HAZARDOUS (CLASSIFIED) LOCATION ELECTRICAL EQUIPMENT

INTRODUCTION

Flammable vapors, flammable gases, combustible dusts and ignitable fibers are hazardous materials found in many manufacturing facilities. These materials are necessary for, or are unavoidable byproducts of, the manufacturing process.

These materials can also be found in non-manufacturing facilities. Many hospitals, repair shops, laboratories and commercial laundries contain these readily-ignitable hazardous materials.

A hazardous (classified) location is a space where any of the following apply:

- An atmosphere in which an ignitable concentration of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors is present or has the potential to occur.
- An atmosphere in which combustible dust is in suspension in sufficient quantity to cause an explosive or ignitable mixture or where the potential exists for this condition to occur.
- Electrical equipment on which combustible dust might accumulate, so as to interfere with heat dissipation from the equipment.
- Surfaces on which easily ignitable fibers or flyings accumulate.

Ordinary electrical systems are likely to ignite these gases, vapors, dusts and fibers. To prevent ignition, special electrical constructions, features or system arrangements are required.

History has proven the effectiveness of several distinct loss control techniques. These are commonly documented in national, state or community codes. This guideline describes common loss prevention approaches for hazardous (classified) locations. It does not discuss loss mitigation, such as the use of automatic sprinklers and explosion venting for fire and explosion loss control.

POSITION

Implement an electrical classification system, like the system defined in Article 500 (section 500.5) of the *National Electrical Code*® (NEC), to classify hazardous locations in which ordinary electrical equipment may cause a fire or explosion due to the presence, occasional presence or potential presence of:

- Flammable gases;
- Flammable or combustible liquid-produced vapors;

- Combustible dusts; or
- Ignitable fibers or flyings.

Inside a hazardous (classified) location, use electrical equipment designed, constructed and maintained to prevent ignition of the hazardous atmosphere, dust accumulation or fibers. Always comply with local codes and standards.

In a location where dust or flying material can collect on or in a motor and interfere with ventilation or cooling to cause a dangerous increase of temperature, use a suitably enclosed motor that will not overheat under the prevailing conditions.

NOTE: This guidance is irrespective of area classification. It is presented in this section as a reminder of general dust-hazard precautions.

When selecting heat-producing electrical equipment for a hazardous (classified) location, compare its hottest, external-surface operating temperature to the ignition temperature of the surrounding gas, vapor or dust. Consider the possibility of a lowering of ignition temperature for organic dusts that dehydrate or carbonize. Select only equipment that will not ignite hazardous materials in the area.

The NEC has established temperature classifications (T Codes) that correspond to the maximum surface temperatures for electrical equipment. These usually apply to heat generating equipment such as motors, generators, circuit breakers and luminaires. AS/NSZ EN 60079-10, BS EN 60079-10 and IEC 60079-10 establish similar codes. See Table 1.

The T code should be identified on the device and usually on the classification label.

TABLE 1

Temperature Classifications

Temperature °C	NFPA 70 Temperature Classification (T Code)	IEC 60079-10 Temperature Classification
450	T1	T1
300	T2	T2
280	T2A	
260	T2B	
230	T2C	
215	T2D	
200	T3	T3
180	T3A	
165	T3B	
160	T3C	
135	T4	T4
120	T4A	
100	T5	T5
85	T6	T6

SI Units: 1 °F = (°C+32)*0.55

Take appropriate precautions to maintain hazardous (classified) location equipment in a manner that does not jeopardize the integrity of protection. Follow guidance offered by the manufacturer, listing agency and NFPA 70B.

As practicable, reduce or eliminate the chances of electrical equipment igniting a combustible gas, vapor, dust or flying, as follows:

- Eliminate the use of materials which necessitate designating hazardous (classified) areas. Alternate processes or material substitutions may accomplish this.
- Limit hazardous (classified) areas by using ventilation, barriers, enclosures or other suitable means.
- Locate electrical equipment outside of hazardous (classified) locations or replace electrical operators with manual or pneumatic operators.

DISCUSSION

Historical Classification Method in the U.S.

Hazardous (classified) locations have traditionally been designated by Class, Division and Group. Equipment used in areas so designated is selected, and systems are designed, based on requirements established for the classification. This approach is defined in Article 500 of the NEC and has been in use for over 70 years.

Three distinct classes of hazardous (classified) locations have been established:

- Class I hazardous atmospheres are characterized as areas where flammable vapors escaping from a flammable or heated combustible liquid, and/or flammable gases are or may be present.
- Class II locations are areas where combustible dust is or may be suspended in air or where combustible dust accumulations can interfere with heat dissipation from electrical equipment or can be ignited by that equipment.
- Class III areas contain easily ignitable fibers or flyings that are not likely to be in suspension in the air in sufficient quantities to produce ignitable mixtures.

Divisions within each class are further established to define areas likely to contain the hazardous condition during normal operations (Division 1) and areas likely to contain the hazardous condition only under abnormal circumstances (Division 2). These divisions, which are based on the likelihood of an atmosphere being hazardous, control or prescribe the design, construction and operating features of equipment in that area. Engineering practice tolerates lower levels of protection where there is less likelihood of a hazardous material being present. Thus, Division 1 locations require equipment built to higher standards than equipment built for Division 2 locations.

Equipment protective features also depend on the degree or severity of a hazard to which equipment is exposed. For convenience, Class I hazardous materials are typically placed into one of four groups, depending on their physical properties and characteristics. Dusts, which are Class II materials, are similarly designated in one of three groups by degree of hazard.

NFPA 497 and NFPA 499 list hundreds of substances that fit into these Classes and provide guidance on area classification. NFPA 497 describes materials and area designations applicable to Class I materials while NFPA 499 addresses the same for Class II materials.

Class I Locations

Area classification is only necessary if an ignitable quantity of gas or vapor may be present under normal or abnormal conditions. The area classification does contemplate system and process failures. However it does not assume catastrophic failure of systems and equipment.

From NFPA 70, 500.5(b)(2) Informational Note 2, the mere presence of piping installed in accordance with the appropriate NFPA code without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. As an example, properly installed piping using welded joints rarely leak. A catastrophic failure would be needed to result in a release.

Electrical equipment in Class I locations should not have any exposed surface that operates at a temperature in excess of the ignition temperature of the specific gas or vapor.

Division 1

A Division 1 area is likely to contain the hazardous condition during normal operations, or frequently because of maintenance and repair, or as a result of a mechanical breakdown or faulty operation of equipment that might also result in the failure of electrical equipment such as to directly cause the electrical equipment to become a source of ignition. Ignitable concentrations are concentrations between the lower and upper explosive (flammability) limits. NFPA 70, 500.5 contains a list of locations that typically are included in this Division.

Division 2

A Division 2 location is likely to contain the hazardous condition only under abnormal circumstances. It includes locations:

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

Class II Locations

Two criteria are used to determine the need for area classification. The first is the presence of an ignitable dust cloud and the second is dust accumulation on surfaces. An ignitable dust cloud is a combustible dust in suspension in the air in a concentration that at or above its minimum explosive concentration (MEC).

From a practical standpoint a dust at its MEC would present a significant visual impairment and be well above the personal health limit. A cloud of coal dust of 40 g/m^3 (e.g., at or below many coal dust MEC's) in air is so dense that a glowing 25 W light bulb can hardly be seen through a dust cloud of 2 m thickness[i].

Dust accumulation on equipment can interfere with heat dissipation. Dust accumulation on, and penetration into moving parts such as shafts and joints can also interfere with safe equipment operation.

There is no hard criterion for dust layer thickness in the NEC for area classification. However NFPA 499 uses a rule of thumb of ⅛ inch (3.2 mm). Table 2 contains the layer thickness guidance.

TABLE 2

Area Classification using Dust Layer Thickness

Area Classification	Dust Layer Thickness
Division 1	> 1/8 inch (3.2 mm)
Division 2	< 1/8 inch (3.2 mm) but surface color not discernible
Unclassified	Surface color discernible under dust layer

[i] Eckhoff, Dust Explosion in the process industries, 2nd Ed, Figure 1.5

Electrical equipment in Class II locations should not have any exposed surface greater than the ignition temperature of the specific dust that may accumulate on it. For organic dusts that may dehydrate or carbonize, the temperature marking should not exceed the lower of either the ignition temperature or 165°C (329°F).

As an example, a motor is being installed in an area where accumulation of corn dust is expected. For this material, NFPA 499 lists an ignition temperature 250°C (482 °F). Therefore the motor should possess a T2C temperature classification.

Division 1

A Division 1 location is a location:

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

The intent of “hazardous quantities” in (3) above is to describe those locations where the dust may not be in suspension in the air in sufficient quantity to cause an explosion, but might have settled on electrical equipment so that the electrically conductive particles can penetrate the openings in the equipment and cause an electrical failure. In addition, metals dusts are very abrasive. If the dust enters the bearing housings of rotating electrical equipment, overheating of bearings and subsequent ignition could occur. Therefore any location where a Group E dust layer is present (e.g., color of surface under layer is not discernible) is a Class II, Div 1 location (i.e. there are no Class II, Div 2 locations for Group E dusts).

Division 2

A Division 2 location is a location:

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

Note that Division 2 locations do not exist for Group E dusts. Therefore, if an area is classified as Division 2 and the dust under consideration is Group E, the area would be considered Division 1.

Class III Locations

For Class III locations, the division classification is based on whether the area is used for processing or for storage. A manufacturing area is a Division 1 location; a warehouse is a Division 2 location.

Expansion of Class I Designations in the U.S.

Today, the NEC also provides an alternative method of classifying hazardous locations involving Class I atmospheres. This expansion brings the code more in line with standards used in other countries. Either the historical method or the alternative method must be selected for a given hazardous (classified) location.

In lieu of Group A, B, C and D atmospheres, the alternative system establishes Groups I, IIA, IIB and IIC atmospheres. Group I electric apparatus is equipment for use in underground mines. The NEC

goes no further in discussing such equipment since underground mines are not intended to be covered by the code.

A Group IIA atmosphere is equivalent to a Group D atmosphere. Group IIB is equivalent to Group C. Group IIC is equivalent to Groups A and B combined. These comparisons are shown in Table 3.

TABLE 3
Comparison Of Historic And Alternate NEC Class I Grouping Systems

Class I Content (Liquid, Gas or Vapor)	Historical Approach	Alternate Approach
Atmospheres containing acetylene.	Group A	Group IIC
Atmospheres containing hydrogen, fuel and combustible process gases containing more than 30% hydrogen by volume, or gases or vapors of equivalent hazard such as butadiene, ethylene oxide, propylene oxide and acrolein.	Group B	Group IIC
Atmospheres containing acetaldehyde, ethylene, or gases or vapors of equivalent hazard.	Group C	Group IIB
Atmospheres containing acetone, ammonia, benzene, butane, cyclopropane, ethanol, gasoline, hexane, methanol, methane, natural gas, naphtha, propane, or gases or vapors of equivalent hazard.	Group D	Group IIA

TABLE 4
Comparison Of NEC Division And Zone Classification Systems

Historical Approach	Alternate Approach
Class I, Division 1 -- Where ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors can exist: • Normally during operating periods. • Frequently because of repair, maintenance or leakage. • Accidentally where the possibility exists of a simultaneous release of ignitable concentrations of gas (vapor) and failure of electrical equipment. Fine Print Note No. 2 in the Code states where ignitable concentrations of flammable gases (vapors) can exist continually or for long periods of time, electrical equipment should be avoided altogether, or, intrinsically safe systems should be used.	Class I, Zone 0 -- Where ignitable concentrations of flammable gases (vapors) can exist: • Continually. • For long periods of time. Fine Print Note No. 3 in the Code states it is not good practice to install electrical equipment in Zone 0 locations unless absolutely necessary, and when it is installed it is good practice to provide intrinsically safe systems. Class I, Zone 1 -- Where ignitable concentrations of flammable gases (vapors) can exist: • Normally during operating periods. • Frequently because of repair, maintenance or leakage. • Accidentally where the possibility exists of a simultaneous release of gas (vapor) and failure of electrical equipment so as to cause ignition. • Because the area is adjacent to a Zone 0 area, from which gas (vapor) can be communicated.
Class I, Division 2 -- • Areas containing volatile flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors, where these materials are normally confined to closed containers and systems from which the materials can escape only upon the rupture or breakdown of containment or upon abnormal operation of equipment or process. • Where ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are normally prevented by positive mechanical ventilation, but which might become hazardous through failure or abnormal operation of ventilating equipment. • Where adjacent to a Class I, Division 1 location from which ignitable concentrations of gases (vapors) might occasionally be communicated.	Class I, Zone 2 -- • Where ignitable concentrations of flammable gases (vapors) are not likely to occur during normal operations, and if they do occur, where they will exist for only a short period of time. • Areas containing volatile flammable liquids or gases, where these materials are normally confined to closed containers and systems from which the materials can escape only upon the rupture or breakdown of containment or upon abnormal operation of equipment or process. • Where ignitable concentrations of gases (vapors) are normally prevented by positive mechanical ventilation, but which might become hazardous through failure or abnormal operation of ventilating equipment. • Where adjacent to a Class I, Zone 1 location from which ignitable concentrations of gases (vapors) might occasionally be communicated.

In lieu of Division 1 and 2 locations, this newer (to the NEC) system establishes Zones 0, 1 and 2. Zones 0 and 1 comprise what was originally Division 1. Zone 2 is comparable to Division 2. A comparison of NEC Division and Zone classification systems is shown in Table 4.

This more recent approach has been in use for many years in most European countries. Originally, each country had its own National requirements. Then, based on the work done by the IEC (International Electrochemical Commission), standards were harmonized through the work of CENELEC (Comite Europeen de Normalisation Electrotechnique). Harmonized standards, published as European Standards (EN), have to be adopted by the participating countries as National standards. Some of the countries that have adopted these are: Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

NEC Article 501 defines electrical equipment suitable for use in Class I, Division 1 and 2 locations. Article 505 defines equipment suitable for use in Class I, Zone 0, 1, and 2 locations. Mixing classification methods in a single classified location is not permitted. Equipment requirements are established by the single classification method selected for that area. However, Class I, Zone 2 locations are permitted to abut, but not overlap, Class I, Division 2 locations. Class I, Zone 0 or Zone 1 locations are not allowed to abut Class I, Division 1 or Division 2 locations.

If the alternate classification system presented by Article 505 is used; area classification, engineering and design, wiring methods, equipment selection, and inspection must be done by qualified personnel. (This is the only section of the NEC that identifies such control.)

TABLE 5
NEC Class II And III Hazardous (Classified) Locations

Content (dust, fibers or flyings)	Class	Group
Atmospheres containing combustible metal dusts, including aluminum and magnesium dusts.	II	Group E
Atmospheres containing combustible carbonaceous dusts, including carbon black, charcoal, coke, and coal dust.	II	Group F
Atmospheres containing other combustible dusts, such as flour, grain, wood and plastic dusts.	II	Group G
Locations containing combustible fibers or flyings, but in which these materials are not likely to be in suspension in the atmosphere in significant quantities to form an ignitable mixture. Examples include flour, grain, wood, plastic, and chemicals.	III	(none)

Class II and III Locations

Class and Group designations for hazardous (classified) locations other than Class 1—that is for locations containing combustible dust, fibers and flyings – have not been changed or expanded. These designations are identified in Table 3. Divisions 1 and 2 were described earlier.

European harmonization of the zone concept for Class II and Class III locations is still under development. Generally, the European community treats Class III locations the same as Class II locations.

Equipment

Once a hazardous location has been classified, appropriate electrical equipment must be chosen for that area. In general, equipment must be approved for use in that hazardous classified area. The Authority Having Jurisdiction (AHJ) is responsible for such decisions. To guide their decisions, AHJs typically depend on information from testing labs. The AHJ determines which labs or organizations can best test, label, list or approve equipment suitable for installation in accordance with their legislated Code. The testing lab must be familiar with the applicable code in order to list suitable equipment.

The NEC defines “listed” as: Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Who is the AHJ for the NEC? Generally, the electrical inspector for the jurisdiction has primary responsibility. But the AHJ is not necessarily limited to that one body. For loss control purposes, insurance companies can selectively claim participation in the AHJ function, as can designers, installers, consultants and users.

Listed equipment for hazardous (classified) areas is normally marked to show in which code-specified environments it can be safely used. These markings often include the maximum surface temperature of the equipment under normal operating conditions. However, a Fine Print Note in the definitions section of the NEC states: *The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. Use of the system employed by the listing organization allows the authority having jurisdiction to identify a listed product.*

The best-known type of hazardous location electrical equipment in the U.S. is explosionproof equipment. Explosionproof equipment is designed to contain explosions without allowing the escape of enough energy to ignite the hazardous atmosphere in the area. Explosionproof apparatus is suitable for use in Class I, Division 1and 2 locations when listed for use in those atmospheres as per Section 500.7(A) of the NEC. However, the NEC does not specifically reference explosionproof apparatus as a protection technique for Class I, Zone 0, 1 and 2 areas, but rather refers to the use of intrinsic safety in Zones 0, 1 and 2 or flameproof “d” in Zones 1 and 2. It should be noted that flameproof and explosionproof enclosures are very similar approaches, with explosionproof apparatus having more stringent design requirements. Explosionproof enclosures are designed to withstand 4 times the explosive pressure of the gases, while flameproof enclosures may be designed and tested to withstand 1.5 times the explosive pressure. Section 505.8 of the NEC outlines all acceptable protection techniques for electrical equipment in Class I, Zone 0, 1 and 2 locations.

Comparable equipment suitable for use in Class II, Division 1 locations is called dust-ignitionproof. Dust-tight equipment is designed for use in Class II, Division 2 locations. These terms should not be confused with equipment designated “dustproof.” Dustproof equipment is constructed or protected so that dust will not interfere with its successful operation. This term does not imply the equipment is suitable for use in a hazardous (classified) area.

The NEC requires certain equipment to be explosionproof and other equipment to be dust-ignitionproof. It references an ANSI/UL 1203 test standard. Typically, AHJ approval will verify such equipment meets this UL test. Listing by UL is one method of such assurance.

One problem in accepting equipment not specifically tested for application with the NEC is that means of approved connection may not be available. Equipment designed for use in a Class I, Group D, Division 1 location must also be connected to the system (installed) in a manner permitted by code. Equipment listing is only part of the system requirement.

To assist AHJ’s, some testing organizations have pursued agreements with labs outside of their country of origin and are able to list or certify equipment for foreign use with applicable codes. As an example of how this has developed, UL (in the U.S.) can perform CENELEC tests and their partner, DEMKO (in Denmark), can issue a test certificate for equipment use in the European community. Also, through its European subsidiaries, UL is able to provide technical support to declare products conform to CE Marking (Conformité Européenne) requirements. In addition, UL International DEMKO A/S can test and certificate for the Keymark and ENEC Mark, both of which are pan-European safety marks for a variety of electrical products. Other reciprocal testing agreements continue to be developed in today’s global market.

Other kinds of electrical equipment may also be used in hazardous locations. One kind is purged or pressurized electrical equipment. This equipment works by using air or nonflammable protective gas flow or pressure to prevent hazardous materials from entering the enclosure. NFPA 496 defines three types of purged and pressurized equipment as identified in Table 6.

TABLE 6
Purged And Pressurized Electrical Equipment Enclosures

Type	Description
X	Reduces enclosure classification from Division 1 or Zone 1 to unclassified.
Y	Reduces enclosure classification from Division 1 to Division 2, or Zone 1 to Zone 2.
Z	Reduces enclosure classification from Division 2 or Zone 2 to unclassified.

Another kind of electrical equipment suitable for use in hazardous locations is equipment whose maximum possible energy output is insufficient to ignite the hazardous material. The electrical input to this equipment must be controlled by a specially-designed electrical barrier. Such electrical equipment must be compatible. ANSI/UL 913 defines low energy intrinsically safe electrical equipment and associated apparatus permitted in Division 1 areas. Nonincendive electrical equipment is permitted in Division 2 locations. Table 7 describes intrinsically safe and nonincendive equipment and identifies permitted uses.

TABLE 7
Low Energy Electrical Equipment For Hazardous Locations

Type	Description	Where Used
Intrinsically Safe (referred to as Intrinsic Safety “i” for Zone locations)	Will not ignite the most ignitable concentration of the hazardous material at 1.5 times the highest energy possible under normal conditions, under 1.5 times the energy of the worst single fault, and under the energy of the worst combination of two faults.	Class I, Division 1 or 2; Class I, Zone 0, 1,or 2; Class II, Division 1 or 2; and Class III Locations.
Nonincendive	Will not ignite the most ignitable concentration of the hazardous material under normal conditions.	Class I, Division 2; Class II, Division 2; and Class III Locations.

Intrinsically safe type “i” equipment approved for use in the European community might not pass UL 913 tests for intrinsically safe designation in the U.S. The standards are close, but not identical. AHJs should avoid integrating components intended for different codes or systems, unless approved by an appropriately licensed or certified electrical engineer.

Table 8 identifies additional alternate (zone) classification protection methods.

TABLE 8
Other Equipment Protection Types For Alternate (Zone) Classification System

Type	Description	Where Used
Flameproof “d”	Equipment enclosure will withstand an internal explosion of a flammable mixture without suffering damage and without causing ignition.	Class I, Zone 1, or 2.
Type of Protection “n”	Electrical equipment that when in normal operation is not capable of igniting an explosive atmosphere and a fault that is capable of causing ignition is unlikely to occur. This protection type is further subdivided into nA, nC, and nR.	Class I, Zone 2.
Oil Immersion “o”	Electrical equipment immersed in a protective liquid in such a way that an explosive atmosphere cannot be ignited.	Class I, Zone 1 or 2.
Increased Safety “e”	Electrical equipment that does not produce arcs or sparks during normal service and under specified abnormal conditions.	Class I, Zone 1 or 2.
Encapsulation “m” and “mb”	Electrical parts are enclosed in a compound in such a way that they cannot ignite an explosive atmosphere.	Class I, Zone 1 or 2.
Encapsulation “ma”	Same as type “m” but also designated for use in Zone 0 locations.	Class I, Zone 0, 1 or 2.
Powder Filling “q”	Electrical parts are completely surrounded by glass or quartz filling to prevent ignition of an explosive atmosphere.	Class I, Zone 1 or 2.
Combustible Gas Detection System	A combustible gas detection system is permitted as a protection means in industrial sites with restricted public access and where there is maintenance and supervision provided by qualified persons. There are restrictions to this approach – reference is made to section 505.8 (K), notes 1, 2, and 3 of the NEC for further details.	Class I, Zone 1 or 2.

Class I Equipment

The NEC specifies the type of electrical equipment that must be installed in classified areas. Table 9 contains a brief synopsis of this information for the most common equipment. Division 1 equipment is suitable for Division 2.

TABLE 9

Class I Equipment Types

Equipment Type	Division 1	Division 2
Wiring	Threaded rigid metal conduit or threaded steel intermediate metal conduit or Type MI cable terminated with fittings listed for the location or Type MC-HL cable listed for use in Class I, Division 1 locations with fittings listed for the application. (allowed in industrial establishments with restricted public access) or Type ITC-HL cable listed for use in Class I, Division 1 locations and terminated with fittings listed for the application. Boxes and fittings must be approved for Class I, Division 1. Conduit seals required at entrances to enclosures; when leaving a Class I, Division 1 location, within 3.05 m (10 ft) on either side of the boundary; and between Division 1 and Division 2 equipment. Cable seals required as indicated in NEC.	Type PLTC and Type PLTC-ER, including installation in cable tray systems, terminated with listed fittings or Type ITC and Type ITC-ER cable as permitted in 727.4 terminated with listed fittings or Type MC, MV, or TC cable, including installation in cable tray systems, terminated with listed fittings or Listed reinforced thermosetting resin conduit (RTRC), factory elbows, and associated fittings, all marked with the suffix -XW, and Schedule 80 PVC conduit, factory elbows, and associated fittings. (allowed in industrial establishments with restricted public access) or Nonincendive field wiring using any of the wiring methods permitted for unclassified locations. Boxes and fittings do not need to be explosionproof except as required for Meters, Instruments, and Relays; Switches, Circuit Breakers, Motor Controllers, and Fuses; and Signaling, Alarm, Remote-Control, and Communications Systems. Seals not required unless providing connection to an explosionproof enclosure or for conduit runs passing from Division 2 into an unclassified location. Cable seals required as indicated in the NEC.
Flexible Connections	Flexible fittings listed for the location, or flexible cord as indicated below for flexible cords terminated with cord connectors listed for the location.	Listed flexible metal fittings or Flexible metal conduit with listed fittings or Liquidtight flexible metal conduit with listed fittings or Liquidtight flexible nonmetallic conduit with listed fittings or Flexible cord listed for extra-hard usage and terminated with listed fittings. A conductor for use as an equipment grounding conductor shall be included in the flexible cord.
Transformers and Capacitors	Equipment that contains liquid that will burn must be installed in 3 hour fire rated vaults. No door or other communicating opening between the vault and the Division 1 location. Ample ventilation required for the continuous removal of flammable gases or vapors. Vent openings or ducts must lead to a safe location outside of buildings. Vent ducts and openings must be of sufficient area to relieve explosion pressures within the vault, and all portions of vent ducts within the buildings shall be of reinforced concrete construction. Equipment that does not contain liquid that will burn must be listed for Division 1 location or be installed in a vault as indicated above.	Dry Transformers < 112.5 kVA: Separated at least 300 mm (12 in.) from combustible material unless separated from the combustible material by a fire resistant, heat-insulated barrier or 600 volts, nominal, or less, completely enclosed, with or without ventilating openings. Dry Transformers > 112.5 kVA: Installed in a transformer room of fire-resistant construction with at least a 1 hour fire rating. (exceptions exist for class 155 and higher transformers) Dry Transformers > 35,000 V: Installed in 3 hour fire rated vault. Oil Insulated Transformers: Installed in 3 hour fire rated vault. (exceptions exist). Capacitors containing more than 11 L (3 gal) of flammable liquid must be enclosed in vaults.

TABLE 9 (Cont''d)

Class I Equipment Types

Equipment Type	Division 1	Division 2
Switches, Circuit Breakers, Motor Controllers, and Fuses	Provided with enclosures identified for the location (this includes pressurized and purged enclosures).	Same as Division 1 unless general-purpose enclosures are provided where: (1) Interruption of current occurs within a chamber hermetically sealed against the entrance of gases and vapors. (2) The current make-and-break contacts are oil-immersed and of the general-purpose type having a 50 mm (2 in.) minimum immersion for power contacts and a 25 mm (1 in.) minimum immersion for control contacts. (3) The interruption of current occurs within a factory sealed explosionproof chamber. (4) The device is a solid state, switching control without contacts, where the surface temperature does not exceed 80 percent of the ignition temperature in degrees Celsius.
Motors and Generators	Classified for Class I, Div. 1 locations or Totally enclosed type supplied with positive pressure ventilation from a source of clean air with discharge to a safe area, so arranged to prevent energizing of the machine until ventilation has been established and the enclosure has been purged with at least 10 volumes of air, and also arranged to automatically de-energize the equipment when the air supply fails or Totally enclosed inert gas-filled type supplied with a suitable reliable source of inert gas for pressurizing the enclosure, with devices provided to ensure a positive pressure in the enclosure and arranged to automatically de-energize the equipment when the gas supply fails or Designed to be submerged in a liquid that is flammable only when vaporized and mixed with air, or in a gas or vapor at a pressure greater than atmospheric and that is flammable only when mixed with air; and the machine is so arranged to prevent energizing it until it has been purged with the liquid or gas to exclude air, and also arranged to automatically de-energize the equipment when the supply of liquid or gas or vapor fails or the pressure is reduced to atmospheric The external operating temperatures of the totally enclosed motors above in degrees Celsius must be at or below 80 percent of the ignition temperature of the vapor or gas.	Equipment or enclosure identified for Division 1 location if employing devices such as sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent, overloading, and overtemperature devices), or integral resistance devices; unless such devices are provided with enclosures identified for Class I, Division 2 locations. Open or non-explosionproof enclosed motors, such as squirrel-cage induction motors without brushes, switching mechanisms, or similar arc producing devices that are not identified for use in a Class I, Division 2 location are permitted.

TABLE 9 (Cont'd)

Class I Equipment Types

Equipment Type	Division 1	Division 2
Luminaires (Lighting	Classified for Div. 1 locations and clearly marked to indicate the maximum wattage of the lamp for which it is designed. Be protected against physical damage by a suitable guard or by location. Pendant luminaires are to be suspended by and supplied through threaded rigid metal conduit stems or threaded steel intermediate conduit stems, and threaded joints must be provided with set-screws or other effective means to prevent loosening. Portable luminaires must be specifically listed as a complete assembly for that use.	Classified for Div. 1 or of a type that has been tested in order to determine the marked operating temperature or temperature class (T Code). Be protected against physical damage by a suitable guard or by location. Portable luminaires same as Div. 1.
Flexible cords	Listed for extra-hard usage. Equipped with a grounding conductor. Terminated with a cord connector listed for the location.	Listed for extra-hard usage. Equipped with a grounding conductor. In Division 2 locations, the cord shall be terminated. Terminated with a listed dusttight connector.
Receptacles and Attachment Plugs	Classified for Div. 1 locations. Provide for connection to the equipment grounding conductor of a flexible cord.	Classified for Div. 2 locations. Provide for connection to the equipment grounding conductor of a flexible cord.

Class II Equipment

The NEC specifies the type of electrical equipment that must be installed in classified areas. Table 10 contains a brief synopsis of this information for the most common equipment. Division 1 equipment is suitable for Division 2.

TABLE 10

Class II Equipment Types

Equipment Type	Division 1	Division 2
Wiring	Threaded rigid metal conduit, or threaded steel intermediate metal conduit or Type MI cable with termination fittings listed for the location or Type MC-HL cable, listed for use in Class II, Division 1 locations. Fittings and boxes shall be provided with threaded bosses for connection to conduit or cable terminations and shall be dusttight. Fittings and boxes in which taps, joints, or terminal connections are made, or that is used in Group E locations, must be identified for Class II locations. Seals are required between dust-ignitionproof and non-dust-ignitionproof enclosures. This can consistent of a physical seal or raceway distance.	Rigid metal conduit, intermediate metal conduit, electrical metallic tubing, dusttight wireways. Fittings and boxes shall be dusttight.
Flexible Connections	Dusttight flexible connectors or Liquidtight flexible metal conduit with listed fittings or Liquidtight flexible nonmetallic conduit with listed fittings or Interlocked armor Type MC cable having an overall jacket of suitable polymeric material and provided with termination fittings listed for Class II, Division 1 locations or Flexible cord listed for extra-hard usage and terminated with listed dusttight fittings	Same as Division 1
Transformers and Capacitors	If equipment contains liquid that will burn, install in 3 hour fire rated vaults with self-closing fire doors. Equip doors with suitable seals (such as weather stripping) to minimize the entrance of dust into the vault. Vent openings and ducts must communicate only with the outside air. Not allowed in Group E locations.	If equipment contains liquid that will burn, install in 3 hour fire rated vaults. If equipment contains Askarel (e.g. PCB liquid) and rated in excess of 25 kVA, it must be provided with pressure-relief vents, a means for absorbing any gases generated by arcing inside the case, or the pressure-relief vents must be connected to a chimney or flue that will carry such gases outside the building. A clear space of not less than 150 mm (6 in.) between the transformer cases and any adjacent combustible material must be maintained. Dry type transformers must be installed in vaults or must have their windings and terminal connections enclosed in tight metal housings without ventilating or other openings and shall operate at not over 600 volts, nominal
Switches, Circuit Breakers, Motor Controllers, and Fuses	Provided with enclosures identified for the location (this includes pressurized and purged enclosures).	Dusttight or provided with enclosures identified for the location.

TABLE 10 (Cont'd)

Class II Equipment Types

Equipment Type	Division 1	Division 2
Motors and Generators	Classified for Div. 1 locations. Totally enclosed pipe-ventilated and meet temperature limitations.	Totally enclosed nonventilated, totally enclosed pipe-ventilated, totally enclosed water-air-cooled, totally enclosed fan-cooled or dust-ignitionproof for which maximum full-load external temperature does not exceed the ignition temperature of the dust for normal operation when operating in free air (not dust blanketed) and shall have no external openings.
Luminaires (Lighting)	Classified for Class II, Div. 1 locations and clearly marked to indicate the maximum wattage of the lamp for which it is designed. Be protected against physical damage by a suitable guard or by location. Pendant luminaires must be suspended by threaded rigid metal conduit stems, by threaded steel intermediate metal conduit stems, by chains with approved fittings, or by other approved means.	Provided with enclosures that are dusttight or otherwise identified for the location and clearly marked to indicate the maximum wattage of the lamp that shall be permitted so that the exposed surface temperature does not exceed the ignition temperature of the dust.
Flexible cords	Listed for extra-hard usage. Equipped with a grounding conductor. Terminated with a cord connector listed for the location.	Listed for extra-hard usage. Equipped with a grounding conductor. In Division 2 locations, the cord shall be terminated. Terminated with a listed dusttight connector.
Receptacles and Attachment Plugs	Classified for Div. 1 locations. Provide for connection to the equipment grounding conductor of a flexible cord.	Provides for connection to the equipment grounding conductor of the flexible cord. Designed so that connection to the supply circuit cannot be made or broken while live parts are exposed.

Equipment Avoidance or Maintenance

Electrical equipment suitable for classified locations can be expensive and hard to maintain. Options to using this equipment are sometimes available. These options include eliminating the hazardous materials, separating the hazardous location from the electrical equipment, moving electrical equipment outside the hazardous location, or replacing electrical operations with manual or pneumatic operations. It is frequently possible to locate much of the equipment in less hazardous or in nonhazardous locations and, thus, to reduce the amount of special equipment required.

Special precautions are required to maintain equipment used in hazardous (classified) locations. Details and examples are identified in section 27.2 of NFPA 70B. All work should be done in a way that maintains the integrity of protection. If maintenance work voids the listing applying to a device, the device should not be re-energized in the hazardous (classified) area. A replacement device should be obtained.