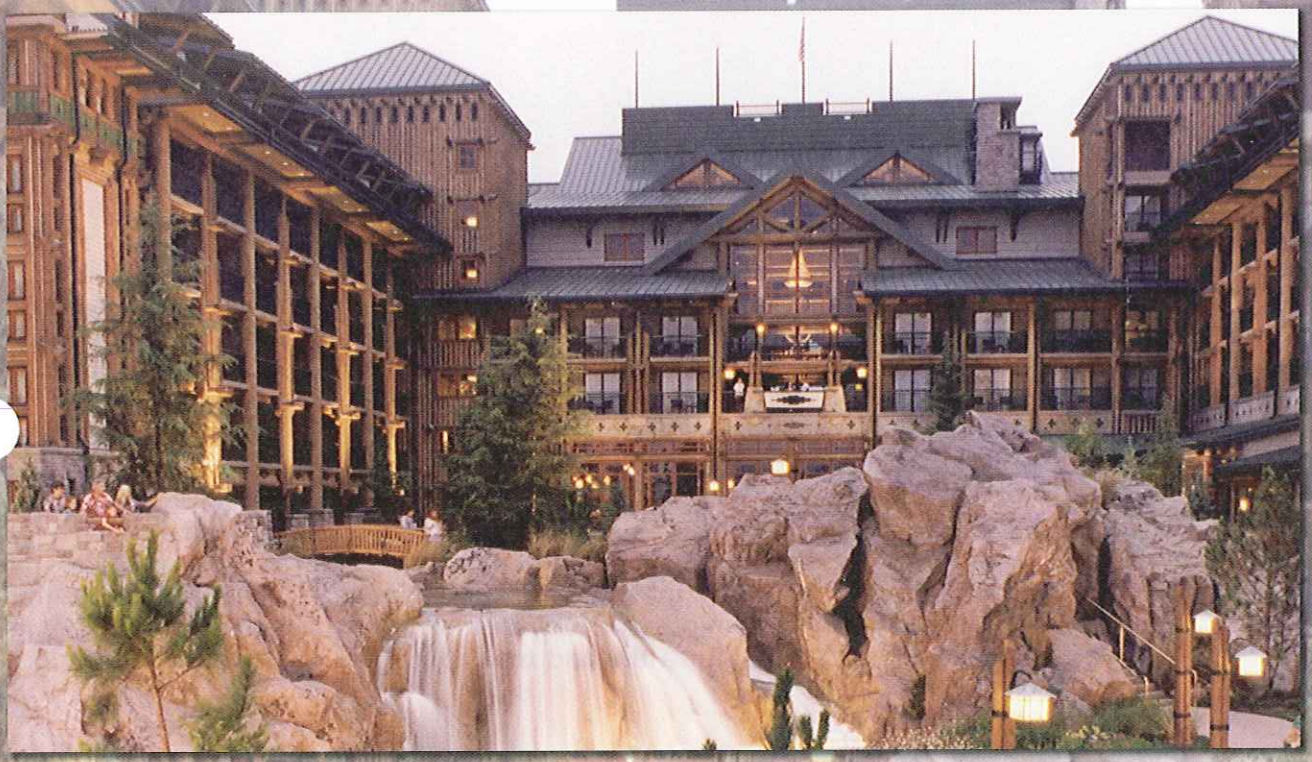
Hazardous Locations

26312-05



Walt Disney World's Wilderness Lodge

Walt Disney World's Wilderness Lodge is modeled after the Old Faithful Inn that was built inside Yellowstone National Park in 1902; it even includes a functional reproduction of Old Faithful Geyser. Installation of the electrical work involved highly detailed coordination to ensure that the various lighting and power systems would be concealed and not detract from the period feel of the building.

26312-05
Hazardous Locations

Topics to be presented in this module include:

Overview

Hazardous locations are those that contain both combustible materials and energized electrical components. The *NEC®* uses a system of classes and divisions to identify hazardous locations. Classes identify the type of combustible material, while divisions define the state or presence of the material. Class I locations contain combustible gases or vapors; combustible dust is present in Class II locations; and Class III locations contain combustible fibers or flyings.

Equipment that houses electrical components in hazardous locations must meet certain standards or guidelines depending on the division to which it is assigned. Special fittings are available for conduit systems to physically seal off the passage through the interior of the conduit in order to prevent combustible material from traveling from the hazardous area to potential ignition points. *NEC Chapter 5* contains rules and regulations that apply to hazardous locations.

Objectives

When you have completed this module, you will be able to do the following:

1. Define the various classifications of hazardous locations.
2. Describe the wiring methods permitted for branch circuits and feeders in specific hazardous locations.
3. Select seals and drains for specific hazardous locations.
4. Select wiring methods for Class I, Class II, and Class III hazardous locations.
5. Follow *National Electrical Code®* (*NEC®*) requirements for installing explosionproof fittings in specific hazardous locations.

Trade Terms

Approved
Conduit
Conduit body
Equipment
Explosionproof
Explosionproof apparatus
Hazardous (classified) location
Sealing compound
Sealoff fittings

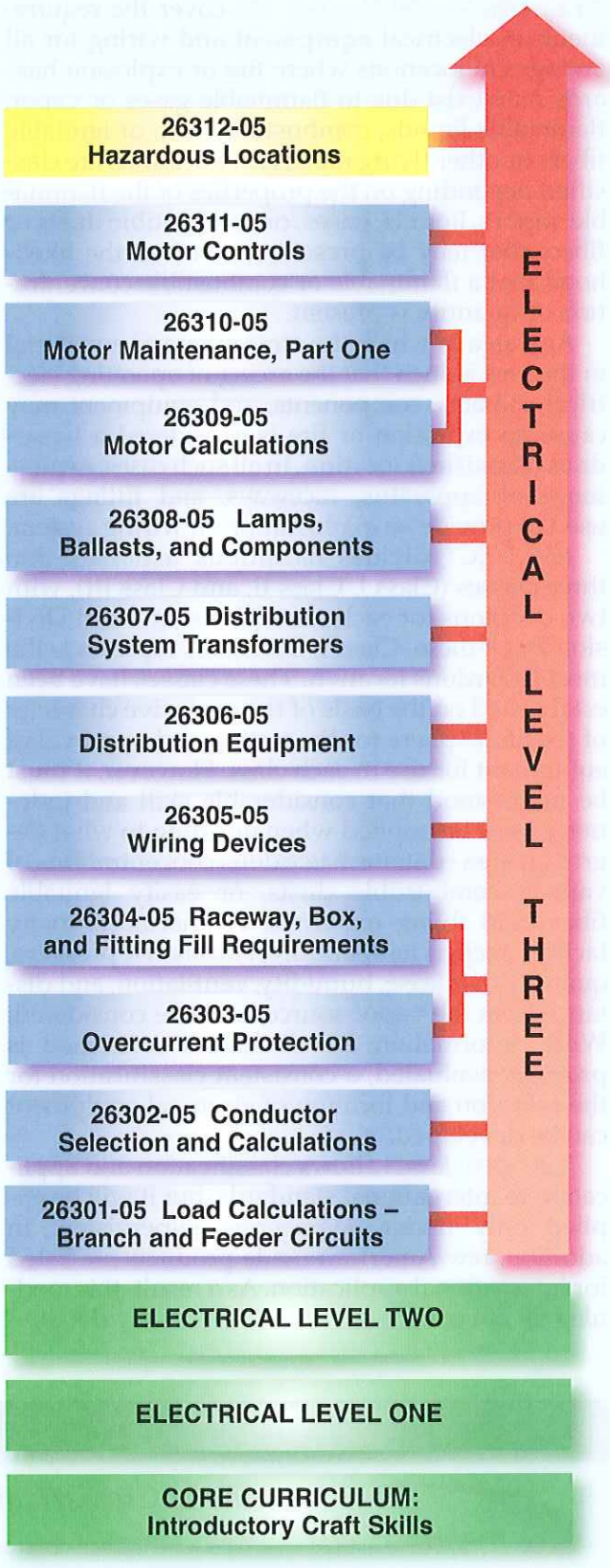
Required Trainee Materials

1. Pencil and paper
2. Appropriate personal protective equipment
3. Copy of the latest edition of the *National Electrical Code®*

Prerequisites

Before you begin this module, it is recommended that you successfully complete *Core Curriculum; Electrical Level One; Electrical Level Two; Electrical Level Three,* Modules 26301-05 through 26311-05.

This course map shows all of the modules in *Electrical Level Three.* The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map. The local Training Program Sponsor may adjust the training order.



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1.0.0 ◆ INTRODUCTION

NEC Articles 500 through 504 cover the requirements of electrical **equipment** and wiring for all voltages in locations where fire or explosion hazards may exist due to flammable gases or vapor, flammable liquids, combustible dust, or ignitable fibers or other flying materials. Locations are classified depending on the properties of the flammable vapors, liquids, gases, or combustible dusts or fibers that may be present, as well as the likelihood that a flammable or combustible concentration or quantity is present.

Any area in which the atmosphere or a material in the area is such that the arcing of operating electrical contacts, components, and equipment may cause an explosion or fire is considered a **hazardous (classified) location.** In all such cases, **explosionproof apparatus,** raceways, and fittings are used to provide an **explosionproof** wiring system.

The *NEC®* divides hazardous materials into three classes (Class I, Class II, and Class III), with two divisions for each class (Division 1 and Division 2). Of these, Class I, Division 1 represents the most hazardous location. These classes have been established on the basis of the explosive character of the atmosphere for the testing and approval of equipment for use in each class. However, it must be understood that considerable skill and judgment must be applied when deciding to what degree an area contains hazardous concentrations of vapors, combustible dusts, or easily ignitable fibers and flying materials. Furthermore, many factors, such as temperature, barometric pressure, quantity of release, humidity, ventilation, and distance from the vapor source, must be considered. When information on all factors concerned is properly evaluated, a consistent classification for the selection and location of electrical equipment can be developed.

NEC Article 505 allows classification and application to international standards, but it will be applied only under engineering supervision. In addition, few American-made products are listed for international application. As a result, this module will not cover *NEC Article 505* in any detail.

1.1.0 Class I Locations

Class I atmospheric hazards are divided into Divisions 1 and 2, and also into four groups (A, B, C and D). Group A represents the most hazardous location.

Those locations in which flammable gases or vapors may be present in the air in quantities sufficient to produce explosive or ignitable mixtures are identified as Class I locations. If these gases or vapors are present during normal operation, frequent repair or maintenance operations, or where breakdown or faulty operation of process equipment might also cause simultaneous failure of electrical equipment, the area is designated as Class I, Division 1. Examples of such locations are interiors of paint spray booths where volatile, flammable solvents are used, inadequately ventilated pump rooms where flammable gas is pumped, anesthetizing locations of hospitals (to a height of 5' above floor level), and drying rooms for the evaporation of flammable solvents (see *Figure 1*).

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

1.2.0 Class II Locations

Class II locations are those that are hazardous because of the presence of combustible dust. Class II, Division 1 locations are areas in which combustible dust may be present in the air under normal operating conditions in quantities sufficient to produce explosive or ignitable mixtures; examples are working areas of grain-handling and storage plants and rooms containing grinders or pulverizers (*Figure 2*). Class II, Division 2 locations are areas in which dangerous concentrations of suspended dust are not likely, but where dust might accumulate.

INSIDE TRACK

Zone Classifications

The zone system covered in ***NEC Article 505*** is an alternative to the division classification covered in ***NEC Article 500.*** All electrical components and devices must be rated for the specific zone or division in which they are installed, regardless of the level of protection provided by the device.

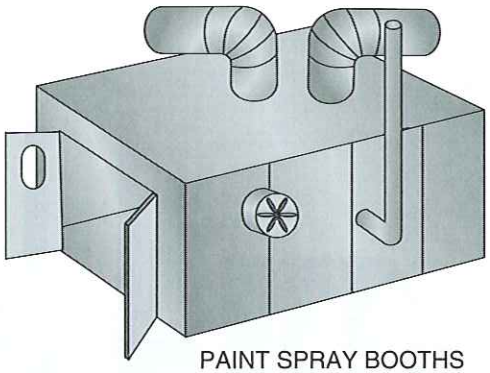

Figure 1 ◆ Typical *NEC*® Class I locations.

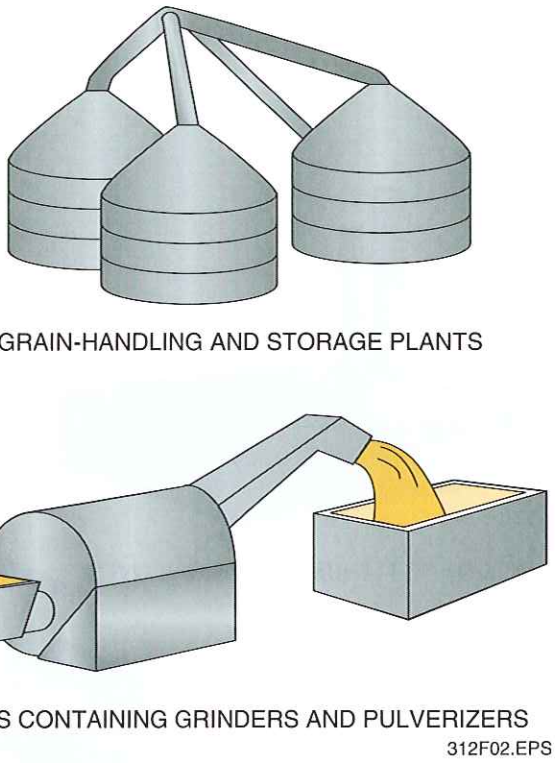

Figure 2 ◆ Typical *NEC*® Class II locations.

Besides the two divisions, Class II atmospheric hazards also cover three groups of combustible dusts (E, F, and G). The groupings are based on the resistivity of the dust. Group E is always Division 1. Groups F and G may be either Division 1 or 2, depending on their resistivity. Because the *NEC*® is considered the definitive classification tool and contains explanatory data about hazardous atmospheres, refer to *NEC Section 500.5* for exact definitions of Class II, Divisions 1 and 2.

1.3.0 Class III Locations

Class III locations are those areas that are hazardous because of the presence of easily ignitable fibers or other flying materials, but such materials are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Such locations usually include certain areas of rayon, cotton, and textile mills, clothing manufacturing plants, and woodworking plants (*Figure 3*).

1.4.0 Applications

Hazardous atmospheres are summarized in *Table 1*. For a more complete listing of flammable liquids, gases, and solids, see *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, National Fire Protection Association Publication No. 497.

Once the class of an area is determined, the conditions under which the hazardous material may be present determine the division. In Class I and Class II, Division 1 locations, the hazardous gas or dust may be present in the air under normal operating conditions in dangerous concentrations. In Division 2 locations, the hazardous material is not normally in the air, but it might be released if there is an accident or if there is faulty operation of equipment.

Tables 2 through *6* provide a summary of the various classes of hazardous locations as defined by the *NEC*®.

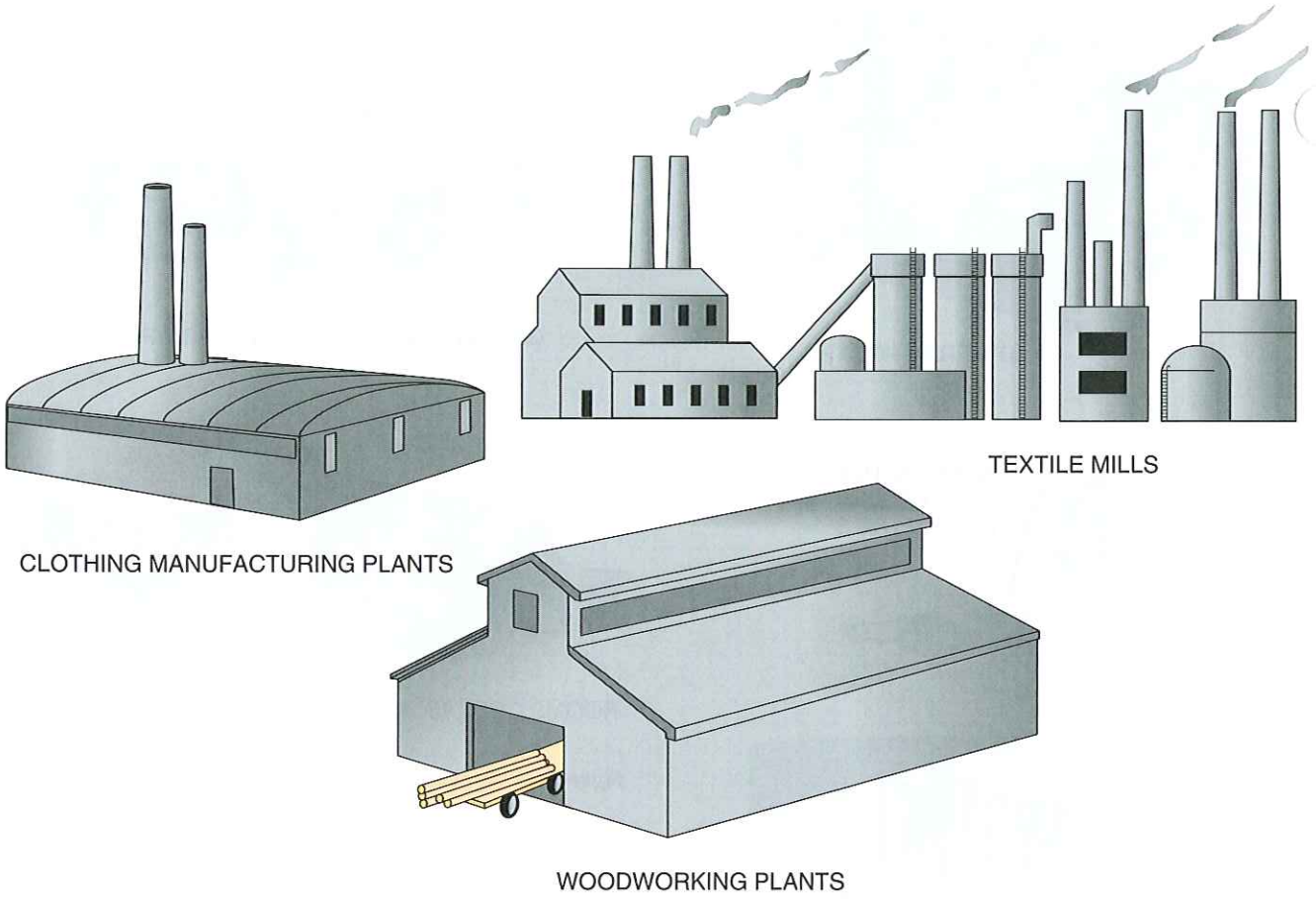

Figure 3 ◆ Typical *NEC*® Class III locations.

Table 1 Summary of Hazardous Atmospheres

Hazardous Area	Class Subdivisions	Groups
	Class I Divisions	**Class I, Division Groups**
Class I: Material present is a flammable gas or vapor	Division 1: Locations in which hazardous concentrations of flammable gases or vapors are present normally or frequently	Group A: Atmospheres containing acetylene
	Division 2: Locations in which hazardous concentrations of flammable gases or vapors are present as a result of infrequent failure of equipment or containers	Group B: Atmospheres containing hydrogen, manufactured gases containing more than 30% hydrogen by volume, or gases or vapors of equivalent hazard Group C: Atmospheres containing ethylene, cyclopropane, or gases or vapors of equivalent hazard Group D: Atmospheres containing propane, gasoline, or gases or vapors of equivalent hazard
	Class I Zones	**Class I, Zone Groups**
	Zone 0: Locations in which combustible material is present continuously or for long periods	Group IIC: Atmospheres containing acetylene or hydrogen or other gases or vapors meeting Group IIC criteria
	Zone 1: Locations in which combustible material is likely to be present normally or frequently because of repair or maintenance operations or leakage	Group IIB: Atmospheres containing acetaldehyde, ethylene, or other gases or vapors meeting Group IIB criteria
	Zone 2: Locations in which combustible material is not likely to occur in a normal operation and, if it does occur, will exist only for a short period	Group IIA: Atmospheres containing propane, gasoline, or other gases or vapors meeting Group IIA criteria
		Class II, Division Groups
Class II: Material present is a combustible dust	Division 1: Locations in which hazardous concentrations of combustible dust are present normally or may exist because of equipment breakdown or where electrically conductive combustible dusts are present in hazardous quantities	Group E: Atmospheres containing combustible metal dusts including aluminum, magnesium, and other metals of similar hazards
	Division 2: Locations in which hazardous concentrations of combustible dust are not normally suspended in the air but may occur as a result of infrequent malfunction of equipment or where dust accumulation may interfere with safe dissipation of heat or may be ignitable by abnormal operation of electrical equipment	Group F: Atmospheres containing combustible carbonaceous dusts, including carbon black, charcoal, coals, or dusts that have been sensitized by other materials so that they present an explosion hazard Group G: Atmospheres containing combustible nonconductive dusts not included in Group E or F, including flour, grain, wood, and plastic
Class III: Material present is an ignitable fiber or flying	Division 1: Locations in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used	No Groups
	Division 2: Locations in which easily ignitable fibers are stored or handled, except in the manufacturing process	

Table 2 Application Rules for Class I, Division 1

Components	Characteristics	*NEC*® Reference
Boxes, fittings	Explosionproof and threaded for connection to conduit	*NEC Section 501.10(A)*
Sealoffs	Approved for purpose	*NEC Section 501.15(A)*
Wiring methods	Rigid metal conduit, steel intermediate metal conduit, Type MI cable, and, under certain conditions, ITC and MC cable	*NEC Section 501.10(A)*
Receptacles	Approved for the location	*NEC Section 501.145*
Lighting fixtures	Approved for Class I, Division 1	*NEC Section 501.130(A)*
Panelboards	Class I enclosure	*NEC Section 501.115(A)*
Circuit breakers	Class I enclosure	*NEC Section 501.115(A)*
Fuses	Class I enclosure	*NEC Section 501.115(A)*
Switches	Class I enclosure	*NEC Section 501.115(A)*
Motors	Class I, Division 1, totally-enclosed or submerged	*NEC Section 501.125(A)*
Liquid-filled transformers	Installed in an approved vault	*NEC Section 501.100(A)*
Dry-type transformers	Class I, Division 1 enclosure	*NEC Section 501.120(A)*
Utilization equipment	Class I, Division 1	*NEC Section 501.135(A)*
Flexible connections	Class I, explosionproof	*NEC Section 501.10(A)*
Portable lamps	Class I, Division 1, approved as a portable assembly	*NEC Section 501.130(A)*
Generators	Class I, Division 1, totally enclosed or submerged	*NEC Section 501.125(A)*
Alarm systems	Class I, Division 1	*NEC Section 501.150(A)*

Table 3 Application Rules for Class I, Division 2

Components	Characteristics	*NEC*® Reference
Boxes, fittings	Do not have to be explosionproof unless current interrupting contacts are exposed	*NEC Section 501.15(C)*
Sealoffs	Approved for purpose	*NEC Section 501.15(B)*
Wiring methods	Rigid metal conduit, steel intermediate metal conduit, Types MI, MC, MV, TC, ITC, or PLTC cables, or enclosed gasketed busways or wireways	*NEC Section 501.10(B)*
Receptacles	Approved for the location	*NEC Section 501.145*
Lighting fixtures	Protected from physical damage	*NEC Section 501.130(B)*
Panelboards	General purpose with exceptions	*NEC Section 501.115(B)*
Circuit breakers	Class I enclosure	*NEC Section 501.115(B)(1)*
Fuses	Class I enclosure	*NEC Section 501.105(B)(3)*
Switches	Class I enclosure	*NEC Section 501.115(B)*
Motors	General purpose unless motor has sliding contacts, switching contacts, or integral resistance devices; if so, use Class I, Division 1	*NEC Section 501.125(B)*
Motor controls	Class I, Division 2	*NEC Section 501.115(B)*
Liquid-filled transformers	General purpose	*NEC Section 501.100(B)*
Dry-type transformers	Class I, general purpose except switching mechanism Division 1 enclosures	*NEC Section 501.120(B)*
Utilization equipment	Class I, Division 2	*NEC Section 501.135(B)*
Flexible connections	Class I, explosionproof	*NEC Section 501.10(B)*
Portable lamps	Explosionproof	*NEC Section 501.130(B)*
Generators	Class I, totally enclosed or submerged	*NEC Section 501.125(B)*
Alarm systems	Class I, Division 2	*NEC Section 501.150(B)*

Table 4 Application Rules for Class II, Division 1

Components	Characteristics	*NEC*® Reference
Boxes, fittings	Class II boxes required when using taps, joints, or other connections; otherwise, use dust-tight boxes with no openings	*NEC Section 502.10(A)(4)*
Wiring methods	Rigid metal conduit, steel intermediate metal conduit, or Types MI and, under certain conditions, MC cables listed for use in Class II, Division 1 locations	*NEC Section 502.10(A)*
Receptacles	Class II	*NEC Section 502.145(A)*
Lighting fixtures	Class II	*NEC Section 502.130(A)*
Panelboards	Dust/ignitionproof	*NEC Section 502.115(A)(1)*
Circuit breakers	Dust/ignitionproof enclosure	*NEC Section 502.115(A)*
Fuses	Dust/ignitionproof enclosure	*NEC Section 502.115(A)*
Switches	Dust/ignitionproof enclosure	*NEC Section 502.115(A)*
Motors	Class II, Division 1 or totally enclosed	*NEC Section 502.125(A)*
Motor controls	Dust/ignitionproof	*NEC Section 502.115(A)*
Liquid-filled transformers	Install in an approved vault	*NEC Section 502.100(A)*
Dry-type transformers	Class II, vault	*NEC Section 502.100(A)*
Utilization equipment	Class II	*NEC Section 502.135(A)*
Flexible connections	Extra-hard usage cord, liquid-tight, and others	*NEC Section 502.10(A)(2)*
Portable lamps	Class II	*NEC Section 502.130(A)*
Generators	Class II, Division 1 or totally enclosed	*NEC Section 502.125(A)*

Table 5 Application Rules for Class II, Division 2

Components	Characteristics	*NEC*® Reference
Boxes, fittings	Use tight covers to minimize entrance of dust	*NEC Section 502.10(B)(4)*
Wiring methods	Rigid metal conduit, steel intermediate metal conduit, electrical metallic tubing (EMT), Types MI, MC, TC, ITC, or PLTC cables, or enclosed dust-tight busways or wireways	*NEC Section 502.10(B)*
Receptacles	Exposed live parts are not allowed	*NEC Section 502.145(B)*
Lighting fixtures	Class II	*NEC Section 502.130(B)*
Panelboards	Dust-tight enclosure	*NEC Section 502.115(B)*
Circuit breakers	Dust-tight enclosure	*NEC Section 502.115(B)*
Fuses	Dust-tight enclosure	*NEC Section 502.115(B)*
Switches	Dust-tight enclosure	*NEC Section 502.115(B)*
Motors	Class II, Division 1 or totally enclosed	*NEC Section 502.125(B)*
Motor controls	Dust-tight enclosure	*NEC Section 502.115(B)*
Liquid-filled transformers	Install in vault	*NEC Section 502.100(B)*
Dry-type transformers	Class II vault	*NEC Section 502.100(B)*
Utilization equipment	Class II	*NEC Section 502.135(B)*
Flexible connections	Extra-hard usage cord, liquid-tight, and others	*NEC Section 502.10(B)(2)*
Portable lamps	Class II	*NEC Section 502.130(B)(1)*
Generators	Class II, Division 1 or totally enclosed	*NEC Section 502.125(B)*

Table 6 Application Rules for Class III, Divisions 1 and 2

Components	Characteristics	*NEC*® Reference
Boxes, fittings	Dust-tight	*NEC Section 503.10(A)(1)*
Wiring methods	Rigid metal conduit, steel intermediate metal conduit, EMT, Types MI and MC cables, or enclosed dust-tight busways or wireways	*NEC Section 503.10(A)*
Receptacles	Minimize accumulation of fibers or flyings	*NEC Section 503.145*
Lighting fixtures	Tight enclosure with no openings	*NEC Section 503.130*
Panelboards	Dust-tight enclosure	*NEC Section 503.115*
Circuit breakers	Dust-tight enclosure	*NEC Section 503.115*
Fuses	Dust-tight enclosure	*NEC Section 503.115*
Switches	Dust-tight enclosure	*NEC Section 503.115*
Motors	Totally enclosed	*NEC Section 503.125*
Motor controls	Dust-tight enclosure	*NEC Section 503.115*
Liquid-filled transformers	Install in an approved vault	*NEC Section 503.100*
Dry-type transformers	Dust-tight enclosure	*NEC Section 503.100*
Utilization equipment	Class III	*NEC Section 503.135*
Flexible connections	Extra-hard usage cord and other flexible conduit/fittings	*NEC Section 503.10(A)(2)*
Portable lamps	Unswitched, guarded with tight enclosure for lamp	*NEC Section 503.130*
Generators	Totally enclosed	*NEC Section 503.125*

INSIDE TRACK

Delayed Action Receptacles

The receptacle shown here is rated for Class I, Division 1 and 2 locations and features a delayed action rotating sleeve that prevents complete withdrawal of the plug in one continuous movement. This delay allows any arc-generated heat to be dissipated before the plug is released.

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2.0.0 ◆ PREVENTION OF EXTERNAL IGNITION/EXPLOSION

The main purpose of using explosionproof fittings and wiring methods in hazardous areas is to prevent ignition of flammable liquids or gases and to prevent an explosion.

2.1.0 Sources of Ignition

In certain atmospheric conditions when flammable gases or combustible dusts are mixed in the proper proportion with air, any source of energy is all that is needed to touch off an explosion.

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

Other hazards are devices that produce heat, such as lighting fixtures and motors. In this case, the surface temperatures may exceed the safe limits of many flammable atmospheres.

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

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

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

2.2.0 Combustion Principles

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

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

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

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

WARNING!

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

INSIDE TRACK

Explosionproof Equipment

Explosionproof equipment must be marked to show class and group. See *NEC Section 500.8(B) plus Exception.* Always make sure that the device selected is rated for the hazardous location in which it will be installed.

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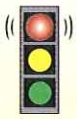
3.0.0 ◆ EXPLOSIONPROOF EQUIPMENT

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

The wide assortment of explosionproof equipment now available makes it possible to provide adequate electrical installations under any of the various hazardous conditions. However, you must be thoroughly familiar with all *NEC®* requirements and know what fittings are available, how to install them properly, and where and when to use the various fittings. For example, some electricians are under the false impression that a fitting rated for Class I, Division 1 can be used under any hazardous conditions. However, remember the groups. For example, a fitting rated for Class I, Division 1, Group C cannot be used in areas classified as Groups A or B. On the other hand, fittings rated for use in Group A may be used for any group beneath A; fittings rated for use in Class I, Division 1, Group B can be used in areas rated as Group B areas or below, and so on.



WARNING!

Never interchange fittings or covers between one hazardous area and another. Such items must be rated for the appropriate class, division, and group.

Explosionproof fittings are rated for both classification and groups. All parts of these fittings (including covers) are rated accordingly. Therefore, if a Class I, Division 1, Group A fitting is required, a Group B (or below) fitting cover must not be used. The cover itself must be rated for Group A locations. Consequently, when working on electrical systems in hazardous locations, always make certain that fittings and their related components match the condition at hand.

3.1.0 Intrinsically Safe Equipment

Intrinsically safe equipment is incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration. The use of intrinsically safe equipment is primarily limited to process control instrumentation because these electrical systems lend themselves to the low energy requirements.

Installation rules for intrinsically safe equipment are covered in *NEC Article 504*. In general, intrinsically safe equipment and its associated wiring must be installed so that it is positively separated from the non-intrinsically safe circuits, because induced voltages could defeat the concept of intrinsically safe circuits. Underwriters Laboratories, Inc. and Factory Mutual list several devices in this category.

3.2.0 Explosionproof Conduit and Fittings

A typical floor plan for a hazardous area is shown in *Figure 4*.

In hazardous locations where threaded metal **conduit** is required, the conduit must be threaded with a standard conduit cutting die (*Figure 5*) that provides ¾" taper per foot. The conduit should be made up wrench-tight to prevent sparking in the event fault current flows through the raceway system *[NEC Section 501.10(A)(1)(a)]*. All boxes, fittings, and joints shall be threaded for connection to the conduit system and shall be an approved, explosionproof type (*Figure 6*). Threaded joints must be made up with at least five threads full engaged. Where it becomes necessary to employ flexible connectors at motor or fixture terminals (*Figure 7*), flexible fittings approved for the particular class location shall be used. Unions are provided to facilitate the installation and removal of equipment.

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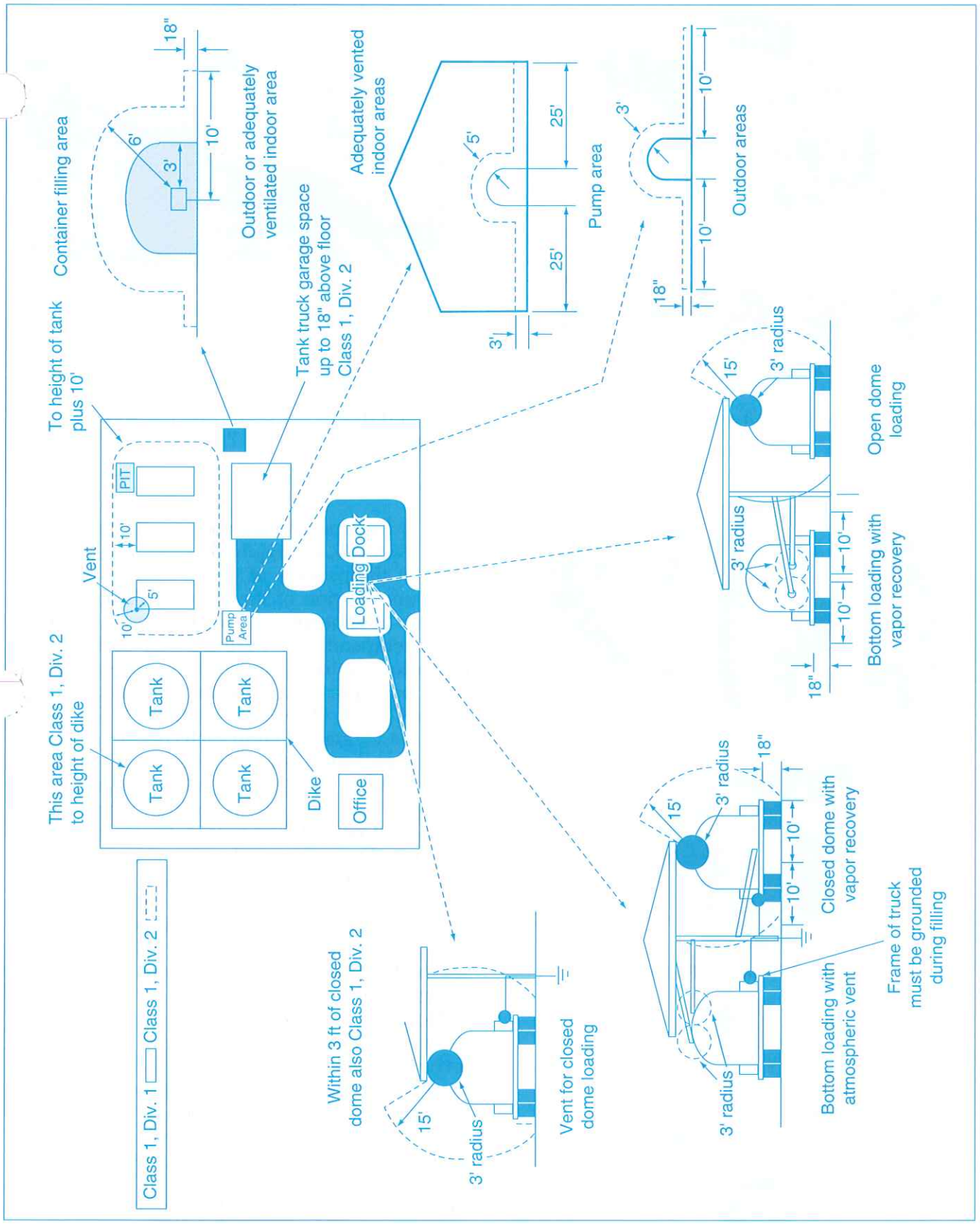

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Figure 4 ◆ Floor plan of a hazardous location.

Figure 5 ◆ Portable conduit threader.

Figure 6 ◆ Typical fittings approved for hazardous areas.

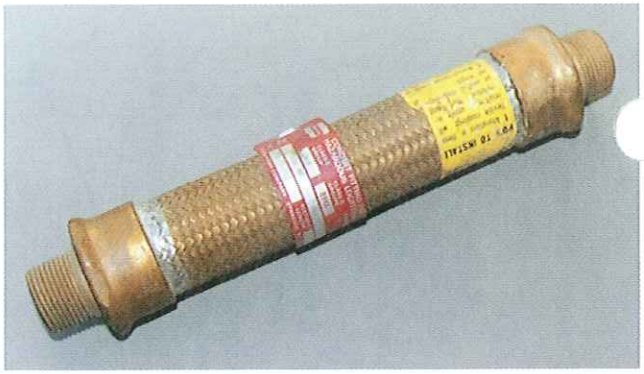

Figure 7 ◆ Explosionproof flexible connector.

3.3.0 Seals and Drains

Seals and drains are both used to protect conduit systems.

3.3.1 Seals

Sealoff fittings, also known as sealing fittings or seals *(Figure 8)*, are required in conduit systems to prevent the passage of gases, vapors, or flames from one portion of the electrical installation to another at atmospheric pressure and normal ambient temperatures. Furthermore, sealoffs limit explosions to the enclosure and prevent precompression of pressure piling in conduit systems.

For Class I, Division 1 locations, *NEC Section 501.15(A)(1)* states that in each conduit run entering an enclosure for switches, circuit breakers, fuses, relays, resistors, or other apparatus that may produce arcs, sparks, or high temperatures, seals shall be installed within 18" from such enclosures. Explosionproof unions, couplings, reducers, elbows, capped elbows, and **conduit bodies** similar to L, T, and cross types shall be the only enclosures or fittings permitted between the sealing fitting and the enclosure. The conduit bodies shall not be larger than the largest trade size of the conduit.

However, one exception to this rule is that conduits are not required to be sealed if the current interrupting contacts are enclosed within a chamber hermetically sealed against the entrance of gases or vapors, immersed in oil in accordance with *NEC Section 501.15(A)(1), Exception*, or enclosed within a factory-sealed explosionproof chamber within an enclosure approved for the location and marked *FACTORY SEALED* or equivalent.

Seals are also required in Class II locations where a raceway provides communication between an enclosure that is required to be dust ignitionproof and one that is not *(NEC Section 502.15)*.

INSIDE TRACK

Pressure Piling

Pressure piling occurs when an explosion in one section of a raceway creates expanding gases that cause the vapors to compress further down in the raceway, which will then cause a secondary explosion of a greater magnitude. This explosion will result in additional expanding gases and compressed vapors, continuing to create additional explosions, which may potentially exceed the containment capabilities of the raceway system.

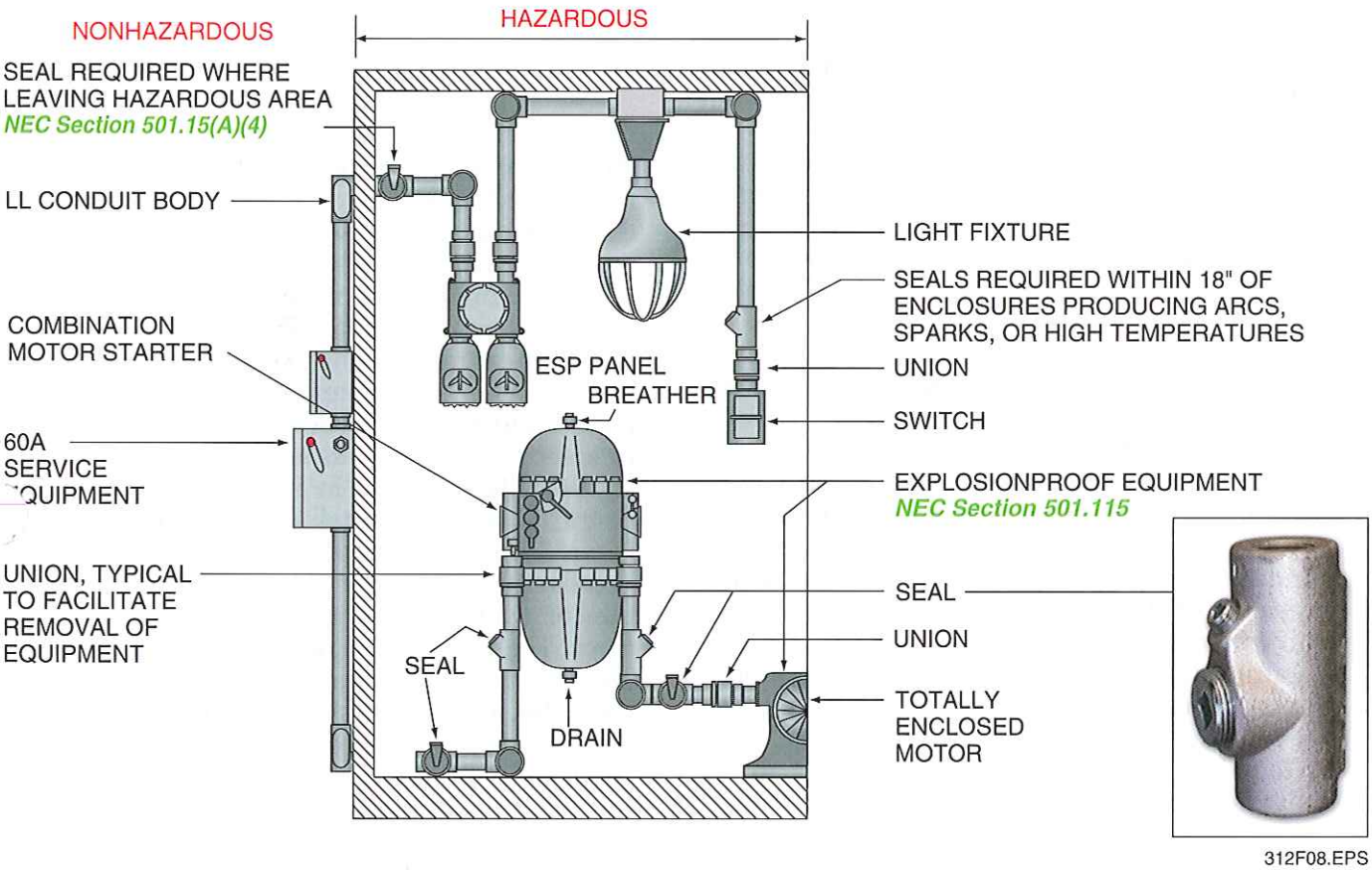

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Figure 8 ◆ Installation of seals in Class I, Division 1 locations.

A permanent and effective seal is one method of preventing the entrance of dust into the dust/ignitionproof enclosure through the raceway. A horizontal raceway, not less than 10' long, is another approved method, as is a vertical raceway not less than 5' long and extending downward from the dust/ignitionproof enclosure.

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

Where sealing fittings are used, all must be accessible.

While it is not an *NEC*® requirement, many electrical designers sectionalize long conduit runs by inserting seals not more than 50' to 100' apart, depending on the conduit size. This is done in order to minimize the effects of pressure piling.

In general, seals are installed at the same time as the conduit system. However, the conductors are installed after the raceway system is complete and prior to packing and sealing the fittings.

Fill Requirements

THINK ABOUT IT

Why do the standards for listing sealoff fittings allow only a 25% fill for these fittings, while conduits are permitted to have a 40% fill?

3.3.2 Drains

In humid atmospheres or wet locations where it is likely that water will gain entrance to the raceway system, the raceways should be inclined so that water will not collect in enclosures or on seals, but will be led to low points where it may pass out through integral drains.

If the arrangement of raceway runs makes this impractical, special drain/seal fittings should be used, such as the type shown in *Figure 9*. These fittings prevent water from accumulating above the seal and meet the requirements of *NEC Section 501.15(F)*.

Even if the location is not typically humid or wet, surprising amounts of water may still collect in conduit systems. This is because no conduit system is completely airtight. Alternate increases and decreases in temperature and/or barometric pressure due to weather changes or to the nature of the process carried on in the location where the conduit is installed will cause the introduction of outside air. If this air carries sufficient moisture, it will condense within the system when the temperature drops. Because the internal conditions are unfavorable to evaporation, the resultant water will remain and accumulate over time.

To avoid the accumulation of moisture, install drain/seal fittings with drain covers or fittings with inspection covers. This is a recommended practice even if prevailing conditions at the time of planning or installation do not indicate a moisture problem.

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Figure 9 ◆ Typical drain seal.

3.3.3 Selection and Installation of Seals and Drains

Always select the proper sealoff fitting for the hazardous location (such as Class 1, Groups A, B, C, or D) and for the proper use in respect to its mounting position. This is particularly critical when the conduit run crosses between hazardous and nonhazardous areas. The improper positioning of a seal may permit hazardous gases or vapors to enter the system beyond the seal and escape into another portion of the hazardous area or enter a nonhazardous area. Some seals are designed to be mounted in any position; others are restricted to horizontal or vertical mounting. *Figure 10* shows various types of seals.

Install the seals on the proper side of the partition or wall, as recommended by the manufacturer. The installation of seals should be made only by trained personnel in strict compliance with the instruction sheets furnished with the seals and **sealing compound.** *NEC Section 501.15(C)(4)* prohibits splices or taps in sealoff fittings. Sealoff fittings are listed by UL for use in Class I hazardous locations with approved sealing compound only. This compound, when properly mixed and poured, hardens into a dense, strong mass that is insoluble in water, not attacked by chemicals, and not softened by heat. It is designed to withstand the pressure of the exploding trapped gases or vapors. Conductors sealed in the compound may be any approved thermoplastic or rubber insulated type. Conductors may or may not be lead-covered.

3.3.4 Sealing Compounds and Dams

Poured seals should be made only by qualified personnel following the manufacturer's instructions. Improperly poured seals serve no purpose. Sealing compound must be approved for the purpose, not be affected by the surrounding

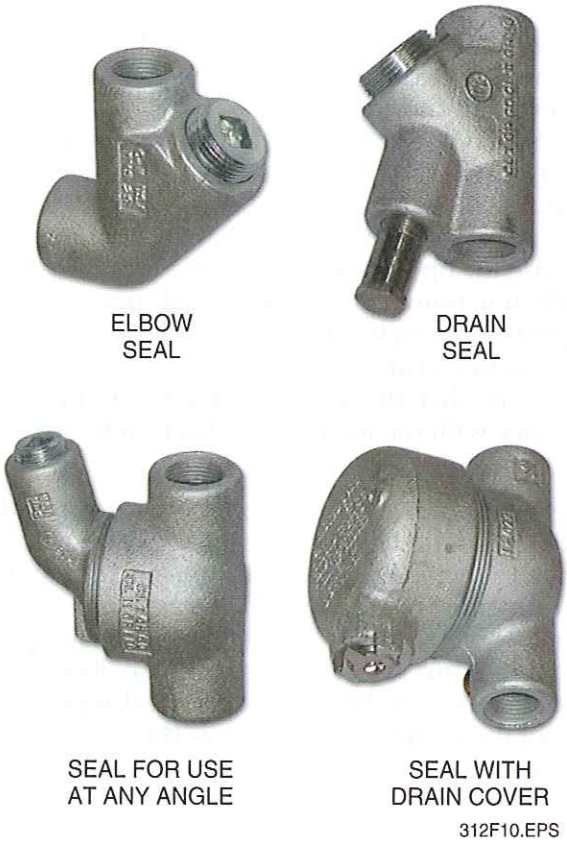


Figure 10 ◆ Various types of seals.

mosphere or liquids, and not have a melting point of less than 200°F (93°C). The sealing compound and dams must also be approved for the type and manufacturer of the fitting. For example, Crouse-Hinds CHICO® A sealing compound is the only sealing compound approved for use with Crouse-Hinds ECM fittings.

To pack the sealoff, remove the threaded plug or plugs from the fitting and insert the fiber supplied with the packing kit. Tamp the fiber between the wires and the hub before pouring the sealing compound into the fitting, then pour in the sealing cement and reset the threaded plug tightly. The fiber packing prevents the sealing compound from entering the conduit lines in the liquid state.

Sealing compound is poured after the conduit system and seals are installed and the conductors and packing fiber have been installed. Most sealing compound kits contain a powder in a polyethylene bag within an outer container. Remove the bag of powder, fill the outside container, pour in the powder, and mix.

CAUTION

Always make certain that the sealing compound is compatible for use with the packing material, brand and type of fitting, and type of conductors used in the system.

In practical applications, dozens of seals may be required for a particular installation. Consequently, after the conductors are pulled, each seal in the system is first packed. To prevent the possibility of overlooking a seal, a certain color of paint is normally sprayed on the seal hub to indicate

INSIDE TRACK

Sealing Conductors

On a multi-conductor cable traveling between areas where sealoff fittings are required, strip the insulation from the cable in the middle of the fitting and slightly unravel and separate (birdcage) the conductors. This ensures that the sealing compound fully surrounds each conductor to prevent the passage of gas through the seal. See ***NEC Section 501.15(D)(2)***. This may require special consideration when selecting a sealoff fitting.

Pouring Vertical Seals

When pouring a vertical seal that penetrates the top of an enclosure, such as starters or panelboards, open the door while you are pouring the seal to observe whether or not the seal is leaking into the enclosure.

Anti-Seize Compound

When preparing sealing fittings, apply an approved anti-seize compound to the screw threads and interior surfaces of the caps and plugs. This will facilitate removal of the plugs for inspection purposes.

that the seal has been packed. When the sealing compound is poured, a different color paint is sprayed on the seal hub to indicate a finished job. This method permits the job supervisor to visually inspect the conduit run, and if a seal is not painted the appropriate color, he or she knows that the proper installation on this seal was not done; therefore, action can be taken to correct the situation immediately. The sealoff fittings in *Figure 11* are typical of those used. The type in *Figure 11(A)* is for vertical mounting and is provided with a threaded, plugged opening into which the sealing cement is poured. The sealoff in *Figure 11(B)* has an additional plugged opening in the lower hub to facilitate packing fiber around the conductors to form a dam for the sealing cement. *Figure 11(C)* shows a sealoff fitting along with fiber material and sealing compound.

The following guidelines should be observed when preparing sealing compound:

- Use a clean mix vessel for every batch. Particles of previous batches or dirt will spoil the seal.
- Recommended proportions are by volume—usually two parts powder to one part clean water. Slight deviations in these proportions will not affect the results.
- Do not mix more than can be poured in 15 minutes after water is added. Use cold water; warm water increases the setting speed. Stir immediately and thoroughly.
- If the batch starts to set, do not attempt to th it by adding water or by stirring. Such a procedure will spoil the seal. Discard the partially set material and make a fresh batch. After pouring, close the opening immediately.
- Do not pour compound in sub-freezing temperatures or when these temperatures are likely to occur during curing.
- Ensure that the compound level is in accordance with the instruction sheet for the specific fitting.

Most other explosionproof fittings are provided with threaded hubs for securing the conduit as described previously. Typical fittings include switch and junction boxes, conduit bodies, unions and connectors, flexible couplings, explosionproof lighting fixtures, receptacles, and panelboard and motor starter enclosures. A practical representation of these and other fittings is shown in *Figures 12* through *14*.

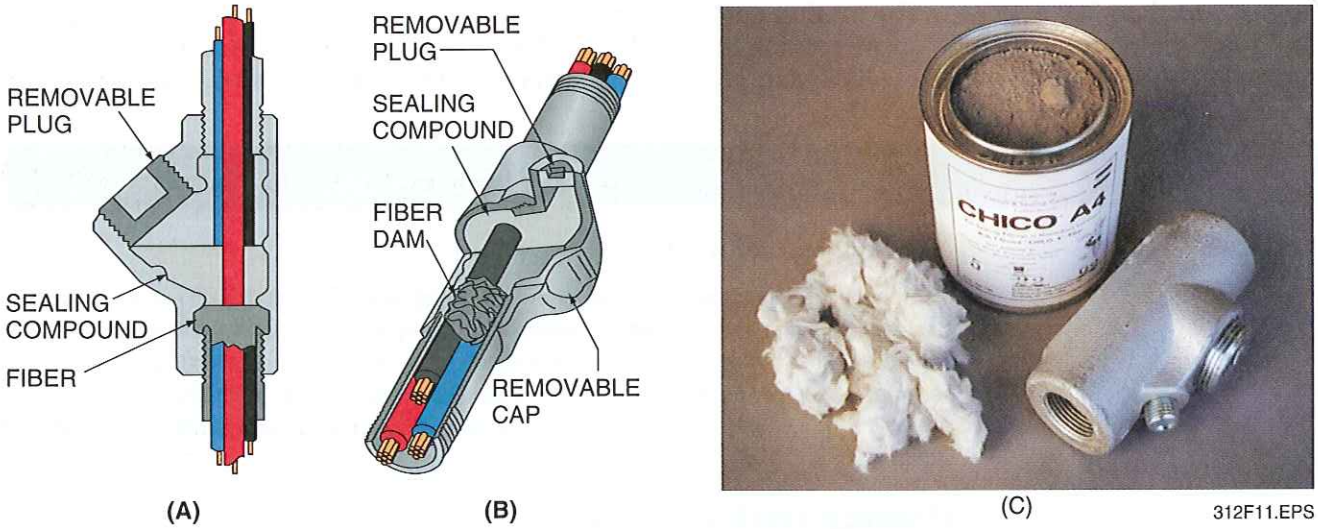


Figure 11 ◆ Seals made with fiber dams and sealing compound.

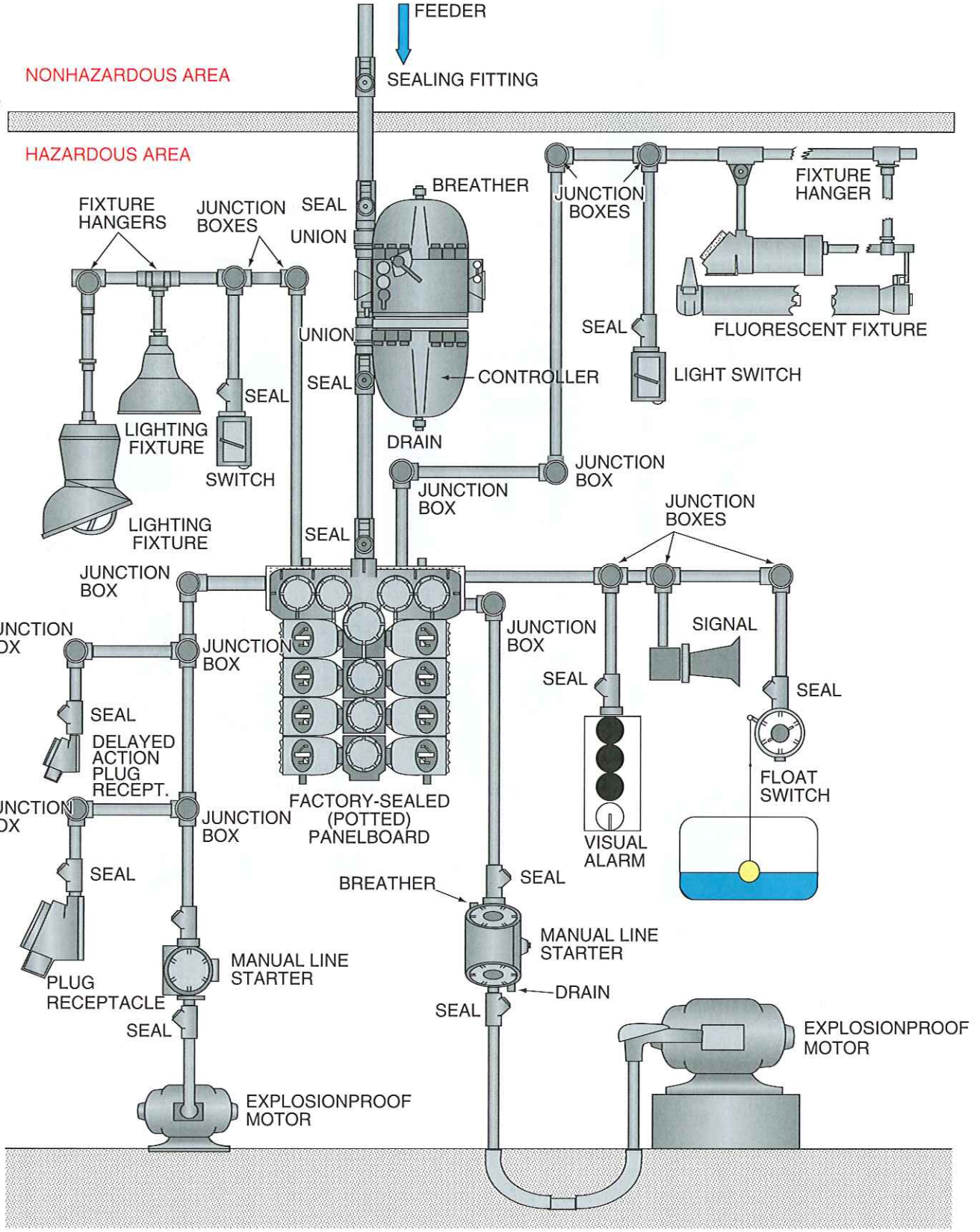


Figure 12 ◆ Class I, Division 1 electrical installation.

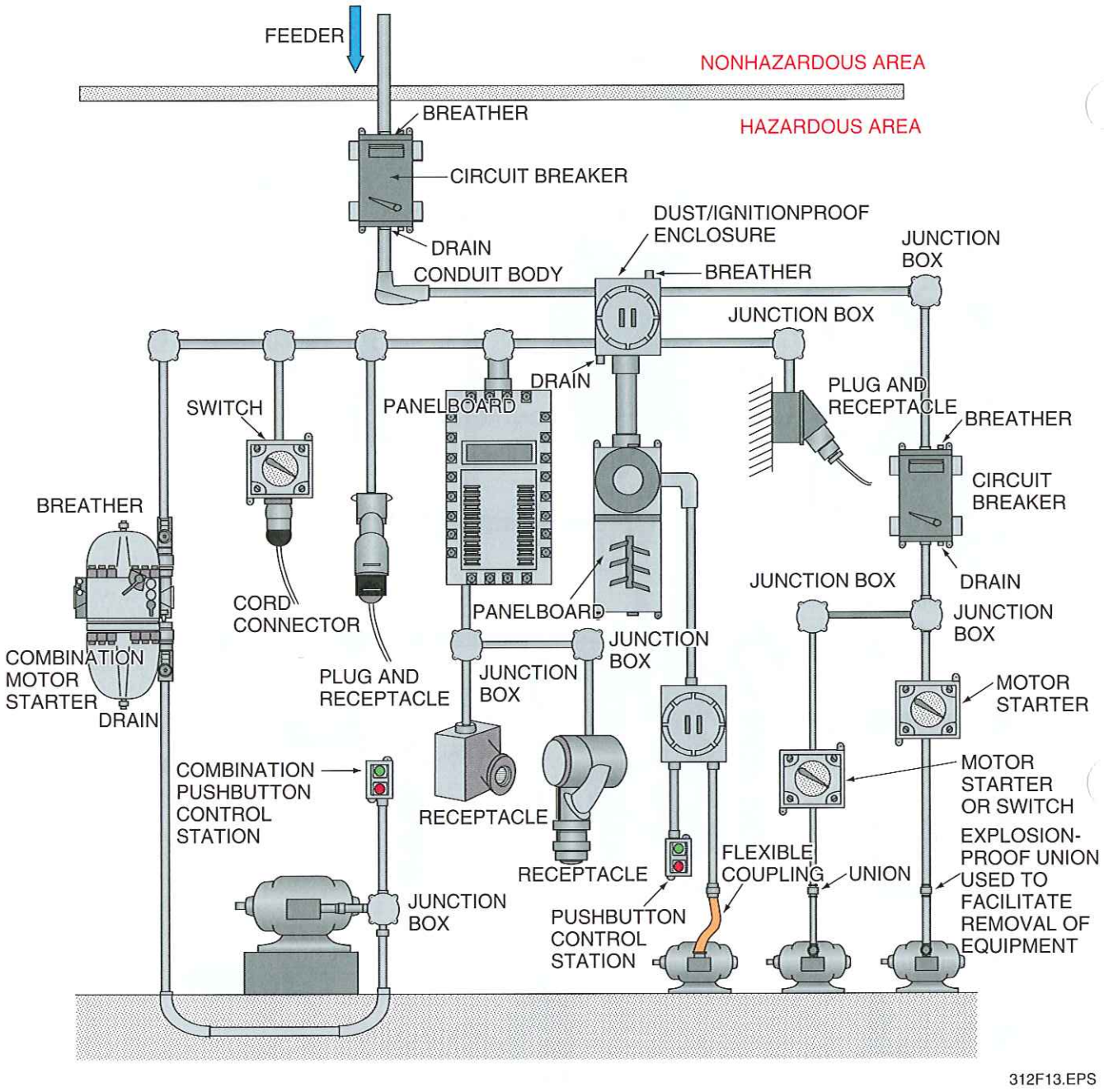


Figure 13 ◆ Class II, Division 1 electrical installation.

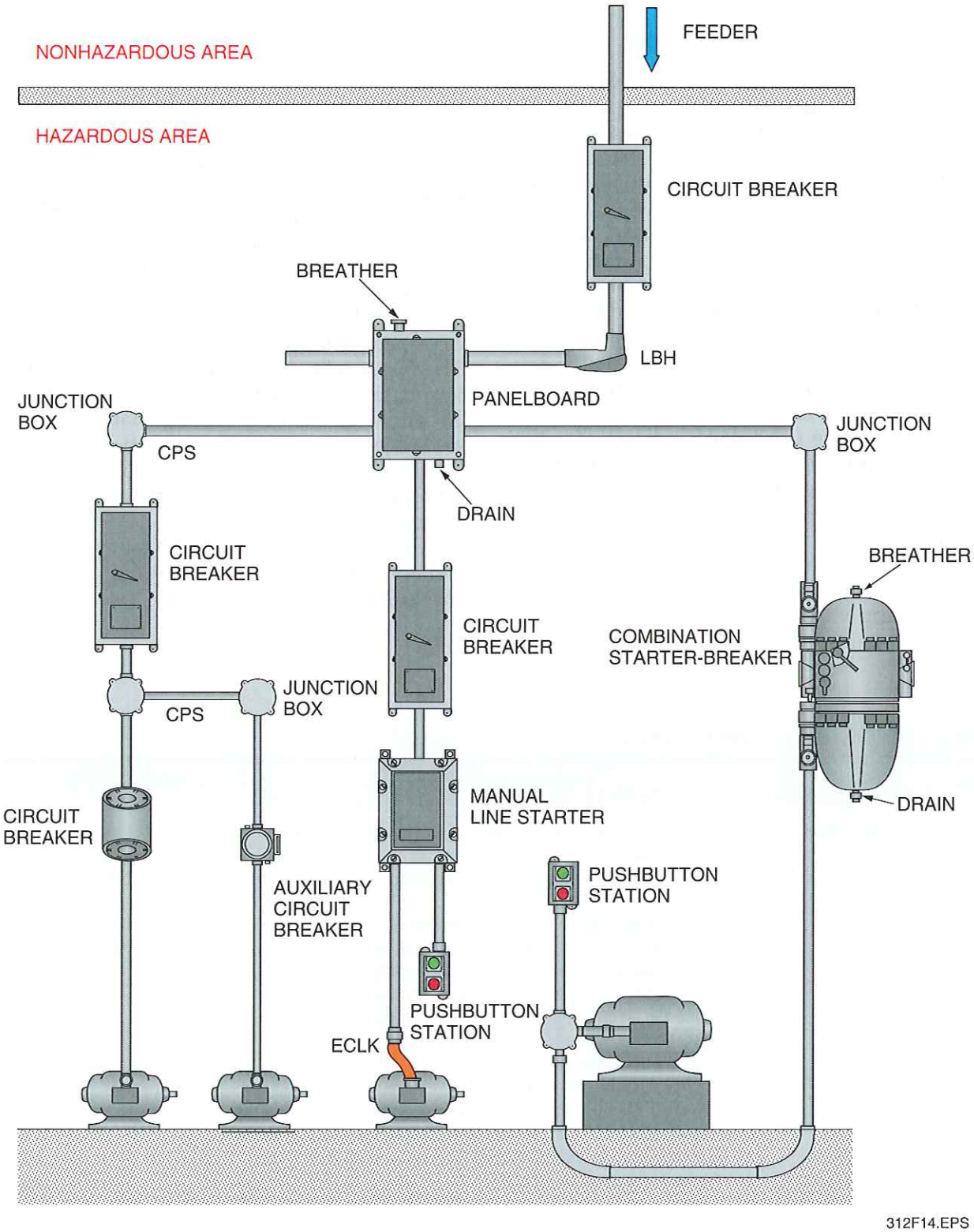


Figure 14 ◆ Class II power installation.

4.0.0 ◆ GARAGES AND SIMILAR LOCATIONS

Garages and similar locations where volatile or flammable liquids are handled or used as fuel in self-propelled vehicles (including automobiles, buses, trucks, and tractors) are not usually considered critically hazardous locations. However, the entire area up to a level 18" above the floor is considered a Class I, Division 2 location, and certain precautionary measures are required by the *NEC®*. Likewise, any pit or depression below floor level shall be considered a Class I, Division 2 location, and the pit or depression may be judged as a Class I, Division 1 location if it is unvented.

Normal raceway (conduit) and wiring may be used for the wiring method above this hazardous level, except where conditions indicate that the area concerned is more hazardous than usual. In this case, the applicable type of explosionproof wiring may be required.

Approved sealoff fittings should be used on all conduit passing from hazardous areas to nonhazardous areas. The requirements set forth in *NEC Article 501* apply to horizontal as well as vertical boundaries of the defined hazardous areas. Raceways embedded in a masonry floor or buried beneath a floor are considered to be within the hazardous area above the floor if any connection or extensions lead into or through such an area. However, conduit systems terminating to an open raceway in an outdoor unclassified area shall not be required to be sealed between the point at which the conduit leaves the classified location and enters the open raceway.

Figure 15 shows a typical automotive service station with applicable *NEC®* requirements. The space in the immediate vicinity of the gasoline dispensing island is denoted as Class I, Division 1. The surrounding area, within a radius of 20' of the island, falls under Class I, Division 2 to a height of 18" above grade. Bulk storage plants for gasoline are subject to comparable restrictions.

NEC Article 514 covers gasoline dispensing and service stations. *NEC Article 511* covers commercial garages.

A summary of *NEC®* rules governing the installation of electrical wiring at and near gasoline dispensing pumps is shown in *Table 7*.

Table 7 ***NEC®*** **Application Rules for Service Stations**

Application	*NEC®* Regulation	*NEC®* Reference
Equipment in hazardous locations	All wiring and components must conform to the rules for Class I locations.	*NEC Section 514.4*
Equipment above hazardous locations	All wiring must conform to the rules for such equipment in commercial garages.	*NEC Section 514.4*
Gasoline dispenser	A disconnecting means must be provided for each circuit leading to or through a dispensing pump to disconnect all voltage sources, including feedback, during periods of service and maintenance. An approved seal (sealoff) is required in each conduit entering or leaving a dispenser.	*NEC Sections 514.7 and 514.13*
Grounding	Metal portions of all noncurrent-carrying parts of dispensers must be effectively grounded.	*NEC Section 514.16*
Underground wiring	Underground wiring installed within 2' of ground level shall be in threaded rigid metal conduit or IMC. If underground wiring is buried 2' or more, rigid nonmetallic conduit may be used along with the types mentioned above; Type MI cable may also be used in some cases.	*NEC Section 514.8*

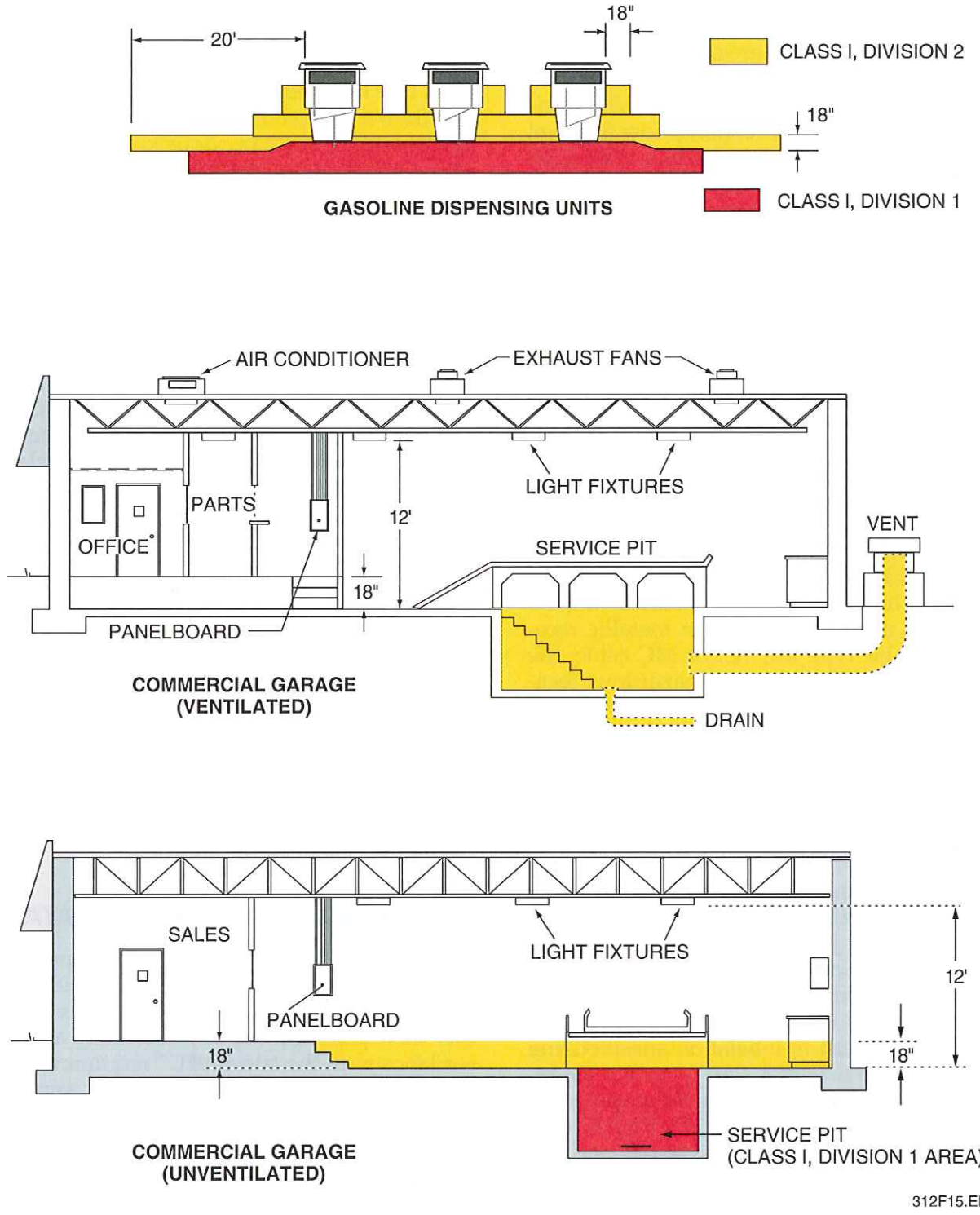


Figure 15 ◆ Commercial service station and garage classifications.

5.0.0 ◆ AIRPORT HANGARS

Buildings used for storing or servicing aircraft in which gasoline, jet fuels, or other volatile flammable liquids or gases are used fall under *NEC Article 513*. In general, any depression below the level of the hangar floor is considered to be a Class I, Division 1 location. The entire area of the hangar, including any adjacent and communicating area not suitably cut off from the hangar, is considered to be a Class I, Division 2 location up to a level of 18" above the floor. The area within 5' horizontally from aircraft power plants, fuel tanks, or structures containing fuel is considered to be a Class I, Division 2 hazardous location; this area extends upward from the floor to a level 5' above the upper surface of wings and engine enclosures.

Adjacent areas in which hazardous vapors are not likely to be released, such as stockrooms and electrical control rooms, should not be classified as hazardous when they are adequately ventilated and effectively cut off from the hangar itself by walls or partitions. All fixed wiring in a hangar not within a hazardous area as defined in *NEC Section 513.3* must be installed in metallic raceways or shall be Type MI, TC, or MC cable; the only exception is wiring in nonhazardous locations as defined in *NEC Section 513.3(D)*, which may be of any type recognized in *NEC Chapter 3*. *Figure 16* summarizes the *NEC*® requirements for airport hangars.

6.0.0 ◆ HOSPITALS

Hospitals and other healthcare facilities fall under *NEC Article 517*. *NEC Article 517, Part II* covers the general wiring in patient areas of healthcare facilities. *NEC Article 517, Part III* covers essential electrical systems for hospitals. *NEC Article 517, Part IV* gives the performance criteria and wiring methods used in inhalation anesthetizing locations. *NEC Article 517, Part V* covers the requirements for electrical wiring and equipment in X-ray installations. *NEC Article 517, Part VI* covers communications, signaling systems, and fire alarm systems. *NEC Article 517, Part VII* covers isolated power systems.

Anesthetizing locations of hospitals are considered Class I, Division 1 to a height of 5' above the floor. Gas storage rooms are designated as Class I, Division 1 throughout. Most of the wiring in these areas, however, can be limited to lighting fixtures only by locating all switches and other devices outside of the hazardous area.

The *NEC*® recommends that electrical equipment for hazardous locations be located in less hazardous areas wherever possible. It also suggests that by adequate, positive-pressure ventilation from a clean source of outside air, the hazard may be reduced or hazardous locations limited or eliminated. In many cases, the installation of dust-collecting systems can greatly reduce the hazards in a Class II area.

7.0.0 ◆ PETROCHEMICAL HAZARDOUS LOCATIONS

Most manufacturing facilities involving flammable liquids, vapors, or fibers must have their wiring installations conform strictly to the *NEC*® as well as governmental, state, and local ordinances. Therefore, the majority of electrical installations for these facilities are carefully designed by experts in the field—either the plant in-house engineering staff or an independent consulting engineering firm.

Industrial installations dealing with petroleum or some types of chemicals are particularly susceptible to several restrictions involving many governmental agencies. Electrical installations for petrochemical plants will therefore have many pages of electrical drawings and specifications, which require approval from all the agencies involved. Once approved, these drawings and specifications must be followed exactly, because any change whatsoever must once again go through the various agencies for approval.

8.0.0 ◆ MANUFACTURERS' DATA

Manufacturers of explosionproof equipment and fittings expend a lot of time, energy, and expense in developing guidelines and brochures to ensure that their products are used correctly and in accordance with the latest *NEC*® requirements. The many helpful charts, tables, and application guidelines available from manufacturers are invaluable to anyone working on projects involving hazardous locations. Therefore, it is recommended that you obtain as much of this data as possible. Once obtained, study this data thoroughly. Doing so will enhance your qualifications for working in hazardous locations of any type. Manufacturers' data is usually available to qualified personnel at little or no cost and can be obtained from local distributors or directly from the manufacturer.

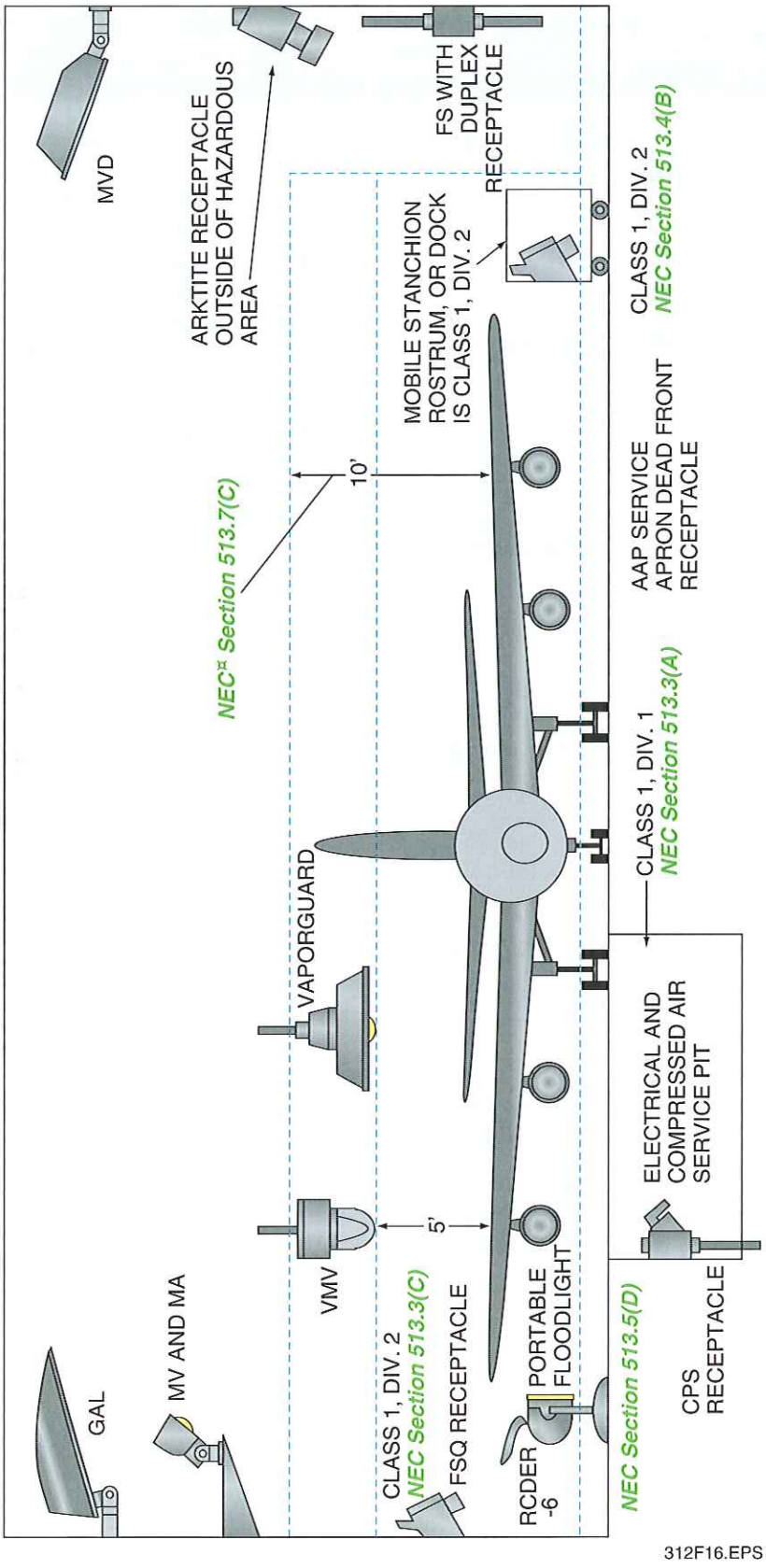
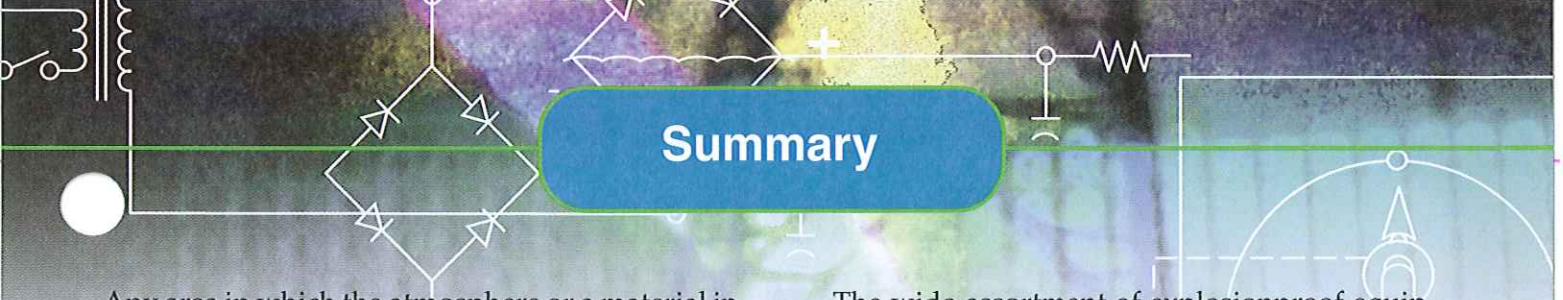


Figure 16 ◆ Sections of an airport hangar showing hazardous locations.



Summary

Any area in which the atmosphere or a material in the area is such that the arcing of operating electrical contacts, components, and equipment may cause an explosion or fire is considered a hazardous location. In all such cases, explosionproof equipment, raceways, and fittings are used to provide an explosionproof wiring system.

The wide assortment of explosionproof equipment now available makes it possible to provide adequate electrical installations under any of the various hazardous conditions. However, you must be thoroughly familiar with all *NEC*® requirements and know what fittings are available, how to install them properly, and where and when to use the various fittings.

Notes

Trade Terms Introduced in This Module

Approved: Acceptable to the authority having jurisdiction.

Conduit: A tubular raceway such as electrical metallic tubing (EMT); rigid metal conduit, rigid nonmetallic conduit, etc.

Conduit body: A separate portion of a conduit or tubing system that provides access through removable covers to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system.

Equipment: A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as a part of (or in connection with) an electrical installation.

Explosionproof: Designed and constructed to withstand an internal explosion without creating an external explosion or fire.

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

Hazardous (classified) location: A location in which ignitable vapors, dust, or fibers may cause a fire or explosion.

Sealing compound: The material poured into an electrical fitting to seal and minimize the passage of vapors.

Sealoff fittings: Fittings required in conduit systems to prevent the passage of gases, vapors, or flames from one portion of the electrical installation to another through the conduit. Also referred to as sealing fittings or seals.

Additional Resources

This module is intended to present thorough resources for task training. The following reference works are suggested for further study. These are optional materials for continued education rather than for task training.

American Electrician's Handbook. Terrell Croft and Wilfred I. Summers. New York, NY: McGraw-Hill, 1996.

Code Digest. Latest Edition. Syracuse, NY: Crouse-Hinds.

National Electrical Code® Handbook. Latest Edition. Quincy, MA: National Fire Protection Association.