ground support equipment shall be of the extra-hard-usage type and shall include a bonding conductor.

As the cords will be subject to considerable wear and tear, the use of extra-hard-usage cables is mandated. Further information on hard usage cords can be found in Table 11 of the *Canadian Electrical Code*.

20-520 Mobile Servicing Equipment with Electrical Components

(1) Mobile servicing equipment such as vacuum cleaners, air compressors, air movers, etc., having electrical wiring and equipment not suitable for Class I, Zone 2 locations shall

(a) be designed and mounted so that all such wiring and equipment is at least 450 mm above the floor;

(b) not be operated within the hazardous areas defined in Rule 20-502(3); and

(c) carry at least one permanently affixed warning sign stating that the equipment is to be kept 1.5 m clear of aircraft engines and fuel tank areas.

Mobile servicing equipment used within the hanger that is not suitable for use in a Class I, Zone 2 Hazardous Location must not be used within the 450 mm hazardous area above the floor or within the hazardous area around aircraft. Such equipment must carrying a minimum of one warning sign to that effect.

(2) Flexible cords used for mobile equipment shall be of the extra-hard-usage type and shall include a bonding conductor.

As the cords will be subject to considerable wear and tear, the use of extra-hard-usage cables is mandated. Further information on hard-usage cords can be found in Table 11 of the *Canadian Electrical Code.*

(3) Attachment plugs and receptacles shall provide for the connection of the bonding conductor to the raceway system.
Attachment plugs and receptacles must have provision for properly connecting the bonding conductor to the bonding means in the raceway system supplying the equipment.

(4) Equipment shall not be operated in areas where maintenance operations likely to release hazardous vapours are in progress, unless the equipment is at least suitable for use in a Class I, Zone 2 location.

Equipment not approved to a method suitable for use in a Class I, Zone 2 Hazardous Location should not be used in an area where hazardous vapours are likely to be released as a result of maintenance operations. This may include the use of cleaners and solvents that are used at temperatures above their flash points.

20-522 Bonding

All metal raceways, and all non-current-carrying metal portions of fixed or portable equipment, regardless of voltage, shall be bonded to ground in accordance with Section 10.

Section 10 requires that all noncurrent-carrying parts of the electrical system are bonded to ground with a properly sized bonding conductor. This is to prevent shock or ignition hazard by ensuring a conductive path of low enough impedance to properly operate protective over-current devices.

SECTION 22

Locations in Which Corrosive Liquids, Vapours, or Excessive Moisture Are Likely to Be Present

General

22-000 Scope

This Section applies to electrical equipment and installations in locations in which corrosive liquids, vapours, or excessive moisture are likely to be present, and supplements or amends the general requirements of this Code.

Sewage Lift and Treatment Plants

22-700 Scope

(1) Rules 22-702 to 22-710 apply to the installation of electrical facilities in sewage lift and pumping stations, and in primary and secondary sewage treatment plants where the environment could contain multiple hazards such as moisture, corrosion, explosions, fire, and atmospheric poisoning.

(2) Rules 22-702 to 22-710 do not apply to methane generation facilities associated with some treatment facilities.

22-702 Special Terminology

In ths Subsection, the following definitions apply:

Continuous Positive Pressure Ventilation – a ventilation system capable of maintaining a positive pressure in a room or area and of changing the air in the room or area at least six times an hour with means for detecting ventilation failure.

Dry well – the location below ground designed to accommodate equipment associated with wastewater pumping and isolated from the wet well location to prevent the migration of gases and vapours into the dry well.

Suitably cut off – an area rendered impermeable and cut off from an adjoining area with no means of liquid, gas, or vapour communication between the areas at atmospheric pressure.

Wet well – the location below ground where the raw sewage is collected and temporarily stored before passing through the lift pumps or being processed in a treatment plant.

Category 1 - the location is one in which moisture in the form of vapour or liquid is present in quantities that are liable to interfere with the normal operation of electrical equipment, whether the moisture is caused by condensation, the dripping or splashing of liquid, or otherwise; and

Appendix B Notes

22-704

Sewage Lift and Treatment Plants

Sewage lift and treatment plants produce a combination of conditions that may require specialized attention to the electrical installation. Abnormal hazardous conditions can occur due to the build-up of methane gas and the spills of chemical, gasoline or other volatile liquids into the sewer system. Reference material for hazardous area classification can be found in NFPA 820. Wet well areas normally contain an atmosphere of high humidity and corrosive hydrogen sulphide vapours.

An extreme hazard to personnel working in wet wells exists because of the presence of sewer gas (hydrogen sulphide). This gas is treacherous because the ability to sense it by smell is quickly lost. If workers ignore the first notice of the gas, their senses will give them no further warning. If the concentration is high enough, loss of consciousness and death can result.

Before work in wet well locations begins, the air in the wet well area should be purged, and ventilation with fresh air should be maintained while work continues in the area.

Category 2 - the location is one in which corrosive liquids or vapours are likely to be present in quantities that are likely to interfere with the normal operation of electrical equipment.

22-704 Classification of Areas (See Appendix B)

Hydrogen Sulfide (H_2S) can be identified by its odor (rotten egg smell) at concentrations as low as 1 part per million (ppm). It becomes lethal in the range of 200 to 500ppm and all concentrations above. Its lower explosive limit is 4% concentration in air which is 40,000 ppm. While it is unlikely that H_2S concentrations in the air will reach explosive levels in Sewage Lift and Treatment Plants, it is easily possible for them to reach lethal levels.

Methane gas, on the other hand, is not lethal but it can ignite at concentrations of 5% to 15% (50,000 to 150,000 ppm) in air. Methane gas is produced in sufficient quantity to reach explosive concentrations in Sewage Lift and Treatment Plants if sufficient ventilation is not provided to continuously dilute the methane vapours produced. If the ventilation system fails for any reason, methane will continue to be generated and could reach ignitable concentrations in the air under these conditions, hence the need to classify those locations where methane is produced as Class I Hazardous Locations.

(1) Sewage lift and treatment plants shall be classified for

(a) hazardous areas in accordance with Section 18; and

(b) corrosive liquids, vapours, or moisture in accordance with this Section.

(2) Wet wells provided with adequate continuous positive pressure ventilation shall be considered Class I, Zone 2.

(3) Except as permitted by Subrule 5(c), all locations below ground suitably cut off from locations in which sewage gases may be present shall be considered Category 1.

(4) All locations in which sewage gases may be present in explosive concentrations shall be considered hazardous areas and Category 2.

(5) The following areas shall be permitted to be classified as ordinary locations:

(a) all locations suitably cut off from a Category 2 location and not classified as a Category 1 location;

(b) all locations not suitably cut off from a Category 2 location but with adequate continuous positive pressure ventilation; and

(c) dry well locations below ground where adequate heating and adequate continuous positive pressure ventilation is installed.

22-706 Wiring Methods

(1) Wiring methods within hazardous areas shall be in accordance with Section 18.

(2) Wiring methods in a Category 1 or a dry Category 2 location shall be in accordance with Rules 22-200 and 22-202, respectively.

(3) Wiring methods in a wet or damp Category 2 location shall be in accordance with Rule 22-202, with the following exceptions:

(a) rigid steel conduit and electrical metallic tubing shall not be used;

(b) armoured cable, mineral-insulated cable, aluminum-sheathed cable, and copper-sheathed cable shall be permitted to be used provided that the cable is spaced from walls by at least 12 mm, has a corrosion-resistant jacket, and the cable connectors are adequately sealed against ingress of corrosive liquids or vapours; and

(c) grounding and bonding conductors shall be insulated or otherwise protected from corrosion, and the point of connection to ground, if exposed to a corrosive atmosphere, shall be protected from corrosion or be of a material resistant to the specific corrosive environment.

(4) Conduits installed from the wet well to an electrical enclosure shall be sealed with a suitable compound to prevent the entrance of moisture, vapour, or gases into the enclosure.

This will not necessarily require the use of an explosion seal. If a seal (explosion seal) is not required under the rules in Section 18, the requirements of this Rule could be met with materials such as a silicone sealing material.

22-708 Electrical Equipment

(1) Electrical equipment installed in hazardous areas shall be in accordance with Section 18.

(2) Electrical equipment installed in a Category 1 or a dry Category 2 location shall be in accordance with the applicable requirements of this Code.

(3) Electrical equipment installed in a wet or damp Category 2 location shall be in accordance with the applicable requirements of the Code, with the following exceptions:

(a) receptacles shall be fitted with self-closing covers, and if of the duplex type, have individual covers over each half of the receptacle;

(b) lighting switches shall have weatherproof covers;

(c) unit emergency lighting equipment and emergency lighting control units, other than remote lamps, shall not be located in such locations;

(d) heating equipment shall be approved for such locations or installed outside the corrosive location;

(e) motors shall be totally enclosed and fan cooled and shall not incorporate dissimilar metals relative to the motor frame and connection box; and

(f) electrical equipment in wet well areas shall not contain devices that will cause an open arc or spark during normal operation.

(4) Ventilation fans shall not be located within the wet well, and fan blades shall be of spark-resistant material.

(5) Areas provided with continuous positive pressure ventilation shall be interlocked to de-energize all electrical equipment not approved for a Class I location in case the ventilating equipment is inoperative.

22-710 Grounding of Structural Steel

Structural steel below ground in contact with the surrounding earth shall be bonded to the system ground.

Introduction to Appendix I and Appendix II

Table II in Appendix I lists many gases and vapours used in business and industry and shows their Class I groups, their ignition temperatures, their flash points, their upper and lower explosive limits, and their vapour densities. In order to determine the type of equipment needed for a particular Hazardous Location, it is first necessary to identify the gases and vapours that could be released into the air in sufficient quantity to form an explosive atmosphere. The pertinent characteristics of the gases and vapours can then be obtained from published tables such as the tables in Appendix I. Additional information can be found in NFPA 497 (Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapours and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas) or IEC 60079-20 (Data for Flammable Gases and Vapours Relating to the Use of Electrical Apparatus). Also see sections 2.1 to 2.5 of this Code.

Once the various gases and vapours have been identified and their characteristics have been determined from tables (or in some cases Material Safety Data Sheets), depending on the Class I Zone in which the electrical equipment will be located, the various characteristics of the gas or vapour, in combination with the pertinent Rules in the CEC, will allow the designer to determine the specific requirements for the electrical equipment.

Flammable gases and vapours are divided into Groups A, B, C, and D for electrical equipment designed to most North American standards or Groups IIC, IIB, or IIA. For electrical equipment designed to IEC standards, flammable gases and vapours are divided into Groups IA, IIB and IIIC. Gases and vapours are grouped to simplify the design of electrical equipment. The classification relates mainly to the requirements to construct explosionproof or flameproof equipment or to the design of intrinsically safe equipment and circuitry. If there were no Gas Groups electrical equipment for each gas or vapour would need to be uniquely designed, thus leading to the need for literally hundreds of different designs and an associated increase in cost. For example, for explosionproof enclosures, there is a need for only four different types of enclosures as opposed to hundreds if Gas Groups had not been established. Similarly, there is only a need for four different types of intrinsic safety barriers for Class I electrical equipment.

The grouping of gases and vapours is based mainly on two characteristics of each gas or vapour, based on tests data using specific test apparatus. The characteristics are:

- Maximum experimental safe gap (MESG) - related to explosionproof and flameproof equipment, and
- Minimum igniting current ratio (MIC) – related to intrinsically safe equipment and circuitry

The MESG of a gas or vapour is a determination of the maximum opening of a 25 mm wide flame-path, in a specified test apparatus, that prevents transmission of an explosion of a specified gas. For example, in the IEC gas grouping, the following apply:

- Group IIA: MESG above or equal to 0.9 mm
- Group IIB: MESG greater than 0.5 mm and less than 0.9 mm
- Group IIC: MESG less than or equal to 0.5 mm

The MIC ratio of a gas or vapour is a determination of the minimum current, in a specified test apparatus, that will ignite a specified gas as a ratio with that of laboratory methane. For example, in the IEC gas grouping, the following apply:

- Group IIA: MIC ratio above 0.8
- Group IIB: MIC ratio between 0.45 and 0.8
- Group IIC: MIC ratio below 0.45

Note that the MESG and MIC values are “relative”, not “absolute” values and are used only as a means of grouping gases and vapours. This can be best illustrated with MIC values as the maximum allowable current of a gas in intrinsically safe circuits varies with the voltage and the inductance and capacitance, in the circuits.

The *Flash Point* of a liquid is the minimum temperature at which it gives off sufficient vapour 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.

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 vapour 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.

Two useful publications relative to the ignition of gas or vapor from hot surfaces are:

API Recommended Practice #2216 – Ignition Risk of Hydrocarbon liquids and Vapours by Hot Surfaces in the Open Air

IEEE Paper # PCIC-97-04 – Flammable Vapor Ignition Initiated by Hot Rotor Surfaces Within an Induction Motor – Reality or Not?

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 vapours which form flammable mixtures with air or oxygen, there is a minimum concentration of vapour in air or oxygen below which propagation of flame does not occur on contact with a source of ignition. Gases and vapours may form flammable mixtures in atmospheres other than air or oxygen, as for example, hydrogen in chlorine. There is also a maximum proportion of vapour or gas in air above which propagation of flame does not occur. These boundary-line mixtures of vapour 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 vapour 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 II 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.

Propagation of Flame means the spread of flame from the source of ignition through a flammable mixture. A gas or vapour 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.

Vapour Density. Vapour density is the weight of a volume of pure vapour 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 vapour density figure less than 1 indicates that the vapour is lighter than air and will tend to rise in a relatively calm atmosphere. A figure greater than 1 indicates that the vapour is heavier than air and may travel at low levels for a considerable distance to a source of ignition and flash back (if the vapour is flammable).

Gases or vapours with relative vapour densities will not quickly rise or quickly sink to ground level. They will have a tendency to move slowly relative to the release point than gases or vapours that are significantly lighter or significantly heavier than air. As a consequence, they will may have a tendency to spread further horizontally from the point of release before dispersing to concentrations below their LFL, thus having an effect on the boundary of the hazardous area around the point of release. API RP500 and RP505 suggest that for gases or vapours with a relative density between 0.8 and 1.2, the possibility of the gases or vapours acting as both heavier and lighter than air should be considered.

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.

Table III in Appendix II lists many of the combustible dusts which are commonly found in business and industry. The *CEC* 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 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. Also refer to section 2.6 of this Guide for more information on Minimum Explosive Concentration and Minimum Ignition Temperature of Dusts.*

Appendix I - Gases and Vapours

Hazardous Substances Used in Business and Industry

TABLE II

Class I* Group		Substance	Auto-* Ignition Temp. °F	Auto-* Ignition Temp. °C	Flash** Point °F	Flash** Point °C	Flammable Limits** Percent by Volume Lower	Flammable Limits** Percent by Volume Upper	Vapour** Density (Air Equals 1.0)
C	IIB	Acetaldehyde	347	175	-38	-39	4.0	60	1.5
D	IIA	Acetic Acid	867	464	103	39	4.0	19.9 @ 200°F	2.1
D	IIA	Acetic Anhydride	600	316	120	49	2.7	10.3	3.5
D	IIA	Acetone	869	465	-4	-20	2.5	13	2.0
D	IIA	Acetone Cyanohydrin	1270	688	165	74	2.2	12.0	2.9
D	IIA	Acetonitrile	975	524	42	6	3.0	16.0	1.4
A	IIC	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	IIA	Acrylic Acid	820	438	122	50	2.4	8.0	2.5
D	IIA	Acrylonitrile	898	481	32	0	3.0	17	1.8
D	IIA	Adiponitrile	—	—	200	93	—	—	—
C	IIB	Allyl Alcohol	713	378	70	21	2.5	18.0	2.0
D	IIA	Allyl Chloride	905	485	-25	-32	2.9	11.1	2.6
B(C)		Allyl Glycidyl Ether[1]	—	—	—	—	—	—	—
D	IIA	Ammonia[2]	928	498	gas	gas	15	28	0.6
D	IIA	n-Amyl Acetate	680	360	60	16	1.1	7.5	4.5
D	IIA	sec-Amyl Acetate	—	—	89	32	—	—	4.5
D	IIA	Aniline	1139	615	158	70	1.3	11	3.2
D	IIA	Benzene	928	498	12	-11	1.3	7.9	2.8
D	IIA	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	IIA	Butane	550	288	-76	-60	1.6	8.4	2.0
D	IIA	1-Butanol	650	343	98	37	1.4	11.2	2.6
D	IIA	2-Butanol	761	405	75	24	1.7 @ 212°F	9.8 @ 212°F	2.6
D	IIA	n-Butyl Acetate	790	421	72	22	1.7	7.6	4.0
D	IIA	iso-Butyl Acetate	790	421	—	—	—	—	—
D	IIA	sec-Butyl Acetate	—	—	88	31	1.7	9.8	4.0
D	IIA	t-Butyl Acetate	—	—	—	—	—	—	—
D	IIA	n-Butyl Acrylate (inhibited)	559	293	118	48	1.5	9.9	4.4
C	IIB	n-Butyl Formal	—	—	—	—	—	—	—
B(C)		n-Butyl Glycidyl Ether[1]	—	—	—	—	—	—	—
C	IIB	Butyl Mercaptan	—	—	35	2	—	—	3.1
D	IIA	t-Butyl Toluene	—	—	—	—	—	—	—
D	IIA	Butylamine	594	312	10	-12	1.7	9.8	2.5
D	IIA	Butylene	725	385	gas	gas	1.6	10.0	1.9
C	IIB	n-Butyraldehyde	425	218	-8	-22	1.9	12.5	2.5
D	IIA	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	IIB	Carbon Monoxide	1128	609	gas	gas	12.5	74.0	1.0
C	IIB	Chloroacetaldehyde	—	—	—	—	—	—	—
D	IIA	Chlorobenzene	1099	593	82	28	1.3	9.6	3.9
C	IIB	1-Chloro-1-Nitropropane	—	—	144	62	—	—	4.3
D	IIA	Chloroprene	—	—	-4	-20	4.0	20.0	3.0
D	IIA	Cresol	1038-1110	559-599	178-187	81-86	1.1-1.4	—	—
C	IIB	Crotonaldehyde	450	232	55	13	2.1	15.5	2.4
D	IIA	Cumene	795	424	96	36	0.9	6.5	4.1
D	IIA	Cyclohexane	473	245	-4	-20	1.3	8.0	2.9
D	IIA	Cyclohexanol	572	300	154	68	—	—	3.5
D	IIA	Cyclohexanone	473	245	111	44	1.1 @ 212°F	9.4	3.4
D	IIA	Cyclohexene	471	244	<20	<-7	—	—	2.8
D	IIA	Cyclopropane	938	503	gas	gas	2.4	10.4	1.5
D	IIA	p-Cymene	817	436	117	47	0.7 @ 212°F	5.6	4.6
C	IIB	n-Decaldehyde	—	—	—	—	—	—	—
D	IIA	n-Decanol	550	288	180	82	—	—	5.5
D	IIA	Decene	455	235	<131	<55	—	—	4.84
D	IIA	Diacetone Alcohol	1118	603	148	64	1.8	6.9	4.0
D	IIA	o-Dichlorobenzene	1198	647	151	66	2.2	9.2	5.1
D	IIA	1,1-Dichloroethane	820	438	22	-6	5.6	—	—
D	IIA	1,2-Dichloroethylene	860	460	36	2	5.6	12.8	3.4
C	IIB	1,1-Dichloro-1-Nitroethane	—	—	168	76	—	—	5.0
D	IIA	1,3-Dichloropropene	—	—	95	35	5.3	14.5	3.8
C	IIB	Dicyclopentadiene	937	503	90	32	—	—	—
D	IIA	Diethyl Benzene	743-842	395-450	133-135	56-57	—	—	4.6
C	IIB	Diethyl Ether	320	160	-49	-45	1.9	36.0	2.6
C	IIB	Diethylamine	594	312	-9	-23	1.8	10.1	2.5
C	IIB	Diethylaminoethanol	—	—	—	—	—	—	—
C	IIB	Diethylene Glycol Monobutyl Ether	442	228	172	78	0.85	24.6	5.6
C	IIB	Diethylene Glycol Monomethyl Ether	465	241	205	96	—	—	—
D	IIA	Di-isobutyl Ketone	745	396	120	49	0.8 @ 200°F	7.1 @ 200°F	4.9
D	IIA	Di-isobutylene	736	391	23	-5	0.8	4.8	3.9
C	IIB	Di-isopropylamine	600	316	30	-1	1.1	7.1	3.5
C	IIB	N-N-Dimethyl Aniline	700	371	145	63	—	—	4.2
D	IIA	Dimethyl Formamide	833	455	136	58	2.2 @ 212°F	15.2	2.5
D	IIA	Dimethyl Sulfate	370	188	182	83	—	—	4.4
C	IIB	Dimethylamine	752	400	gas	gas	2.8	14.4	1.6
C	IIB	1,4-Dioxane	356	180	54	12	2.0	22	3.0
D	IIA	Dipentene	458	237	113	45	0.7 @ 302°F	6.1 @ 302°F	4.7
C	IIB	Di-n-propylamine	570	299	63	17	—	—	3.5
C	IIB	Dipropylene Glycol Methyl Ether	—	—	186	86	—	—	5.11
D	IIA	Dodecene	491	255	—	—	—	—	—
C	IIB	Epichlorohydrin	772	411	88	31	3.8	21.0	3.2
D	IIA	Ethane	882	472	gas	gas	3.0	12.5	1.0

Appendix I - Gases and Vapours

Hazardous Substances Used in Business and Industry

TABLE II (Cont'd)

Class I* Group		Substance	Auto-* Ignition Temp. °F	Auto-* Ignition Temp. °C	Flash** Point °F	Flash** Point °C	Flammable Limits** Percent by Volume Lower	Flammable Limits** Percent by Volume Upper	Vapour** Density (Air Equals 1.0)
D	IIA	Ethanol	685	363	55	13	3.3	19	1.6
D	IIA	Ethyl Acetate	800	427	24	-4	2.0	11.5	3.0
D	IIA	Ethyl Acrylate (inhibited)	702	372	50	10	1.4	14	3.5
D	IIA	Ethyl sec-Amyl Ketone	—	—	—	—	—	—	—
D	IIA	Ethyl Benzene	810	432	70	21	0.8	6.7	3.7
D	IIA	Ethyl Butanol	—	—	—	—	—	—	—
D	IIA	Ethyl Butyl Ketone	—	—	115	46	—	—	4.0
D	IIA	Ethyl Chloride	966	519	-58	-50	3.8	15.4	2.2
D	IIA	Ethyl Formate	851	455	-4	-20	2.8	16.0	2.6
D	IIA	2-Ethyl Hexanol	448	231	164	73	0.88	9.7	4.5
D	IIA	2-Ethyl Hexyl Acrylate	485	252	180	82	—	—	—
C	IIB	Ethyl Mercaptan	572	300	<0	<-18	2.8	18.0	2.1
C	IIB	n-Ethyl Morpholine	—	—	—	—	—	—	—
C	IIB	2-Ethyl-3-Propyl Acrolein	—	—	155	68	—	—	4.4
D	IIA	Ethyl Silicate	—	—	125	52	—	—	7.2
D	IIA	Ethylamine	725	385	<0	<-18	3.5	14.0	1.6
C	IIB	Ethylene	842	450	gas	gas	2.7	36.0	1.0
D	IIA	Ethylene Chlorohydrin	797	425	140	60	4.9	15.9	2.8
D	IIA	Ethylene Dichloride	775	413	56	13	6.2	16	3.4
C	IIB	Ethylene Glycol Monobutyl Ether	460	238	143	62	1.1 @ 200°F	12.7 @ 275°F	4.1
C	IIB	Ethylene Glycol Monobutyl Ether Acetate	645	340	160	71	0.88 @ 200°F	8.54 @ 275°F	—
C	IIB	Ethylene Glycol Monoethyl Ether	455	235	110	43	1.7 @ 200°F	15.6 @ 200°F	3.0
C	IIB	Ethylene Glycol Monoethyl Ether Acetate	715	379	124	52	1.7	—	4.72
D	IIA	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	IIA	Ethylenediamine	725	385	104	40	2.5	12.0	2.1
C	IIB	Ethylenimine	608	320	12	-11	3.3	54.8	1.5
C	IIB	2-Ethylhexaldehyde	375	191	112	44	0.85 @ 200°F	7.2 @ 275°F	4.4
B	IIC	Formaldehyde (Gas)	795	429	gas	gas	7.0	73	1.0
D	IIA	Formic Acid (90%)	813	434	122	50	18	57	1.6
B	IIC	Fuel and Combustible Process Gas (containing more than 30 percent H_2 by volume)	—	—	—	—	—	—	—
D	IIA	Fuel Oils	410-765	210-407	100-336	38-169	0.7	5	—
C	IIB	Furfural	600	316	140	60	2.1	19.3	3.3
C	IIB	Furfuryl Alcohol	915	490	167	75	1.8	16.3	3.4
D	IIA	Gasoline	536-880	280-471	-36 to -50	-38 to -46	1.2-1.5	7.1-7.6	3-4
D	IIA	Heptane	399	204	25	-4	1.05	6.7	3.5
D	IIA	Heptene	500	260	<32	<0	—	—	3.39
D	IIA	Hexane	437	225	-7	-22	1.1	7.5	3.0
D	IIA	Hexanol	—	—	145	63	—	—	3.5
D	IIA	2-Hexanone	795	424	77	25	—	8	3.5
D	IIA	Hexenes	473	245	<20	<-7	—	—	3.0
D	IIA	sec-Hexyl Acetate	—	—	—	—	—	—	—
C	IIB	Hydrazine	74-518	23-270	100	38	2.9	9.8	1.1
B	IIC	Hydrogen	968	520	gas	gas	4.0	75	0.1
C	IIB	Hydrogen Cyanide	1000	538	0	-18	5.6	40.0	0.9
C	IIB	Hydrogen Selenide	—	—	—	—	—	—	—
C	IIB	Hydrogen Sulfide	500	260	gas	gas	4.0	44.0	1.2
D	IIA	Isoamyl Acetate	680	360	77	25	1.0 @ 212°F	7.5	4.5
D	IIA	Isoamyl Alcohol	662	350	109	43	1.2	9.0 @ 212°F	3.0
D	IIA	Isobutyl Acrylate	800	427	86	30	—	—	4.42
C	IIB	Isobutyraldehyde	385	196	-1	-18	1.6	10.6	2.5
C	IIB	Isodecaldehyde	—	—	185	85	—	—	5.4
C	IIB	Iso-octyl Alcohol	—	—	180	82	—	—	—
C	IIB	Iso-octyl Aldehyde	387	197	—	—	—	—	—
D	IIA	Isophorone	860	460	184	84	0.8	3.8	—
D	IIA	Isoprene	428	220	-65	-54	1.5	8.9	2.4
D	IIA	Isopropyl Acetate	860	460	35	2	1.8 @ 100°F	8	3.5
D	IIA	Isopropyl Ether	830	443	-18	-28	1.4	7.9	3.5
C	IIB	Isopropyl Glycidyl Ether	—	—	—	—	—	—	—
D	IIA	Isopropylamine	756	402	-35	-37	—	—	2.0
D	IIA	Kerosene	410	210	110-162	43-72	0.7	5	—
D	IIA	Liquified Petroleum Gas	761-842	405-450	—	—	—	—	—
		Manufactured Gas (see Fuel and Combustible Process Gas)	—	—	—	—	—	—	—
D	IIA	Mesityl Oxide	652	344	87	31	1.4	7.2	3.4
D	IIA	Methane	999	537	gas	gas	5.0	15.0	0.6
D	IIA	Methanol	725	385	52	11	6.0	36	1.1
D	IIA	Methyl Acetate	850	454	14	-10	3.1	16	2.8
D	IIA	Methyl Acrylate	875	468	27	-3	2.8	25	3.0
D	IIA	Methyl Amyl Alcohol	—	—	106	41	1.0	5.5	—
D	IIA	Methyl n-Amyl Ketone	740	393	102	39	1.1 @ 151°F	7.9 @ 250°F	3.9
C	IIB	Methyl Ether	662	350	gas	gas	3.4	27.0	1.6
D	IIA	Methyl Ethyl Ketone	759	404	16	-9	1.7 @ 200°F	11.4 @ 200°F	2.5
D	IIA	2-Methyl-5-Ethyl Pyridine	—	—	155	68	1.1	6.6	4.2
C	IIB	Methyl Formal	460	238	—	—	—	—	—
D	IIA	Methyl Formate	840	449	-2	-19	4.5	23	2.1

Appendix I - Gases and Vapours

Hazardous Substances Used in Business and Industry

TABLE II (cont'd)

Class I* Group		Substance	Auto-* Ignition Temp. °F	°C	Flash** Point °F	°C	Flammable Limits** Percent by Volume Lower	Upper	Vapour** Density (Air Equals 1.0)
D	IIA	Methyl lsobutyl Ketone	840	440	64	18	1.2 @ 200°F	8.0 @ 200°F	3.5
D	IIA	Methyl lsocyanate	994	534	19	-7	5.3	26	1.97
C	IIB	Methyl Mercaptan	—	—	—	—	3.9	21.8	1.7
D	IIA	Methyl Methacrylate	792	422	50	10	1.7	8.2	3.6
D	IIA	2-Methyl-1-Propanol	780	416	82	28	1.7 @ 123°F	10.6 @ 202°F	2.6
D	IIA	2-Methyl-2-Propanol	892	478	52	11	2.4	8.0	2.6
D	IIA	alpha-Methyl Styrene	1066	574	129	54	1.9	6.1	—
C	IIB	Methylacetylene	—	—	gas	gas	1.7	—	1.4
C	IIB	Methylacetylene-Propadiene (stabilized)	—	—	—	—	—	—	—
D	IIA	Methylamine	806	430	gas	gas	4.9	20.7	1.0
D	IIA	Methylcyclohexane	482	250	25	-4	1.2	6.7	3.4
D	IIA	Methylcyclohexanol	565	296	149	65	—	—	3.9
D	IIA	o-Methylcyclohexanone	—	—	118	48	—	—	3.9
D	IIA	Monoethanolamine	770	410	185	85	—	—	2.1
D	IIA	Monoisopropanolamine	705	374	171	77	—	—	2.6
C	IIB	Monomethyl Aniline	900	482	185	85	—	—	3.7
C	IIB	Monomethyl Hydrazine	382	194	17	-8	2.5	92	1.6
C	IIB	Morpholine	590	310	98	37	1.4	11.2	3.0
D	IIA	Naphtha (Coal Tar)	531	277	107	42	—	—	—
D	IIA	Naphtha (Petroleum)[4]	550	288	<0	<-18	1.1	5.9	2.5
D	IIA	Nitrobenzene	900	482	190	88	1.8 @ 200°F	—	4.3
C	IIB	Nitroethane	778	414	82	28	3.4	—	2.6
C	IIB	Nitromethane	785	418	95	35	7.3	—	2.1
C	IIB	1-Nitropropane	789	421	96	36	2.2	—	3.1
C	IIB	2-Nitropropane	802	428	75	24	2.6	11.0	3.1
D	IIA	Nonane	401	205	88	31	0.8	2.9	4.4
D	IIA	Nonene	—	—	78	26	—	—	4.35
D	IIA	Nonyl Alcohol	—	—	165	74	0.8 @ 212°F	6.1 @ 212°F	5.0
D	IIA	Octane	403	206	56	13	1.0	6.5	3.9
D	IIA	Octene	446	230	70	21	—	—	3.9
D	IIA	n-Octyl Alcohol	—	—	178	81	—	—	4.5
D	IIA	Pentane	470	243	<-40	<-40	1.5	7.8	2.5
D	IIA	1-Pentanol	572	300	91	33	1.2	10.0 @ 212°F	3.0
D	IIA	2-Pentanone	846	452	45	7	1.5	8.2	3.0
D	IIA	1-Pentene	527	275	0	-18	1.5	8.7	2.4
D	IIA	Phenylhydrazine	—	—	190	88	—	—	—
D	IIA	Propane	842	450	gas	gas	2.1	9.5	1.6
D	IIA	1-Propanol	775	413	74	23	2.2	13.7	2.1
D	IIA	2-Propanol	750	399	53	12	2.0	12.7 @ 200°F	2.1
D	IIA	Propiolactone	—	—	165	74	2.9	—	2.5
C	IIB	Propionaldehyde	405	207	-22	-30	2.6	17	2.0
D	IIA	Propionic Acid	870	466	126	52	2.9	12.1	2.5
D	IIA	Propionic Anhydride	545	285	145	63	1.3	9.5	4.5
D	IIA	n-Propyl Acetate	842	450	55	13	1.7 @ 100°F	8	3.5
C	IIB	n-Propyl Ether	419	215	70	21	1.3	7.0	3.53
B	IIC	Propyl Nitrate	347	175	68	20	2	100	—
D	IIA	Propylene	851	455	gas	gas	2.0	11.1	1.5
D	IIA	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	IIA	Pyridine	900	482	68	20	1.8	12.4	2.7
D	IIA	Styrene	914	490	88	31	0.9	6.8	3.6
C	IIB	Tetrahydrofuran	610	321	6	-14	2.0	11.8	2.5
D	IIA	Tetrahydronaphthalene	725	385	160	71	0.8 @ 212°F	5.0 @ 302°F	4.6
C	IIB	Tetramethyl Lead	—	—	100	38	—	—	6.5
D	IIA	Toluene	896	480	40	4	1.1	7.1	3.1
D	IIA	Tridecene	—	—	—	—	—	—	—
C	IIB	Triethylamine	480**	249**	16	-9	1.2	8.0	3.5
D	IIA	Triethylbenzene	—	—	181	83	—	—	5.6
D	IIA	Tripropylamine	—	—	105	41	—	—	4.9
D	IIA	Turpentine	488	253	95	35	0.8	—	—
D	IIA	Undecene	—	—	—	—	—	—	—
C	IIB	Unsymmetrical Dimethyl Hydrazine (UDMH)	480	249	5	-15	2	95	2.0
C	IIB	Valeraldehyde	432	222	54	12	—	—	3.0
D	IIA	Vinyl Acetate	756	402	18	-8	2.6	13.4	3.0
D	IIA	Vinyl Chloride	882	472	-108.4	-78	3.6	33.0	2.2
D	IIA	Vinyl Toluene	921	494	127	53	0.8	11.0	4.1
D	IIA	Vinylidene Chloride	1058	570	-19	-28	6.5	15.5	3.4
D	IIA	Xylenes	867-984	464-529	81-90	27-32	1.0-1.1	7.0	3.7

[1]If equipment is isolated by sealing all conduit 1/2 in. or larger, in accordance with Section 501.5(A) of NFPA 70, *National Electrical Code,* equipment for the group classification shown in parentheses is permitted.

[2]For 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,* ANSl/CGA G2.1.

[3]Certain 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.

[4]Petroleum 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 497M-1991, *Classification of Gases, Vapours, and Dusts for Electrical Equipment in Hazardous (Classified) Locations.*

** Data from NFPA 325M-1991, *Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.*

Appendix II - Dusts

Hazardous Substances Used in Business and Industry

TABLE III

Material[2]	Minimum Cloud or Layer Ignition Temp.[1] °F		°C
Class II, Group E			
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		230
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
Corncob 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
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

Class II, Group G (cont'd)	Minimum Cloud or Layer Ignition Temp. °F		°C
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-phenetidide	1040	NL	560
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 lsophthalate	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
lsotoic 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 Anydride	1202	M	650
Phthalimide	1166	M	630
Salicylanilide	1130	M	610
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-Acetylamino-5-nitrothiazole	842		450
2-Amino-5-nitrothiazole	860		460
Aspirin	1220	M	660
Gulasonic Acid, Diacetone	788	NL	420
Mannitol	860	M	460
Nitropyridone	806	M	430
1-Sorbose	698	M	370
Vitamin B1, mononitrate	680	NL	360
Vitamin C (Ascorbic Acid)	536		280

Appendix II - Dusts

Hazardous Substances Used in Business and Industry

TABLE III
Class II, Group G (cont'd)

Material	Minimum Cloud or Layer Ignition Temp.[1] °F		°C
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	248		120
Sevin	284		140
∝ ∝ - Trithiobis (N,N-Dimethylthio-formamide)	446		230
THERMOPLASTIC RESINS AND MOLDING COMPOUNDS			
Acetal Resins			
Acetal, Linear (Polyformaldehyde)	824	NL	440
Acrylic Resins			
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	480
Methyl Methacrylate-Ethyl Acrylate-Styrene Copolymer	824	NL	440
Methyl Methacrylate-Styrene-Butadiene-Acrylonitrile Copolymer	896	NL	480
Methacrylic Acid Polymer	554		290
Cellulosic Resins			
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
Carboxymethyl Cellulose	554		290
Hydroxyethyl Cellulose	644		340
Chlorinated Polyether Resins			
Chlorinated Polyether Alcohol	860		460
Nylon (Polyamide) Resins			
Nylon Polymer (Polyhexa-methylene Adipamide)	806		430
Polycarbonate Resins			
Polycarbonate	1310	NL	710
Polyethylene Resins			
Polyethylene, High Pressure Process	716		380
Polyethylene, Low Pressure Process	788	NL	420
Polyethylene Wax	752	NL	400
Polymethylene Resins			
Carboxypolymethylene	968	NL	520

[1]Normally, 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 sublimes before it ignites; the cloud ignition temperature is shown.

[2]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) and minimum ignition energies lower than any material classified in any of the Class I or Class II groups.

Class II, Group G (cont'd)

Material	Minimum Cloud or Layer Ignition Temp. °F		°C
Polypropylene Resins			
Polypropylene (No Antioxidant)	788	NL	420
Rayon Resins			
Rayon (Viscose) Flock	482		250
Styrene Resins			
Polystyrene Molding Cmpd.	1040	NL	560
Polystyrene Latex	932		500
Styrene-Acrylonitrile (70-30)	932	NL	500
Styrene-Butadiene Latex (>75% Styrene; Alum Coagulated)	824	NL	440
Vinyl Resins			
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			
Allyl Resins			
Allyl Alcohol Derivative (CR-39)	932	NL	500
Amino Resins			
Urea Formaldehyde Molding Compound	860	NL	460
Urea Formaldehyde-Phenol Formaldehyde Molding Compound (Wood Flour Filler)	464		240
Epoxy Resins			
Epoxy	1004	NL	540
Epoxy - Bisphenol A	950	NL	510
Phenol Furfural	590		310
Phenolic Resins			
Phenol Formaldehyde	1076	NL	580
Phenol Formaldehyde Molding Cmpd. (Wood Flour Filler)	932	NL	500
Phenol Formaldehyde, Polyalkylene-Polyamine Modified	554		290
Polyester Resins			
Polyethylene Terephthalate	932	NL	500
Styrene Modified Polyester-Glass Fibre Mixture	680		360
Polyurethane Resins			
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-lndene, Hard	968	NL	520
Ethylene Oxide Polymer	662	NL	350
Ethylene-Maleic Anhydride Copolymer	1004	NL	540
Lignin, Hydrolized, 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

Appendix III - Electrical Equipment for Class I Locations

The following table outlines the electrical equipment acceptable in Class I, Zones 0, 1, and Divisions 1 and 2. This table is located in the introduction to Appendix J in the *Canadian Electrical Code.*

<table>
<tr><td colspan="4">Acceptable equipment comparison for Class I locations</td></tr>
<tr><td colspan="2">Zone System</td><td colspan="2">Division System</td></tr>
<tr><td>Intrinsically safe, i or ia</td><td>Zone 0</td><td rowspan="2">Division 1</td><td rowspan="2">Class I, Division 1

Intrinsically safe i, ia</td></tr>
<tr><td>Equipment acceptable in Zone 0
Class I, Division 1

Powder- filled q
Flame-proof d
Pressurized p
Oil immersed o
Increased safety e
Intrinsically safe ib
Encapsulation m</td><td>Zone 1</td></tr>
<tr><td>Equipment acceptable in Zone 0

Equipment acceptable in Zone 1
Class I, Division 2

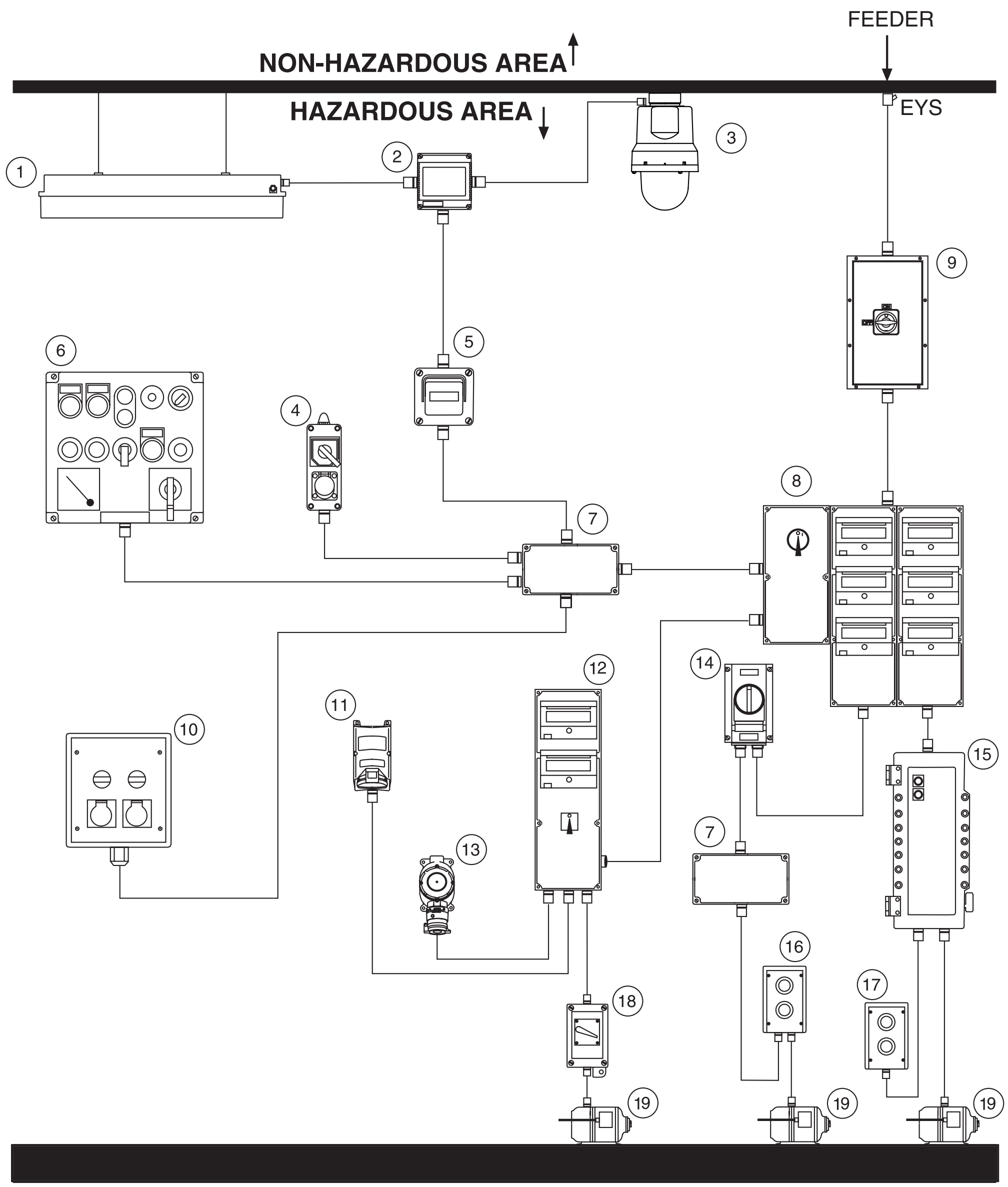
Method of protection n
Non-incendive
Other electrical apparatus*</td><td>Zone 2</td><td>Division 2</td><td>Class I, Division 1

Class I, Division 2, Zone 0, 1 or 2
Flame-proof d
Pressurized p
Intrinsically safe ib
Oil immersed o
Increased safety e
Powder- filled q
Method of protection n
Encapsulation m
Non-incendive
Other electrical apparatus*</td></tr>
<tr><td colspan="4">* Other electrical apparatus “means electrical apparatus complying with the requirements of a recognized standard for industrial electrical apparatus that does not in normal service have ignition-capable hot surfaces and does not in normal service produce incendive arcs or sparks.”

Other electrical apparatus “also makes reference to equipment or systems currently acceptable as alternative means of protection (see Rules J18-064 and J18-070).”

Because Division 1 encompasses the equivalent of Zone 0, methods of protection designed for Zone 1 would not be allowed in Division 1; e.g., an increased safety device would not be allowed in a Class I, Division 1 location.</td></tr>
</table>

Appendix IV - Diagram for Class I Zone 1 or 2 or Class I Division 2. Power & Lighting Installation



Key to Numerals*

1. eLLK or FVS Fluorescent Luminaire with TMCX Terminator™ cable gland

2. eAZK Lighting Junction Box with Zone 1 Myers™ hubs

3. EVLS, EVLP or EVMA HID Luminaire with TMCX Terminator cable gland

4. GHG Switched IEC 309 Receptacle with Zone 1 Myers hubs

5. GHG 273 Ex Push-Button Light Switch with Zone 1 Myers hubs

6. GHG 44 Control Panel with Zone 1 Myers hubs

7. GHG 744 Terminal Box with Zone 1 Myers hubs

8. D2Z Molded Plastic Distribution Panel with Zone 1 Myers hubs

9. GHG 26 Series Control Switch with TMC Terminator cable gland

10. GHG 981 Socket Distribution Panel with Zone 1 Myers hubs

11. GHG Interlocked IEC 309 Receptacle with Zone 1 Myers hubs

12. D2Z Molded Plastic Distribution Panel with Zone 1 Myers hubs

13. FSQC Arktite Interlocked Receptacle with TMCX Terminator cable gland

14. GHG 635 Manual Motor Starter with Zone 1 Myers hubs

15. EBMS Magnetic Motor Starter with TMCX Terminator cable gland

16. N2SCU SpecOne™ Control Station with Zone 1 Myers hubs

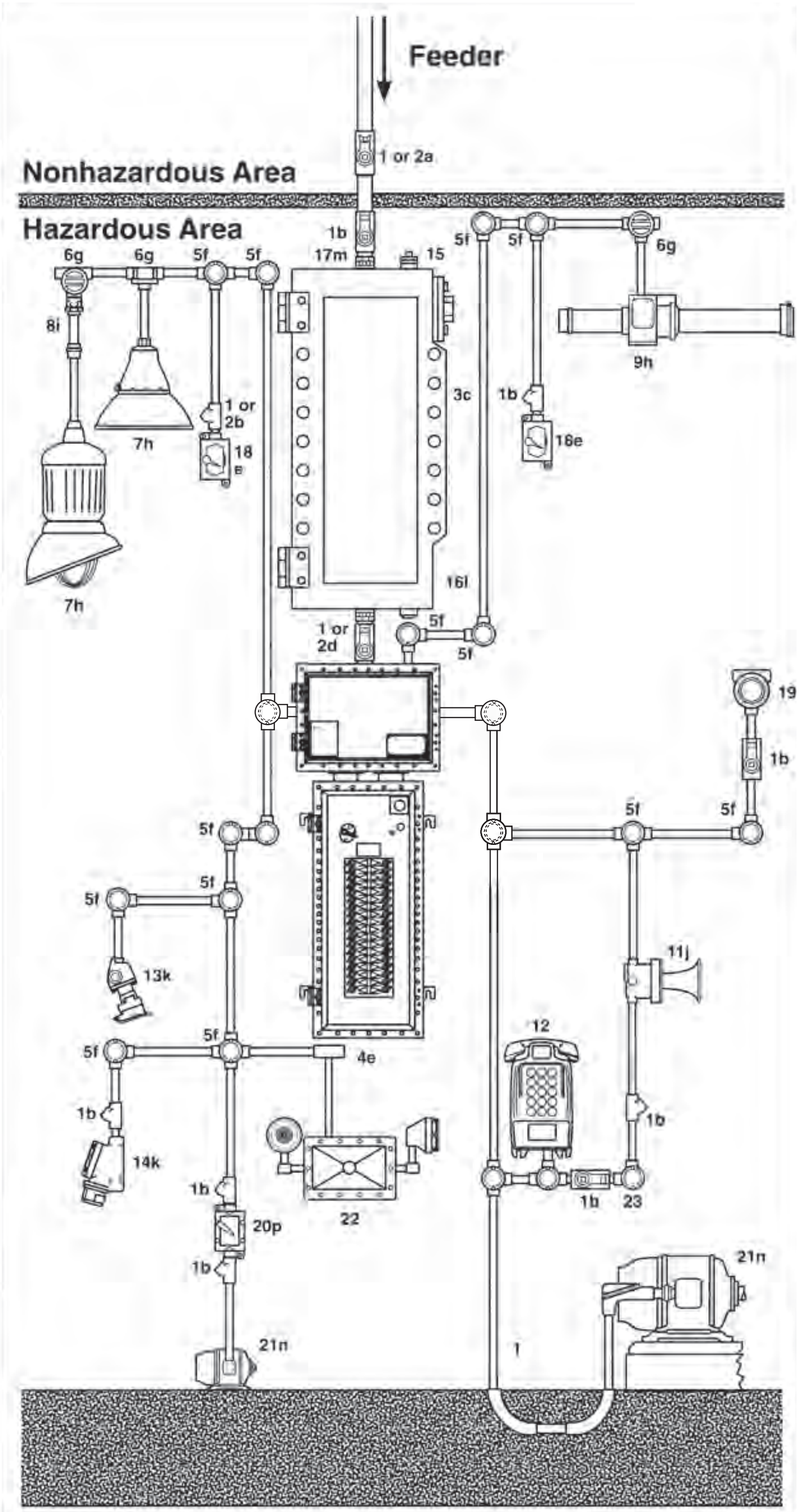
17. GHG 43 SpecOne Control Station with Zone 1 Myers hubs

18. EDS Motor Starter with TMCX Terminator cable gland

19. Zone 1 Rated Motor with TMC or TMCX Terminator cable gland

* Canadian Wiring Rules allow the use of cables approved for Hazardous Locations (marked with HL) or rigid conduit for Class I, Zone 1 Hazardous Locations. When entering a non-metallic enclosure, use cable glands suitable for the cable being used and the requirements of the code e.g. TMC, TMCX, TECK.

Appendix V- Diagram for Class I, Div. 1* Lighting Installation



*Also applicable for Class I, Zone 1, see rules 18-100 to 18-130.

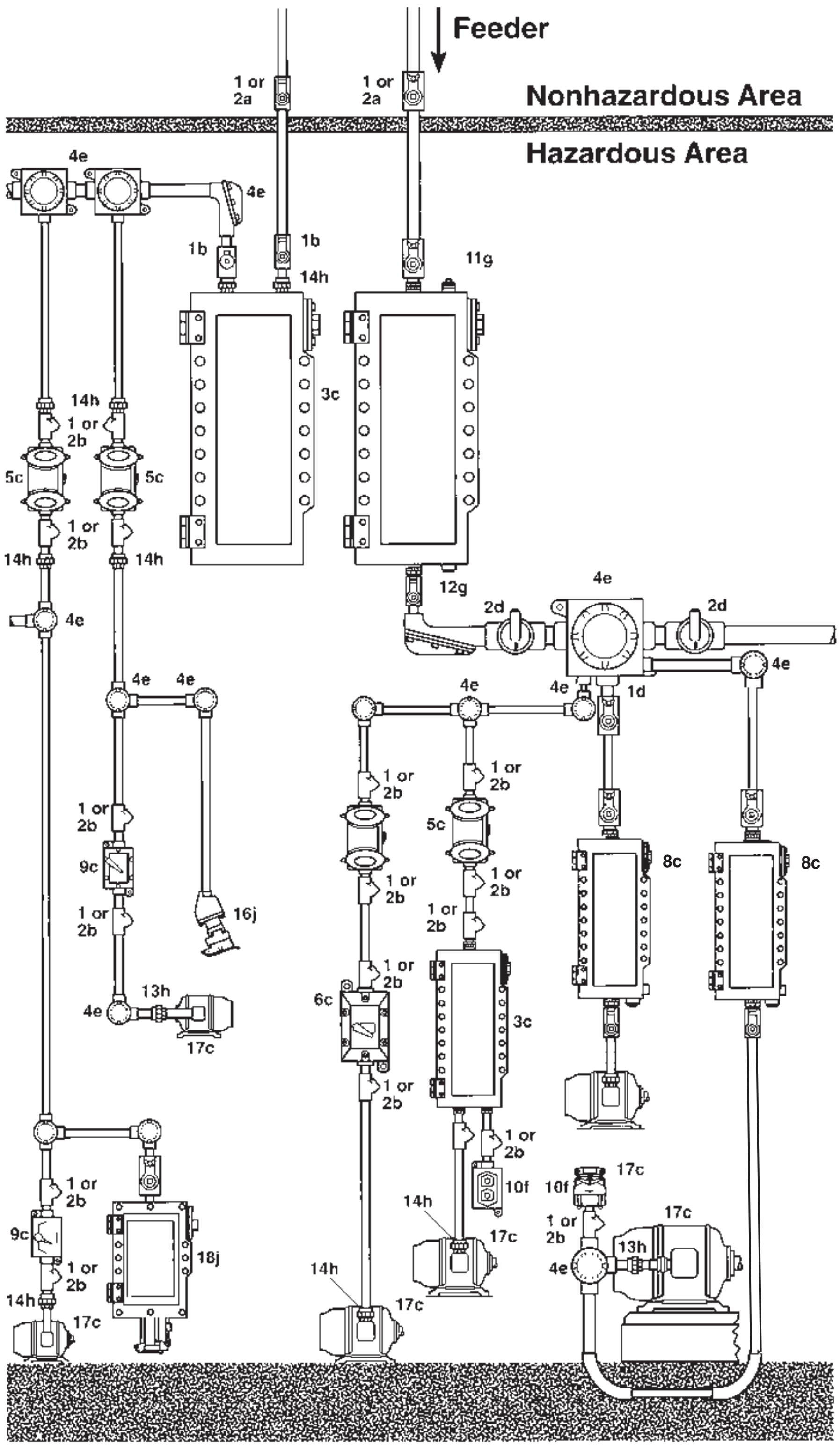
Key to Numerals

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. FSQ. 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.

Canadian Electrical Code References

a. 18-154(1)(c), 18-154(5), 18-154(6). Seals may be required at the boundary on Zone 2 areas
b. 18-154(1)(a) Seals are required within 450mm of enclosures required to be flameproof or explosion-proof (e.g. containing arcing devices)
c. 14-606. Overcurrent protection required ahead of panelboards in most instances
d. 18-150 (1). Fixed luminaires need to be approved for the location
e. 18-150 (1), Arcing and sparking devices must be housed in explosion-proof or flameproof housing, hermetically sealed, intrinsically safe or non-incendive.
f. 18-150(2)(c) Boxes do not need to be explosion-proof or flameproof if they meet the requirements of this rule
h. 18-156(3).Portable lighting luminaires must meet the the same requirements as for Class I Zone 1.
i. 18-156(2). Pendant luminaires must be approved by rigid conduit stems or other approved means. Stems longer than 300mm must either be braced or have a flexible connector approved for the purpose.
j. 18-150(1). Signaling equipment must be approved for the location as per rule 18-150.
k. 18-124, 18-150. Receptacles and plugs must provide for connection to the grounding conductor and meet the requirements of rule 18-150(1)
m. 18-150(2)(c) Boxes do not need to be explosion-proof or flameproof if they meet the requirements of this rule
n. 18-150(2)(e). Motors that contain arcing, sparking, or heat producing components must comply with the requirements of 18-100
p. 28-300 Motors and circuit conductors require overload protection

Appendix VI - Diagram for Class I, Div. 1 Power Installation*



*Also applicable for Class I, Zone 1, see rules 18-100 to 18-130.

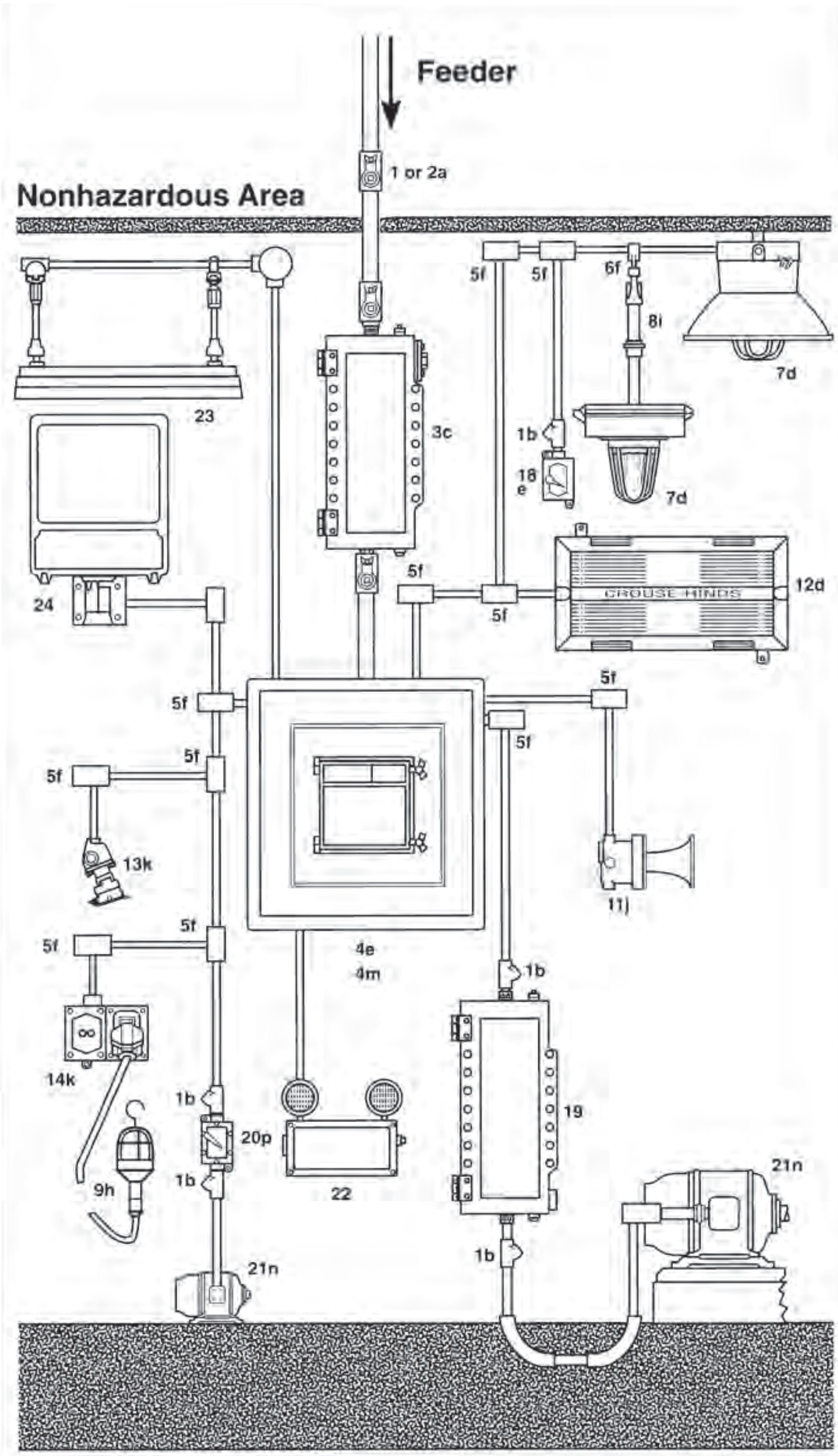
Key to Numerals

1. Sealing fitting. EYS for horizontal or vertical.
2. Sealing fitting. EZS for vertical or horizontal conduits.
3. Circuit breaker EBMB.
4. Junction box Series GUA, GUB, EAB, and EAJ have threaded covers. Series CPS and Type LBH have ground flat surface covers.
5. Circuit breaker FLB.
6. Manual line starter EMN.
7. Magnetic line starter EBMS.
8. Combination circuit breaker and line starter EPC.
9. Switch or motor starter. Series EFS, EDS, or EMN.
10. Pushbutton station. Series EFS or OAC.
11. Breather. ECD.
12. Drain. ECD.
13. Union. UNF.
14. Union. UNY.
15. Flexible coupling. EC.
16. Plug receptacle. CES. Factory sealed.
17. Motor for hazardous location.
18. Plug receptacle. EBBR Interlocked Arktite® receptacle with circuit breaker.

Canadian Electrical Code References

a. J18-108(1)(c). Seals required where conduit passes from hazardous to nonhazardous area.
b. J18-108(1)(a). Seals required within 450 mm of enclosures containing arcing devices.
c. Section 28 should be studied for detailed requirements for conductors, motor feeders, motor feeder and motor branch circuit protection, motor overcurrent protection, motor controller, and motor disconnecting means.
d. J18-108(1)(b). Seals required if conduit is 53 trade size (2 inches) or larger.
e. J18-106(2). All boxes must be explosionproof and threaded for connection to conduit or cable glands.
f. J18-110. Pushbutton stations must be explosionproof.
g. J18-108(4)(c). Breathers and drains are required where liquid or condensed vapor may be trapped within enclosures or the raceway system.
h. J18-106. Joints and fittings must be explosionproof.
j. J18-124. Receptacles and attachment plugs must be explosion-proof and must be of the type providing for connection to the bonding conductor required in flexible cords by Rule J12-122.

*Appendix VII - Diagram for Class I, Zone 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 EPC.
- **4** Panelboard. D2Z. 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. FMV.

Canadian Electrical Code References

a. 18-158(3)(b) & (c). Seals required where conduit passes from hazardous to nonhazardous area.

b. 18-158(3)(a). Seals required within 450 mm of enclosures containing arcing devices.

c. 14-606. Circuit breaker protection required ahead of the panelboard.

d. 18-172(b)(ii). Fixed lighting fixtures must meet the requirements of Rule J18-150 (Allows for a variety of constructions).

e. Various Rules. Arcing and sparking devices must be explosionproof, flameproof, hermetically sealed, intrinsically safe or non-incendive.

f. 18-156. Boxes and fittings need not be explosionproof or flameproof except where specifically required in Zone 2 Rules.

h. 18-172(1)(a). Portable lighting fixtures must meet the protection same protection requirements as in Class I, Zone 1.

i. 18-172(2) Pendant fixtures must be suspended by rigid conduit stems or other approved means. Stems longer than 300 mm must have flexible connector or be braced.

j. 18-150 Signaling equipment must meet one or more of the protection requirements in Rule 18-150. (not necessarily required to be explosionproof).

k. 18-124. Receptacles and plugs must provide for connection to the grounding conductor and meet the requirements of Rule 18-150.

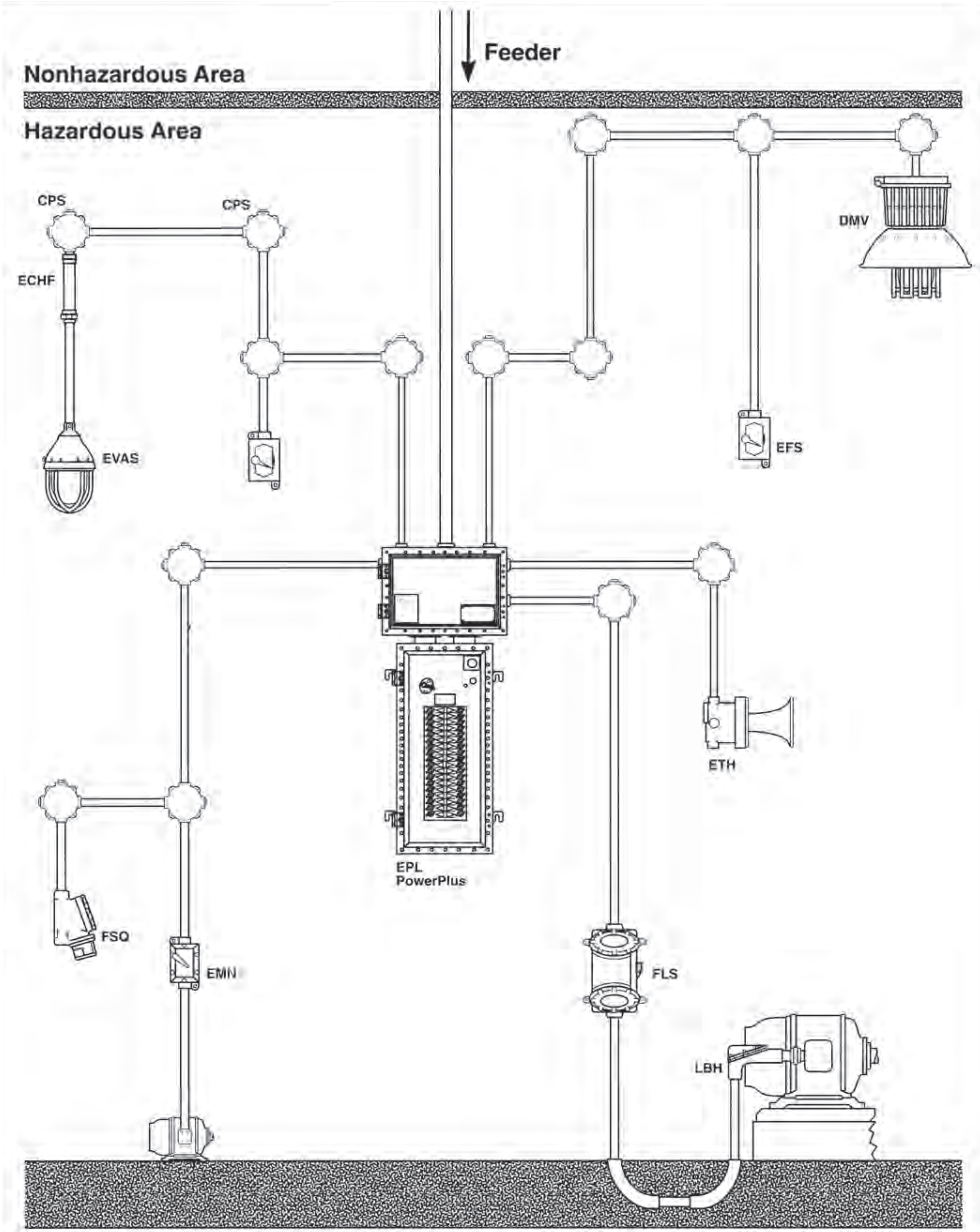
m. 18-156(7). Only boxes, joints and fittings specifically required by Zone 2 Rules need to be explosionproof or flameproof.

n. 18-168. Only motors incorporating arcing, sparking or heat producing resistance components are required to be explosionproof.

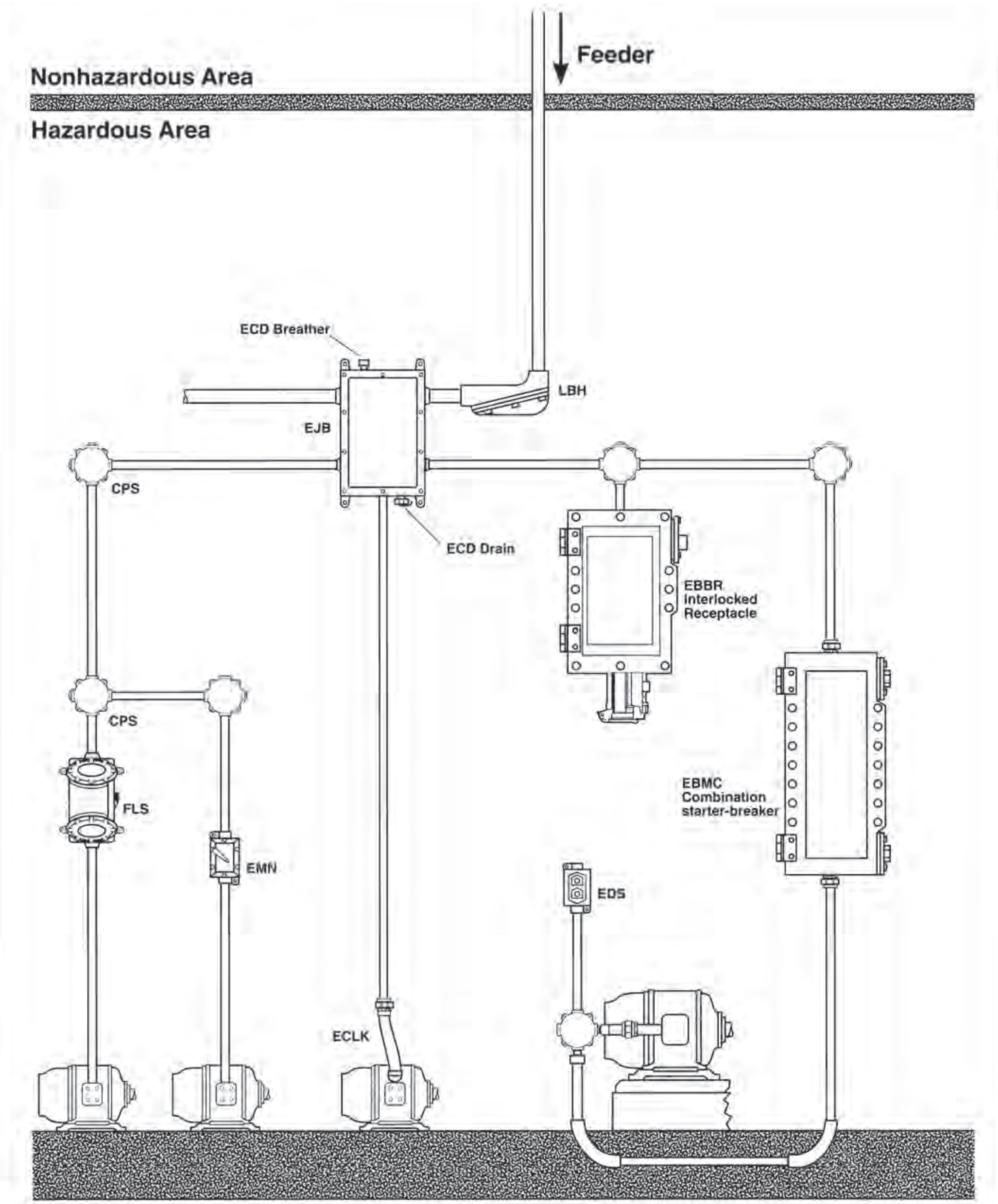
p. 28-300 Motors and circuit conductors require overload protection.

* Rules in Annex J18 for Class I, Division 2 Hazardous Locations parallel the above.

Appendix VIII - Diagram for Class II Lighting Installation



Appendix IX - Diagram for Class II Power Installation



Appendix X - Suggestions for Installation and Maintenance

Section 2 of the *CEC* 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-energising 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-energised.

B. Assembly or Disassembly of Explosion-proof or Flameproof Enclosures.

Hammers or prying tools must not be allowed to damage the flat-joint surfaces of explosion-proof or flameproof enclosures as these surfaces are flame paths.. 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 mechanical injury. 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 alive. Leaving screws or bolts loose may render 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 render it unsafe.

D. Cleaning and Lubrication.

Particles of foreign material should not be allowed to accumulate on flat and 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 original 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 outside 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 explosion-proof 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 should be used with this equipment must 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.

Appendix XI

General Guide for Product Material Selection

When designing a new facility or improving an old one, corrosion control can mean the difference between trouble free operation and costly downtime.

At Cooper Crouse-Hinds, our years of experience in corrosion control can help you reduce equipment failures and loss of production.

The general guide below can help you in selecting the most suitable material for products used in corrosive environments.

A = Excellent B = Good C = Adequate D = Unsatisfactory

CHEMICAL ATMOSPHERE	Krydon	Copper-Free Aluminum	Feraloy	Corro-Free Epoxy Coating	Silicon Bronze	316 Stainless Steel	PPS	Valox 357
Acetic Acid	A	C	C	C	C	A	A	A
Acetic Anhydride	A	A	D	C	C	A	A	C
Acetone	A	A	A	C	A	A	A	C
Acetylene	A	A	A	A	D	A	A	B
Aluminum Chloride	A	D	D	A	C	D	A	B
Aluminum Sulfate	A	C	D	A	C	B	A	B
Ammonium Carbonate	A	A	A	A	D	A	C	C
Ammonium Chloride	A	D	D	A	D	D	A	C
Ammonium Hydroxide	A	A	B	A	D	B	A	D
Ammonium Nitrate	A	A	B	A	D	A	A	B
Ammonium Phosphate	A	C	B	A	D	B	A	B
Amyl Acetate	A	A	B	C	A	A	A	D
Amyl Alcohol	A	A	A	A	A	B	B	D
Aniline	A	B	D	B	C	A	A	D
Arsenious Acid	A	A	D	A	C	B	D	B
Asphalt	A	A	A	A	A	A	B	A
Barium Carbonate	A	D	A	A	A	B	B	B
Barium Chloride	A	D	D	A	C	B	B	A
Barium Hydroxide	A	D	A	A	A	A	B	C
Beer	A	A	A	A	A	A	B	A
Beet Sugar Liquors	A	A	A	A	A	A	B	A
Benzene	A	A	A	C	A	A	A	D
Benzoic Acid	A	A	D	A	A	A	A	D
Borax	A	B	A	A	A	A	B	A
Boric Acid	A	B	A	A	A	B	B	B
Bromine, Wet	B	D	D	C	C	D	D	D
Butane	A	A	A	A	A	B	B	B
Butyl Alcohol	A	A	B	A	A	A	B	A
Butyric Acid	A	A	D	C	A	B	A	B
Calcium Bisulfite	A	A	D	A	C	D	B	B
Calcium Chloride	A	C	B	A	A	D	A	A
Calcium Hydroxide	A	D	A	A	A	B	A	B
Calcium Hypochlorite	A	B	D	A	C	D	D	C
Calcium Sulfate	A	A	A	A	A	B	B	B
Cane Sugar Liquors	A	A	A	A	A	A	A	B
Carbon Dioxide, Dry	A	A	A	A	A	A	B	A
Carbon Dioxide, Wet	A	A	B	A	C	A	C	A
Carbon Disulfide	A	A	B	C	C	B	B	C
Carbon Tetrachloride	A	A	B	C	A	A	C	C
Carbonic Acid	A	A	B	A	C	B	C	B
Castor Oil	A	A	A	A	A	B	A	B
Chlorine	A	D	A	B	D	B	D	C
Chloroform	B	B	C	B	A	C	C	D
Citric Acid	A	A	D	A	A	B	A	A
Cottonseed Oil	A	A	A	A	A	B	B	C
Chromic Acid	A	B	B	C	D	C	B	D
Crude Oil	A	A	A	A	A	A	A	C
Ethyl Acetate	A	A	A	C	A	B	A	D
Ethyl Alcohol	A	A	A	A	A	A	B	B
Ethyl Chloride	A	B	B	B	A	A	B	B
Ethylene Dichloride	B	A	A	C	A	B	B	D
Ethylene Glycol	A	A	A	A	A	B	A	B
Fatty Acids	A	A	B	A	C	B	A	C
Ferric Chloride	A	D	D	A	D	D	B	B
Ferric Sulfate	A	D	D	A	D	B	A	B
Formaldehyde	A	A	B	A	A	B	B	D
Formic Acid	A	B	D	A	A	B	C	B
Freons, Dry	A	A	A	A	A	B	A	A
Fuel Oil	A	A	A	A	A	B	B	A
Furfural	D	A	A	C	A	B	A	C
Gasoline	A	A	A	A	A	A	A	A
Glue	A	A	A	A	A	B	B	B
Glycerine	A	A	A	A	A	A	A	C
Concd. Hydrochloric Acid	C	D	D	C	D	D	D	B
Hydrofluoric Acid	D	D	D	C	D	D	C	D
Hydrogen	A	A	A	A	A	A	A	A

Appendix XI

General Guide for Product Material Selection

When designing a new facility or improving an old one, corrosion control can mean the difference between trouble free operation and costly downtime.

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The general guide below can help you in selecting the most suitable material for products used in corrosive environments.

A = Excellent B = Good C = Adequate D = Unsatisfactory

CHEMICAL ATMOSPHERE	Krydon	Copper-Free Aluminum	Feraloy	Corro-Free Epoxy Coating	Silicon Bronze	316 Stainless Steel	PPS	Valox 357
Hydrogen Peroxide	A	A	D	C	C	B	D	C
Hydrogen Sulfide	A	A	C	A	B	B	B	C
Kerosene	A	A	A	A	A	B	A	C
Ketones	A	A	A	C	A	B	A	D
Lacquers	A	A	B	A	A	A	C	B
Lacquer Solvents	A	A	B	C	A	A	C	C
Lactic Acid	A	B	D	B	B	B	A	B
Lime	B	B	A	B	A	B	C	C
Linseed Oil	A	A	A	A	A	B	A	A
Magnesium Chloride	A	B	D	A	A	B	A	B
Magnesium Hydroxide	A	D	A	A	A	A	A	C
Magnesium Sulfate	A	A	A	A	A	B	A	B
Marine Atmosphere	A	A	D	A	A	B	A	A
Mercuric Chloride	A	D	D	A	D	D	D	B
Mercury	A	D	B	A	D	A	D	B
Methyl Alcohol	A	A	A	A	A	B	B	D
Methyl Chloride	B	D	B	D	B	A	A	D
Methyl Ethyl Ketone	A	A	B	B	A	B	B	D
Mine Waters	A	B	D	B	B	A	B	B
Motor Oil	A	A	A	A	A	B	A	A
Nickel Chloride	A	D	D	A	D	D	D	A
Nickel Sulfate	A	D	D	A	C	B	B	B
Nitric Acid	C	A	D	A	D	B	D	B
Oleic Acid	A	A	B	A	B	B	D	C
Oxalic Acid	A	B	B	A	A	D	B	D
Oxygen	A	A	A	A	A	B	B	A
Perchloric Acid	A	D	D	C	D	D	D	C
Phenol	A	A	B	B	A	A	A	C
Phosphoric Acid	A	D	C	B	B	C	B	C
Picric Acid	A	A	B	B	D	B	D	C
Potassium Carbonate	A	B	A	A	A	A	A	A
Potassium Chloride	A	D	B	A	B	B	A	B
Potassium Cyanide	A	D	B	A	D	B	A	B
Potassium Hydroxide	C	D	A	B	C	B	A	B
Potassium Nitrate	A	A	A	A	B	B	A	A
Potassium Sulfate	A	A	A	A	A	A	A	A

CHEMICAL ATMOSPHERE	Krydon	Copper-Free Aluminum	Feraloy	Corro-Free Epoxy Coating	Silicon Bronze	316 Stainless Steel	PPS	Valox 357
Propane	A	A	A	A	A	B	B	B
Rosin	A	A	B	A	A	A	C	C
Sea Water	A	B	D	A	A	B	A	B
Sodium Bicarbonate	A	A	B	A	A	A	A	A
Sodium Bisulfate	A	B	D	A	A	B	B	B
Sodium Bisulfite	A	B	D	A	B	B	B	B
Sodium Carbonate	A	C	A	A	A	B	A	A
Sodium Chloride	A	D	B	A	A	B	A	B
Sodium Cyanide	A	D	B	A	D	A	B	B
Sodium Hydroxide	B	D	A	B	B	B	B	C
Sodium Hypochlorite	A	D	D	B	B	C	D	C
Sodium Nitrate	A	A	A	A	B	B	A	A
Sodium Phosphate	A	D	A	A	B	B	B	B
Sodium Silicate	A	B	A	A	A	A	A	B
Sodium Sulfate	A	A	A	A	A	A	A	C
Sodium Sulfite	A	A	B	A	A	B	A	C
Stearic Acid	A	A	B	A	B	A	A	B
Sulfur	A	A	A	A	D	A	A	A
Sulfur Dioxide, Dry	A	B	A	A	A	B	B	B
Sulfur Trioxide, Dry	A	A	A	A	A	B	C	C
Sulfur Trioxide, Wet	A	D	D	B	C	C	C	C
Sulfuric Acid	A	A	D	B	C	D	A	B
Sulfurous Acid	A	B	D	B	B	D	B	B
Tannic Acid	A	A	B	A	A	B	B	B
Tar	A	A	A	A	A	A	D	C
Tartaric Acid	A	A	B	B	B	A	A	C
Toluene	A	A	A	C	A	A	A	D
Trichlorethylene	A	A	B	C	A	B	C	C
Turpentine	A	A	A	A	A	A	A	C
Vegetable Oils	A	A	A	A	A	A	B	A
Vinegar	A	B	B	A	A	B	B	A
Vinyl Chloride	A	B	B	B	D	B	D	D
Waxes	A	A	A	A	A	B	B	A
Xylene	A	A	A	C	A	B	A	D
Zinc Chloride	A	B	B	A	D	B	B	B
Zinc Sulfate	A	B	B	A	C	A	C	A

Appendix XI

Chemical stability of plastics for explosion-protected apparatus.

Explosion-protected electrical apparatus is often made in the economical type of protection "increased safety." This calls for the use of high-grade, specially selected and tested plastics that meet these demanding requirements and provide a mechanical, thermal and chemical stability.

The plastics listed in the table beside have been used in practice for years and have proved to be reliable.

The adjacent table gives details issued by the manufacturers of the plastics relating to the chemical stability of the plastics listed compared to a series of media.

These details can, however, only be applied up to a degree for the evaluation of the usability of explosion-protected electrical apparatus in chemical and petrochemical installations, as the aggressive atmosphere often only occurs for a short time and in a relatively low concentration.

CHEMICAL STABILITY OF PLASTICS			
Material	**Polyamide**	**Polyester**	**Polycarbonate**
Acetone	+	+	-
Ethyl Alcohol (up to 30%)	O	+	0,96%
Ethyl glycol	O	+	+
Ammonia (at 23 °C)	+	+10%	-
Benzene 60/140 °C	+	+	+
Benzol (at 23 °C)	+	+	-
Boric acid 3%	+	+	+
Butane	+	+	+
Chlorine bleaching solution	O	+	
Chloric gas (damp)	O	+	-
Chloride of lime	O	+	+
Chromic acid 10%	-	+	+
Cyclohexane	+	+	+
Diesel oil	+	+	+
Jet fuel	+	+	+
Acetic acid (up to 25%)	O	+	+ 10 °C
Formaldehyde	+	+	+
Glycol	+	+	+
Glycerine	+	+	+
Uric acid (up to 20%)	+	+	+
Fuel oil	+	+	+
Machinery oil	O	+	+
Sea water	+	+	+
Methyl alcohol conc. 20%	O	+	O
Lactic acid	+	+	+
Mineral oil	+	+	
Sodium chloride	O	+	+
Soda lye (20-25 °C)	+	+5%	-
Petroleum	+	+	-
Phosphoric acid conc.	-	+	+
Soap suds (at 23 °C)	+	+	+
Sulphuric acid 5 – 30% and 70%	O	+	+
Sulphuric dioxide, dry (at 23 °C)	+	+	O
Super fuel (at 60 °C)	+	+	-
Turpentine (at 23 °C)	+	+	-
Tartaric acid	O	+	+ up to 10%
Citric acid up to 32%	+	+	+
Explanation of symbols: + = stable o= limited stability - = non-stable			

Appendix XII - Reference Information

MISCELLANEOUS FORMULAS

Ohms Law

Ohms = Volts/Amperes (R = E/I)
Amperes = Volts/Ohms (I = E/R)
Volts = Amperes x Ohms (E = IR)

Power—A.C. Circuits

$$\text{Efficiency} = \frac{746 \text{ x Output Horsepower}}{\text{Input Watts}}$$

$$\text{Three-Phase Kilowatts} = \frac{\text{Volts x Amperes x Power Factor x } 1.732}{1000}$$

Three-Phase Volt-Amperes = Volts x Amperes x 1.732

$$\text{Three-Phase Amperes} = \frac{746 \text{ x Horsepower}}{1.732 \text{ x Volts x Efficiency x Power Factor}}$$

$$\text{Three-Phase Efficiency} = \frac{746 \text{ x Horsepower}}{\text{Volts x Amperes x Power Factor x } 1.732}$$

$$\text{Three-Phase Power Factor} = \frac{\text{Input Watts}}{\text{Volts x Amperes x } 1.732}$$

$$\text{Single-Phase Kilowatts} = \frac{\text{Volts x Amperes x Power Factor}}{1000}$$

$$\text{Single-Phase Amperes} = \frac{746 \text{ x Horsepower}}{\text{Volts x Efficiency x Power Factor}}$$

$$\text{Single-Phase Power Factor} = \frac{\text{Input Watts}}{\text{Volts x Amperes}}$$

Horsepower (3 Phase) = Volts x Amperes x 1.732
$$\frac{\text{Efficiency Power Factor}}{746}$$

Horsepower (1 Phase) = Volts x Amperes
$$\frac{\text{Efficiency Power Factor}}{746}$$

Power—D.C. Circuits

Watts = Volts x Amperes (W = EI)

$$\text{Amperes} = \frac{\text{Watts}}{\text{Volts}} \quad (I = W/E)$$

$$\text{Horsepower} = \frac{\text{Volts x Amperes x Efficiency}}{746}$$

Speed—A-C Machinery

$$\text{Synchronous RPM} = \frac{\text{Hertz x } 120}{\text{Poles}}$$

$$\text{Percent Slip} = \frac{\text{Synchronous RPM} - \text{Full Load RPM}}{\text{Synchronous RPM}} \text{ x } 100$$

Motor Application

$$\text{Torque (lb.-ft.)} = \frac{\text{Horsepower x } 5350}{\text{RPM}}$$

$$\text{Horsepower} = \frac{\text{Torque (lb.-ft.) x RPM}}{5250}$$

Time for Motor to Reach Operating Speed (seconds)

$$\text{Seconds} = \frac{WK^2 \text{ x Speed Change}}{308 \text{ x Avg. Accelerating Torque}}$$

WK^2 = Inertia of Rotor + Inertia of Load (lb.-ft.)^2

$$\text{Average Accelerating Torque} = \frac{[(FLT + BDT)/2] + BDT + LRT}{3}$$

FLT = Full-Load Torque BDT = Breakdown Torque
LRT = Locked-Rotor Torque

$$\text{Load } WG^2 \text{ (at motor shaft)} = \frac{WG^2 \text{ (Load) x Load } RPM^2}{\text{Motor } RPM^2}$$

$$\text{Shaft Stress P.S.I.} = \frac{\text{HP x } 321{,}000}{\text{RPM x Shaft Diam.}^3}$$

Pump Motor Application

$$\text{Horsepower} = \frac{\text{GPM x Head in Feet x Specific Gravity}}{3960 \text{ x Efficiency of Pump}}$$

Head in Feet = 2.31 P.S.I.G.

Fan and Blower Motor Application

$$\text{Horsepower} = \frac{\text{CFM x Pressure (lb./sq.ft.)}}{33000 \text{ x Efficiency}}$$

Volume of Liquid in a Tank

Gallons = 5.875 x D^2 x H

D = Tank Diameter (ft.)

H = Height of Liquid (ft.)

Conversion Factors

MULTIPLY		BY		TO OBTAIN
LENGTH				
Centimeters	x	.3937	=	Inches
Fathoms	x	6.0	=	Feet
Feet	x	12.0	=	Inches
Feet	x	.3048	=	Metres
Inches	x	2.54	=	Centimeters
Kilometers	x	.6214	=	Miles
Metres	x	3.281	=	Feet
Metres	x	39.37	=	Inches
Metres	x	1.094	=	Yards
Miles	x	5280.0	=	Feet
Miles	x	1.609	=	Kilometers
Rods	x	5.5	=	Yards
Yards	x	.9144	=	Metres
AREA				
Acres	x	43560.0	=	Square feet
Acres	x	4840.0	=	Square yards
Circular mils	x	7.854×10^{-7}	=	Square inches
Circular mils	x	.7854	=	Square mils
Square cent.	x	.155	=	Square inches
Square feet	x	144.0	=	Square inches
Square feet	x	.0929	=	Square Metres
Square inches	x	6.452	=	Square cent.
Square Metres	x	1.196	=	Square yards
Square miles	x	640.0	=	Acres
Square mils	x	1.273	=	Circular mils
Square yards	x	.8361	=	Square Metres
VOLUME				
Cubic feet	x	.0283	=	Cubic Metres
Cubic feet	x	7.481	=	Gallons
Cubic inches	x	.5541	=	Ounces (fluid)
Cubic Metres	x	35.31	=	Cubic feet
Cubic Metres	x	1.308	=	Cubic yards
Cubic yards	x	.7646	=	Cubic Metres
Gallons	x	.1337	=	Cubic feet
Gallons	x	3.785	=	Liters
Liters	x	.2642	=	Gallons
Liters	x	1.057	=	Quarts (liquid)
Ounces (fluid)	x	1.805	=	Cubic inches
Quarts (liquid)	x	.9463	=	Liters

Conversion Factors

WEIGHT	
1 short ton = 2000 pounds 1 short ton = 907.2 kilograms 1 kilogram = 2.205 pounds	1 pound = 453.6 grams 1 ounce = 28.35 grams 1 gram = .0353 ounces
DRY VOLUME	
1 cu. meter = 1.308 cu. yards 1 cu. yard = .7646 cu. Metres	1 cu. meter = 35.31 cu. feet 1 cu. foot = .0283 cu. Metres
LIQUID VOLUME	
1 U.S. gallon = 3.785 liters 1 liter = .2642 U.S. gallons	1 U.S. quart = .9463 liters 1 liter = 1.057 U.S. quarts
POWER	
1 horsepower = 746 watts 1 horsepower = 3,300 ft-lbs./min 1 horsepower = 550 ft-lbs./min	1 BTU/hour = .293 watts 1 BTU = 252 gram-calories 1 BTU = 778.3 ft.-lbs.

Conversion Factors

MULTIPLY		BY		TO OBTAIN
FORCE AND WEIGHT				
Grams	x	.0353	=	Ounces
Kilogram	x	2.205	=	Pounds
Newtons	x	.2248	=	Pounds (force)
Ounces	x	28.35	=	Grams
Pounds	x	453.6	=	Grams
Pounds(force)	x	4.448	=	Newtons
Tons(short)	x	907.2	=	Kilograms
Tons(short)	x	2000.0	=	Pounds
TORQUE				
Gram centimeters	x	.0139	=	Ounce-inches
Newton-Metres	x	.7376	=	Pound-feet
Newton-Metres	x	8.851	=	Pound-inches
Ounce-inches	x	72.0	=	Gram-centimeters
Pound-feet	x	1.3558	=	Newton-Metres
Pound-inches	x	.113	=	Newton-Metres
ENERGY OR WORK				
Btu	x	778.2	=	Foot-pounds per minute
Btu	x	252.0	=	Gram-calories
POWER				
Btu per hour	x	.293	=	Watts
Horsepower	x	33000.0	=	Foot-pounds per minute
Horsepower	x	550.0	=	Foot-pounds per second
Horsepower	x	746.0	=	Watts
Kilowatts	x	1.341	=	Horsepower
PLANE ANGLE				
Degrees	x	.0175	=	Radians
Minutes	x	.01667	=	Degrees
Minutes	x	2.9×10^{-4}	=	Radians
Quadrants	x	90.0	=	Degrees
Quadrants	x	1.5708	=	Radians
Radians	x	57.3	=	Degrees

Conversion Factors

AREA	
1 sq. mile = 640 acres 1 acre = 4,840 sq. yards 1 acre = 43,560 sq. ft. 1 sq. foot = 144 sq. inches 1 sq. yard = .836 sq. Metres 1 sq. meter = 1.196 sq. yards	1 sq. ft. = .0929 sq. Metres 1 cir. mil = 7.854 x 10.7 sq. inch. 1 cir. mil = .7854 sq. mils 1 sq. mil = 1.273 sq. mils 1 sq. inch = 6.452 sq. cm. 1 sq. cm. = .155 sq. inch
ANGLE	
1 quadrant = 90 degrees 1 quadrant = 1.57 radians 1 radian = 57.3 degrees	1 degree = .0175 radian 1 minute = .01667 degree 1 minute = 2.9×10^{-4} radian
LENGTH	
1 mile = 5280 feet 1 mile = 1.609 kilometers 1 kilometer = .621 miles 1 yard = .9144 Metres 1 meter = 3.28 feet 1 meter = 39.37 inches 1 meter = 1.094 yards	1 foot = 12 inches 1 foot = .3048 1 inch = 2.54 centimeters 1 centimeter = .394 inch 1 fathom = 6 feet 1 rod = 5-1/2 yards

TEMPERATURE CONVERSION TABLE								
"Locate known temperature in 0°C/°F column. Read converted temperature in °C or °F column."								
°C	**°C/°F**	**°F**	**°C**	**°C/°F**	**°F**	**°C**	**°C/°F**	**°F**
-45.4	-50	-58	15.5	60	140	76.5	170	338
-42.7	-45	-49	18.3	65	149	79.3	175	347
-40	-40	-40	21.1	70	158	82.1	180	35.6
-37.2	-35	-31	23.9	75	167	85	185	365
-34.4	-30	-22	26.6	80	176	87.6	190	374
-32.2	-25	-13	29.4	85	185	90.4	195	383
-29.4	-20	-4	32.2	90	194	93.2	200	932
-26.6	-15	5	35	95	203	96	205	401
-23.8	-10	14	37.8	100	212	98.8	210	410
-20.5	-5	23	40.5	105	221	101.5	215	419
-17.8	0	32	43.4	110	230	104.4	220	428
-15	5	41	46.1	115	239	107.2	225	437
-12.2	10	50	48.9	120	248	110	230	446
-9.4	15	59	51.6	125	257	112.8	235	455
-6.7	20	68	54.4	130	266	115.6	240	464
-3.9	25	77	57.1	135	275	118.2	245	473
-1.1	30	86	60	140	284	120.9	250	482
1.7	36	95	62.7	145	293	123.7	255	491
4.4	40	104	65.5	150	302	126.5	260	500
7.2	45	113	68.3	155	311	129.3	265	509
10	50	122	71	160	320	132.2	270	518
12.8	55	131	73.8	166	329	136	275	527
°F = (9/5 x °C) + 32 °C = 5/9 (°F – 32)								

VOLTAGE DROP ESTIMATING TABLE

K Factor-voltage drop per ampere per circuit kilometer. For three conductor cables or three single conductor cables in conduit. K factors are calculated for 60-75° C wire temperature since this is an estimate of the average temperature at which a circuit operates in service.

For circuits known to be operating at 90° C, multiply the voltage drop by 1.102 for copper and 1.105 for aluminum.

To correct voltage drop per 1000 metres to voltage drop per 1000 ft, multiply by 0.3048.

Size AWG or MCM	COPPER						ALUMINUM					
	Magnetic Conduit or Armour			Non-Magnetic Conduit or Armour			Magnetic Conduit or Armour			Non-Magnetic Conduit or Armour		
	80% P.F.	*90% P.F.*	*100% P.F.*	*80% P.F.*	*90% P.F.*	*100% P.F.*	*80% P.F.*	*90% P.F.*	*100% P.F.*	*80% P.F.*	*90% P.F.*	*100% P.F.*
14	8.329	9.341	10.320	8.296	9.304	10.280						
12	5.265	5.896	6.496	5.244	5.873	6.470						
10	3.335	3.726	4.087	3.322	3.711	4.070						
8	2.134	2.374	2.582	2.118	2.355	2.562	3.453	3.858	4.231	3.440	3.843	4.214
6	1.368	1.512	1.625	1.357	1.500	1.612	2.198	2.445	2.662	2.191	2.438	2.654
4	0.882	0.966	1.021	0.875	0.959	1.013	1.410	1.561	1.682	1.403	1.553	1.674
3	0.711	0.775	0.810	0.706	0.769	0.804	1.130	1.246	1.334	1.125	1.241	1.328
2	0.575	0.623	0.642	0.573	0.620	0.639	0.908	0.997	1.058	0.903	0.992	1.053
1	0.469	0.503	0.509	0.467	0.501	0.507	0.733	0.800	0.839	0.729	0.796	0.835
1/0	0.383	0.407	0.404	0.381	0.405	0.402	0.592	0.642	0.665	0.592	0.642	0.665
2/0	0.314	0.330	0.320	0.314	0.330	0.320	0.480	0.517	0.527	0.480	0.517	0.527
3/0	0.260	0.270	0.254	0.260	0.270	0.254	0.392	0.418	0.418	0.392	0.418	0.418
4/0	0.218	0.223	0.203	0.217	0.222	0.201	0.321	0.339	0.332	0.321	0.339	0.332
250	0.193	0.195	0.172	0.192	0.194	0.171	0.280	0.293	0.281	0.280	0.293	0.281
300	0.171	0.170	0.145	0.169	0.169	0.144	0.242	0.250	0.234	0.242	0.250	0.234
350	0.155	0.153	0.127	0.153	0.151	0.124	0.216	0.221	0.203	0.214	0.220	0.201
400	0.142	0.139	0.112	0.141	0.137	0.110	0.195	0.198	0.177	0.193	0.196	0.176
500	0.126	0.121	0.093	0.123	0.118	0.089	0.167	0.168	0.145	0.165	0.165	0.142
600	0.115	0.109	0.080	0.112	0.105	0.076	0.148	0.146	0.122	0.146	0.144	0.119
750	0.101	0.094	0.064	0.105	0.098	0.069	0.131	0.127	0.101	0.132	0.129	0.102
1000	0.096	0.088	0.058	0.090	0.082	0.051	0.114	0.108	0.081	0.110	0.104	0.076

Notes: In general the voltage drop on an aluminum conductor is approximately the same as that for a copper conductor two guage sizes smaller. For non-metallic sheathed cables, use K Factor for non-magnetic conduit or armour.

TEMPERATURE CLASSIFICATION OF INSULATION SYSTEMS
FOR ELECTRICAL AND ELECTRONIC EQUIPMENT

INSULATION SYSTEM		TEMPERATURE CLASSIFICATION	
Class A	Class 105	105°C	221°F
Class E*	Class 120	120°C	248°F
Class B	Class 130	130°C	266°F
Class F	Class 155	155°C	311°F
Class H	Class 180	180°C	356°F
Class N	Class 200	200°C	392°F
Class R	Class 220	220°C	428°F
Class S	Class 240	240°C	464°F
Class C	Class over-240	Over 240°C	Over 464°F
*Used in European Equipment			

The insulation systems are arranged in order of their insulation level and classified by a letter symbol or by a numerical value.

The numerical value relates to the temperature classification of the insulation system.

The temperature classification indicates the maximum (hot-spot) temperature at which the insulation system can be operated for normal expected service life.

In general, all materials used in a given insulation system should be rated for temperatures equal to, or exceeding the temperature classification of the system.

MOTOR TEMPERATURE RATINGS

Motor full load temperature ratings are often given as temperature rises. Temperature rise is based on temperature rise above 40ºC ambient. After running the motor at full load the winding temperature is measured by measuring the resistance of the winding. This gives an average temperature of the motor winding. It is assumed the hottest spot in the winding may be as much as 10ºC higher than the average.

EXAMPLE:

Class F insulation temperature rating	155ºC
Motor temperature rise	105ºC
Ambient temperature	40ºC
Hot spot allowance	10ºC
Total	155ºC

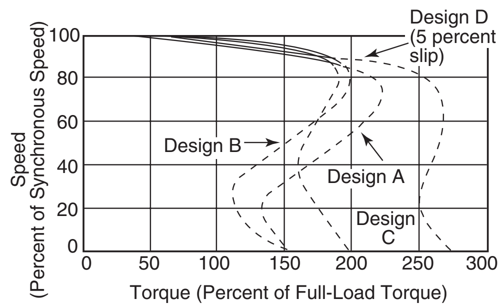
Users often specify a motor to be manufactured with Class F (155ºC) insulation but with a class B (130ºC) full load temperature rise, thus giving extra load capacity without overheating the winding beyond it’s rating. In this situation the full load rating is as follows:

Full load temperature rise	80ºC
Ambient temperature	40ºC
Hot spot allowance	10ºC
Total	130ºC

This allows the user to overload the motor 25ºC beyond full load without exceeding the rating of the winding insulation.

MOTOR INSULATION TEMPERATURE TABLE				
Service Factor 1.0				
Insulation Class	A	B	F	H
Ambient	40°C	40°C	40°C	40°C
Rise by Resistance	60°C	80°C	105°C	125°C
Hot Spot Allowance	5°C	10°C	10°C	15°C
Total Temperature	105°C	130°C	155°C	180°C

GENERAL SPEED-TORQUE CHARACTERISTICS
THREE-PHASE INDUCTION MOTORS



NEMA TORQUE DESIGNS FOR POLYPHASE MOTORS				
NEMA Design	**Starting Current**	**Locked Rotor**	**Breakdown Torque**	**% Slip**
B	Medium	Medium Torque	High	Max 5%
	Applications: Normal starting torque for fans, blowers, rotary pumps, unloaded compressors, some conveyors, metal cutting machine tools, and misc. machinery. Slight speed change with changing load.			
C	Medium	High Torque	Medium	Max 5%
	Applications: High inertia starts, such as large, centrifugal blowers, fly wheels, and crusher drums. Loaded starts, such as piston pumps, compressors and conveyors. Slight speed change with changing load.			
D	Medium	Extra High Torque	Low	5% or more
	Applications: Very high inertia and loaded starts. Also, considerable variation in load speed. Punch presses, shears and forming machine tools. Cranes, Hoists, Elevators, and Oil Well Pumping Jacks.			
NEMA Design A is a variation of Design B having higher locked rotor current.				

ENCLOSURES FOR STARTERS

TYPE	NEMA ENCLOSURE
1	General Purpose—Indoor
2	Dripproof—Indoor
3	Dusttight, Raintight, Sleettight—Outdoor
3R	Rainproof, Sleet Resistant—Outdoor
3S	Dusttight, Raintight, Sleetproof—Outdoor
4	Watertight, Dusttight, Sleet Resistant—Indoor & Outdoor
4X	Watertight, Dusttight, Corrosion Resistant—Indoor & Outdoor
5	Dusttight—Indoor
6	Submersible, Watertight, Dusttight, Sleet Resistant—Indoor & Outdoor
7	Class I, Group A, B, C, or D Hazardous Locations, Air Break—Indoor
8	Class I, Group A, B, C or D Hazardous Locations, Oil Immersed—Indoor
9	Class II, Group E, F, or G Hazardous Locations, Air Break—Indoor
10	Bureau of Mines
11	Corrosion Resistant and Dripproof, Oil Immersed—Indoor
12	Industrial Use, Dusttight and Driptight—Indoor
13	Oiltight and Dusttight—Indoor

COMMON AC MOTOR ENCLOSURE TYPES

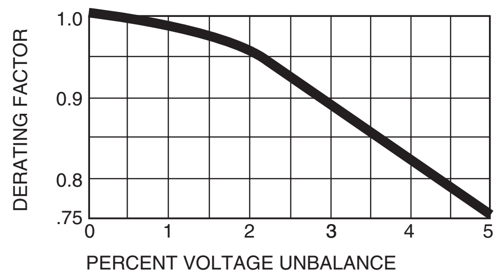
ODP	Open Drip-proof
TEFC	Totally Enclosed Fan Cooled
TEFV	Totally Enclosed Force Ventilated
TEAO	Totally Enclosed Air Over
TEXP	Totally Enclosed Explosion Proof
TEWAC	Totally Enclosed Water/Air Cooled
WPI	Weatherproof I
WPII	Weatherproof II

EFFECTS OF UNBALANCED VOLTAGE ON MOTOR PERFORMANCE

When the line voltages applied to a polyphase induction motor are not equal, unbalanced currents in the stator windings will result. A small percentage voltage unbalance will result in a much larger percentage current unbalance. Consequently, the temperature rise of the motor operating at a particular load and percentage voltage unbalance will be greater than for the motor operating under the same conditions with balanced voltages.

Should voltages be unbalanced, the rated horsepower of the motor should be multiplied by the factor shown in Fig. 1 to reduce the possibility of damage to the motor. Operation of the motor above a 5 percent voltage unbalance condition is not recommended.

FIG. 1



INTEGRAL HORSEPOWER MOTOR DERATING FACTOR DUE TO UNBALANCED VOLTAGE

$$\text{Percent Voltage Unbalance} = 100 \times \frac{\text{Maximum voltage deviation from average voltage}}{\text{Average voltage}}$$

EXAMPLE—With voltages of 220, 214 and 210, the average is 215, the maximum deviation from the average is 5, and the percent

$$\text{Unbalance} = 100 \times \frac{5}{215} = 2.3 \text{ percent}$$

Reference NEMA Standards MGI-14.35

NEMA SIZE	NEMA Size Starters - Maximum Horsepower - Polyphase Motors											
	FULL VOLTAGE STARTING			AUTO TRANSF. STARTING			PART WINDING STARTING			WYE-DELTA STARTING		
	200V	230V	460V 575V	200V	230V	460V 575V	200V	230V	460V 575V	200V	230V	460V 575V
00	1-1/2	1-1/2	2	–	–	–	–	–	–	–	–	–
0	3	3	5	–	–	–	–	–	–	–	–	–
1	7-1/2	7-1/2	10	7-1/2	7-1/2	10	10	10	15	10	10	15
2	10	15	25	10	15	25	20	25	40	20	25	40
3	25	30	50	25	30	50	40	50	75	40	50	75
4	40	50	100	40	50	100	75	75	150	60	75	150
5	75	100	200	75	100	200	150	150	350	150	150	300
6	150	200	400	150	200	400	–	300	600	300	350	700
7	–	300	600	–	300	600	–	450	900	500	500	1000
8	–	450	900	–	450	900	–	700	1400	750	800	1500
9	–	800	1600	–	800	1600	–	1300	2600	1500	1500	3000

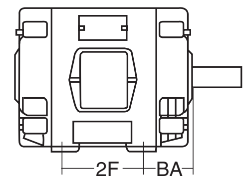
Maximum Locked Rotor Currents						
3-Phase Motors						
Voltage						
HP	200				2300	4160
1/2	23	20	10	8		
3/4	29	25	12.5	10		
1	34.5	30	15	12		
1-1/2	46	40	20	16		
2	57.5	50	25	20		
3	73.5	64	32	25		
5	106	92	46	37		
7-1/2	146	127	63	51		
10	186	162	81	65		
15	267	232	116	93		
20	334	290	145	116		
25	420	365	182	146	35	19
30	500	435	217	174	41	23
40	667	580	290	232	55	30
50	834	725	362	290	69	38
60	1000	870	435	348	83	46
75	1250	1085	492	435	104	57
100	1670	1450	725	580	139	76
125	2085	1815	907	726	173	96
150	2500	2170	1085	870	208	115
200	3340	2900	1450	1160	278	153
250	4200	3650	1825	1460	349	193
300	5050	4400	2200	1760	420	232
350	5860	5100	2550	2040	488	270
400	6670	5800	2900	2320	555	306
450	7470	6500	3250	2600	620	344
500	8340	7250	3625	2900	693	383
Based on NEMA Standards MGI—12.34—June,1972						

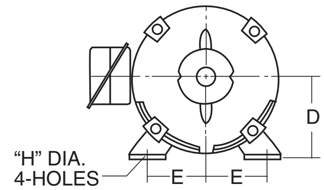
NEMA Code Letters			
NEMA Code Letter	Locked Rotor KVA Per HP	NEMA Code Letter	Locked Code Letter
A	0–3.15	L	9.0–10.0
B	3.15–3.55	M	10.0–11.2
C	3.55–4.0	N	11.2–12.5
D	4.0–4.5	P	12.5–14.0
E	4.5–5.0	R	14.0–16.0
F	5.0–5.6	S	16.0–18.0
G	5.6–6.3	T	18.0–20.0
H	6.3–7.1	U	20.0–22.4
J	7.1–8.0	V	22.4 and up
K	8.0–9.0		
NEMA Standards MG I—10.36—June, 1972			

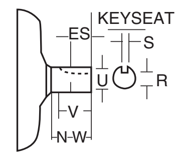
Code Letters Usually Applied to Ratings of Motors Normally Started on Full Voltage							
Code Letters		F	G	H	J	K	L
	3-phase	15 up	10–7 ½	5	3	2–1½	1
	1-phase	–	5	3	2-1/2	1-3/4	1/2

NEMA FRAME DIMENSIONS A-C MOTORS AND GENERATORS

Frame	D	E	2F	H	U	BA	N-W	V min.	R	ES min.	S
48	3	2.12	2.75	.34	.5	2.5	1.5		.453		Flat
56	3.5	2.44	3	.34	.625	2.75	1.88		.517	1.41	.188
143	3.5	2.75	4	.34	.75	2.25	2	1.75	.643	1.41	.188
143T	3.5	2.75	4	.34	.875	2.25	2.25	2	.771	1.41	.188
145	3.5	2.75	5	.34	.75	2.25	2	1.75	.643	1.41	.188
145T	3.5	2.75	5	.34	.875	2.25	2.25	2	.771	1.14	.188
182	4.5	3.75	4.5	.41	.875	2.75	2.25	2	.771	1.41	.188
182T	4.5	3.75	4.5	.41	1.125	2.75	2.75	2.5	.986	1.78	.25
184	4.5	3.75	5.5	.41	.875	2.75	2.25	2	.771	1.41	.188
203	5	4	5.5	.41	.75	3.12	2.25	2	.643	1.53	.188
204	5	4	6.5	.41	.75	3.12	2.25	2	.643	1.53	.188
213	5.25	4.25	5.5	.41	1.125	3.5	3	2.75	.986	2.03	.25
213T	5.25	4.25	5.5	.41	1.375	3.5	3.38	3.12	1.201	2.41	.312
215	5.25	4.25	7	.41	1.125	3.5	3	2.75	.986	2.03	.25
215T	5.25	4.25	7	.41	1.375	3.5	3.38	3.12	1.201	2.41	.312
224	5.5	4.5	6.75	.41	1	3.5	3	2.75	.857	2.03	.25
225	5.5	4.5	7.5	.41	1	3.5	3	2.75	.857	2.03	.25
254	6.25	5	8.25	.53	1.125	4.25	3.37	3.12	.986	2.03	.25
254T	6.25	5	8.25	.53	1.625	4.25	4	3.75	1.416	2.91	.375
256U	6.25	5	10	.53	1.375	4.25	3.75	3.5	1.201	2.78	.312
265T	6.25	5	10	.53	1.625	4.25	4	3.75	1.416	2.91	.375
284	7	5.5	9.5	.53	1.25	4.75	3.75	3.5	.986	2.03	.25
284U	7	5.5	9.5	.53	1.625	4.75	4.88	4.62	1.416	3.78	.375
284T	7	5.5	9.5	.53	1.875	4.75	4.62	4.38	1.591	3.28	.5
284TS	7	5.5	9.5	.53	1.625	4.75	3.25	3	1.416	1.91	.375
286U	7	5.5	11	.53	1.625	4.75	4.88	4.62	1.416	3.78	.375
286T	7	5.5	11	.53	1.875	4.75	4.62	4.38	1.591	3.28	.5
286TS	7	5.5	11	.53	1.625	4.75	3.25	3	1.416	1.91	.375
324	8	6.25	10.5	.66	1.625	5.25	4.87	4.62	1.416	3.78	.375
324U	8	6.25	10.5	.66	1.875	5.25	5.62	5.38	1.591	4.28	.5
324S	8	6.25	10.5	.66	1.625	5.25	3.25	3	1.416	1.91	.375
324T	8	6.25	10.5	.66	2.125	5.25	5.25	5	1.845	3.91	.5
324TS	8	6.25	10.5	.66	1.875	5.25	3.75	3.5	1.591	2.03	.5
326	8	6.25	12	.66	1.625	5.25	4.87	4.62	1.416	3.78	.375
326U	8	6.25	12	.66	1.875	5.25	5.62	5.38	1.591	4.28	.5
326S	8	6.25	12	.66	1.625	5.25	3.25	3	1.416	1.91	.375
326T	8	6.25	12	.66	2.125	5.25	5.25	5	1.845	3.91	.5
326TS	8	6.25	12	.66	1.875	5.25	3.75	3.5	1.591	2.03	.5

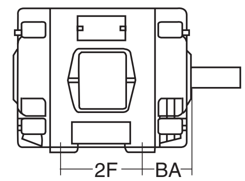


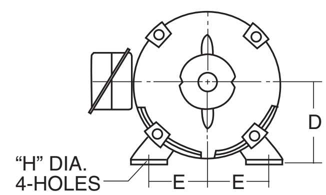


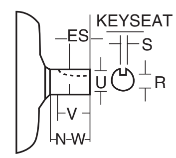


NEMA FRAME DIMENSIONS AC MOTORS AND GENERATORS

Frame	D	E	2F	H	U	BA	N-W	V min.	R	ES min.	S
364	9	7	11.25	.66	1.875	5.88	5.62	5.38	1.591	4.28	.5
364S	9	7	11.25	.66	1.625	5.88	3.25	3	1.416	1.91	.375
364U	9	7	11.25	.66	2.125	5.88	6.37	6.12	1.845	5.03	.5
364US	9	7	11.25	.66	1.875	5.88	3.75	3.5	1.591	2.03	.5
364T	9	7	11.25	.66	2.375	5.88	5.88	5.62	2.01	4.28	.625
364TS	9	7	11.25	.66	1.875	5.88	3.75	3.5	1.591	2.03	.5
365	9	7	12.25	.66	1.875	5.88	5.62	5.38	1.591	4.28	.5
365S	9	7	12.25	.66	1.625	5.88	3.25	3	1.416	1.91	.375
365U	9	7	12.25	.66	2.125	5.88	6.37	6.12	1.845	5.03	.5
365US	9	7	12.25	.66	1.875	5.88	3.75	3.5	1.591	2.03	.5
365T	9	7	12.25	.66	2.375	5.88	5.88	5.62	2.021	4.28	.625
365TS	9	7	12.25	.66	1.875	5.88	3.75	3.5	1.591	2.03	.5
404	10	8	12.25	.81	2.125	6.62	6.37	6.12	1.845	5.03	.5
404S	10	8	12.25	.81	1.875	6.62	3.75	3.5	1.591	2.03	.5
404U	10	8	12.25	.81	2.375	6.62	7.12	6.88	2.021	5.53	.625
404US	10	8	12.25	.81	2.125	6.62	4.25	4.	1.845	2.78	.5
404T	10	8	12.25	.81	2.875	6.62	7.25	7	2.45	5.65	.75
404TS	10	8	12.25	.81	2.125	6.62	4.25	4	1.845	2.78	.5
405	10	8	13.75	.81	2.125	6.62	6.37	6.12	1.845	5.03	.5
405S	10	8	13.75	.81	1.875	6.62	3.75	3.5	1.591	2.03	.5
405U	10	8	13.75	.81	2.375	6.62	7.12	6.88	2.021	5.53	.625
405US	10	8	13.75	.81	2.125	6.62	4.25	4	1.845	2.78	.5
405T	10	8	13.75	.81	2.875	6.62	7.25	7.	2.45	5.65	.75
405TS	10	8	13.75	.81	2.125	6.62	4.25	4	1.845	2.78	.5
444	11	9	14.5	.81	2.375	7.5	7.12	6.88	2.021	5.53	.625
444S	11	9	14.5	.81	2.125	7.5	4.25	4	1.845	2.78	.5
444U	11	9	14.5	.81	2.875	7.5	8.62	8.38	2.45	7.03	.75
444US	11	9	14.5	.81	2.125	7.5	4.25	4	1.845	2.78	.5
444T	11	9	14.5	.81	3.375	7.5	8.5	8.25	2.88	6.91	.875
444TS	11	9	14.5	.81	2.375	7.5	4.75	4.5	2.021	3.03	.625
445	11	9	16.5	.81	2.375	7.5	7.12	6.88	2.021	5.53	.625
445S	11	9	16.5	.81	2.125	7.5	4.25	4	1.845	2.78	.5
445U	11	9	16.5	.81	2.875	7.5	8.62	8.38	2.45	7.03	.75
445US	11	9	16.5	.81	2.125	7.5	4.25	4	1.845	2.78	.5
445T	11	9	16.5	.81	3.375	7.5	8.5	8.25	2.88	6.91	.875
445TS	11	9	16.5	.81	2.375	7.5	4.75	4.5	2.021	3.03	.625
447TS	11	9	20	DIMENSIONS VARY WITH MANUFACTURER							
449TS	11	9	25	DIMENSIONS VARY WITH MANUFACTURER							
504U	12.5	10	16	.94	2.875	8.5	8.62	8.38	2.45	7.28	.75
505	12.5	10	18	.94	2.875	8.5	8.62	8.38	2.45	7.28	.75
505S	12.5	10	18	.94	2.125	8.5	4.25	4	1.845	2.78	.5







When power factor correction capacitors are used, the total corrective KVAR on the load side of the motor controller should not exceed the value required to raise the no-load power factor to unity. Corrective KVAR in excess of this value may cause over excitation that results in high transient voltages, currents and torques that can increase safety hazards to personnel and possibly damage the motor or driven equipment.

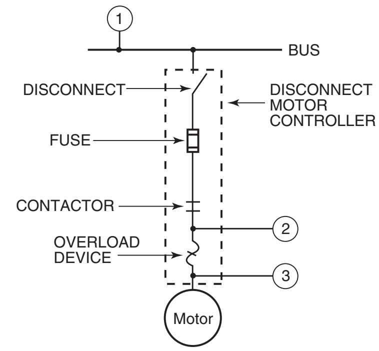
Do not connect power factor correction capacitors at motor terminals on elevator motors, multispeed motors, plugging or jogging applications or open transition, wye-delta, auto-transformer starting and some part-winding start motors.

If possible, capacitors should be located at position No. 2 (see diagram). This does not change the current flowing through motor overload protectors. Connection of capacitors at position No. 3 requires a change of overload protectors. Capacitors should be located at position No. 1 for applications listed in paragraph 2 above. Be sure bus power factor is not increased above 95 percent under all loading conditions to avoid over excitation.

(To give capacitor KVAR required to improve factor from original to desired value—see sample below.)

ORIGINAL POWER FACTOR PERCENT	Desired Power Factor–Percent				
	100	95	90	85	80
60	1.333	1.004	0.849	0.713	0.583
62	1.266	0.937	0.782	0.646	0.516
64	1.201	0.872	0.717	0.581	0.451
66	1.138	0.809	0.654	0.581	0.388
68	1.078	0.749	0.594	0.518	0.328
70	1.020	0.691	0.536	0.458	0.270
72	0.964	0.635	0.480	0.400	0.214
74	0.909	0.580	0.425	0.344	0.159
76	0.855	0.526	0.371	0.289	0.105
77	0.829	0.500	0.345	0.235	0.079
78	0.802	0.473	0.318	0.209	0.052
79	0.776	0.447	0.292	0.182	0.026
80	0.750	0.421	0.266	0.156	
81	0.724	0.395	0.240	0.130	
82	0.698	0.369	0.214	0.104	
83	0.672	0.343	0.188	0.078	
84	0.646	0.317	0.162	0.052	
85	0.620	0.291	0.136	0.206	
86	0.593	0.264	0.109		
87	0.567	0.238	0.083		
88	0.540	0.211	0.056		
89	0.512	0.183	0.028		
90	0.484	0.155			
91	0.456	0.127			
92	0.426	0.097			
93	0.395	0.066			
94	0.363	0.034			
95	0.329				
96	0.292				
97	0.251				
99	0.143				

Assume total plant load is 100 KW at 60 percent power factor. Capacitor KVAR necessary to improve power factor to 80 percent is found by multiplying KW (100) by multiplier in table (0.583) which gives KVAR (58.3). Nearest standard rating (60 KVAR) should be recommended.



Induction Motor Horse-power Rating	Maximum Suggested Capacitor KVAR For Use With Tefc, 3 Phase, 60 Hertz, 600 Volts Or Less, T Frame, NEMA Design B Motors											
	Nominal Motor Speed in RPM and Number of Poles											
	3600		1800		1200		900		720		600	
	KVAR	% AR	KVAR	% AR	KVAR	% AR	KVAR	% AR	KVAR	% AR	KVAR	% AR
25	5	10	7.5	17	10	21	10	22	10	22	20	31
30	5	10	7.5	17	10	21	15	22	15	22	20	31
40	10	10	10	12	15	21	20	22	20	22	30	31
50	10	10	15	12	25	21	23	21	25	22	35	31
60	12	9	15	12	25	19	25	19	30	22	40	30
75	15	9	20	12	25	15	30	19	35	21	40	30
100	20	9	30	12	25	13	40	19	40	12	50	30
125	20	9	35	12	30	13	45	18	50	12	50	30
150	25	9	40	11	25	13	55	18	50	12	70	30
200	30	9	40	8	60	13	60	18	70	12	75	30
250	60	9	50	8	60	13	115	18	100	12	125	30
300	65	7	50	8	60	13	140	18	125	12	150	30
350	70	7	55	8	80	13	160	18	150	12	150	30
400	70	7	60	8	130	13	160	17	175	12	175	30
450	90	7	95	8	145	13	160	17	175	12	200	30
500	100	7	110	7	170	13	210	17	–	–	–	–
% AR – Percent Ampere Reduction												

Induction Motor Horse-power Rating	Maximum Suggested Capacitor KVAR For Use With Open-Type, 3 Phase, 60 Hertz, 600 Volts Or Less, T Frame, NEMA Design B Motors											
	Nominal Motor Speed in RPM and Number of Poles											
	3600 2		1800 4		1200 6		900 8		720 10		600 12	
	KVAR	% AR	KVAR	% AR	KVAR	% AR	KVAR	% AR	KVAR	% AR	KVAR	% AR
20	5	11	7.5	17	7.5	19	10	23	10	29	15	34
25	7.5	11	7.5	17	7.5	19	10	23	10	24	20	34
30	7.5	10	7.5	17	10	19	15	23	15	24	25	32
40	7.5	10	15	17	15	19	20	23	20	24	30	32
50	10	10	20	17	20	19	25	23	20	24	35	32
60	10	10	20	17	30	19	30	23	30	22	45	32
75	15	10	25	14	30	16	30	17	35	21	40	19
100	15	10	30	14	30	12	35	16	40	15	45	17
125	30	10	35	12	30	12	50	16	45	13	50	17
150	30	10	35	11	35	12	50	14	50	13	60	17
200	35	10	50	11	55	12	70	14	70	13	90	17
250	35	10	55	9	70	12	85	14	90	13	100	17
300	35	10	65	9	75	12	95	14	100	13	110	17
350	40	10	80	9	85	12	125	14	120	13	150	17
400	100	10	80	8	100	12	140	14	150	13	150	17
450	100	9	90	8	140	12	150	13	150	13	175	17
500	100	8	115	8	150	12	150	12	175	13	175	17
% AR – Percent Ampere Reduction												

FULL LOAD CURRENT—THREE PHASE TRANSFORMERS						
	Voltage (Line to Line)					
KVA Rating	208	240	480	600	2400	4160
3	8.3	7.2	3.6	2.9	.72	.415
6	16.6	14.4	7.2	5.8	1.44	.83
9	25	21.6	10.8	8.7	2.16	1.25
15	41.6	36.0	18.0	14.4	3.6	2.1
30	83	72	36	29	7.2	4.15
45	125	108	54	43	10.8	6.25
75	208	180	90	72	18	10.4
100	278	241	120	96	24	13.9
150	416	360	180	144	36	20.8
225	625	542	271	217	54	31.2
300	830	720	360	290	72	41.5
500	1390	1200	600	480	120	69.4
750	2080	1800	900	720	180	104
1000	2775	2400	1200	960	240	139
1500	4150	3600	1800	1400	360	208
2000	5550	4800	2400	1930	480	277
2500	6950	6000	3000	2400	600	346
5000	13900	12000	6000	4800	1200	694
7500	20800	18000	9000	7200	1800	1040
10000	27750	24000	12000	9600	2400	1386

For other KVA Rating of Voltages:

$$\text{Amperes} = \frac{\text{KVA x 1000}}{\text{Volts x 1.732}}$$

FULL LOAD CURRENT—SINGLE PHASE TRANSFORMERS						
	Voltage					
KVA Rating	120	208	240	480	600	2400
1	8.34	4.8	4.16	2.08	1.67	42
3	25	14.4	12.5	6.25	5.0	1.25
5	41.7	24.0	20.8	10.4	8.35	2.08
7.5	62.5	36.1	31.2	15.6	12.5	3.12
10	83.4	48	41.6	20.8	16.7	4.16
15	125	72	62.5	31.2	25.0	6.25
25	208	120	104	52	41.7	10.4
37.5	312	180	156	78	62.5	15.6
50	417	240	208	104	83.5	20.8
75	625	361	312	156	125	31.2
100	834	480	416	208	167	41.6
125	1042	600	520	260	208	52.0
167.5	1396	805	698	349	279	70.0
200	1666	960	833	416	333	83.3
250	2080	1200	1040	520	417	104
333	2776	1600	1388	694	555	139
500	4170	2400	2080	1040	835	208

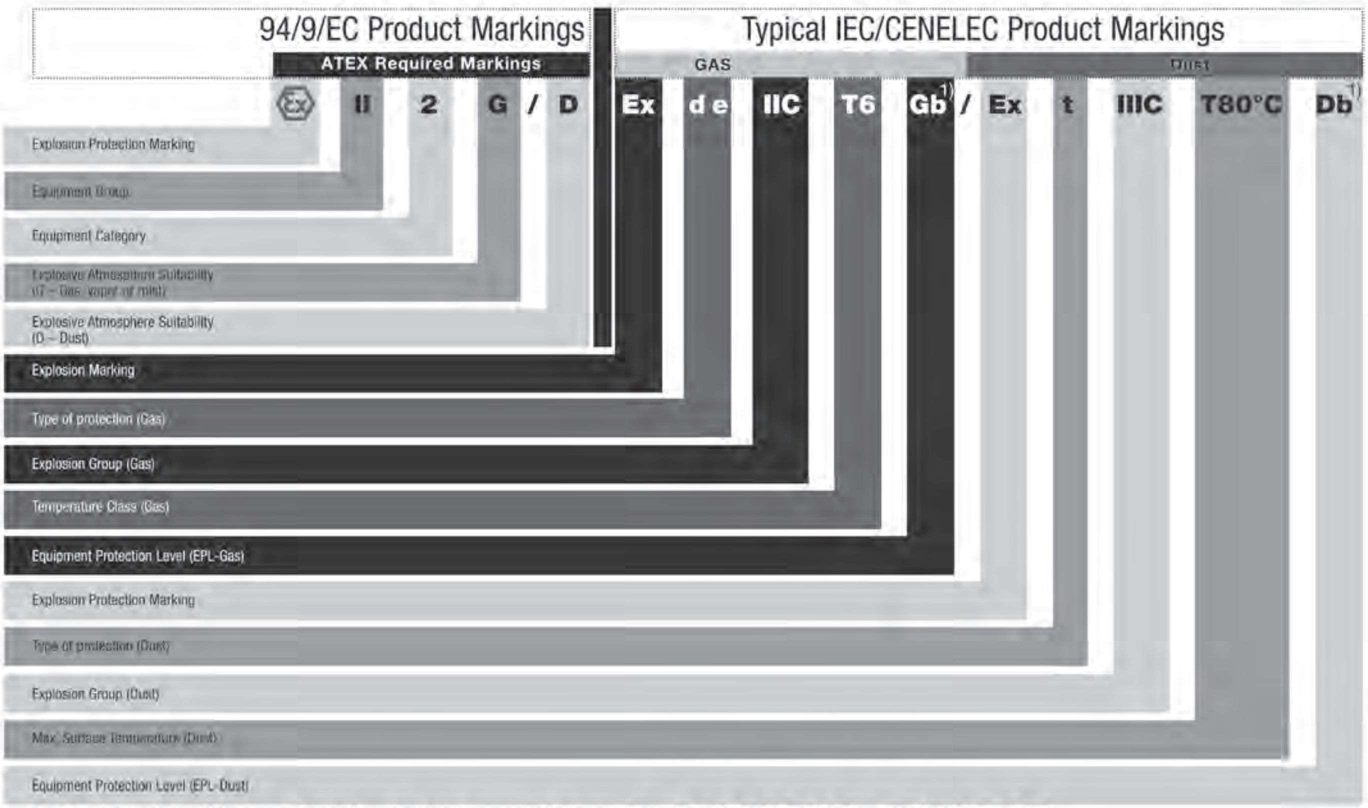
For other KVA Rating of Voltages:

$$\text{Amperes} = \frac{\text{KVA x 1000}}{\text{Volts x 1.732}}$$

CROUSE-HINDS®

HAZARDOUS AREA AND EQUIPMENT PROTECTION REFERENCE

A condensed guide to worldwide explosion protection methods, codes, categories, classifications and testing authorities.



1) Standard marking - alternate marking possible e.g.: **Ex db eb IIC T6 / Ex tb IIIC T80°C**

Method of Explosion Protection

Electrical Type of Protection for Atmospheres made explosive by gases, vapors and mists

Type of Protection	Type of Protection	Zone	/ ATEX Category/ EPL		CENELEC /IEC Standard	Protection Concept
-	General Requirements				EN 60079-0 / IEC 60079-0	-
d	Flameproof Enclosure	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-1 / IEC 60079-1	Contain the explosion, prevent the flame propagation
e	Increased Safety	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-7 / IEC 60079-7	No arcs, sparks or hot surfaces
ia	Intrinsic Safety	Zone 0, 1 or 2	/ 1G	/ Ga	EN 60079-11 / IEC 60079-11	Limit the energy of the spark and the surface temperature
ib	Intrinsic Safety	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-11 / IEC 60079-11	Limit the energy of the spark and the surface temperature
ic	Intrinsic Safety	Zone 2	/ 3 G	/ Gc	EN 60079-11 / IEC 60079-11	Limit the energy of the spark and the surface temperature
	Intrinsically Safe Systems	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-25 / IEC 60079-25	Limit the energy of the spark and the surface temperature
	Intrinsically Safe Fieldbus Systems (FISCO)	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-27 / IEC 60079-27	Limit the energy of the spark and the surface temperature
	Non-sparking Fieldbus Systems (FNICO)	Zone 1 or 2	/ 3 G	/ Gc	EN 60079-27 / IEC 60079-27	Limit the energy of the spark and the surface temperature
ma	Encapsulation	Zone 0, 1 or 2	/ 1 G	/ Ga	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
mb	Encapsulation	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
mc	Encapsulation	Zone 2	/ 3 G	/ Gc	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
nA	Non-Sparking	Zone 2	/ 3 G	/ Gc	EN 60079-15 / IEC 60079-15	No arcs, sparks or hot surfaces
nC	Enclosed Break	Zone 2	/ 3 G	/ Gc	EN 60079-15 / IEC 60079-15	Prevent the flame propagation
nR	Restricted Breathing	Zone 2	/ 3 G	/ Gc	EN 60079-15 / IEC 60079-15	Protection by enclosure
o	Oil Immersion	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-6 / IEC 60079-6	Exclusion of Ex-atmosphere
op is,	Optical Radiation	Zone 0, 1 or 2	/ 1 G, 2 G or 3 G	/ Ga, Gb, Gc	EN 60079-28 / IEC 60079-28	Limit or prevent energy transmission from optical radiation
op pr, op sh	Optical Radiation	Zone 1 or 2	/ 2 G or 3 G	/ Gb, Gc	EN 60079-28 / IEC 60079-28	Limit or prevent energy transmission from optical radiation
px, py	Pressurized Enclosure	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-2 / IEC 60079-2	Exclusion of Ex-atmosphere
pz	Pressurized Enclosure	Zone 2	/ 3 G	/ Gc	EN 60079-2 / IEC 60079-2	Exclusion of Ex-atmosphere
q	Powder Filling	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-5 / IEC 60079-5	Prevent the flame propagation

Electrical Type of protection for Atmospheres made explosive by dusts

Type of Protection	Description of Protection	ATEX Zone	/ ATEX Category/ EPL		CENELEC /IEC Standard	Protection Concept
-	General Requirements				EN 60079-0 / IEC 60079-0	-
ia	Intrinsic Safety	Zone 20, 21, 22	/ 1 D	/ Da	EN 61241-11 / IEC 61241-11	Limit the surface temperature
ib	Intrinsic Safety	Zone 21, 22	/ 2 D	/ Db	EN 61241-11 / IEC 61241-11	Limit the surface temperature
ma	Encapsulation	Zone 20, 21, 22	/ 1 D	/ Da	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
mb	Encapsulation	Zone 21 or 22	/ 2 D	/ Db	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
mc	Encapsulation	Zone 20, 21, 22	/ 1 D	/ Da	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
p	Pressurized	Zone 22	/ 3 D	/ Dc	EN 61241-4 / IEC 61241-4	Exclusion of Ex-atmosphere
t	Protection by enclosure	Zone 20, 21, 22	/ 1 D, 2 D or 3 D	/ Da, Db, Dc	EN 60079-31 / IEC 60079-31	Keep the combustible dust out and avoid hot surfaces

ATEX (**At**mosphères **Ex**plosibles) - The Directive 94/9/EC (ATEX) regulates within its scope for the European Market the Essential Health and Safety Requirements for apparatus for use in hazardous areas and conformity assessment procedures which must be applied to equipment.

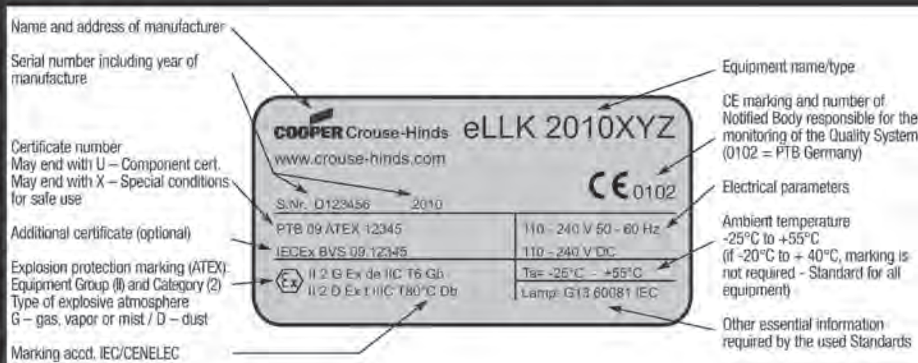
Zone Classification / Equipment Protection Level

Hazardous mixture	Period of presence of the flammable substances	Zone Classification	Necessary Marking for the Equipment: According 94/9/EC – Equipment Group	According 94/9/EC – Category	According IEC 60079-0 – Protection Group	According IEC 60079-0 – Equipment Protection Level EPL	Protection Level
Gas Mist Vapor	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 does occur only rarely and for a short period	Zone 2	II	3 G	II	Gc	increased
Dust	Continuously for long periods or frequently	Zone 20	III	1 D	III	Da	very high
	Occasional occurrence	Zone 21	III	2 D	III	Db	high
	Not likely, but if it does occur only rarely and for a short period	Zone 22	III	3 D	III	Dc	increased
Methane		Mining	I	M1	I	Ma	very high
Coal dust		Mining	I	M2	I	Mb	high

Explosion Groups

Explosive Atmospheres:	Typical Hazardous Material	Explosion Group
Gases and Vapors	Acetylene Hydrogen Ethylene Propane	IIC IIC or IIB+H2 IIB IIA
Dusts	Metal dust Coal dust Grain dust	IIIC IIIC IIIB
Fibres & Flyings	Wood, paper, or cotton processing	IIIA

Typical Nameplate Marking



Ingress Protection (IP) Codes and NEMA Enclosure Types

Ingress Protection Codes IP ... according IEC 60079

FIRST NUMERAL
Protection against solid bodies

- 0 - NO PROTECTION
- 1 - OBJECTS EQUAL TO OR GREATER THAN 50 mm
- 2 - OBJECTS EQUAL TO OR GREATER THAN 12.5 mm
- 3 - OBJECTS EQUAL TO OR GREATER THAN 2.5 mm
- 4 - OBJECTS EQUAL TO OR GREATER THAN 1.0 mm
- 5 - DUST-PROTECTED
- 6 - DUST-TIGHT

IP56

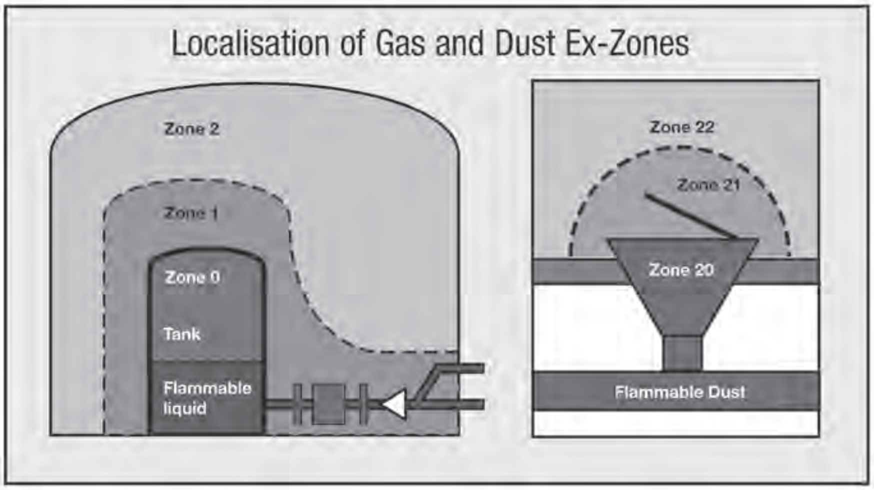
SECOND NUMERAL
Protection against liquid

- 0 - NO PROTECTION
- 1 - VERTICALLY DRIPPING WATER
- 2 - 75 TO 105°-ANGLED DRIPPING WATER
- 3 - SPRAYING WATER
- 4 - SPLASHING WATER
- 5 - WATER JETS
- 6 - HEAVY SEAS, POWERFUL WATER JETS
- 7 - EFFECTS OF IMMERSION
- 8 - INDEFINITE IMMERSION

NEMA Enclosure Types

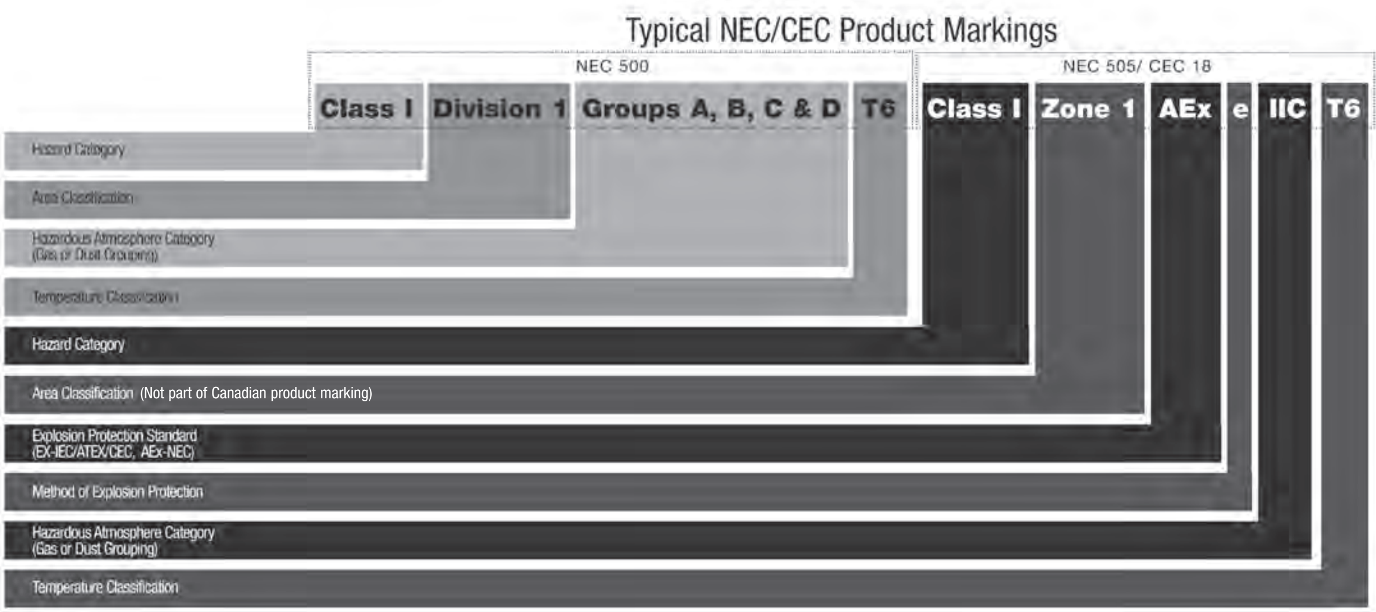
Enclosure Type	Intended Use	Equivalent IP Rating*
1	Indoor use, limited amounts of falling dirt	20
3	Outdoor use, rain, sleet, windblown dust, external formation of ice	55
3R	Outdoor use, rain, sleet, external formation of ice	54
3S	Outdoor use, rain, sleet, windblown dust, external mechanisms operable when ice laden	55
4	Indoor or outdoor use, windblown dust and rain, splashing water, hose directed water, external formation of ice	56
4X	Indoor or outdoor use, windblown dust and rain, splashing water, hose directed water, corrosion, external formation of ice	56
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 and 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)



Temperature Classification

Maximum Surface Temperature	IEC NEC® 505	CEC 18	NEC 500 - Table 500.8(C)
450°C (842°F)	T1	T1	T1
300°C (572°F)	T2	T2	T2
280°C (536°F)		T2A	T2A
260°C (500°F)		T2B	T2B
230°C (446°F)		T2C	T2C
215°C (419°F)		T2D	T2D
200°C (392°F)	T3	T3	T3
180°C (356°F)		T3A	T3A
165°C (329°F)		T3B	T3B
160°C (320°F)		T3C	T3C
135°C (275°F)	T4	T4	T4
120°C (248°F)		T4A	T4A
100°C (212°F)	T5	T5	T5
85°C (185°F)	T6	T6	T6



Note: Equipment Protection Level (Ga, Gb, Gc) may also be included in product markings for Canada.

Method of Explosion Protection

Type of Protection	Description of Protection	Permitted for use in United States NEC 500 Division	United States NEC 505 Zone	Canada CEC 18 Division	Canada CEC 18 Zone	Protection Concept
e	Increased Safety	2	1, 2	2	1, 2	No arcs, sparks
n	Non-Incendive	2	2	2	2	or hot surfaces
d	Flameproof	2	1, 2	2	1, 2	Contain the explosion,
-	Explosionproof	1, 2	2	1, 2	1, 2	prevent the flame
q	Powder Filled	2	1, 2	2	1, 2	propagation
ia	Intrinsic Safety	1, 2	0, 1, 2	1, 2	0, 1, 2	Limit the energy of
ib	Intrinsic Safety	2	1, 2	2	1, 2	the spark and the surface temperature
p	Pressurized (Purged)	1, 2	1, 2	1, 2	1, 2	Keep the flammable
m	Encapsulation	2	1, 2	2	1, 2	gas out
o	Oil Immersion	2	1, 2	2	1, 2	

CENELEC (European Committee for Electro-technical Standardization) publishes standards covering the electrotechnical field for countries in Europe.

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) global organization that prepares and publishes international standards for electrical, electronic and related technologies.

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)

Hazardous Atmosphere Category (Gas or Dust Grouping)

Explosive Atmosphere	Typical Hazard Material	North America NEC 500-503 / CEC 18 Hazard Category	Grouping	NEC 505*/CEC 18 Gas Grouping
Gases and Vapors	Acetylene	Class I	Group A	IIC
	Hydrogen	Class I	Group B	IIC or IIB+H2
	Ethylene	Class I	Group C	IIB
	Propane	Class I	Group D	IIA
Dusts	Metal dust	Class II	Group E	-
	Coal dust	Class II	Group F	-
	Grain dust	Class II	Group G	-
Fibres & Flyings	Wood, paper, or cotton processing	Class III	-	-

* NEC 505 covers explosive gases and vapors only.

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 1	Zone 2

Notes

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