Hazardous Locations
A Primer

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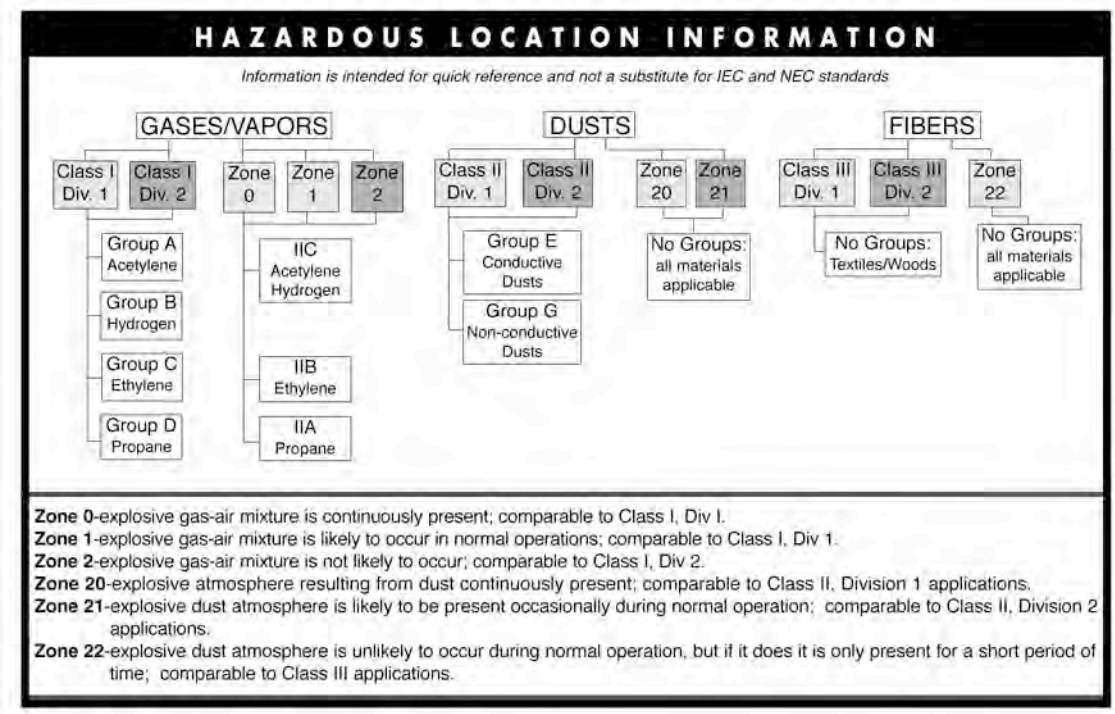
Introduction

When applying electrical instrumentation in a wide variety of industrial environments we must be aware of the type of area the devices are being installed within. By this we mean the "type" of area from an electrical code standpoint. This white paper serves to provide some information and guidance regarding area classifications and required approvals for electrical instrumentation. However, this paper is not authoritative on this subject and the National Electrical Code and other governmental regulations will be authority in this matter.



Defining "Explosive" Environments

The National Electrical Code (NEC) classifies flammable and combustible liquids on the likelihood of explosive vapors being present. A *flammable liquid* is one having a flash point below 100°F and a vapor pressure not exceeding 40psia. A *combustible liquid* is one having a flash point at or above 100°F. The flash point is the minimum temperature at which the liquid emits vapor in sufficient concentration to form an ignitable mixture with air at the air/liquid interface.

Example: Consider aviation grade gasoline. This fluid has a flash point of –50°F and emits explosive vapors at most ambient air conditions. Number1-D diesel fuel has a flash point of 100°F and does not emit vapor unless heated to higher temperatures. Facilities handling Number1-D diesel fuel would not necessarily be classified as hazardous except in hot locations, or locations where the fluid could come into contact with hot surfaces.

All flammable gases and liquids heated above their flash points can be ignited. However, there is something else that needs to be discussed and considered, that is

"concentration". There is generally a minimum and maximum concentration in air below and above which propagation of flame does not occur (mixtures are too lean or too rich). These concentrations are known as the lower and upper flammable or explosive limits of the fluid. The general effect of an increase in temperature or pressure is to lower the lower limit and raise the upper limit. A decrease in temperature or pressure has the opposite effect. Some materials have a very wide flammable range and some materials have a narrow range. Acetylene has a low concentration limit of 2.5% (by volume) in air and an upper limit of 100%. Gasoline on the other hand has a narrow range of 1.4% to 7.6%.

Combustible dusts also have flammable limits, usually called explosion concentrations. Dust clouds can be so thick that it is impossible to discern objects more than three to five feet away, even when present in minimum explosion concentrations. Typically, the concentration is probably below the lower explosion limit if you can see the hand in front of your face.

Defining Hazardous Areas

The term hazardous area, hazardous location and classified location are used interchangeably in most manufacturers' literature. These terms are interchangeable as used in National Fire Protection Association (NFPA) codes and standards and the NEC. Hazardous locations are areas where fire or explosion hazards may exist due to the presence of flammable gases/vapors, flammable liquids, combustible dust, or ignitable fibers. The type of hazard is defined as an "explosion hazard" in Class I and II locations, and a "fire hazard" in Class III locations.

Materials do not have to be in the gaseous state for an explosion. Combustible dusts, and atomized liquids are other examples.

Class I Locations

Class I locations are areas in which flammable gases/vapors may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations are divided into Divisions and also Groups within the Divisions. The Divisions indicate how likely or prevalent the hazardous gas/vapor is in the area. We'll discuss these a little later.

Groups: Groups exist to permit classification of locations based on fluids that exhibit similar explosion characteristics, regardless of the Division classification as defined later. The NEC definition of Class I Groups is as follows:

- **Group A:** acetylene
- **Group B:** hydrogen, or gases/vapors of equivalent hazard
- **Group C:** ethyl ether vapors, ethylene or cyclopropane
- **Group D:** gasoline, hexane, naptha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors, natural gas

Instrumentation/Equipment Design: In building equipment and instrumentation to be suitable for use in a Class I environment ("explosionproof") it is assumed the flammable mixture will enter the enclosure. The objective and intent of the equipment/instrumentation manufacturer is to build the enclosure strong enough to withstand the anticipated explosion and to prevent the resulting flames and hot gases from igniting the surrounding atmosphere outside of the equipment/instrumentation enclosure.

To assist the equipment/instrumentation manufacturer during design a "maximum experimental safety gap" (MESG) is defined for each Group or type of fluid. The MESG is a maximum dimension through which an ignition on the inside of the enclosure will not propogate flame to a flammable mixture on the outside. Each fluid is sorted into the Group based upon its value for MESG, which is determined experimentally.

Group D materials have an MESG greater than 0.029"; Group C between 0.012"-0.029"; and Groups A & B between 0.003"-0.012". Any fluid having an MESG below 0.003" is incapable of classification. Carbon disulfide is one such material (0.002").

Group classification by MESG is also reviewed based on recorded explosion pressures. If the explosion pressure for a fluid is higher than those typical of that Group, consideration is given to reclassification of that material into a more dangerous Group. The lower the letter of the Group, the more dangerous the Group. For example, Group A is more dangerous than Group B, etc.

The ignition temperature of a flammable material is critical in determining the acceptability of equipment/instrumentation that operates in hazardous locations as the external surface of the enclosure can act as an ignition source if the surface temperature exceeds the ignition temperature of the flammable material. High surface temperatures can result from normal operation of the equipment; abnormal operation (i.e. overheating); or because of a fault condition.

Prior to 1971, the ignition temperature was limited by the group classification. In 1971 the NEC was revised to remove the ignition temperature as a criterion for group classification. Today, equipment destined for installation in hazardous areas is marked with a code representing the maximum external surface temperature. Equipment cannot be used in hazardous areas when the maximum surface temperature is greater than the ignition temperature of the gases/vapors present. The allowable ambient temperature may be limited to comply with the temperature rating of the device. External surface identification numbers are shown in the following table:

Maximum Temperature	Identification Number
842 F	T1
572 F	T2
536 F	T2A
500 F	T2B
446 F (230 C)	T2C
446 F (215 C)	T2D
392 F	T3
356 F	T3A
329 F	T3B
320 F	T3C
275 F	T4
248 F	T4A
212 F	T5
185 F	T6

Divisions: In the NEC system, division classifications are used to identify the likelihood of a flammable mixture being present. Divisions within Class I are set up as follows:

Class I, Division 1: ignitable concentrations of flammable gases/vapors can exist under normal conditions; ignitable concentrations may exist frequently because of maintenance or leakage; ignitable concentrations may exist due to faulty operation of equipment/processes which also cause simultaneous failure of electronic equipment.

Enclosures approved for Class I, Division 1 locations include explosionproof / flameproof and purged & pressurized. Explosionproof/flameproof enclosures are the most common protection method for electrical equipment and instrumentation in hazardous locations. The enclosure is capable of withstanding an internal explosion of a specified gas/vapor and preventing ignition of said gas/vapor in the atmosphere from sparks, flashes, etc. External temperature of the enclosure is such that surrounding flammables will not be ignited.

An alternate method to designing an enclosure to meet the full requirements of Class I, Division 1 for a specific Group is to purge and pressurize the enclosure. The purged and pressurized technique eliminates the presence of flammable vapors from within the enclosure. Enclosures not otherwise acceptable for hazardous locations may be used in accordance with the NEC when using this technique. Purging supplies an enclosure with a protective gas (typically nitrogen) at a sufficient flow rate and pressure to reduce the concentration of any flammable gas to an acceptable level. Type “X” purging reduces the enclosure classification from Division 1 to general purpose; type “Y” purging from Division 1 to Division 2; type “Z” purging from Division 2 to general purpose.

General purpose type enclosures (those suitable for Ordinary locations, non-hazardous) are also acceptable for Class I, Division 1 areas if the electronics are intrinsically safe (and the proper barriers are installed on the I/O circuits). Intrinsically safe electronics have low energy circuitry that keeps energy levels below those needed to ignite any flammable gas/vapor present. Intrinsic safety takes into account energy available during normal and abnormal operations.

Class I, Division 2: locations where flammable liquids or gases are handled, processed or used but in which the fluid is normally confined and can only escape due to accidental rupture of containers or abnormal operation; location where accumulation of ignitable gases/vapors is prevented by mechanical ventilation and only occur through failure or abnormal operation of equipment; locations adjacent to Class I, Division 1 areas and to which ignitable mixtures might be communicated.

Enclosures approved for Class I, Division 2 locations can be the same type as supplied for Class I, Division 1. General purpose enclosures are acceptable if current interrupting contacts are hermetically sealed against the entrance of gas/vapor, or the electronics are nonincendive/intrinsically safe.

Nonincendive only applies to Division 2 areas. A nonincendive circuit is one in which any arc or thermal effect produced under normal operating conditions is not capable of igniting a flammable gas/vapor/dust mixture. Nonincendive circuits are not allowed in Division 1 areas because they only take into account normal operating conditions and not abnormal conditions. Nonincendive circuits are referred to as intrinsically safe circuits for Division 2 locations only.

Class I, Division 3: areas arbitrarily established by individual companies that usually extend beyond a Division 2 location. The only basic requirement is for the use of enclosed equipment.

The IEC (International Electrotechnical Commission): The IEC classification system differs from the NEC system, although both exist for the same purpose. The IEC system reserves Group I for equipment in underground mines. All other materials are classified using a Group II designation and a letter. The lettering of the groups under the IEC system is reversed compared to the NEC system (Acetylene is group IIC, not group IIA for example). In addition, the IEC system has only three groups (A, B and C). The IEC system also uses zone designations rather than divisions. There are three zones (0, 1, and 2). Zone 0 corresponds to the most hazardous part of Division 1. Zone 1 is the remainder of Division 1 and Zone 2 is the same as Division 2.

Class II Locations

Whereas Class I deals with explosive gases/vapors, Class II deals specifically with combustible dusts. The dust may be suspended in the air, in a cloud or in a layer on electrical equipment. The ignition temperature of a dust layer is usually lower than for a dust cloud. Class II locations are broken down into Divisions, which represent the likelihood of a dust explosion if ignition sources are not carefully controlled.

Groups: Class II locations are divided into three Groups:

- **Group E:** metal dusts (aluminum, magnesium and their alloys) and other combustible dusts whose particle size, abrasiveness and conductivity present similar hazard
- **Group F:** carbonaceous dusts (carbon black, charcoal, coal or coke) that have more than 8% total entrapped volatiles, or dusts sensitized by other materials so they present an explosion hazard
- **Group G:** combustible dusts not included in groups E & G

Class II, Division 1: combustible dust is in the air under normal conditions in sufficient quantity to produce explosive/ignitable mixtures; failure or abnormal operation of machinery can cause such mixtures and are a source of ignition; combustible dusts of an electrically conductive nature are present.

Class II, Division 2: combustible dust is not normally in the air in quantities sufficient to pose a hazard and dust accumulation is insufficient to interfere with electrical equipment, but may be in suspension in the air as the result of infrequent malfunctions of equipment.

The IEC (International Electrotechnical Commission): The IEC classification system differs from the NEC system, although both exist for the same purpose. The IEC system reserves Group I for equipment in underground mines. All other materials are classified using a Group II designation and a letter. The lettering under the IEC system for dusts (Class II equivalent) is Zone 20, 21 and 22. Zone 20 is when a hazardous dust cloud is likely to be present continuously or for long periods of time. Zone 21 is when the hazardous dust cloud is likely to be present occasionally in normal operation. Zone 22 is when the hazardous dust cloud is unlikely to occur during normal operation, but if it does it is only present for a short period of time.

Class III Locations:
Class III locations are hazardous because of the presence of easily ignitable fibers or “flyings”, however such fibers are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. There are no Group subdivisions for Class III locations. Class III locations are divided into divisions based on the likelihood of material being present. The Class III divisions are set up as follows:

Class III, Division 1: are areas where easily ignitable fibers or materials producing combustible “flyings” are handled, manufactured or used.

Class III, Division 2: easily ignitable fibers are stored or handled (except in the process of manufacture).

The IEC (International Electrotechnical Commission): The IEC classification system differs from the NEC system, although both exist for the same purpose. The IEC system reserves Group I for equipment in underground mines. All other materials are classified using a Group II designation and a letter. The lettering under the IEC system for Class III fibers is Zone 22, which also applies to Class II, Division 2 dusts.

Testing Agencies

Instrumentation and other electrical equipment being used within any of the above hazardous areas should have an approval or certification for the intended area from a third party testing agency. The primary testing laboratories in North America that can test to NEC standards and render an approved or certified status for the equipment include:

- **Canadian Standards Association**
- **Factory Mutual**
- **Underwriters Laboratories**

The above agencies are approved by OSHA to perform testing equipment to determine compliance to NEC standards. Most all have bi-lateral arrangements allowing for testing to both USA and Canadian standards and approvals or certifications for each are accepted almost everywhere in North America. Certification by CSA for devices to NEC standards are acceptable in the USA. UL and FM are capable of testing to Canadian standards and providing an approval acceptable within Canada.

Enclosure NEMA Ratings

In addition to classification by hazardous area, enclosures are classified on the amount of protection they provide against environmental/ambient conditions. Environmental classifications are shown in the following table.

Enclosure Type Number	Protection Against The Following Environmental Conditions
1	Indoor use "Indoor use only"
2	Indoor use, limited amount of falling water "driptight"
3R	Outdoor use, undamaged by formation of ice "rainproof"
3	Same as 3R plus windblown dust "raintight", "dusttight"
3S	Same as 3 with external mechanisms remaining operable when ice laden "raintight", "dusttight"
4	Outdoor use, splashing water, windblown dust, hose-directed water, undamaged by ice formation "raintight", "watertight"
4X	Same as 4 plus corrosion resistant "raintight", "watertight"
5	Indoor use to provide a degree of protection against settling airborne dust, falling dirt, and dripping noncorrosive liquids "driptight", "dusttight"
6	Same as 3R plus entry of water during temporary submersion at limited depth "raintight", "watertight"
6P	Same as 3R plus entry of water during prolonged submersion at limited depth "raintight", "watertight"
7	Indoor use, in hazardous locations classified as Class I, Division 1, Groups A, B, C or D
8	Indoor or Outdoor use in hazardous locations classified as Class I, Division 1, Groups A, B, C or D
9	Indoor use in hazardous areas classified as Class II, Division 1, Groups E, F or G
12, 12K	Indoor use, dust, dripping noncorrosive liquids "driptight", "dusttight"
13	Indoor use, dust, spraying of water, oil and noncorrosive coolants "driptight", "dusttight"