Allen-Bradley

Class/Division Hazardous Location

Rockwell Automation

Bringing Together Leading Brands in Industrial Automation

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Introduction

A major safety concern in industrial plants is the occurrence of fires and explosions. No other aspect of industrial safety receives more attention in the form of codes, standards, technical papers, and engineering design. Regulatory bodies like the Occupational Safety and Health Administration (OSHA) have established systems that classify locations which exhibit potentially dangerous conditions to the degree of hazard presented.

OSHA Publication 3073 defines a hazardous location as follows:

Hazardous locations are areas where flammable liquids, gases or vapors or combustible dusts exist in sufficient quantities to produce an explosion or fire. In hazardous locations, specially designed equipment and special installation techniques must be used to protect against the explosive and flammable potential of these substances.

The National Electrical Code (NEC) and the Canadian Electrical Code (CEC) defines hazardous areas as the following:

An area where a potential hazard (e.g., a fire, an explosion, etc.) may exist under normal or abnormal conditions because of the presence of flammable gases or vapors, combustible dusts or ignitable fibers or flyings.

Hazardous locations can also be described as those locations where electrical equipment might be installed and which, by their nature, might present a condition which could become explosive if the elements for ignition are present. Unfortunately, flammable substances are not always avoidable, e.g., methane and coal dust in mines. Therefore, it is of great importance that a user of electrical equipment, such as push buttons and pilot lights, be aware of the environment in which these products will be installed. The user's understanding of the hazard will help ensure that the electrical equipment is properly selected, installed and operated to provide a safe operating system.

There are a great variety of applications, especially in the chemical and petrochemical industries, that require explosion protected equipment. As a result, there have been principles and technologies developed to allow electrical instrumentation and control devices to be used even in environments where there is a danger of explosion. However, focus on explosion protected electrical equipment is not limited to utilization and processing of oil and natural gas. It has expanded into new fields such as waste disposal, landfills and the utilization of bio-gas.

Basic Requirements for an Explosion

What is an explosion?

An explosion is defined as a sudden reaction involving rapid physical or chemical decay accompanied by an increase in temperature or pressure or both.

When will an explosion occur?

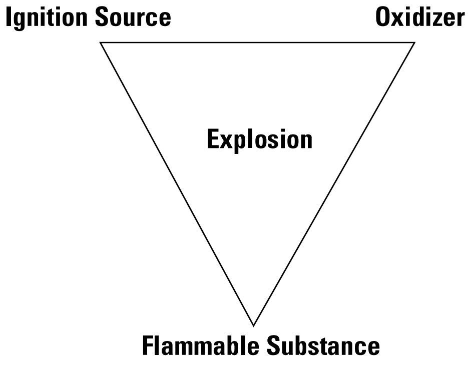
The most common types of reaction are between flammable gases, vapors, or dust with oxygen contained in the surrounding air.

As a rule, 3 basic requirements must be met for an explosion to take place in atmospheric air:

1. Flammable substance — needs to be present in sufficient quantity to produce an ignitable or explosive mixture.
2. Oxidizer — must be present in sufficient quantity in combination with the flammable substance to produce an explosive mixture. Most common is air (O_2).
3. Source of ignition — a spark or high heat must be present.

The presence of these three elements make up the sides of the ignition triangle. If any one of the three elements is missing, an explosion will not occur. All three elements must exist simultaneously for an explosion to occur.

Figure 1.



Flammable Substance

Flammable substances can be divided into three subgroups:

- Flammable gas
- Flammable liquids/vapors
- Flammable solids

Table A.

Flammable Substance	Examples	Description
Flammable Gas	Hydrogen, etc.	• Often compounds of hydrogen and carbon that require very little to react with atmospheric oxygen.
Flammable Liquids/ Vapors	Hydrocarbons such as ether, acetone, lighter fluids, etc.	• Even at room temperature, sufficient quantities of these hydrocarbons can evaporate to form a potentially explosive atmosphere at their surface. Other liquids require higher temperature for this to occur. • The flash point of a flammable liquid is the lowest temperature at which a sufficient quantity of vapor will arise to permit ignition under laboratory conditions. This is an important factor in the classification of hazardous areas. • Flammable liquids with a high flash point are less hazardous than liquids with a low flash point.
Flammable Solids	Dust, fibers, and flyings	• The cumulative nature of the dust hazard is the most significant difference between a gas/vapor hazard and the dust hazard. • A dust cloud will settle on nearby surfaces if it is not ignited. Unless removed, layers of dust can build up and will serve as fuel for subsequent ignition. • The typical dust explosion starts with the ignition of a small dust cloud resulting in relatively small damages. • Pressure waves of the small initial explosion are the most damaging part of the dust explosions. These pressure waves release dust layers from surrounding vertical or horizontal surfaces to produce a larger cloud which is ignited by the burning particles of the initial cloud. In this way, the small initial explosion can produce a much larger explosion. In some cases a series of explosions occur, each stronger than the previous.

Note: Every flammable gas or vapor has specific lower and upper flammability limits. If the substance or concentration in the oxidizer is either below a specific value (lower flammability limit) or above a specific value (upper flammability limit), ignition might occur; however, a flame will not propagate.

If a flammable gas or vapor cloud is released and ignited, all the material may be consumed in one explosion. If the flammable gas or vapor cloud is not ignited, convection and diffusion will eventually disperse the flammable cloud, the immediate danger passes, and the particular fuel source is lost.

Oxidizer

The oxidizer referred to in all common hazardous location standards and explosion-proof equipment is air at normal atmospheric conditions. The oxygen in the air is only enough for the combustion of a certain quantity of flammable material. Air must be present in sufficient volume to propagate a flame before the air-fuel mixture becomes a hazard. When the amount of available atmospheric oxygen is more or less in equilibrium with the quantity of flammable material, the effect of an explosion — both temperature and pressure — is most violent. If the quantity of flammable material is too small, combustion will spread with difficulty or cease altogether. The same applies if the quantity of flammable material is too great for the available oxygen.

Each flammable material has an upper and lower explosion limit above or below which no explosion will take place. This can be exploited by diluting the flammable substances with air or preventing the ingress of air/oxygen. The latter option is ruled out in environments where people work regularly and is feasible only in a chemical plant where there are no human beings.

The presence of an oxygen-enriched atmosphere or a pressurized enclosure alters the conditions for ignition and dictates the use of special means for prevention and containment of explosions. No means of explosion protection considered safe for atmospheric mixtures should be used in either oxygen-enriched or pressurized situations without careful study.

Ignition Source

The amount of energy required to cause ignition is dependent upon these factors:

- The concentration of the hazardous substance within its specific flammability limits.
- The explosive characteristics of the particular hazardous substance.
- The volume of the location in which the hazardous substance is present.

Ignition may occur from sources such as the following:

- Open flames
- Hot gas
- Chemical reactions or biological processes which occur spontaneously at certain oxygen levels or temperatures
- Lightning
- Intense electromagnetic radiation
- Ionizing radiation
- Adiabatic compression and shock waves
- Static electricity
- Sparks or arcs from electrical equipment or wiring
- Hot surfaces of electrical equipment or wiring

Further classification of sources of ignition in industrial electrical equipment are as follows:

Table B.

Ignition Sources (Industrial Electrical Equipment)	**Examples**
Hot Surfaces	Surfaces heated by coils, resistors, lamps, brakes, or hot bearings. Hot surface ignition can occur at the Auto-Ignition Temperature (AIT) or spontaneous ignition temperature at which a hazardous substance will spontaneously ignite without further energy.
Electrical Sparks	Occurs when circuits are broken or static discharge takes place. In low voltage circuits, arcs are often created through the making and breaking of electrical contacts.
Friction and Impact Sparks	When casings or enclosures are struck.

The design of explosion-proof electrical equipment eliminates these sources of ignition and this is confirmed by testing and certification.

Where do explosions most frequently occur?

Typically in chemical plants, refineries, paint shops, cleaning facilities, mills, flour silos, tanks, and loading facilities for flammable gases, liquids, and solids.

How is the explosion controlled?

Reduction of hazards is not absolute. There is no absolute safety. Removing one of the elements from the ignition triangle can provide explosion protection and preclude unwanted, uncontrolled, and often disastrous explosions. If one of the three elements of the ignition triangle is missing, ignition will not occur. Since flammable substance and oxidizers cannot be frequently eliminated with certainty, inhibiting ignition of a potentially explosive atmosphere can eliminate danger at the source.

The objective of selecting an electrical apparatus and the means of installation is to reduce the hazard of the electrical apparatus to an acceptable level. An acceptable level might be defined as selecting protective measures and installation means to ensure that the probability of an explosion is not significantly greater due to the presence of electrical apparatus than it would have been had there been no electrical apparatus present.

The most certain method of preventing an explosion is to locate electrical equipment outside of hazardous (classified) areas whenever possible. In situations where this is not practical, installation techniques and enclosures are available which meet the requirements for locating electrical equipment in such areas. These methods of reducing hazards are based on the elimination of one or more of the elements of the ignition triangle discussed earlier.

Principles for Ensuring that Electrical Equipment Does Not Become a Source of Ignition

Three principles ensure that electrical equipment does not become a source of ignition. The basic point is to ensure that parts to which a potentially explosive atmosphere has free access do not become hot enough to ignite an explosive mixture.

Table C.

No.	Principles	Protection Method
1	Explosive mixtures can penetrate the electrical equipment and be ignited. Measures are taken to ensure that the explosion cannot spread to the surrounding atmosphere	Confine the explosion • Explosion-proof enclosure • Dust ignition-proof enclosure • Conduit and cable seals
2	The equipment is provided with an enclosure that prevents the ingress of a potentially explosive mixture and/or contact with sources of ignition arising from the functioning of the equipment	Isolate the hazard • Pressurization and purging • Oil immersion • Hermetic sealing • Encapsulation (potting) • Restricted breathing
3	Potentially explosive mixtures can penetrate the enclosure but must not be ignited. Sparks and raised temperatures must only occur within certain limits.	Limit the energy • Intrinsic safety • Pneumatics • Fiber optics

Note: It is important that operators of hazardous location plants ensure that their personnel know when explosions are likely to happen and how to prevent it. A joint effort by the manufacturers of explosion-proof electrical equipment and the constructors and operators of industrial plants can help ensure the safe operation of electrical equipment in hazardous locations.

Design Regulations for Explosion-Proof Electrical Equipment

Explosion hazards arising from the handling of flammable gases, vapors, and dust are attributable to normal chemical and physical processes. Regulation on hazardous location by means of the Class/Division system have now been formulated by the NEC, CEC, OSHA, and the National Fire Protection Association (NFPA).

Adherence to these regulations is required by manufacturers and operators of equipment and is monitored by accredited Test Houses. These standards allow the design of electrical equipment that eliminates the risk of explosion hazards. These standards enable manufacturers to design safe, explosion-protected electrical equipment that is tested with uniform and binding tests at test centers. On successful completion of tests, these centers issue confirmations, i.e., conformity certificates, which state that the required uniform safety standards for explosion protected electrical equipment have been met, the prerequisite for the equipment to go into production.

There are advantages to products specifically designed for use in the Class/Division designated areas since it is the dominant method used in North America. An understanding of the Class/Division system is very important. This paper is dedicated to help explain the application in Class/Division designated areas.

Definitions

Area Classification

Area classification methods provide a succinct description of the hazardous material that may be present, and the probability that it is present, so that the appropriate equipment may be selected and safe installation practices may be followed. It is intended that each room, section, or area of a facility shall be considered individually in determining its classification. The hazardous location areas take into account the different dangers presented by potentially explosive atmospheres. This enables protective measures to be taken which account for both cost and safety factors.

In North America, the classification system that is most widely utilized is defined by the NFPA Publication 70, NEC, and CEC. They define the type of hazardous substances that is, or may be, present in the air in quantities sufficient to produce explosive or ignitable mixtures. The NFPA establishes area classifications based on Classes, Divisions, and Groups which are factors combined to define the hazardous conditions of a specific area.

Actually determining the classification of a specific location requires a thorough understanding of the particular site. An exhaustive study of the site must be undertaken before a decision can be made as to what Class, Division, and Group is to be assigned. It is beyond the scope of this paper to engage in a detailed discussion of how a location is actually classified. The local inspection authority has the responsibility for defining a Class, Division, and Group classification for specific areas.

IMPORTANT

Class Definition

The NFPA Publication 70, NEC, and CEC define three categories of hazardous materials that have been designated as Class I, Class II, or Class III. The Classes define the type of explosive or ignitable substances which are present in the atmosphere such as:

- Class I locations are those in which flammable vapors and gases may be present.
- Class II locations are those in which combustible dust may be found.
- Class III locations are those which are hazardous because of the presence of easily ignitable fibers or flyings.

The rest of this paper will concentrate mainly on the Class I locations. Please refer to Appendix A, Figure 6 and Figure 7, for information on Class II and Class III.

Division Definition

Each of the three Classes, discussed earlier, is further subdivided into two Divisions, Division 1 or Division 2.The Division defines the likelihood of the hazardous material being present in a flammable concentration.

Table D.

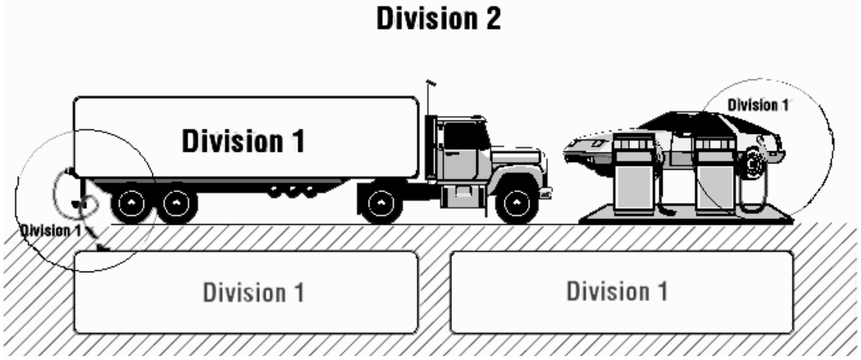
Division	Definitions ❶
Division 1	In which ignitable concentrations of hazards exists under normal operation conditions and/or where hazard is caused by frequent maintenance or repair work or frequent equipment failure.
Division 2	In which ignitable concentrations of hazards are handled, processed or used, but which are normally in closed containers or closed systems from which they can only escape through accidental rupture or breakdown of such containers or systems.

❶ Per NEC article 500, CEC section 18

Figure 2 provides a graphical illustration to help with the understanding of the Division definition. The NEC and CEC, like all other such codes at the present time, do not attempt to quantify the definition of Division 1 and Division 2.

The installation and conduit requirements for Division 1 locations are more stringent than for Division 2 locations.

Figure 2. Division Definition



This graphic is for illustration purposes only

Group Definition

The explosive characteristics of the air mixtures of gases, vapors, or dusts vary with the specific material involved. Materials have been placed in groups based on their ignition temperatures and explosion pressures. Class I and Class II Divisions are further subdivided into Groups of hazardous materials. The Groups define substances by rating their flammable nature in relation to other known substances.

Combustible and flammable gases and vapors are divided into four Groups. The classification is based on maximum explosion pressures, and maximum safe clearance between parts of a clamped joint in an enclosure per NEC section500-5(a)(4) FPN No. 2.

Refer to Appendix A for diagrams that show the relationship between Classes, Divisions and Groups.

The table below provides examples of which materials actually make up specific Groups.

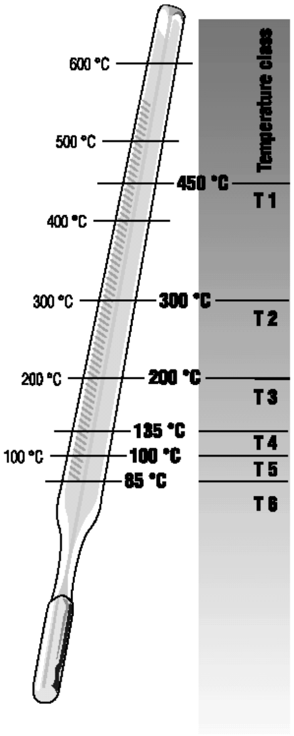
Table E.

Class	Division	Group	Flammable Material	Maximum Experimental Safe Gap (MESG)	Minimum Igniting Current Ratio (MIC)
Class I	Division 1 & 2	A	Acetylene	—	—
Class I	Division 1 & 2	B	• Hydrogen • Butadiene • Ethylene Oxide • Propylene Oxide	≤ 0.4 mm	≤ 0.4
Class I	Division 1 & 2	C	• Ethylene • Cyclopropane • Ethyl Ether	> 0.45 mm ≤ 0.75 mm	> 0.4 ≤ 0.8
Class I	Division 1 & 2	D	• Propane • Acetone • Ammonia • Bezene • Butane • Ethanol • Gasoline • Methanol • Natural Gas	≥ 0.75 mm	> 0.8

Temperature Class Definition

The temperature classes are used to designate the maximum operating temperatures on the surface of the equipment which should not exceed the ignition temperature of the surrounding atmosphere. Ignition temperature is the minimum temperature required, at normal atmospheric pressure in the absence of a spark or flame, to set afire or cause self-sustained combustion independently of the heating or heated element.

Figure 3.



Class I temperature marking shall not exceed the ignition temperature of the specific gas or vapor to be encountered as specified in NEC section 500-5(d).

Table F.

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

Protection Methods

For all protection methods the rule applies that parts to which the potentially explosive atmosphere has unhindered access must not attain unacceptable temperatures. The temperatures must fall within the temperature class that applies to the particular potentially explosive atmosphere. The principles of protecting against the likelihood of ignition or explosion by electrical equipment are described in the following sections.

A. Confine the Explosion

Enclosures can be used to contain an explosion. They are designed and tested for situations where a hazardous substance enters the enclosure and is ignited by an electrical spark or hot surface. However, the explosion is confined within the enclosure.

The National Electrical Manufacturers Association (NEMA) has developed a rating system to identify the ability of a device or system to afford protection from the outside environment. NEMA Standard Publication 250, *Enclosures for Electrical Equipment*, establishes requirements that must be met for an enclosure to gain a specific Type designation. Underwriters Laboratories (UL) has adopted the NEMA Type designations, and UL Publication 698, *Standard for Industrial Control Equipment for Use in Hazardous Locations*, sets forth similar requirements. Factory Mutual (FM) Research Corporation Approval Standard, *Explosion-proof Electrical Equipment, Class Number 3615*, sets forth construction requirements and performance tests. These rating systems provide information that assists users in making informed product choices in selecting the proper enclosures for hazardous locations.

1. Explosion-Proof Enclosures

Article 100 of the NEC provides the following definition for Explosion-Proof Apparatus:

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

Type 7 enclosures are designed to meet explosion-proof requirements. They are for indoor use in locations classified as Class I, Groups A, B, C, or D. Type 7 enclosures are designed to be capable of withstanding the pressures resulting from an internal explosion of specified gases, and contain such an explosion sufficiently that an explosive gas-air mixture existing in the atmosphere surrounding the enclosure will not be ignited. Enclosed heat generating devices are designed not to cause external surfaces to reach temperatures capable of igniting explosive gas-air mixtures in the surrounding atmosphere.

2. Dust Ignition-Proof Enclosures

Article 502-1 of the NEC provides the following definition for Dust Ignition-Proof Electrical Installations:

The apparatus is enclosed in a manner that will exclude ignitable amounts of dusts and will not permit arcs, sparks or heat generated or liberated inside the enclosures to cause ignition of exterior dust accumulations on the enclosure or of atmospheric dust suspensions in the vicinity of the enclosure.

Type 9 enclosures are designed to meet dust ignition-proof requirements. They are intended for indoor use in locations classified as Class II, Groups E, F, or G. Type 9 enclosures are designed to be capable of preventing the entrance of dust. Enclosed heat generating devices are designed not to cause external surfaces to reach temperatures capable of igniting or discoloring dust on the enclosure or ignition dust-air mixtures in the surrounding atmosphere.

3. Conduit and Cable Seals

The NEC requires sealing each conduit run entering an enclosure that contains apparatus which may produce arcs, sparks, or high temperatures. These seals are to be installed within 18 inches of the enclosure. This prevents the propagation of flames and explosive pressures from the interior of an enclosure into the conduit system.

Note: Type 7 and Type 9 enclosures may have an additional rating such as Type 3R or Type 4 for outdoor applications if they are capable of passing the associated test.

B. Limit the Energy

If the available energy is insufficient to ignite the hazardous substance that is or may be present, the special enclosures described above are not required. Methods that are used to limit or eliminate the available energy are discussed below.

1. Intrinsic Safety

Intrinsic safety is a designed/engineered explosion protection technique that is integral to the electrical circuit. Intrinsically safe equipment and wiring shall not be capable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration. Intrinsically safe systems limit the energy even under worse cases of multiple failure conditions. Energy controlling apparatus known as intrinsically safe barriers can be used to limit the energy that would be released as a result of a wiring or component failure so that ignition will not occur.

2. Pneumatics

Pneumatic systems are by their nature a safe means of control because they use air instead of electrical energy as a means of powering the control apparatus.

3. Fiber Optics

Fiber optic systems are inherently safe because they are powered by light. These systems eliminate electrical energy from the area where the hazardous substance may be present and no source is available to cause a spark or an elevated temperature.

C. Isolate the Hazard

This technique prevents or delays the diffusion of a hazardous substance into an enclosure where possible ignition could occur. This technique includes the following methods:

1. Pressurization and Purging

With pressurization, the interior of the enclosure that contains the electrical equipment is kept at a pressure slightly higher than the atmosphere surrounding the enclosure. Any hazardous substance that may be present in the atmosphere cannot enter the enclosure and be ignited.

In a related technique, purging, the interior of the enclosure is not only pressurized but a flow of air or inert gas is maintained which is sufficient to dilute the concentration of a hazardous substance which might be present.

2. Oil Immersion

This technique is most often used in power equipment. The electrical components are immersed in inert oil that quenches any spark or flame and controls surface temperature to a safe level.

3. Hermetic Sealing

Devices of this type are sealed within an envelope by fusion, e.g., soldering, brazing, welding, or the fusion of glass to metal to seal against the entrance of an external atmosphere. Typically the electrical contact is sealed within a glass tube.

4. Encapsulation (Potting)

A molding material is used to encase the source of electrical energy and prevent any spark from coming in contact with the hazardous substance.

5. Restricted Breathing

This is a form of sealing the enclosure with gaskets. The principle employed is that in Division 2 the enclosure is sufficiently tight that it is highly unlikely that a flammable cloud of gas would surround the enclosure for the length of time necessary for enough material to enter the enclosure to produce a flammable mixture.

The next page contains a summary of the advantages and disadvantages of some of the protection methods that were mentioned above.

Summary of Protection Methods

Table G.

Method	Advantages	Disadvantages
Intrinsic Safety	• High reliability • Small for ease of installation • Ease of maintenance and low down time — equipment may be calibrated and maintained without disconnecting power • Intrinsic safety standards are recognized worldwide • Low cost — does not require expensive accessories	• Operates on low power levels • Requires careful planning and engineering design • Expensive
Explosion-proof	• High degree of safety — psychological security • Operates at normal power levels unlike intrinsic safety	• Difficult to install — big, bulky, and heavy • Expensive — requires heavy conduit and seals
Pressurized	Reduces hazard classification	Additional cost of pump, ducts, and filters; requires special operating procedures
Oil Immersion	Simple method	May contain PCBs in oil; potential health hazard; possible leakage
Hermetic Sealing	Low cost	Operates at reduced current levels
Encapsulation (Potting)	Low cost	Components generally not reusable
Restricted Breathing	Low cost	Seal failure potential
Pneumatic System	• Easy-to-service system • Safe means — powered by air	• Slow reaction time • Limited number of control operations • Limited by distance
Fiber Optics	• Safe means — powered by light • Idea for clean rooms	• Limited by distance • Beams effectiveness affected by dust and mist

Marking

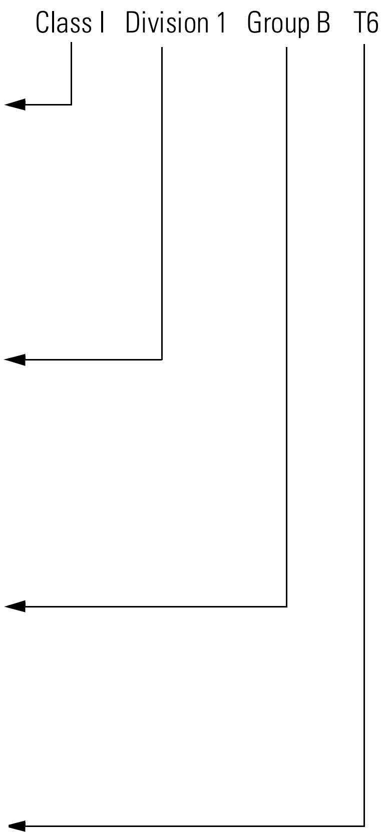
The rules for marking the electrical equipment are uniformly laid down in the standards relating to general technical requirements. The equipment must be distinctively marked in accordance to the classified area in which it can be installed.

The minimal marking must indicate the following:

- Class
- Division
- Group
- The maximum safe operating temperature or temperature range, based on a 40°C ambient.
- Any special conditions that have to be observed (such as NEC section 500-5(d))

Execution to NEC/CEC Standards

Figure 4.



Type of Flammable Substance

Class I — Approved for the strictest Class, therefore all Classes

- Class I — Flammable gas, vapors, and liquids
- Class II — Combustible dusts
- Class III — Ignitable fibers and flyings

Area Classification

Division 1 — Approved for the strictest Division, therefore both Divisions

- Division 1 — Flammable substances are continually present or are likely to exist under normal operating conditions
- Division 2 — Flammable substances are not likely to exist under normal operating conditions

Gas Group

Group B — Approved for Group B; therefore also approved for Groups C and D, but not Group A. If no Groups are listed, approved for all Groups.

The gases are grouped according to certain physical characteristics on their explosive behavior

Temperature Code

If no temperature code is listed, meets strictest temperature code (T6)

This is the maximum temperature that the equipment is allowed to emit without causing an explosion/fire.

Comparisons between the Class/Division vs. Zone System

The Class/Division standard that we have discussed in this paper is not the only standard that exists for hazardous location applications. There is another standard known as the Zone standard which is predominantly used outside North America.

The comparisons between these two systems are not easily accomplished. Both systems are good and were developed independently from each other. They each have their own approach to area classification and each has its own advocates and approval organizations. No one system is better than the other as neither has been proven to be safer than the other. Each has its own merits. Which system is preferred depends on the user preference, how the areas are classified and the wiring system used in the facility.

The Class/Division method is the dominant method used in North America with requirements set by NEC/CEC, although the Zone system has wider use throughout the world in the chemical and petrochemical industries. The Zone method may seem more complicated because it offers more choices as to how to handle a particular application. On the other hand, the Class/Division method is very straightforward, with little interpretation as to the classification and what electrical materials can or cannot be used. This is because Division equipment for hazardous location are marked in accordance to the area that the equipment is classified to use, whereas the Zone method marks equipment in accordance with the type of protection used by the equipment. It is then the user's responsibility to apply the proper method of protection in each of the Zones. However, under the new approach, directive 94/9/EC requires additional markings to specify exactly which categories and Zones the product may be used in. Both methods are meant to serve all hazardous areas from oil to sewage treatment and from paint spray areas to everyday gas stations, as deemed appropriate by the user.

Standards for electrical installations have been established and are governed by a variety of organizations throughout the world to ensure safe electrical systems in hazardous locations. The NEC and the CEC govern the North American Standards. In Europe, the CENELEC has developed standards called Euronorm (EN) Standards to which many European countries work. Other countries either work to their standards based on the international standards governed by the IEC or accept products and systems certified to European and/or North American Standards.

For a simplified side-by-side comparison between the NEC (Class/Division) standard and IEC (Zone), NEC (Class/Zone), CEC section 18 Zone standards, please refer to Appendix A of this publication. Please reference Publication 800-WP004A-EN-P for more detailed information on Zone applications.

Appendix A

Comparing IEC, NEC, and CEC Zone Standards with NEC/CEC Class/Division Standards

Table H. Class I Area Classification Comparison

<table>
<tr><th>Zone 0</th><th>Zone 1</th><th>Zone 2</th></tr>
<tr><td>Where ignitable concentrations of flammable gases, vapors, or liquids are present continuously or for long periods of time under normal operating conditions.</td><td>Where ignitable concentrations of flammable gases, vapors, or liquids:
• Are likely to exist under normal operating conditions
• May exist frequently because of repair, maintenance operations, or leakage</td><td>Where ignitable concentrations of flammable gases, vapors, or liquids:
• Are not likely to exist under normal operating conditions
• Occur for only a short period of time
• Become hazardous only in case of an accident or some unusual operating condition</td></tr>
<tr><th colspan="2">Division 1</th><th>Division 2</th></tr>
<tr><td colspan="2">Where ignitable concentrations of flammable gases, vapors, or liquids:
• Are likely to exist under normal operating conditions
• Exist frequently because of maintenance/repair work or frequent equipment failure</td><td>Where ignitable concentrations of flammable gases, vapors, or liquids:
• Are not likely to exist under normal operating conditions
• Are normally in closed containers where the hazard can only escape through accidental rupture or breakdown of such containers or in case of abnormal operation of equipment</td></tr>
</table>

Note: Per NEC Article 505-10(b)(1), a Division classified product may be installed in a Zone classified location but the reverse is not true. Typically, Zone classified product provides protection utilizing a protection method not available in the Class/Division scheme.

Table I. Class 1 Group Comparison

Zone	Class/Division
IIC — Acetylene and Hydrogen	A — Acetylene
	B — Hydrogen
IIB — Ethylene	C — Ethylene
IIA — Propane	D — Propane

Table J. Class 1 Protection Method Comparison

Zone 0	Zone 1	Zone 2
• Intrinsically safe (2 fault) • Intrinsically safe, “ia” (2 fault) Class I, Division 1 (U.S. only)	• Encapsulation, “m” • Flame-proof, “d” • Increased safety, “e” • Intrinsically safe, “ib” (1 fault) • Oil Immersion, “o” • Powder-filled, “q” • Purged/Pressurized, “p” • Any Class I, Zone 0 method • Any Class I, Division I method (U.S. only)	• Energy limited, “nC” • Hermetically sealed, “nC’ • Nonincendive, “nC” • Non-sparking, “nA” • Restricted breathing, “nR” • Sealed device, “nC” • Any Class I, Zone 0 or 1 method • Any Class I, Division 1 or 2 method (U.S. only)

Division 1	Division 2
• Explosion-proof • Intrinsically safe (2 fault) • Purged/Pressurized (Type X or Y)	• Hermetically sealed • Nonincendive • Non-sparking • Oil immersion • Sealed device • Purged/Pressurized (Type Z) • Any Class I, Zone 1 or 2 method (U.S. only) • Any Class I, Division 1 method

Table K. Class 1 Temperature Class Comparison

Zone 0, 1, and 2	Division 1 and 2	Maximum Temperature
T1	T1	450°C (842°F)
T2	T2	300°C (572°F)
	T2A	280°C (536°F)
	T2B	260°C (500°F)
	T2C	230°C (446°F)
	T2D	215°C (419°F)
T3	T3	200°C (392°F)
	T3A	180°C (356°F)
	T3B	165°C (329°F)
	T3C	160°C (320°F)
T4	T4	135°C (275°F)
	T4A	120°C (248°F)
T5	T5	100°C (212°F)
T6	T6	85°C (185°F)

Hazardous (Classified) Locations in Accordance with Article 500, NEC - 1990

Figure 5. Class I Diagram

Class I Flammable Gases or Vapors

Division 1

In which ignitable concentration of flammable gases or vapors:

- Exists under normal operating conditions
- Exists frequently because of
  - Repair operations
  - Maintenance operations
  - Leakage
- Are released through breakdown or faulty operation of equipment or processes in which the breakdown causes electrical equipment to become a source of ignition.

Division 2

In which ignitable concentration of flammable gases or vapors:

- Are normally confined within closed containers when
  - Handled
  - Processed
  - Used
- Are normally prevented by positive mechanical ventilation
- Are adjacent to a Class I, Division 1 location

Group

Gases are grouped according to certain physical characteristics of their explosive behavior.

Group A

- Acetylene

Group B

- Hydrogen
- Butadiene
- Ethylene Oxide
- Propylene Oxide
- Acrolien

Group C

- Ethylene
- Cyclopropane
- Ethyl Ether

Group D

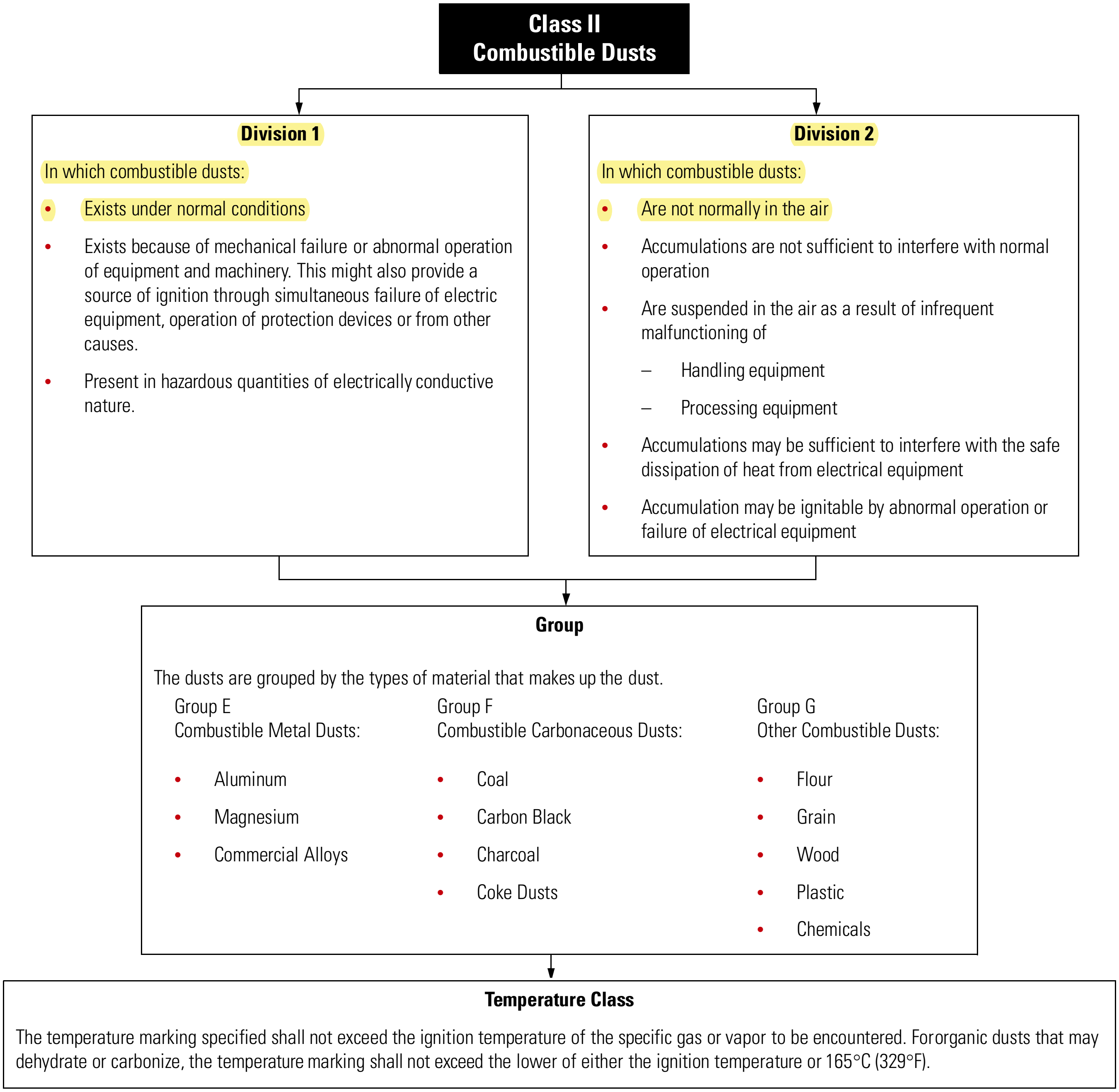
- Propane
- Acetone
- Ammonia
- Benzene
- Butane
- Ethanol
- Gasoline
- Hexane
- Methanol
- Methane
- Naptha
- Natural Gas
- Toluene

Temperature Class

The temperature marking specified shall not exceed the ignition temperature of the specific gas or vapor to be encountered.

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

Figure 6. Class II Diagram



Class II
Combustible Dusts

Division 1

In which combustible dusts:

- Exists under normal conditions
- Exists because of mechanical failure or abnormal operation of equipment and machinery. This might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices or from other causes.
- Present in hazardous quantities of electrically conductive nature.

Division 2

In which combustible dusts:

- Are not normally in the air
- Accumulations are not sufficient to interfere with normal operation
- Are suspended in the air as a result of infrequent malfunctioning of
  - Handling equipment
  - Processing equipment
- Accumulations may be sufficient to interfere with the safe dissipation of heat from electrical equipment
- Accumulation may be ignitable by abnormal operation or failure of electrical equipment

Group

The dusts are grouped by the types of material that makes up the dust.

Group E
Combustible Metal Dusts:

- Aluminum
- Magnesium
- Commercial Alloys

Group F
Combustible Carbonaceous Dusts:

- Coal
- Carbon Black
- Charcoal
- Coke Dusts

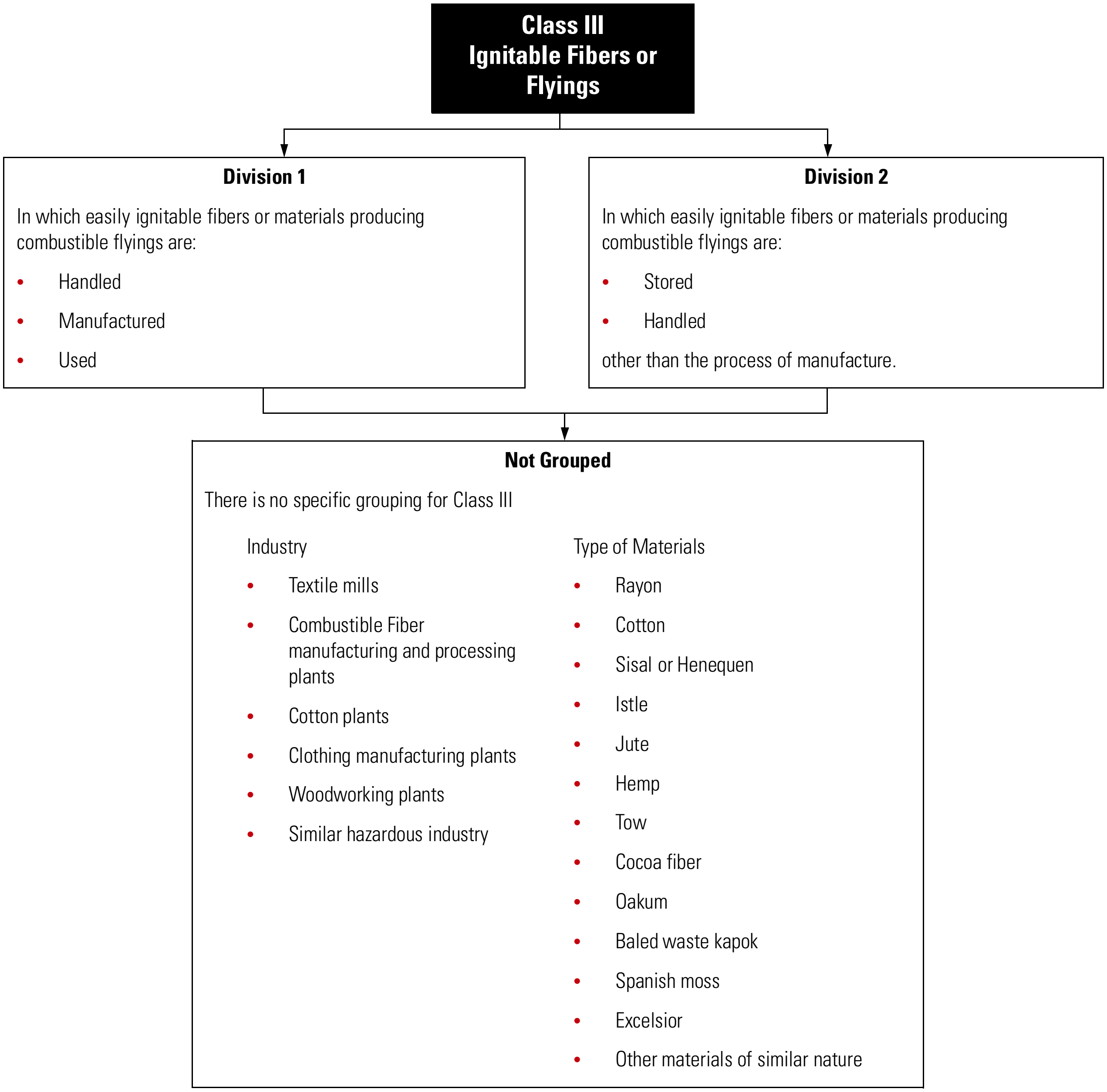
Group G
Other Combustible Dusts:

- Flour
- Grain
- Wood
- Plastic
- Chemicals

Temperature Class

The temperature marking specified shall not exceed the ignition temperature of the specific gas or vapor to be encountered. Fororganic dusts that may dehydrate or carbonize, the temperature marking shall not exceed the lower of either the ignition temperature or 165°C (329°F).

Figure 7. Class III Diagram



Class III Ignitable Fibers or Flyings

Division 1

In which easily ignitable fibers or materials producing combustible flyings are:

- Handled
- Manufactured
- Used

Division 2

In which easily ignitable fibers or materials producing combustible flyings are:

- Stored
- Handled

other than the process of manufacture.

Not Grouped

There is no specific grouping for Class III

Industry

- Textile mills
- Combustible Fiber manufacturing and processing plants
- Cotton plants
- Clothing manufacturing plants
- Woodworking plants
- Similar hazardous industry

Type of Materials

- Rayon
- Cotton
- Sisal or Henequen
- Istle
- Jute
- Hemp
- Tow
- Cocoa fiber
- Oakum
- Baled waste kapok
- Spanish moss
- Excelsior
- Other materials of similar nature

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