NFPA® 497

Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

2008 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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This edition of NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, was prepared by the Technical Committee on Electrical Equipment in Chemical Atmospheres. It was issued by the Standards Council on December 11, 2007, with an effective date of December 31, 2007, and supersedes all previous editions.

This edition of NFPA 497 was approved as an American National Standard on December 31, 2007.

Origin and Development of NFPA 497

The Committee on Electrical Equipment in Chemical Atmospheres began the development of this recommended practice in 1973. The Committee based the diagrams in this document on various codes and standards of the National Fire Protection Association and on the accepted practices of the chemical process industries and the petroleum refining industry. The first edition of this recommended practice was adopted by the Association at the 1975 Annual Meeting.

The Committee began a thorough review of this document in 1980 and completed its work in 1985. The designation was changed to NFPA 497A in anticipation of a similar recommended practice for Class II hazardous (classified) locations. In 1989, the Technical Committee on Electrical Equipment in Chemical Atmospheres recognized a need for editorial revisions to the drawings referenced in Section 3.4. There were also new drawings included for flammable liquid tank truck loading and unloading and for marine terminal handling of flammable liquids.

In 1993, the Technical Committee on Electrical Equipment in Chemical Atmospheres decided to combine the information on group classifications of flammable liquids, gases, and vapors located in NFPA 497M, *Classification of Gases, Vapors, and Dusts for Electrical Equipment in Hazardous (Classified) Locations*, with the information in NFPA 497. The expanded version of 497 was renamed *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*. For the 1997 edition, table information was expanded; examples were provided in the appendix; and Class I, Zones 0, 1, and 2 information was incorporated into the text for this edition. In 2001 the Technical Committee on Electrical Equipment in Chemical Atmospheres entered NFPA 497 into the November 2003 revision cycle.

The 2004 edition was significantly revised and reorganized for conformance with the 2003 NFPA *Manual of Style*. These organizational and editorial changes enhanced the usability of this recommended practice. In addition, editorial changes were made to the text to harmonize with the text of NFPA 70, *National Electrical Code (NEC)*, and the definitions of combustible and flammable liquid were revised to harmonize with the text of NFPA 30, *Flammable and Combustible Liquids Code*.

The 2008 edition is the culmination of a revision cycle that began with the document being entered into cycle in January 2006. NFPA 497 has a close relationship to the electrical installation requirements for hazardous (classified) locations contained in NFPA 70, *National Electrical Code*. To ensure correlation with revisions to any pertinent requirements in the 2008 *NEC*, the Technical Committee on Electrical Equipment in Chemical Atmospheres requested and was granted permission by the NFPA Standards Council to enter into a three-year (Fall 2007) revision cycle. Significant revisions to the 2008 edition include: (1) changes to the scope to specify that explosives, pyrotechnics, and blasting agents have unique hazards that are not addressed by the recommendations of the document; (2) recognition of areas as being unclassified where the gas or vapor concentration is insufficient to reach 25 percent of the lower flammable limit (LFL); (3) additions and revisions to Table 4.4.2 on physical properties of selected chemicals, in order to provide information on commonly used materials not previously covered and to resolve differences that existed between this table and similar information contained in other documents; and (4) revision to the Annex B example on determining the maximum experimental safe gap and *NEC* group classification for mixtures.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on (1) developing data on the properties of chemicals enabling proper selection of electrical equipment for use in atmospheres containing flammable gases, vapors or dusts; (2) making recommendations for the prevention of fires and explosions through the use of continuously purged, pressurized, explosion-proof, or dust-ignition-proof electrical equipment where installed in such chemical atmospheres.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet (•) between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in the recommendations sections of this document are given in Chapter 2 and those for extracts in the informational sections are given in Annex C. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text should be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex C.

Chapter 1 Administration

1.1 Scope.

1.1.1 This recommended practice applies to those locations where flammable gases or vapors, flammable liquids, or combustible liquids are processed or handled; and where their release into the atmosphere could result in their ignition by electrical systems or equipment.

1.1.2 This recommended practice provides information on specific flammable gases and vapors, flammable liquids, and combustible liquids whose relevant combustion properties have been sufficiently identified to allow their classification into the groups established by NFPA 70, *National Electrical Code* (*NEC*), for proper selection of electrical equipment in hazardous (classified) locations. The tables of selected combustible materials contained in this document are not intended to be all-inclusive.

1.1.3 This recommended practice applies to chemical process areas. As used in this document, a chemical process area could be a large, integrated chemical process plant or it could be a part of such a plant. It could be a part of a manufacturing facility where flammable gases or vapors, flammable liquids, or combustible liquids are produced or used in chemical reactions, or are handled or used in certain unit operations such as mixing, filtration, coating, spraying, and distillation.

1.1.4 This recommended practice does not apply to situations that could involve catastrophic failure of or catastrophic discharge from process vessels, pipelines, tanks, or systems.

1.1.5 This recommended practice does not address the unique hazards associated with explosives, pyrotechnics, blasting agents, pyrophoric materials, or oxygen-enriched atmospheres that might be present.

1.2 Purpose. The purpose of this recommended practice is to provide the user with a basic understanding of the parameters that determine the degree and the extent of the hazardous (classified) location. This recommended practice also provides the user with examples of the applications of these parameters.

1.2.1 Information is provided on specific flammable gases and vapors, flammable liquids, and combustible liquids, whose relevant properties determine their classification into groups. This will assist in the selection of special electrical equipment for hazardous (classified) locations where such electrical equipment is required.

1.2.2 This recommended practice is intended as a guide and should be applied with sound engineering judgment. Where all factors are properly evaluated, a consistent area classification scheme can be developed.

1.3 Relationship to NFPA Codes and Standards. This recommended practice is not intended to supersede or conflict with the following NFPA codes and standards:

(1) NFPA 30, *Flammable and Combustible Liquids Code*, 2008 edition.
(2) NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2007 edition.
(3) NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids*, 2007 edition.
(4) NFPA 35, *Standard for the Manufacture of Organic Coatings*, 2005 edition.
(5) NFPA 36, *Standard for Solvent Extraction Plants*, 2004 edition.
(6) NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2004 edition.
(7) NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, 1999 edition.
(8) NFPA 50B, *Standard for Liquified Hydrogen Systems at Consumer Sites*, 1999 edition.
(9) NFPA 58, *Liquefied Petroleum Gas Code*, 2008 edition.
(10) NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, 2006 edition.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this recommended practice and should be considered part of the recommendations of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 30, *Flammable and Combustible Liquids Code,* 2008 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* 2007 edition.

NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids,* 2007 edition.

NFPA 35, *Standard for the Manufacture of Organic Coatings,* 2005 edition.

NFPA 36, *Standard for Solvent Extraction Plants,* 2004 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals,* 2004 edition.

NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites,* 1999 edition.

NFPA 50B, *Standard for Liquified Hydrogen Systems at Consumer Sites,* 1999 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2008 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* 2006 edition.

NFPA 70™, National Electrical Code®, 2008 edition.

2.3 Other Publications.

2.3.1 API Publications. American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005-4070.

ANSI/API RP 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*, 1998. (Reaffirmed, November 2002.)

ANSI/API RP 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*, 1998.

2.3.2 ASHRAE Publications. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., 1791 Tullie Circle NE, Atlanta, GA 30329-2305.

ASHRAE 15, *Safety Code for Mechanical Refrigeration*, 1994.

2.3.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D 323, *Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method)*, 1999.

2.3.4 CGA Publications. Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, VA 20151-2923.

ANSI/CGA G2.1, *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*, 1999.

2.3.5 IEC Publications. International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC/TR3 60079-20, *Electrical apparatus for explosive gas atmospheres — Part 20: Data for flammable gases and vapours, relating to the use of electrical apparatus*, 1996.

2.3.6 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Recommendations Sections.

NFPA 30, *Flammable and Combustible Liquids Code,* 2008 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* 2006 edition.

NFPA 70™, National Electrical Code®, 2008 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter apply to the terms used in this recommended practice. Where terms are not defined in this chapter or within another chapter, they should be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, is the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1 Recommended Practice. A document that is similar in content and structure to a code or standard but that contains only nonmandatory provisions using the word "should" to indicate recommendations in the body of the text.

3.2.2 Should. Indicates a recommendation or that which is advised but not required.

3.3 General Definitions.

3.3.1 Adequate Ventilation. A ventilation rate that affords either 6 air changes per hour, or 1 cfm per square foot of floor area, or other similar criteria that prevent the accumulation of significant quantities of vapor–air concentrations from exceeding 25 percent of the lower flammable limit.

3.3.2* Autoignition Temperature (AIT). The minimum temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gas independently of the heating or heated element.

| **3.3.3 CAS.** Chemical Abstract Service.

3.3.4 Combustible Liquid. Any liquid that has a closed-cup flash point at or above 100°F (37.8°C), as determined by the test procedures and apparatus set forth in NFPA 30. Combustible liquids are classified as Class II or Class III combustible liquids. [**30,** 2008]

3.3.4.1 ***Class II Liquid.*** Any liquid that has a flash point at or above 100°F (37.8°C) and below 140°F (60°C). [**30,** 2008]

3.3.4.2 ***Class IIIA Liquid.*** Any liquid that has a flash point at or above 140°F (60°C), but below 200°F (93°C). [**30,** 2008]

3.3.4.3 ***Class IIIB Liquid.*** Any liquid that has a flash point at or above 200°F (93°C). [**30,** 2008]

3.3.5 Combustible Material. A generic term used to describe a flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode.

3.3.5.1* ***Combustible Material (Class I, Division).*** Class I, Division combustible materials are divided into Groups A, B, C, and D.

3.3.5.1.1 ***Group A.*** Acetylene.

3.3.5.1.2 ***Group B.*** Flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value less than or equal to 0.45 mm or a minimum igniting current ratio (MIC ratio) less than or equal to 0.40. Note: A typical Class I, Group B material is hydrogen.

3.3.5.1.3 ***Group C.*** Flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value greater than 0.45 mm and less than or equal to 0.75 mm, or a minimum igniting current ratio (MIC ratio) greater than 0.40 and less than or equal to 0.80. Note: A typical Class I, Group C material is ethylene.

3.3.5.1.4 ***Group D.*** Flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value greater than 0.75 mm or a minimum igniting current ratio (MIC ratio) greater than 0.80. Note: A typical Class I, Group D material is propane.

3.3.5.2* ***Combustible Material (Class I, Zone).*** Class I, Zone combustible materials are divided into Groups IIC, IIB, and IIA.

3.3.5.2.1 ***Group IIC.*** Atmospheres containing acetylene, hydrogen, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value less than or equal to 0.50 mm or minimum igniting current ratio (MIC ratio) less than or equal to 0.45.

3.3.5.2.2 ***Group IIB.*** Atmospheres containing acetaldehyde, ethylene, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either maximum experimental safe gap (MESG) values greater than 0.50 mm and less than or equal to 0.90 mm or minimum igniting current ratio (MIC ratio) greater than 0.45 and less than or equal to 0.80.

3.3.5.2.3 ***Group IIA.*** Atmospheres containing acetone, ammonia, ethyl alcohol, gasoline, methane, propane, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value greater than 0.90 mm or minimum igniting current ratio (MIC ratio) greater than 0.80.

3.3.6 Flammable Liquid. Any liquid that has a closed-cup flash point below 100°F (37.8°C), as determined by the test procedures and apparatus set forth in NFPA 30. Flammable liquids are classified as Class I liquids, Class IA liquids, Class IB liquids, and Class IC liquids. [**30,** 2008]

3.3.6.1 ***Class I Liquid.*** Any liquid that has a closed-cup flash point below 100°F (37.8°C) and a Reid vapor pressure not exceeding 40 psia (2068.6 mm Hg) at 100°F (37.8°C), as determined by ASTM D 323, *Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method).* [**30,** 2008]

3.3.6.2 ***Class IA Liquids.*** Those liquids that have flash points below 73°F (22.8°C) and boiling points below 100°F (37.8°C). [**30,** 2008]

3.3.6.3 ***Class IB Liquids.*** Those liquids that have flash points below 73°F (22.8°C) and boiling points at or above 100°F (37.8°C). [**30,** 2008]

3.3.6.4 ***Class IC Liquids.*** Those liquids that have flash points at or above 73°F (22.8°C), but below 100°F (37.8°C). [**30,** 2008]

3.3.7 Flash Point. The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitible mixture with air near the surface of the liquid, as specified by test.

3.3.8 Ignitible Mixture. A combustible material that is within its flammable range.

3.3.9 Maximum Experimental Safe Gap (MESG). The maximum clearance between two parallel metal surfaces that has been found, under specified test conditions, to prevent an explosion in a test chamber from being propagated to a secondary chamber containing the same gas or vapor at the same concentration.

3.3.10* Minimum Igniting Current (MIC) Ratio. The ratio of the minimum current required from an inductive spark discharge to ignite the most easily ignitible mixture of a gas or vapor, divided by the minimum current required from an inductive spark discharge to ignite methane under the same test conditions.

3.3.11 Minimum Ignition Energy (MIE). The minimum energy required from a capacitive spark discharge to ignite the most easily ignitible mixture of a gas or vapor.

Chapter 4 Classification of Combustible Materials

4.1 ***National Electrical Code*** **Criteria.**

4.1.1 Articles 500 and 505 of the *NEC* classify a location in which a combustible material is or may be present in the atmosphere in sufficient concentrations to produce an ignitible mixture.

4.1.2* In a Class I hazardous (classified) location, the combustible material present is a flammable gas or vapor.

4.1.3 Class I is further subdivided into either Class I, Division 1 or Class I, Division 2; or Class I, Zone 0, Zone 1, or Zone 2 as detailed in 4.1.3.1 through 4.1.3.5.

4.1.3.1 Class I, Division 1. A Class I, Division 1 location is a location

(1) In which ignitible concentrations of flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors can exist under normal operating conditions, or
(2) In which ignitible concentrations of such flammable gases, flammable liquid–produced vapors, or combustible–liquids above their flash points may exist frequently because of repair or maintenance operations or because of leakage, or
(3) In which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition. [**70:**500.5(B)(1)]

4.1.3.2 Class I, Division 2. A Class I, Division 2 location is a location

(1) 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
(2) In which ignitible 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
(3) That is adjacent to a Class I, Division 1 location, and to which ignitible 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. [**70:**500.5(B)(2)]

4.1.3.3 Class I, Zone 0. A Class I, Zone 0 location is a location in which

(1) Ignitible concentrations of flammable gases or vapors are present continuously, or
(2) Ignitible concentrations of flammable gases or vapors are present for long periods of time. [**70:**505.5(B)(1)]

4.1.3.4 Class I, Zone 1. A Class I, Zone 1 location is a location

(1) In which ignitible concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or
(2) In which ignitible concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or
(3) In which equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of ignitible concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or
(4) That is adjacent to a Class I, Zone 0 location from which ignitible concentrations of vapors could be communicated, unless communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided. [**70:**505.5(B)(2)]

4.1.3.5 Class I, Zone 2. A Class I, Zone 2 location is a location

(1) In which ignitible concentrations of flammable gases or vapors are not likely to occur in normal operation and, if they do occur, will exist only for a short period; or
(2) In which volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used but in which the liquids, gases, or vapors normally are confined within closed containers of closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or system, or as a result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or
(3) In which ignitible concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation but which may become hazardous as a result of failure or abnormal operation of the ventilation equipment; or
(4) That is adjacent to a Class I, Zone 1 location, from which ignitible concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided. [**70:**505.5(B)(3)]

4.1.4 The intent of Articles 500 and 505 of the *NEC* is to prevent combustible material from being ignited by electrical equipment and wiring systems.

4.1.5 Electrical installations within hazardous (classified) locations can use various protection techniques. No single protection technique is best in all respects for all types of equipment used in a chemical plant.

4.1.5.1 Explosionproof enclosures, pressurized equipment, and intrinsically safe circuits are applicable to both Division 1 and Division 2 locations.

4.1.5.2 Nonincendive equipment is permitted in Division 2 locations.

4.1.5.3 Nonsparking electrical equipment and other less restrictive equipment, as specified in the *NEC*, are permitted in Division 2 locations.

4.1.5.4 Factors such as corrosion, weather, maintenance, equipment standardization and interchangeability, and possible process changes or expansion frequently dictate the use of special enclosures or installations for electrical systems. However, such factors are outside the scope of this recommended practice, which is concerned entirely with the proper application of electrical equipment to avoid ignition of combustible materials.

4.1.6 For the purpose of this recommended practice, areas not classified either as Class I, Division 1 or Class I, Division 2, or as Class I, Zone 0, Zone 1, or Zone 2, are "unclassified" areas.

4.2 Behavior of Class I (Combustible Material) Gases, Vapors, and Liquids.

4.2.1 Lighter-than-Air (Vapor Density Less than 1.0) Gases. These gases tend to dissipate rapidly in the atmosphere. They will not affect as great an area as heavier-than-air gases or vapors. Except in enclosed spaces, such gases seldom accumulate to form an ignitible mixture near grade level, where most electrical installations are located. A lighter-than-air gas that has been cooled sufficiently could behave as a heavier-than-air gas until it absorbs heat from the surrounding atmosphere.

4.2.2 Heavier-than-Air (Vapor Density Greater than 1.0) Gases. These gases tend to fall to grade level when released. The gas could remain for a significant period of time, unless dispersed by natural or forced ventilation. A heavier-than-air gas that has been heated sufficiently to decrease its density could behave as a lighter-than-air gas until cooled by the surrounding atmosphere.

4.2.3 Applicable to All Densities. As the gas diffuses into the surrounding air, the density of the mixture approaches that of air.

4.2.4 Compressed Liquefied Gases. These gases are stored above their normal boiling point but are kept in the liquid state by pressure. When released, the liquid immediately expands and vaporizes, creating large volumes of cold gas. The cold gas behaves like a heavier-than-air gas.

4.2.5 Cryogenic Flammable Liquids and Other Cold Liquefied Combustible Materials. Cryogenic liquids are generally handled below −150°F (−101°C). These behave like flammable liquids when they are spilled. Small liquid spills will immediately vaporize, but larger spills may remain in the liquid state for an extended time. As the liquid absorbs heat, it vaporizes and could form an ignitible mixture. Some liquefied combustible materials (not cryogenic) are stored at low temperatures and at pressures close to atmospheric pressure; these include anhydrous ammonia, propane, ethane, ethylene, and propylene. These materials will behave as described in 4.2.1 or 4.2.2.

4.2.6 Flammable Liquids. When released in appreciable quantity, a Class I liquid will begin to evaporate at a rate that depends on its volatility: the lower the flash point, the greater the volatility; hence, the faster the evaporation. The vapors of Class I liquids form ignitible mixtures with air at ambient temperatures more or less readily. Even when evolved rapidly, the vapors tend to disperse rapidly, becoming diluted to a concentration below the lower flammable limit (LFL). Until this dispersion takes place, however, these vapors will behave like heavier-than-air gases. Class I liquids normally will produce ignitible mixtures that will travel some finite distance from the point of origin; thus, they will normally require area classification for proper electrical system design.

4.2.7 Combustible Liquids. A combustible liquid will form an ignitible mixture only when heated above its flash point.

4.2.7.1 With Class II liquids, the degree of hazard is lower because the vapor release rate is low at the normal handling and storage temperatures. In general, these liquids will not form ignitible mixtures with air at ambient temperatures unless heated above their flash points. Also, the vapors will not travel as far because they tend to condense as they are cooled by ambient air. Class II liquids should be considered capable of producing an ignitible mixture near the point of release when handled, processed, or stored under conditions where the liquid could exceed its flash point.

4.2.7.2 Class IIIA liquids do not form ignitible mixtures with air at ambient temperatures unless heated above their flash points. Furthermore, the vapors cool rapidly in air and condense. Hence, the extent of the area requiring electrical classification will be very small or nonexistent.

4.2.7.3 Class IIIB liquids seldom evolve enough vapors to form ignitible mixtures even when heated, and they are seldom ignited by properly installed and maintained general purpose electrical equipment. A Class IIIB liquid will cool below its flash point very quickly when released. Therefore, area classification is seldom needed and Class IIIB liquids are not included in Table 4.4.2.

4.3 Conditions Necessary for Ignition. In a Class I area, the following three conditions must be satisfied for the combustible material to be ignited by the electrical installation:

(1) A combustible material must be present.
(2) It must be mixed with air in the proportions required to produce an ignitible mixture.
(3) There must be a release of sufficient energy to ignite the mixture.

4.4 Classification of Class I Combustible Materials.

4.4.1 Combustible materials are classified into four Class I, Division Groups: A, B, C, and D; or three Class I, Zone Groups: IIC, IIB, and IIA, depending on their properties.

4.4.2* An alphabetical listing of selected combustible materials, with their group classification and relevant physical properties, is provided in Table 4.4.2.

Table 4.4.2 Selected Chemicals

Chemical	CAS No.	Class I Division Group	Type[a]	Flash Point (°C)	AIT (°C)	%LFL	%UFL	Vapor Density (Air = 1)	Vapor Pressure[b] (mm Hg)	Class I Zone Group[c]	MIE (mJ)	MIC Ratio	MESG (mm)
Acetaldehyde	75-07-0	C[d]	I	−38	175	4.0	60.0	1.5	874.9	IIA	0.37	0.98	0.92
Acetic Acid	64-19-7	D[d]	II	39	426		19.9	2.1	15.6	IIA		2.67	1.76
Acetic Acid-tert-Butyl Ester	540-88-5	D	II			1.7	9.8	4.0	40.6				
Acetic Anhydride	108-24-7	D	II	49	316	2.7	10.3	3.5	4.9	IIA			1.23
Acetone	67-64-1	D[d]	I	−20	465	2.5	12.8	2.0	230.7	IIA	1.15	1.00	1.02
Acetone Cyanohydrin	75-86-5	D	IIIA	74	688	2.2	12.0	2.9	0.3				
Acetonitrile	75-05-8	D	I	6	524	3.0	16.0	1.4	91.1	IIA			1.50
Acetylene	74-86-2	A[d]	GAS		305	2.5	100	0.9	36600	IIC	0.017	0.28	0.25
Acrolein (Inhibited)	107-02-8	B(C)[d]	I		235	2.8	31.0	1.9	274.1	IIB	0.13		
Acrylic Acid	79-10-7	D	II	54	438	2.4	8.0	2.5	4.3	IIB			0.86
Acrylonitrile	107-13-1	D[d]	I	0	481	3	17	1.8	108.5	IIB	0.16	0.78	0.87
Adiponitrile	111-69-3	D	IIIA	93	550			1.0	0.002				
Allyl Alcohol	107-18-6	C[d]	I	22	378	2.5	18.0	2.0	25.4	IIB			0.84
Allyl Chloride	107-05-1	D	I	−32	485	2.9	11.1	2.6	366	IIA		1.33	1.17
Allyl Glycidyl Ether	106-92-3	B(C)[e]	II		57			3.9					
Alpha-Methyl Styrene	98-83-9	D	II		574	0.8	11.0	4.1	2.7				
n-Amyl Acetate	628-63-7	D	I	25	360	1.1	7.5	4.5	4.2	IIA			1.02
sec-Amyl Acetate	626-38-0	D	I	23		1.1	7.5	4.5		IIA			
Ammonia	7664-41-7	D[d,f]	GAS		651	15	28	0.6	7498.0	IIA	680	6.85	3.17
Aniline	62-53-3	D	IIIA	70	615	1.2	8.3	3.2	0.7	IIA			

(continues)

Table 4.4.2 ***Continued***

Chemical	CAS No.	Class I Division Group	Type[a]	Flash Point (°C)	AIT (°C)	%LFL	%UFL	Vapor Density (Air = 1)	Vapor Pressure[b] (mm Hg)	Class I Zone Group[c]	MIE (mJ)	MIC Ratio	MESG (mm)
Benzene	71-43-2	D[d]	I	–11	498	1.2	7.8	2.8	94.8	IIA	0.20	1.00	0.99
Benzyl Chloride	98-87-3	D	IIIA		585	1.1		4.4	0.5				
Bromopropyne	106-96-7	D	I	10	324	3.0							
n-Butane	3583-47-9	D[d,g]	GAS		288	1.9	8.5	2.0		IIA	0.25	0.94	1.07
1,3-Butadiene	106-99-0	B(D)[d,e]	GAS		420	2.0	11.5	1.9		IIB	0.13	0.76	0.79
1-Butanol	71-36-3	D[d]	I	36	343	1.4	11.2	2.6	7.0	IIA			0.91
Butyl alcohol (s) (butanol-2)	78-92-2	D[d]	I	23.8	405	1.7	9.8	2.6		IIA			
Butylamine	109-73-9	D	GAS	–12	312	1.7	9.8	2.5	92.9	IIA		1.13	
Butylene	25167-67-3	D	I		385	1.6	10.0	1.9	2214.6	IIA			0.94
n-Butyraldehyde	123-72-8	C[d]	I	–12	218	1.9	12.5	2.5	112.2	IIA			0.92
n-Butyl Acetate	123-86-4	D[d]	I	22	421	1.7	7.6	4.0	11.5	IIA		1.08	1.04
sec-Butyl Acetate	105-46-4	D	II	–8		1.7	9.8	4.0	22.2				
tert-Butyl Acetate	540-88-5	D	II			1.7	9.8	4.0	40.6				
n-Butyl Acrylate (Inhibited)	141-32-2	D	II	49	293	1.7	9.9	4.4	5.5	IIB			0.88
n-Butyl Glycidyl Ether	2426-08-6	B(C)[e]	II										
n-Butyl Formal	110-62-3	C	IIIA						34.3				
Butyl Mercaptan	109-79-5	C	I	2				3.1	46.4				
Butyl-2-Propenoate	141-32-2	D	II	49		1.7	9.9	4.4	5.5				
para tert-Butyl Toluene	98-51-1	D	IIIA										
n-Butyric Acid	107-92-6	D[d]	IIIA	72	443	2.0	10.0	3.0	0.8				
Carbon Disulfide	75-15-0	[d,h]	I	–30	90	1.3	50.0	2.6	358.8	IIC	0.009	0.39	0.20
Carbon Monoxide	630-08-0	C[d]	GAS		609	12.5	74	0.97		IIB			0.54
Chloroacetaldehyde	107-20-0	C	IIIA	88					63.1				
Chlorobenzene	108-90-7	D	I	29	593	1.3	9.6	3.9	11.9				
1-Chloro-1-Nitropropane	2425-66-3	C	IIIA										
Chloroprene	126-99-8	D	GAS	–20		4.0	20.0	3.0					
Cresol	1319-77-3	D	IIIA	81	559	1.1		3.7					
Crotonaldehyde	4170-30-3	C[d]	I	13	232	2.1	15.5	2.4	33.1	IIB			0.81
Cumene	98-82-8	D	I	36	424	0.9	6.5	4.1	4.6	IIA			1.05
Cyclohexane	110-82-7	D	I	–17	245	1.3	8.0	2.9	98.8	IIA	0.22	1.0	0.94
Cyclohexanol	108-93-0	D	IIIA	68	300			3.5	0.7	IIA			
Cyclohexanone	108-94-1	D	II	44	420	1.1	9.4	3.4	4.3	IIA			0.98
Cyclohexene	110-83-8	D	I	–6	244	1.2		2.8	89.4	IIA		0.97	
Cyclopropane	75-19-4	D[d]	I		503	2.4	10.4	1.5	5430	IIA	0.17	0.84	0.91
p-Cymene	99-87-6	D	II	47	436	0.7	5.6	4.6	1.5	IIA			
Decene	872-05-9	D	II		235			4.8	1.7				
n-Decaldehyde	112-31-2	C	IIIA						0.09				
n-Decanol	112-30-1	D	IIIA	82	288			5.3	0.008				
Decyl Alcohol	112-30-1	D	IIIA	82	288			5.3	0.008				
Diacetone Alcohol	123-42-2	D	IIIA	64	603	1.8	6.9	4.0	1.4				
Di-Isobutylene	25167-70-8	D[d]	I	2	391	0.8	4.8	3.8			0.96		
Di-Isobutyl Ketone	108-83-8	D	II	60	396	0.8	7.1	4.9	1.7				
o-Dichlorobenzene	955-50-1	D	IIIA	66	647	2.2	9.2	5.1		IIA			
1,4-Dichloro-2,3 Epoxybutane	3583-47-9	D[d]	I			1.9	8.5	2.0		IIA	0.25	0.98	1.07
1,1-Dichloroethane	1300-21-6	D	I		438	6.2	16.0	3.4	227	IIA			1.82
1,2-Dichloroethylene	156-59-2	D	I	97	460	5.6	12.8	3.4	204	IIA			3.91
1,1-Dichloro-1-Nitroethane	594-72-9	C	IIIA	76				5.0					
1,3-Dichloropropene	10061-02-6	D	I	35		5.3	14.5	3.8					
Dicyclopentadiene	77-73-6	C	I	32	503				2.8	IIA			0.91
Diethylamine	109-87-9	C[d]	I	–28	312	1.8	10.1	2.5		IIA			1.15
Diethylaminoethanol	100-37-8	C	IIIA	60	320			4.0	1.6	IIA			
Diethyl Benzene	25340-17-4	D	II	57	395			4.6					
Diethyl Ether (Ethyl Ether)	60-29-7	C[d]	I	–45	160	1.9	36	2.6	538	IIB	0.19	0.88	0.83
Diethylene Glycol Monobutyl Ether	112-34-5	C	IIIA	78	228	0.9	24.6	5.6	0.02				

Table 4.4.2 *Continued*

Chemical	CAS No.	Class I Division Group	Type[a]	Flash Point (°C)	AIT (°C)	%LFL	%UFL	Vapor Density (Air = 1)	Vapor Pressure[b] (mm Hg)	Class I Zone Group[c]	MIE (mJ)	MIC Ratio	MESG (mm)
Diethylene Glycol Monomethyl Ether	111-77-3	C	IIIA	93	241				0.2				
n-n-Dimethyl Aniline	121-69-7	C	IIIA	63	371	1.0		4.2	0.7				
Dimethyl Formamide	68-12-2	D	II	58	455	2.2	15.2	2.5	4.1	IIA			1.08
Dimethyl Sulfate	77-78-1	D	IIIA	83	188			4.4	0.7				
Dimethylamine	124-40-3	C	GAS		400	2.8	14.4	1.6		IIA			
2,2-Dimethylbutane	75-83-2	D[g]	I	−48	405				319.3				
2,3-Dimethylbutane	78-29-8	D[g]	I		396								
3,3-Dimethylheptane	1071-26-7	D[g]	I		325				10.8				
2,3-Dimethylhexane	31394-54-4	D[g]	I		438								
2,3-Dimethylpentane	107-83-5	D[g]	I		335				211.7				
Di-N-Propylamine	142-84-7	C	I	17	299				27.1	IIA			0.95
1,4-Dioxane	123-91-1	C[d]	I	12	180	2.0	22.0	3.0	38.2	IIB	0.19		0.70
Dipentene	138-86-3	D	II	45	237	0.7	6.1	4.7		IIA			1.18
Dipropylene Glycol Methyl Ether	34590-94-8	C	IIIA	85		1.1	3.0	5.1	0.5				
Diisopropylamine	108-18-9	C	GAS	−6	316	1.1	7.1	3.5		IIA			1.02
Dodecene	6842-15-5	D	IIIA	100	255								
Epichlorohydrin	3132-64-7	C[d]	I	33	411	3.8	21.0	3.2	13.0				
Ethane	74-84-0	D[d]	GAS	−29	472	3.0	12.5	1.0		IIA	0.24	0.82	0.91
Ethanol	64-17-5	D[d]	I	13	363	3.3	19.0	1.6	59.5	IIA		0.88	0.89
Ethylamine	75-04-7	D[d]	I	−18	385	3.5	14.0	1.6	1048		2.4		
Ethylene	74-85-1	C[d]	GAS		490	2.7	36.0	1.0		IIB	0.070	0.53	0.65
Ethylenediamine	107-15-3	D[d]	I	33	385	2.5	12.0	2.1	12.5				
Ethylenimine	151-56-4	C[d]	I	−11	320	3.3	54.8	1.5	211		0.48		
Ethylene Chlorohydrin	107-07-3	D	IIIA	59	425	4.9	15.9	2.8	7.2				
Ethylene Dichloride	107-06-2	D[d]	I	13	413	6.2	16.0	3.4	79.7				
Ethylene Glycol Monoethyl Ether Acetate	111-15-9	C	II	47	379	1.7		4.7	2.3	IIA		0.53	0.97
Ethylene Glycol Monobutyl Ether Acetate	112-07-2	C	IIIA		340	0.9	8.5		0.9				
Ethylene Glycol Monobutyl Ether	111-76-2	C	IIIA		238	1.1	12.7	4.1	1.0				
Ethylene Glycol Monoethyl Ether	110-80-5	C	II		235	1.7	15.6	3.0	5.4				0.84
Ethylene Glycol Monomethyl Ether	109-86-4	D	II		285	1.8	14.0	2.6	9.2				0.85
Ethylene Oxide	75-21-8	B(C)[d,e]	I	−20	429	3	100	1.5	1314	IIB	0.065	0.47	0.59
2-Ethylhexaldehyde	123-05-7	C	II	52	191	0.8	7.2	4.4	1.9				
2-Ethylhexanol	104-76-7	D	IIIA	81		0.9	9.7	4.5	0.2				
2-Ethylhexyl Acrylate	103-09-3	D	IIIA	88	252				0.3				
Ethyl Acetate	141-78-6	D[d]	I	−4	427	2.0	11.5	3.0	93.2	IIA	0.46		0.99
Ethyl Acrylate (Inhibited)	140-88-5	D[d]	I	9	372	1.4	14.0	3.5	37.5	IIA			0.86
Ethyl Alcohol	64-17-5	D[d]	I	13	363	3.3	19.0	1.6	59.5	IIA		0.88	0.89
Ethyl Sec-Amyl Ketone	541-85-5	D	II	59									
Ethyl Benzene	100-41-4	D	I	15	432	0.8	6.7	3.7	9.6				
Ethyl Butanol	97-95-0	D	II	57		1.2	7.7	3.5	1.5				
Ethyl Butyl Ketone	106-35-4	D	II	46				4.0	3.6				
Ethyl Chloride	75-00-3	D	GAS	−50	519	3.8	15.4	2.2					
Ethyl Formate	109-94-4	D	GAS	−20	455	2.8	16.0	2.6		IIA			0.94
Ethyl Mercaptan	75-08-1	C[d]	I	−18	300	2.8	18.0	2.1	527.4	IIB		0.90	0.90
n-Ethyl Morpholine	100-74-3	C	I	32				4.0					

(continues)

Table 4.4.2 *Continued*

Chemical	CAS No.	Class I Division Group	Type[a]	Flash Point (°C)	AIT (°C)	%LFL	%UFL	Vapor Density (Air = 1)	Vapor Pressure[b] (mm Hg)	Class I Zone Group[c]	MIE (mJ)	MIC Ratio	MESG (mm)
2-Ethyl-3-Propyl Acrolein	645-62-5	C	IIIA	68				4.4					
Ethyl Silicate	78-10-4	D	II					7.2					
Formaldehyde (Gas)	50-00-0	B	GAS		430	7	73	1.0		IIB			0.57
Formic Acid	64-18-6	D	II	50	434	18.0	57.0	1.6	42.7	IIA			1.86
Fuel Oil 1	8008-20-6	D	II or IIIA[k]	38–72[k]	210	0.7	5.0						
Fuel Oil 2			II or IIIA[k]	52–96[k]	257								
Fuel Oil 6			IIIA or IIIB[k]	66–132[k]									
Furfural	98-01-1	C	IIIA	60	316	2.1	19.3	3.3	2.3				0.94
Furfuryl Alcohol	98-00-0	C	IIIA	75	490	1.8	16.3	3.4	0.6				
Gasoline	8006-61-9	D[d]	I	–46	280	1.4	7.6	3.0					
n-Heptane	142-82-5	D[d]	I	–4	204	1.0	6.7	3.5	45.5	IIA	0.24	0.88	0.91
n-Heptene	81624-04-6	D[g]	I	–1	204			3.4					0.97
n-Hexane	110-54-3	D[d,g]	I	–23	225	1.1	7.5	3.0	152	IIA	0.24	0.88	0.93
Hexanol	111-27-3	D	IIIA	63				3.5	0.8	IIA			0.98
2-Hexanone	591-78-6	D	I	35	424	1.2	8.0	3.5	10.6				
Hexene	592-41-6	D	I	–26	245	1.2	6.9		186				
sec-Hexyl Acetate	108-84-9	D	II	45				5.0					
Hydrazine	302-01-2	C	II	38	23		98.0	1.1	14.4				
Hydrogen	1333-74-0	B[d]	GAS		500	4	75	0.1		IIC	0.019	0.25	0.28
Hydrogen Cyanide	74-90-8	C[d]	GAS	–18	538	5.6	40.0	0.9		IIB			0.80
Hydrogen Selenide	7783-07-5	C	I						7793				
Hydrogen Sulfide	7783-06-4	C[d]	GAS		260	4.0	44.0	1.2		IIB	0.068		0.90
Isoamyl Acetate	123-92-2	D	I	25	360	1.0	7.5	4.5	6.1				
Isoamyl Alcohol	123-51-3	D	II	43	350	1.2	9.0	3.0	3.2	IIA			1.02
Isobutane	75-28-5	D[g]	GAS		460	1.8	8.4	2.0		IIA			0.95
Isobutyl Acetate	110-19-0	D[d]	I	18	421	2.4	10.5	4.0	17.8				
Isobutyl Acrylate	106-63-8	D	I		427			4.4	7.1				
Isobutyl Alcohol	78-83-1	D[d]	I	–40	416	1.2	10.9	2.5	10.5	IIA		0.92	0.98
Isobutyraldehyde	78-84-2	C	GAS	–40	196	1.6	10.6	2.5		IIA			0.92
Isodecaldehyde	112-31-2	C	IIIA					5.4	0.09				
Isohexane	107-83-5	D[g]			264				211.7	IIA		1.00	
Isopentane	78-78-4	D[g]			420				688.6				
Isooctyl Aldehyde	123-05-7	C	II		197				1.9				
Isophorone	78-59-1	D		84	460	0.8	3.8	4.8	0.4				
Isoprene	78-79-5	D[d]	I	–54	220	1.5	8.9	2.4	550.6				
Isopropyl Acetate	108-21-4	D	I		460	1.8	8.0	3.5	60.4				
Isopropyl Ether	108-20-3	D[d]	I	–28	443	1.4	7.9	3.5	148.7	IIA	1.14		0.94
Isopropyl Glycidyl Ether	4016-14-2	C	I										
Isopropylamine	75-31-0	D	GAS	–26	402	2.3	10.4	2.0			2.0		
Kerosene	8008-20-6	D	II	72	210	0.7	5.0			IIA			
Liquefied Petroleum Gas	68476-85-7	D	I		405								
Mesityl Oxide	141-97-9	D[d]	I	31	344	1.4	7.2	3.4	47.6				
Methane	74-82-8	D[d]	GAS		600	5	15	0.6		IIA	0.28	1.00	1.12
Methanol	67-56-1	D[d]	I	12	385	6.0	36.0	1.1	126.3	IIA	0.14	0.82	0.92
Methyl Acetate	79-20-9	D	GAS	–10	454	3.1	16.0	2.6		IIA		1.08	0.99
Methyl Acrylate	96-33-3	D	GAS	–3	468	2.8	25.0	3.0		IIB		0.98	0.85
Methyl Alcohol	67-56-1	D[d]	I		385	6.0	36	1.1	126.3	IIA			0.91
Methyl Amyl Alcohol	108-11-2	D	II	41		1.0	5.5	3.5	5.3	IIA			1.01
Methyl Chloride	74-87-3	D	GAS	–46	632	8.1	17.4	1.7		IIA			1.00
Methyl Ether	115-10-6	C[d]	GAS	–41	350	3.4	27.0	1.6		IIB		0.85	0.84
Methyl Ethyl Ketone	78-93-3	D[d]	I	–6	404	1.4	11.4	2.5	92.4	IIB	0.53	0.92	0.84
Methyl Formal	534-15-6	C[d]	I	1	238			3.1					
Methyl Formate	107-31-3	D	GAS	–19	449	4.5	23.0	2.1		IIA			0.94
2-Methylhexane	31394-54-4	D[g]	I		280								
Methyl Isobutyl Ketone	141-79-7	D[d]	I	31	440	1.2	8.0	3.5	11				
Methyl Isocyanate	624-83-9	D	GAS	–15	534	5.3	26.0	2.0		IIA			1.21

Table 4.4.2 ***Continued***

Chemical	CAS No.	Class I Division Group	Type[a]	Flash Point (°C)	AIT (°C)	%LFL	%UFL	Vapor Density (Air = 1)	Vapor Pressure[b] (mm Hg)	Class I Zone Group[c]	MIE (mJ)	MIC Ratio	MESG (mm)
Methyl Mercaptan	74-93-1	C	GAS	–18		3.9	21.8	1.7					
Methyl Methacrylate	80-62-6	D	I	10	422	1.7	8.2	3.6	37.2	IIA			0.95
Methyl N-Amyl Ketone	110-43-0	D	II	49	393	1.1	7.9	3.9	3.8				
Methyl Tertiary Butyl Ether	1634-04-4	D	I	–80	435	1.6	8.4	0.2	250.1				
2-Methyloctane	3221-61-2				220				6.3				
2-Methylpropane	75-28-5	D[g]	I		460				2639				
Methyl-1-Propanol	78-83-1	D[d]	I	–40	416	1.2	10.9	2.5	10.1	IIA			0.98
Methyl-2-Propanol	75-65-0	D[d]	I	10	360	2.4	8.0	2.6	42.2				
2-Methyl-5-Ethyl Pyridine	104-90-5	D		74		1.1	6.6	4.2					
Methylacetylene	74-99-7	C[d]	I			1.7		1.4	4306		0.11		
Methylacetylene-Propadiene	27846-30-6	C	I							IIB			0.74
Methylal	109-87-5	C	I	–18	237	1.6	17.6	2.6	398				
Methylamine	74-89-5	D	GAS		430	4.9	20.7	1.0		IIA			1.10
2-Methylbutane	78-78-4	D[g]		–56	420	1.4	8.3	2.6	688.6				
Methylcyclohexane	208-87-2	D	I	–4	250	1.2	6.7	3.4			0.27		
Methylcyclohexanol	25630-42-3	D		68	296			3.9					
2-Methycyclohexanone	583-60-8	D	II					3.9					
2-Methylheptane		D[g]			420								
3-Methylhexane	589-34-4	D[g]			280				61.5				
3-Methylpentane	94-14-0	D[g]			278								
2-Methylpropane	75-28-5	D[g]	I		460				2639				
2-Methyl-1-Propanol	78-83-1	D[d]	I	–40	223	1.2	10.9	2.5	10.5				
2-Methyl-2-Propanol	75-65-0	D[d]	I		478	2.4	8.0	2.6	42.2				
2-Methyloctane	2216-32-2	D[g]			220								
3-Methyloctane	2216-33-3	D[g]			220				6.3				
4-Methyloctane	2216-34-4	D[g]			225				6.8				
Monoethanolamine	141-43-5	D		85	410			2.1	0.4	IIA			
Monoisopropanolamine	78-96-6	D		77	374			2.6	1.1				
Monomethyl Aniline	100-61-8	C			482				0.5				
Monomethyl Hydrazine	60-34-4	C	I	23	194	2.5	92.0	1.6					
Morpholine	110-91-8	C[d]	II	35	310	1.4	11.2	3.0	10.1	IIA			0.95
Naphtha (Coal Tar)	8030-30-6	D	II	42	277					IIA			
Naphtha (Petroleum)	8030-30-6	D[d,i]	I	42	288	1.1	5.9	2.5		IIA			
Neopentane	463-82-1	D[g]		–65	450	1.4	8.3	2.6	1286				
Nitrobenzene	98-95-3	D		88	482	1.8		4.3	0.3	IIA			0.94
Nitroethane	79-24-3	C	I	28	414	3.4		2.6	20.7	IIB			0.87
Nitromethane	75-52-5	C	I	35	418	7.3		2.1	36.1	IIA		0.92	1.17
1-Nitropropane	108-03-2	C	I	34	421	2.2		3.1	10.1	IIB			0.84
2-Nitropropane	79-46-9	C[d]	I	28	428	2.6	11.0	3.1	17.1				
n-Nonane	111-84-2	D[g]	I	31	205	0.8	2.9	4.4	4.4	IIA			
Nonene	27214-95-8	D	I			0.8		4.4					
Nonyl Alcohol	143-08-8	D				0.8	6.1	5.0	0.02	IIA			
n-Octane	111-65-9	D[d,g]	I	13	206	1.0	6.5	3.9	14.0	IIA			0.94
Octene	25377-83-7	D	I	8	230	0.9		3.9					
n-Octyl Alcohol	111-87-5	D						4.5	0.08	IIA			1.05
n-Pentane	109-66-0	D[d,g]	I	–40	243	1.5	7.8	2.5	513	IIA	0.28	0.97	0.93
1-Pentanol	71-41-0	D[d]	I	33	300	1.2	10.0	3.0	2.5	IIA			1.30
2-Pentanone	107-87-9	D	I	7	452	1.5	8.2	3.0	35.6	IIA			0.99
1-Pentene	109-67-1	D	I	–18	275	1.5	8.7	2.4	639.7				
2-Pentene	109-68-2	D	I	–18				2.4					
2-Pentyl Acetate	626-38-0	D	I	23		1.1	7.5	4.5					
Phenylhydrazine	100-63-0	D		89				3.7	0.03				
Process Gas > 30% H_2	1333-74-0	B[j]	GAS		520	4.0	75.0	0.1			0.019	0.45	
Propane	74-98-6	D[d]	GAS		450	2.1	9.5	1.6		IIA	0.25	0.82	0.97

(continues)

Table 4.4.2 *Continued*

Chemical	CAS No.	Class I Division Group	Type[a]	Flash Point (°C)	AIT (°C)	%LFL	%UFL	Vapor Density (Air = 1)	Vapor Pressure[b] (mm Hg)	Class I Zone Group[c]	MIE (mJ)	MIC Ratio	MESG (mm)
1-Propanol	71-23-8	D[d]	I	15	413	2.2	13.7	2.1	20.7	IIA			0.89
2-Propanol	67-63-0	D[d]	I	12	399	2.0	12.7	2.1	45.4	IIA	0.65		1.00
Propiolactone	57-57-8	D				2.9		2.5	2.2				
Propionaldehyde	123-38-6	C	I	–9	207	2.6	17.0	2.0	318.5	IIB			0.86
Propionic Acid	79-09-4	D	II	54	466	2.9	12.1	2.5	3.7	IIA			1.10
Propionic Anhydride	123-62-6	D		74	285	1.3	9.5	4.5	1.4				
n-Propyl Acetate	109-60-4	D	I	14	450	1.7	8.0	3.5	33.4	IIA			1.05
n-Propyl Ether	111-43-3	C[d]	I	21	215	1.3	7.0	3.5	62.3				
Propyl Nitrate	627-13-4	B[d]	I	20	175	2.0	100.0						
Propylene	115-07-1	D[d]	GAS		460	2.4	10.3	1.5		IIA	0.28		0.91
Propylene Dichloride	78-87-5	D	I	16	557	3.4	14.5	3.9	51.7	IIA			1.32
Propylene Oxide	75-56-9	B(C)[d,e]	I	–37	449	2.3	36.0	2.0	534.4	IIB	0.13		0.70
Pyridine	110-86-1	D[d]	I	20	482	1.8	12.4	2.7	20.8	IIA			
Styrene	100-42-5	D[d]	I	31	490	0.9	6.8	3.6	6.1	IIA		1.21	
Tetrahydrofuran	109-99-9	C[d]	I	–14	321	2.0	11.8	2.5	161.6	IIB	0.54		0.87
Tetrahydronaphthalene	119-64-2	D	IIIA		385	0.8	5.0	4.6	0.4				
Tetramethyl Lead	75-74-1	C	II	38				9.2					
Toluene	108-88-3	D[d]	I	4	480	1.1	7.1	3.1	28.53	IIA	0.24		
n-Tridecene	2437-56-1	D	IIIA			0.6		6.4	593.4				
Triethylamine	121-44-8	C[d]	I	–9	249	1.2	8.0	3.5	68.5	IIA	0.75		1.05
Triethylbenzene	25340-18-5	D		83			56.0	5.6					
2,2,3-Trimethylbutane		D[g]			442								
2,2,4-Trimethylbutane		D[g]			407								
2,2,3-Trimethylpentane		D[g]			396								
2,2,4-Trimethylpentane		D[g]			415					IIA			1.04
2,3,3-Trimethylpentane		D[g]			425								
Tripropylamine	102-69-2	D	II	41				4.9	1.5	IIA			1.13
Turpentine	8006-64-2	D	I	35	253	0.8			4.8				
n-Undecene	28761-27-5	D	IIIA			0.7		5.5					
Unsymmetrical Dimethyl Hydrazine	57-14-7	C[d]	I	–15	249	2.0	95.0	1.9		IIB			0.85
Valeraldehyde	110-62-3	C	I	280	222			3.0	34.3				
Vinyl Acetate	108-05-4	D[d]	I	–6	402	2.6	13.4	3.0	113.4	IIA	0.70		0.94
Vinyl Chloride	75-01-4	D[d]	GAS	–78	472	3.6	33.0	2.2		IIA			0.96
Vinyl Toluene	25013-15-4	D		52	494	0.8	11.0	4.1					
Vinylidene Chloride	75-35-4	D	I		570	6.5	15.5	3.4	599.4	IIA			3.91
Xylene	1330-20-7	D[d]	I	25	464	0.9	7.0	3.7		IIA	0.2		1.09
Xylidine	121-69-7	C	IIIA	63	371	1.0		4.2	0.7				

[a]Type is used to designate if the material is a gas, flammable liquid, or combustible liquid. *(See 4.2.6 and 4.2.7.)*

[b]Vapor pressure reflected in units of mm Hg at 25°C (77°F) unless stated otherwise.

[c]Class I, Zone Groups are based on 1996 IEC TR3 60079-20, *Electrical apparatus for explosive gas atmospheres — Part 20: Data for flammable gases and vapours, relating to the use of electrical apparatus*, which contains additional data on MESG and group classifications.

[d]Material has been classified by test.

[e]Where all conduit runs into explosionproof equipment are provided with explosionproof seals installed within 450 mm (18 in.) of the enclosure, equipment for the group classification shown in parentheses is permitted.

[f]For classification of areas involving ammonia, see ASHRAE 15, *Safety Code for Mechanical Refrigeration*, and ANSI/CGA G2.1, *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*.

[g]Commercial grades of aliphatic hydrocarbon solvents are mixtures of several isomers of the same chemical formula (or molecular weight). The autoignition temperatures of the individual isomers are significantly different. The electrical equipment should be suitable for the AIT of the solvent mixture. *(See A.4.4.2.)*

[h]Certain chemicals have characteristics that require safeguards beyond those required for any of the above groups. Carbon disulfide is one of these chemicals because of its low autoignition temperature and the small joint clearance necessary to arrest its flame propagation.

[i]Petroleum naphtha is a saturated hydrocarbon mixture whose boiling range is 20°C to 135°C (68°F to 275°F). It is also known as benzine, ligroin, petroleum ether, and naphtha.

[j]Fuel and process gas mixtures found by test not to present hazards similar to those of hydrogen may be grouped based on the test results.

[k]Liquid type and flash point vary due to regional blending differences.

4.4.3 Table 4.4.3 provides a cross-reference of selected chemicals sorted by their Chemical Abstract Service (CAS) numbers.

Table 4.4.3 Cross-Reference of Chemical CAS Number to Chemical Name

CAS No.	Chemical Name
50-00-0	Formaldehyde (Gas)
57-14-7	Unsymmetrical Dimethyl Hydrazine
57-57-8	Propiolactone
60-29-7	Diethyl Ether (Ethyl Ether)
60-34-4	Monomethyl Hydrazine
62-53-3	Aniline
64-17-5	Ethanol
64-17-5	Ethyl Alcohol
64-18-6	Formic Acid
64-19-7	Acetic Acid
67-56-1	Methanol
67-56-1	Methyl Alcohol
67-63-0	2-Propanol
67-64-1	Acetone
68-12-2	Dimethyl Formamide
71-23-8	1-Propanol
71-36-3	1-Butanol
71-36-5	2-Butanol
71-41-0	1-Pentanol
71-43-2	Benzene
74-82-8	Methane
74-84-0	Ethane
74-85-1	Ethylene
74-86-2	Acetylene
74-87-3	Methyl Chloride
74-89-5	Methylamine
74-90-8	Hydrogen Cyanide
74-93-1	Methyl Mercaptan
74-98-6	Propane
74-99-7	Methylacetylene
75-00-3	Ethyl Chloride
75-01-4	Vinyl Chloride
75-04-7	Ethylamine
75-05-8	Acetonitrile
75-07-0	Acetaldehyde
75-08-1	Ethyl Mercaptan
75-15-0	Carbon Disulfide
75-19-4	Cyclopropane
75-21-8	Ethylene Oxide
75-28-5	Isobutane
75-28-5	2-Methylpropane
75-28-5	3-Methylpropane
75-31-0	Isopropylamine
75-35-4	Vinylidene Chloride
75-52-5	Nitromethane
75-56-9	Propylene Oxide
75-65-0	2-Methyl-2-Propanol
75-74-1	Tetramethyl Lead
75-83-2	Dimethylbutane
75-83-2	Neohexane

Table 4.4.3 ***Continued***

CAS No.	Chemical Name
75-86-5	Acetone Cyanohydrin
77-78-1	Dimethyl Sulfate
78-10-4	Ethyl Silicate
78-59-1	Isophorone
78-78-4	Isopentane
78-78-4	Methylbutane
78-79-5	Isoprene
78-83-1	Isobutyl Alcohol
78-83-1	Methyl-1-Propanol
78-84-2	Isobutyraldehyde
78-87-5	Propylene Dichloride
78-93-3	Methyl Ethyl Ketone
78-96-6	Monoisopropanolamine
79-09-4	Propionic Acid
79-10-7	Acrylic Acid
79-20-9	Methyl Acetate
79-24-3	Nitroethane
79-46-9	2-Nitropropane
80-62-6	Methyl Methacrylate
96-14-0	3-Methylpentane
96-33-3	Methyl Acrylate
97-95-0	Ethyl Butanol
98-00-0	Furfuryl Alcohol
98-01-1	Furfural
98-51-1	tert-Butyl Toluene
98-82-8	Cumene
98-83-9	Alpha-Methyl Styrene
98-87-3	Benzyl Chloride
98-95-3	Nitrobenzene
99-87-6	p-Cymene
100-41-4	Ethyl Benzene
100-42-5	Styrene
100-61-8	Monomethyl Aniline
100-63-0	Phenylhydrazine
100-74-3	n-Ethyl Morpholine
102-69-2	Tripropylamine
103-09-3	Ethyl Hexyl Acrylate
104-76-7	Ethylhexanol
104-90-5	2-Methyl-5-Ethyl Pyridine
105-46-4	sec-Butyl Acetate
106-35-4	Ethyl Butyl Ketone
106-63-8	Isobutyl Acrylate
106-88-7	Butylene Oxide
106-92-3	Allyl Glycidyl Ether
106-96-7	Bromopropyne
106-99-0	1,3-Butadiene
107-02-8	Acrolein (Inhibited)
107-05-1	Allyl Chloride
107-06-2	Ethylene Dichloride
107-07-3	Ethylene Chlorohydrin
107-13-1	Acrylonitrile
107-15-3	Ethylenediamine
107-18-6	Allyl Alcohol
107-20-0	Chloroacetaldehyde
107-31-3	Methyl Formate

(continues)

Table 4.4.3 ***Continued***

CAS No.	Chemical Name
107-83-5	Dimethylpentane
107-83-5	Isohexane
107-83-5	2-Methylpentane
107-87-9	2-Pentanone
107-92-6	n-Butyric Acid
108-03-2	1-Nitropropane
108-05-4	Vinyl Acetate
108-11-2	Methyl Amyl Alcohol
108-18-9	Diisopropylamine
108-20-3	Isopropyl Ether
108-21-4	Isopropyl Acetate
108-24-7	Acetic Anhydride
108-84-9	sec-Hexyl Acetate
108-88-3	Toluene
108-90-7	Chlorobenzene
108-93-0	Cyclohexanol
108-94-1	Cyclohexanone
109-60-4	n-Propyl Acetate
109-66-0	n-Pentane
109-67-1	1-Pentene
109-68-2	2-Pentene
109-73-9	Butylamine
109-79-5	Butyl Mercaptan
109-86-4	Ethylene Glycol Monomethyl Ether
109-87-5	Methylal
109-94-4	Ethyl Formate
109-99-9	Tetrahydrofuran
110-19-0	Isobutyl Acetate
110-43-0	Methyl n-Amyl Ketone
110-54-3	n-Hexane
110-62-3	n-Butyl Formal
110-62-3	Valeraldehyde
110-80-5	Ethylene Glycol Monoethyl Ether
110-82-7	Cyclohexane
110-83-8	Cyclohexene
110-86-1	Pyridine
110-91-8	Morpholine
111-15-9	Ethylene Glycol Monoethyl Ether Acetate
111-27-3	Hexanol
111-43-3	n-Propyl Ether
111-65-9	n-Octane
111-69-3	Adiponitrile
111-76-2	Ethylene Glycol Monobutyl Ether
111-84-2	n-Nonane
111-87-5	n-Octyl Alcohol
112-07-2	Ethylene Glycol Monobutyl Ether Acetate
112-30-1	n-Decanol
112-31-2	Isodecaldehyde
112-31-2	n-Decaldehyde
115-07-1	Propylene
115-10-6	Methyl Ether
119-64-2	Tetrahydronaphthalene
121-44-8	Triethylamine
123-05-7	Ethylhexaldehyde
123-05-7	Isooctyl Aldehyde
123-38-6	Propionaldehyde
123-51-3	Isoamyl Alcohol
123-62-6	Propionic Anhydride
123-72-8	n-Butyraldehyde
123-86-4	n-Butyl Acetate
123-91-1	1,4-Dioxane
123-92-2	Isoamyl Acetate
124-40-3	Dimethylamine
126-99-8	Chloroprene
138-86-3	Dipentene
140-88-5	Ethyl Acrylate (Inhibited)
141-32-2	n-Butyl Acrylate (Inhibited)
141-43-5	Monoethanolamine
141-78-6	Ethyl Acetate
141-79-7	Methyl Isobutyl Ketone
141-97-9	Mesityl Oxide
142-82-5	n-Heptane
143-08-8	Nonyl Alcohol
151-56-4	Ethylenimine
208-87-2	Methylcyclohexane
302-01-2	Hydrazine
463-82-1	Dimethylpropane
463-82-1	Neopentane
534-15-6	Methyl Formal
540-88-5	tert-Butyl Acetate
541-85-5	Ethyl Sec-Amyl Ketone
589-34-4	3-Methylhexane
591-78-6	Hexanone
592-41-6	Hexene
624-83-9	Methyl Isocyanate
626-38-0	sec-Amyl Acetate
627-13-4	Propyl Nitrate
628-63-7	n-Amyl Acetate
630-08-0	Carbon Monoxide
645-62-5	Ethyl-3-Propyl Acrolein
1068-19-5	Methylheptane
1071-26-7	Dimethylheptane
1319-77-3	Cresol
1330-20-7	Xylene
1333-74-0	Hydrogen
1333-74-0	Process Gas > 30% H_2
1634-04-4	Methyl Tertiary Butyl Ether
2216-32-2	2-Methyloctane
2216-33-3	3-Methyloctane
2216-34-4	4-Methyloctane
2425-66-3	1-Chloro-1-Nitropropane
2426-08-6	n-Butyl Glycidyl Ether
2437-56-1	Tridecene
3132-64-7	Epichlorohydrin
3221-61-2	2-Methyloctane
3583-47-9	Butane
4016-14-2	Isopropyl Glycidyl Ether
4170-30-3	Crotonaldehyde
6842-15-5	Dodecene
7664-41-7	Ammonia

Table 4.4.3 ***Continued***

CAS No.	Chemical Name
7783-06-4	Hydrogen Sulfide
7783-07-5	Hydrogen Selenide
8006-61-9	Gasoline
8006-64-2	Turpentine
8008-20-6	Fuel Oil 1
8008-20-6	Kerosene
8030-30-6	Naphtha (Coal Tar)
8030-30-6	Naphtha (Petroleum)
25013-15-4	Vinyl Toluene
25167-67-3	Butylene
25340-18-5	Triethylbenzene
25377-83-7	Octene
25630-42-3	Methylcyclohexanol
26952-21-6	Isooctyl Alcohol
27214-95-8	Nonene
27846-30-6	Methylacetylene-Propadiene
28761-27-5	Undecene
31394-54-4	Dimethylhexane
31394-54-4	2-Methylhexane
34590-94-8	Dipropylene Glycol Methyl Ether
68476-85-7	Liquefied Petroleum Gas
81624-04-6	Heptene

4.4.4 Annex C lists references that deal with the testing of various characteristics of combustible materials.

Chapter 5 Classification of Class I (Combustible Material) Areas

5.1 General. The decision to classify an area as hazardous is based on the possibility that an ignitible mixture may occur. Having decided that an area should be classified, the next step is to determine which classification methodology should be utilized: the U.S. traditional *NEC* Articles 500 and 501, Class, Division, Group; or the *NEC* Article 505, Class, Zone, Group.

5.1.1 Refer to Sections 5.2 and 5.4 for use with the U.S. traditional *NEC* Article 500 Class, Division criteria to determine the degree of hazard: Is the area Division 1 or Division 2?

5.1.2 Refer to Sections 5.3 and 5.4 for using *NEC* Article 505 Class, Zone criteria to determine the degree of hazard: Is the area Zone 0, Zone 1, or Zone 2?

5.2 Class, Division, Classified Locations.

5.2.1 Division 1 Classified Locations.

5.2.1.1 A condition for Division 1 is whether the location is likely to have an ignitible mixture present under normal conditions. For instance, the presence of a combustible material in the immediate vicinity of an open dip tank is normal and requires a Division 1 classification.

5.2.1.2 *Normal* does not necessarily mean the situation that prevails when everything is working properly. For instance, there could be cases in which frequent maintenance and repair are necessary. These are viewed as normal and, if quantities of a flammable liquid or a combustible material are released as a result of the maintenance, the location is Division 1.

5.2.1.3 However, if repairs are not usually required between turnarounds, the need for repair work is considered abnormal. In any event, the classification of the location, as related to equipment maintenance, is influenced by the maintenance procedures and frequency of maintenance.

5.2.2 Division 2 Classified Locations. The criterion for a Division 2 location is whether the location is likely to have ignitible mixtures present only under abnormal conditions. The term *abnormal* is used here in a limited sense and does not include a major catastrophe.

5.2.2.1 As an example, consider a vessel containing liquid hydrocarbons (the source) that releases combustible material only under abnormal conditions. In this case, there is no Division 1 location because the vessel is normally tight. To release vapor, the vessel would have to leak, and that would not be normal. Thus, the vessel is surrounded by a Division 2 location.

5.2.2.2 Chemical process equipment does not often fail. Furthermore, the electrical installation requirements of the *NEC* for Division 2 locations is such that an ignition-capable spark or hot surface will occur only in the event of abnormal operation or failure of electrical equipment. Otherwise, sparks and hot surfaces are not present or are contained in enclosures. On a realistic basis, the possibility of process equipment and electrical equipment failing simultaneously is remote.

5.2.2.3 The Division 2 classification is also applicable to conditions not involving equipment failure. For example, consider an area classified as Division 1 because of the normal presence of an ignitible mixture. Obviously, one side of the Division 1 boundary cannot be normally hazardous and the opposite side never hazardous. When there is no wall, a surrounding transition Division 2 location separates a Division 1 location from an unclassified location.

5.2.2.4 In cases in which an unpierced barrier, such as a blank wall, completely prevents the spread of the combustible material, the area classification does not extend beyond the barrier.

5.3 Class I, Zone Classified Locations.

5.3.1 Zone 0 Classified Locations. A condition for Zone 0 is whether the location has an ignitible mixture present continuously or for long periods of time.

5.3.1.1 Zone 0 classified locations include the following:

(1) Inside vented tanks or vessels containing volatile flammable liquids
(2) Inside inadequately vented spraying or coating enclosures where volatile flammable solvents are used
(3) Between the inner and outer roof sections of a floating roof tank containing volatile flammable liquids
(4) Inside open vessels, tanks, and pits containing volatile flammable liquids
(5) The interior of an exhaust duct that is used to vent ignitible concentrations of gases or vapors
(6) Inside inadequately ventilated enclosures containing normally venting instruments utilizing or analyzing flammable fluids and venting to the inside of the enclosures

5.3.1.2 It is not good practice to install electrical equipment in Zone 0 locations except when the equipment is essential to the process or when other locations are not feasible.

5.3.2 Zone 1 Classified Locations.

5.3.2.1 The criteria for a Zone 1 location include the following:

(1) Is the location likely to have ignitible mixtures present under normal conditions?
(2) Is the location likely to have ignitible mixtures exist frequently because of repair or maintenance operations or because of leakage?
(3) Does the location have conditions in which equipment is operated or processes are carried on, where equipment breakdown or faulty operations could result in the release of ignitible concentrations of flammable gases or vapors, and also could cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition?
(4) Is the location adjacent to a Class I, Zone 0 location from which ignitible concentrations of vapors could be communicated, unless communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided?

5.3.2.2 Zone 1 classified locations include the following:

(1) Locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another, in areas in the vicinity of spraying and painting operations where flammable solvents are used
(2) Adequately ventilated drying rooms or compartments for the evaporation of flammable solvents
(3) Adequately ventilated locations containing fat and oil extraction equipment using volatile flammable solvents
(4) Portions of cleaning and dyeing plants where flammable liquids are used
(5) Adequately ventilated gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape
(6) Inadequately ventilated pump rooms for flammable gas or for flammable liquids
(7) The interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers
(8) Other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operation, but not classified Zone 0

5.3.3 Zone 2 Locations.

5.3.3.1 The criteria for a Zone 2 location include the following:

(1) Ignitible mixtures are not likely to occur in normal operation, and, if they do occur, will exist only for a short period.
(2) Ignitible mixtures are handled, processed, or used in the area, but liquids, gases, or vapors normally are confined within closed containers or closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or system, or as the result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used.
(3) Ignitible mixtures normally are prevented by positive mechanical ventilation, but may become hazardous as the result of failure or abnormal operation of the ventilation equipment.
(4) The location is adjacent to a Class I, Zone 1 location, from which ignitible concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

5.3.3.2 The Zone 2 classification usually includes locations where flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition.

5.4 Unclassified Locations.

5.4.1 Experience has shown that the release of ignitible mixtures from some operations and apparatus is so infrequent that area classification is not necessary. For example, it is not usually necessary to classify the following locations where combustible materials are processed, stored, or handled:

(1) Locations that have adequate ventilation, where combustible materials are contained within suitable, well-maintained, closed piping systems
(2) Locations that lack adequate ventilation, but where piping systems are without valves, fittings, flanges, and similar accessories that may be prone to leaks
(3) Locations where combustible materials are stored in suitable containers
(4) Locations where the use of combustible liquids, or flammable liquids or gases, will not produce gas or vapor sufficient to reach 25 percent of the lower flammable limit (LFL) of that combustible material.

5.4.2 Locations considered to have adequate ventilation include the following:

(1) An outside location
(2) A building, room, or space that is substantially open and free of obstruction to the natural passage of air, either vertically or horizontally. (Such areas could be roofed over with no walls, could be roofed over and closed on one side, or could be provided with suitably designed windbreaks.)
(3) An enclosed or partly enclosed space provided with ventilation equivalent to natural ventilation. (The ventilation system must have adequate safeguards against failure.)

5.4.3 Open flames and hot surfaces associated with the operation of certain equipment, such as boilers and fired heaters, provide inherent thermal ignition sources. Electrical classification is not appropriate in the immediate vicinity of these facilities. However, it is prudent to avoid installing electrical equipment that could be a primary ignition source for potential leak sources in pumps, valves, and so forth, or in waste product and fuel feed lines.

5.4.4 Experience indicates that Class IIIB liquids seldom evolve enough vapors to form ignitible mixtures even when heated, and are seldom ignited by properly installed and maintained general-purpose electrical equipment.

5.4.5 Experience has shown that some halogenated liquid hydrocarbons, such as trichloroethylene; 1,1,1-trichloroethane; methylene chloride; and 1,1-dichloro-1-fluoroethane (HCFC-141b), which do not have flash points, but do have a flammable range, are for practical purposes nonflammable and do not require special electrical equipment for hazardous (classified) locations.

5.5 Extent of Classified Locations.

5.5.1 The extent of a Division 1 or Division 2 location or a Zone 0, Zone 1, or Zone 2 location requires careful consideration of the following factors:

(1) The combustible material

(2) The vapor density of the material
(3) The temperature of the material
(4) The process or storage pressure
(5) The size of release
(6) The ventilation

5.5.2* The first step is to identify the materials being handled and their vapor densities. Hydrocarbon vapors and gases are generally heavier than air, whereas hydrogen and methane are lighter than air. The following guidelines apply:

(1) In the absence of walls, enclosures, or other barriers, and in the absence of air currents or similar disturbing forces, the combustible material will disperse. Heavier-than-air vapors will travel primarily downward and outward; lighter-than-air vapors will travel upward and outward. If the source of the vapors is a single point, the horizontal area covered by the vapor will be a circle.
(2) For heavier-than-air vapors released at or near grade level, ignitible mixtures are most likely to be found below grade level; next most likely at grade level; with decreasing likelihood of presence as height above grade increases. For lighter-than-air gases, the opposite is true: there is little or no hazard at and below grade but greater hazard above grade.
(3) In cases where the source of the combustible material is above grade or below grade or in cases where the combustible material is released under pressure, the limits of the classified area are altered substantially. Also, a very mild breeze could extend these limits. However, a stronger breeze could accelerate dispersion of the combustible material so that the extent of the classified area is greatly reduced. Thus, dimensional limits recommended for either Class I, Division 1 or Division 2; or Class I, Zone 0, Zone 1, or Zone 2 classified areas must be based on experience rather than relying solely on the theoretical diffusion of vapors.

5.5.3 The size of a building and its design could influence considerably the classification of the enclosed volume. In the case of a small, inadequately ventilated room, it could be appropriate to classify the entire room as Class I, Division 1 or Class I, Zone 1.

5.5.4 When classifying buildings, careful evaluation of prior experience with the same or similar installations should be made. It is not enough to identify only a potential source of the combustible material within the building and proceed immediately to defining the extent of either the Class I, Division 1 or Division 2; or Class I, Zone 1 or Zone 2 classified areas. Where experience indicates that a particular design concept is sound, a more hazardous classification for similar installations may not be justified. Furthermore, it is conceivable that an area be reclassified from either Class I, Division 1 to Class I Division 2, or from Class I, Division 2 to unclassified, or from Class I, Zone 1 to Class I, Zone 2, or from Class I, Zone 2 to unclassified, based on experience.

5.5.5 Correctly evaluated, an installation will be found to be a multiplicity of Class I, Division 1 areas of very limited extent. The same will be true for Class I, Zone 1 areas. Probably the most numerous of offenders are packing glands. A packing gland leaking a quart per minute (0.95 L/min), or 360 gallons per day, would certainly not be commonplace. Yet, if a quart bottle were emptied each minute outdoors, the zone made hazardous would be difficult to locate with a combustible gas detector.

5.5.6 The volume of combustible material released is of extreme importance in determining the extent of a hazardous (classified) location, and it is this consideration that necessitates the greatest application of sound engineering judgment. However, one cannot lose sight of the purpose of this judgment; the area is classified solely for the installation of electrical equipment.

5.6 Discussion of Diagrams and Recommendations.

5.6.1 This chapter contains a series of diagrams that illustrate how typical sources of combustible material should be classified and the recommended extent of the various classifications. Some of the diagrams are for single-point sources; others apply to multiple sources in an enclosed space or in an operating area. The basis for the diagrams is explained in Section 5.7.

5.6.2 The intended use of the diagrams is to aid in developing electrical classification maps of operating units, process plants, and buildings. Most of the maps will be plan views. Elevations or sectional views could be required where different classifications apply at different levels.

5.6.3 An operating unit could have many interconnected sources of combustible material, including pumps, compressors, vessels, tanks, and heat exchangers. These in turn present sources of leaks such as flanged and screwed connections, fittings, valves, meters, and so forth. Thus, considerable judgment will be required to establish the boundaries of Division 1 and Division 2 or Zone 0, Zone 1, and Zone 2 locations.

5.6.4 In some cases, individual classification of a multitude of point sources within an operating unit is neither feasible nor economical. In such cases, the entire unit could be classified as a single-source entity. However, this should be considered only after a thorough evaluation of the extent and interaction of the various sources, both within the unit and adjacent to it.

5.6.5 In developing these diagrams, vapor density is generally assumed to be greater than that of air. Lighter-than-air gases, such as hydrogen and methane, will quite readily disperse, and the diagrams for lighter-than-air gases should be used. However, if such gases are being evolved from the cryogenic state [such as liquefied hydrogen or liquefied natural gas (LNG)], caution must be exercised, because for some finite period of time, these gases will be heavier than air due to their low temperature when first released.

5.7 Basis for Recommendations.

5.7.1 The practices of the petroleum refining industry are published by the American Petroleum Institute, in ANSI/API RP 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*; and ANSI/API RP 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2.* These practices are based on an analysis of the practices of a large segment of the industry, experimental data, and careful weighing of pertinent factors. Petroleum facility operations are characterized by the handling, processing, and storage of large quantities of materials, often at elevated temperatures. The recommended limits of classified locations for petroleum facility installations could therefore be stricter than are warranted for more traditional chemical processing facilities that handle smaller quantities.

5.7.2 Various codes, standards, and recommended practices of the National Fire Protection Association include recommendations for classifying hazardous (classified) locations. These recommendations are based on many years of experience. NFPA 30, *Flammable and Combustible Liquids Code*, and NFPA 58, *Liquefied Petroleum Gas Code*, are two of these documents.

5.7.3 Continuous process plants and large batch chemical plants could be almost as large as refineries and should therefore follow the practices of the refining industry. Leakage from pump and agitator shaft packing glands, piping flanges, and valves generally increases with process equipment size, pressure, and flow rate, as does the travel distance and area of dispersion from the discharge source.

5.7.4 In deciding whether to use an overall plant classification scheme or individual equipment classification, process equipment size, flow rate, and pressure should be taken into consideration. Point-source diagrams can be used in most cases for small or batch chemical plants; for large, high-pressure plants, the API recommendations are more suitable. Table 5.7.4 gives ranges of process equipment size, pressure, and flow rate for equipment and piping that handles combustible material.

Table 5.7.4 Relative Magnitudes of Process Equipment and Piping that Handles Combustible Materials

Process Equipment	Units	Small (Low)	Moderate	Large (High)
Size	gal	<5000	5000–25,000	>25,000
Pressure	psi	<100	100–500	>500
Flow rate	gpm	<100	100–500	>500

5.7.5 The majority of chemical plants fall in the moderate range of size, pressure, and flow rate for equipment and piping that handles combustible materials. However, because all cases are not the same, sound engineering judgment is required.

5.8 Procedure for Classifying Locations. The procedure described in 5.8.1 through 5.8.4 should be used for each room, section, or area being classified.

5.8.1 Step One — Determining Need for Classification. The area should be classified if a combustible material is processed, handled, or stored there.

5.8.2 Step Two — Gathering Information.

5.8.2.1 Proposed Facility Information. For a proposed facility that exists only in drawings, a preliminary area classification can be done so that suitable electrical equipment and instrumentation can be purchased. Plants are rarely built exactly as the drawings portray them, so the area classification should be modified later based on the actual facility.

5.8.2.2 Existing Facility History. For an existing facility, the individual plant experience is extremely important in classifying areas within the plant. Both operation and maintenance personnel in the actual plant should be asked the following questions:

(1) Have there been instances of leaks?
(2) Do leaks occur frequently?
(3) Do leaks occur during normal or abnormal operation?
(4) Is the equipment in good condition, questionable condition, or in need of repair?
(5) Do maintenance practices result in the formation of ignitible mixtures?
(6) Does routine flushing of process lines, changing of filters, opening of equipment, and so forth result in the formation of ignitible mixtures?

5.8.2.3 Process Flow Diagram. A process flow diagram showing the pressure, temperature, flow rates, composition, and quantities of various materials (i.e., mass flow balance sheets) passing through the process is needed.

5.8.2.4 Plot Plan. A plot plan (or similar drawing) is needed showing all vessels, tanks, trenches, lagoons, sumps, building structures, dikes, partitions, levees, ditches, and similar items that would affect dispersion of any liquid, gas, or vapor. The plot plan should include the prevailing wind direction.

5.8.2.5* Fire Hazard Properties of Combustible Material. The properties needed for determining area classification for many materials are shown in Table 4.4.2.

5.8.2.5.1 A material could be listed in Table 4.4.2 under a chemical name different from the chemical name used at a facility. Table 4.4.3 is provided to cross-reference the CAS number of the material to the chemical name used in Table 4.4.2.

5.8.2.5.2 Where materials being used are not listed in Table 4.4.2 or in other reputable chemical references, the necessary information can be obtained by the following:

(1) Contact the material supplier to determine if the material has been tested or group-classified. If tested, estimate the group classification using the criteria shown in Annex A.
(2) Have the material tested and estimate the group classification using the criteria shown in Annex A.
(3) Refer to Annex B for a method for determining the group classification for some mixed combustible material streams.

5.8.3 Step Three — Selecting the Appropriate Classification Diagram.

5.8.3.1 The list of combustible materials from the process flow diagram and the material mass balance data should be correlated with the quantities, pressures, flow rates *(see Table 5.7.4)*, and temperatures to determine the following:

(1) Whether the process equipment size is low, moderate, or high
(2) Whether the pressure is low, moderate, or high
(3) Whether the flow rate is low, moderate, or high
(4) Whether the combustible material is lighter than air (vapor density < 1) or heavier than air (vapor density > 1)
(5) Whether the source of leaks is above or below grade
(6) Whether the process is a loading/unloading station, product dryer, filter press, compressor shelter, hydrogen storage, or marine terminal

5.8.3.2 Use Table 5.9 and the information in 5.8.3.1 to select the appropriate classification diagram(s).

5.8.4 Step Four — Determining the Extent of the Classified Location. The extent of the classified area can be determined by using sound engineering judgment to apply the methods discussed in 5.5.2 and the diagrams contained in this chapter.

5.8.4.1 The potential sources of leaks should be located on the plan drawing or at the actual location. These sources can include rotating or reciprocating shafts (e.g., pumps, compressors, and control valves) and atmospheric discharges from pressure relief devices.

5.8.4.2 For each leakage source, an equivalent example should be found from the selected classification diagram to determine the minimum extent of classification around the leakage source. The extent can be modified by considering the following:

(1) Whether an ignitible mixture is likely to occur frequently due to repair, maintenance, or leakage
(2) Where conditions of maintenance and supervision are such that leaks are likely to occur in process equipment, storage vessels, and piping systems containing combustible material
(3) Whether the combustible material could be transmitted by trenches, pipes, conduits, or ducts
(4) Ventilation or prevailing wind in the specific area, and the dispersion rates of the combustible materials

5.8.4.3 Once the minimum extent is determined, utilize distinct landmarks (e.g., curbs, dikes, walls, structural supports, edges of roads) for the actual boundaries of the area classification. These landmarks permit easy identification of the boundaries of the hazardous (classified) locations for electricians, instrument technicians, operators, and other personnel.

5.9 Classification Diagrams for Class I, Divisions. Most diagrams in Section 5.9 and Section 5.10 include tables of "suggested applicability" and use check marks to show the ranges of process equipment size, pressure, and flow rates. *(See Table 5.7.4.)* Unless otherwise stated, these diagrams assume that the material being handled is a flammable liquid. Table 5.9 provides a summary of where each diagram is intended to apply. Class I, Division diagrams include Figure 5.9.1(a) through Figure 5.9.14.

5.9.1 Indoor and Outdoor Process-Flammable Liquids. *[See Figure 5.9.1(a), Figure 5.9.1(b), Figure 5.9.1(c), Figure 5.9.1(d), Figure 5.9.1(e), Figure 5.9.1(f), Figure 5.9.1(g), Figure 5.9.1(h), Figure 5.9.1(i), Figure 5.9.1(j), Figure 5.9.1(k), Figure 5.9.1(l), Figure 5.9.1(m), and Figure 5.9.1(n).]*

5.9.2 Outdoor Process — Flammable Liquid, Flammable Gas, Compressed Flammable Gas, or Cryogenic Liquid. *[See Figure 5.9.2(a) and Figure 5.9.2(b).]*

5.9.3 Product Dryer and Plate and Frame Filter Press — Solids Wet with Flammable Liquids. *[See Figure 5.9.3(a) and Figure 5.9.3(b).]*

5.9.4 Storage Tanks and Tank Vehicles — Flammable Liquids. *[See Figure 5.9.4(a), Figure 5.9.4(b), Figure 5.9.4(c), Figure 5.9.4(d), and Figure 5.9.4(e).]*

5.9.5 Tank Vehicle — Flammable Liquefied Gas, Flammable Compressed Gas, or Flammable Cryogenic Liquid. *(See Figure 5.9.5.)*

5.9.6 Indoor or Outdoor Drum Filling Station— Flammable Liquids. *(See Figure 5.9.6.)*

5.9.7 Emergency Impounding Basins, Emergency Drainage Ditches, or Oil/Water Separators — Flammable Liquids. *(See Figure 5.9.7.)*

5.9.8 Storage of Liquid or Gaseous Hydrogen. *[See Figure 5.9.8(a) and Figure 5.9.8(b).]*

5.9.9 Compressor Shelters — Lighter-than-Air Gas. *[See Figure 5.9.9(a) and Figure 5.9.9(b).]*

5.9.10 Storage Tanks for Cryogenic Liquids. *[See Figure 5.9.10(a), Figure 5.9.10(b), and Figure 5.9.10(c).]*

5.9.11 Outdoor Handling — Liquefied Natural Gas or Other Cryogenic Flammable Gas. *(See Figure 5.9.11.)*

5.9.12 Indoor Handling — Liquefied Natural Gas or Other Cryogenic Flammable Gas. *(See Figure 5.9.12.)*

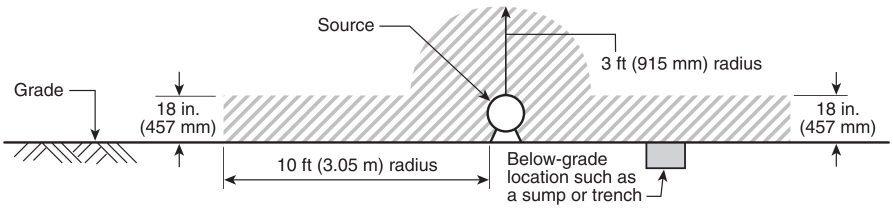
5.9.13 Routinely Operating Bleeds — Liquefied Natural Gas or Other Cryogenic Flammable Gas. *(See Figure 5.9.13.)*

5.9.14 Marine Terminal — Flammable Liquids. *(See Figure 5.9.14.)*

Table 5.9 Matrix of Diagrams Versus Material/Property/Application

Figure Number for Class I													
Division	Zone	Special Condition	VD > 1	VD < 1	Cryogenic	Indoor	Indoor, Poor Ventilation	Outdoor	Above Grade	At Grade	Size	Pressure	Flow
5.9.1(a)	5.10.1(a)		X					X		X	S/M	S/M	S/M
5.9.1(b)	5.10.1(b)		X					X	X		S/M	S/M	S/M
5.9.1(c)	5.10.1(c)		X			X				X	S/M	S/M	S/M
5.9.1(d)	5.10.1(d)		X			X			X		S/M	S/M	S/M
5.9.1(e)	5.10.1(e)		X			X				X	S/M	S/M	S/M
5.9.1(f)	5.10.1(f)		X				X			X	S/M	S/M	S/M
5.9.1(g)	5.10.1(g)		X					X		X	L	M/L	L
5.9.1(h)	5.10.1(h)		X					X	X		L	M/L	L
5.9.1(i)	5.10.1(i)		X				X		X		M/L	L	M/L
5.9.1(j)	5.10.1(j)		X			X			X		M/L	L	M/L
5.9.1(k)	5.10.1(k)		X					X	X	X	S/M	S/M	S/M
5.9.1(l)	5.10.1(l)		X					X	X	X	M/L	M/L	M/L
5.9.1(m)	5.10.1(m)		X					X	X	X	S/M	S/M	S/M
5.9.1(n)	5.10.1(n)		X			X			X	X	S/M	S/M	S/M
5.9.2(a)	5.10.2(a)		X		X			X		X	S/M	M/H	S/M
5.9.2(b)	5.10.2(b)		X		X			X	X		S/M	M/H	S/M
5.9.3(a)	5.10.3(a)	Product dryer	FL			X		X	X				
5.9.3(b)	5.10.3(b)	Filter press	FL			X			X				
5.9.4(a)	5.10.4(a)	Storage tank	FL					X		X	M/L	L	M/L
5.9.4(b)	5.10.4(b)	Tank car loading	FL					X	X				
5.9.4(c)	5.10.4(c)	Tank car loading	FL					X	X	X			
5.9.4(d)	5.10.4(d)	Tank truck loading	FL					X	X	X			
5.9.4(e)	5.10.4(e)	Tank car loading/tank truck loading	FL					X	X	X			
5.9.5	5.10.5	Tank car loading/tank truck loading	FL		X			X	X				
5.9.6	5.10.6	Drum filling station	FL			X		X	X				
5.9.7	5.10.7	Emergency basin	FL					X	X	X			
5.9.8(a)	5.10.8(a)	Liquid H_2 storage		X	X	X		X	X	X			
5.9.8(b)	5.10.8(b)	Gaseous H_2 storage		X		X		X	X	X			
5.9.9(a)	5.10.9(a)	Compressor shelter		X		X			X	X			
5.9.9(b)	5.10.9(b)	Compressor shelter		X			X		X	X			
5.9.10(a)	5.10.10(a)	Cryogenic storage			X			X	X	X			
5.9.10(b)	5.10.10(b)	Cryogenic storage			X			X	X	X			
5.9.10(c)	5.10.10(c)	Cryogenic storage			X			X	X	X			
5.9.11	5.10.11		LNG					X	X	X			
5.9.12	5.10.12		LNG			X			X	X			
5.9.13	5.10.13		LNG						X				
5.9.14	5.10.14	Marine terminal	FL			X		X	X				

Notes: FL: Flammable Liquid. LNG: Liquefied Natural Gas. X: Diagram Applies.
L: Large. M: Moderate. S: Small. H: High.



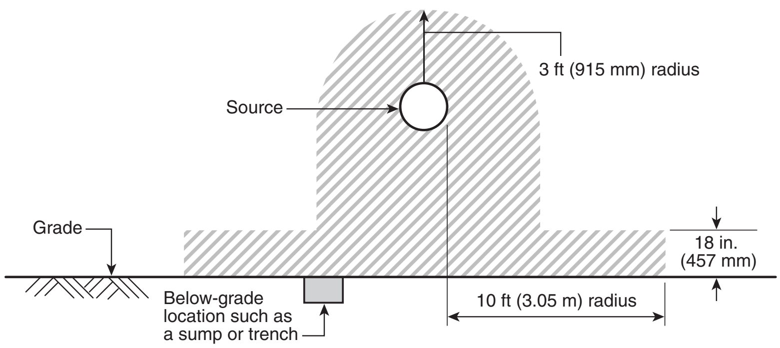
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Division 1

Division 2

FIGURE 5.9.1(a) Leakage Located Outdoors, at Grade. The material being handled is a flammable liquid.



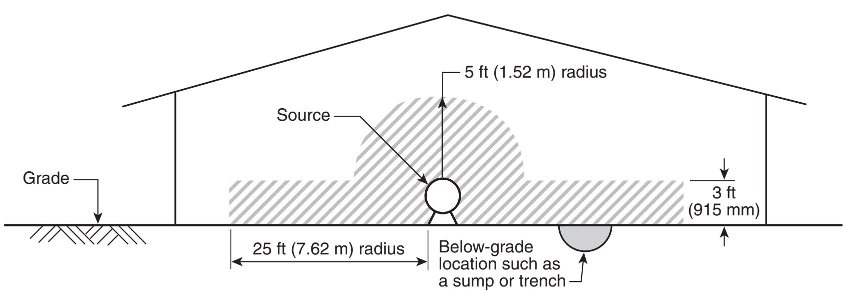
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Division 1

Division 2

FIGURE 5.9.1(b) Leakage Located Outdoors, above Grade. The material being handled is a flammable liquid.



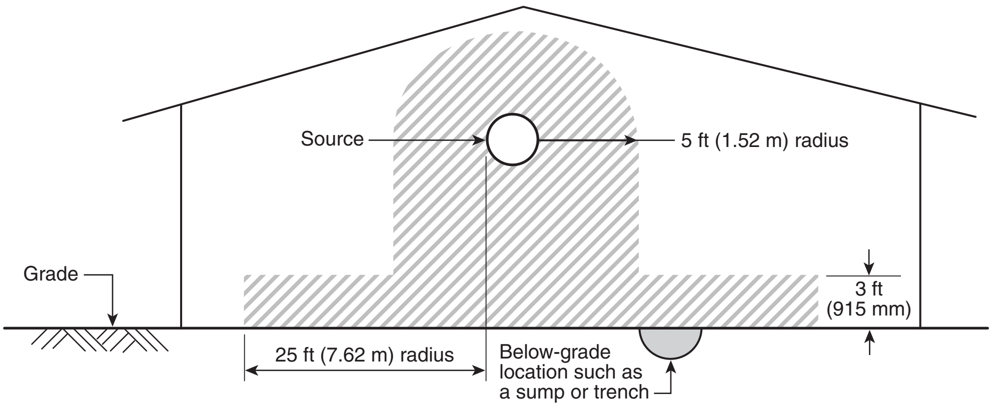
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Division 1

Division 2

FIGURE 5.9.1(c) Leakage Located Indoors, at Floor Level. Adequate ventilation is provided. The material being handled is a flammable liquid.



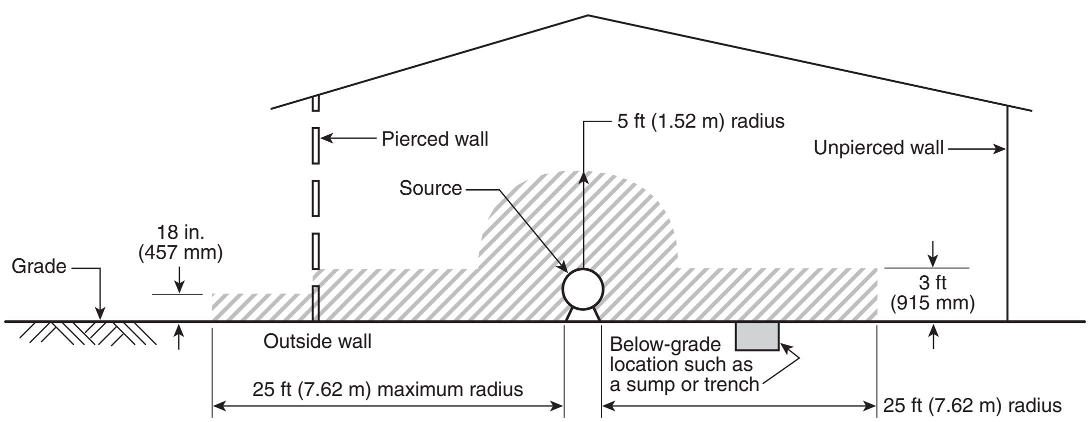
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Division 1

Division 2

FIGURE 5.9.1(d) Leakage Located Indoors, above Floor Level. Adequate ventilation is provided. The material being handled is a flammable liquid.



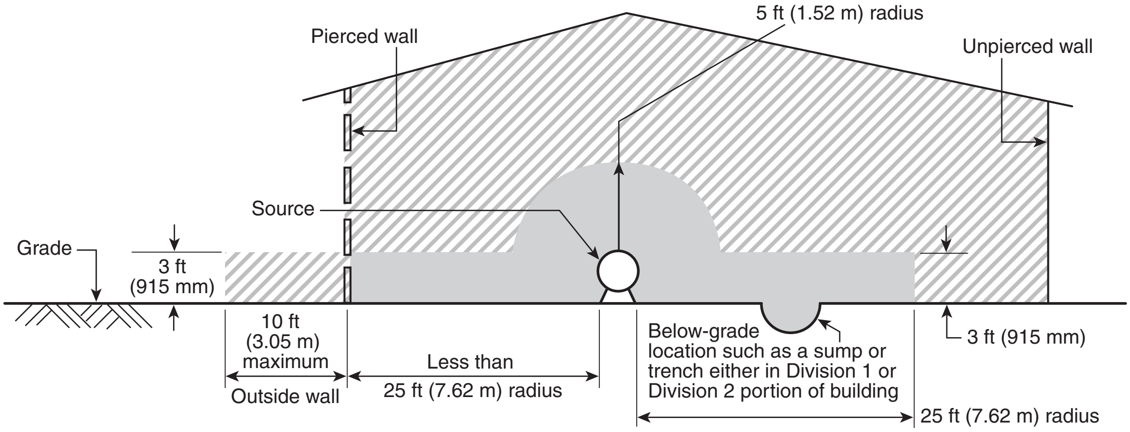
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Division 1

Division 2

FIGURE 5.9.1(e) Leakage Located Indoors, at Floor Level, Adjacent to an Opening in an Exterior Wall. Adequate ventilation is provided. The material being handled is a flammable liquid.



Note: If building is small compared to size of equipment, and leakage can fill the building, the entire building interior is classified Division 1.

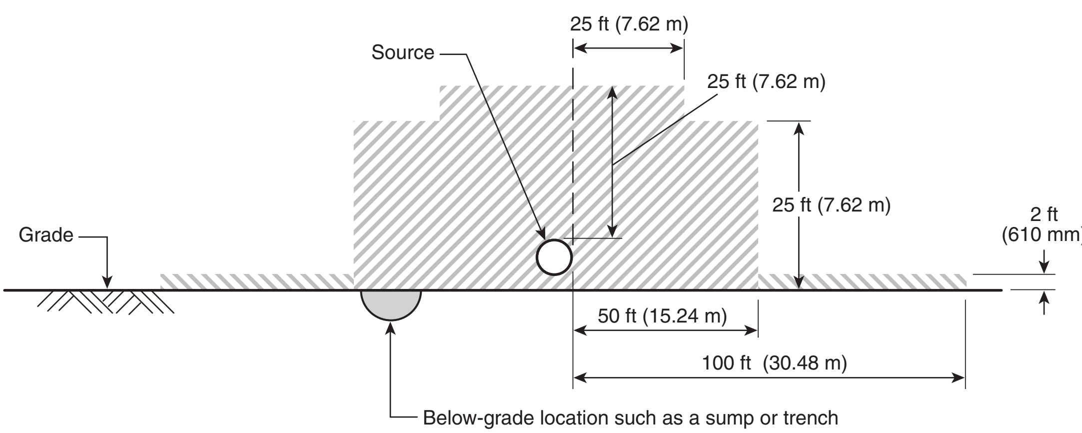
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Division 1

Division 2

FIGURE 5.9.1(f) Leakage Located Indoors, at Floor Level, Adjacent to an Opening in an Exterior Wall. Ventilation is not adequate. The material being handled is a flammable liquid.



Material: Flammable liquid

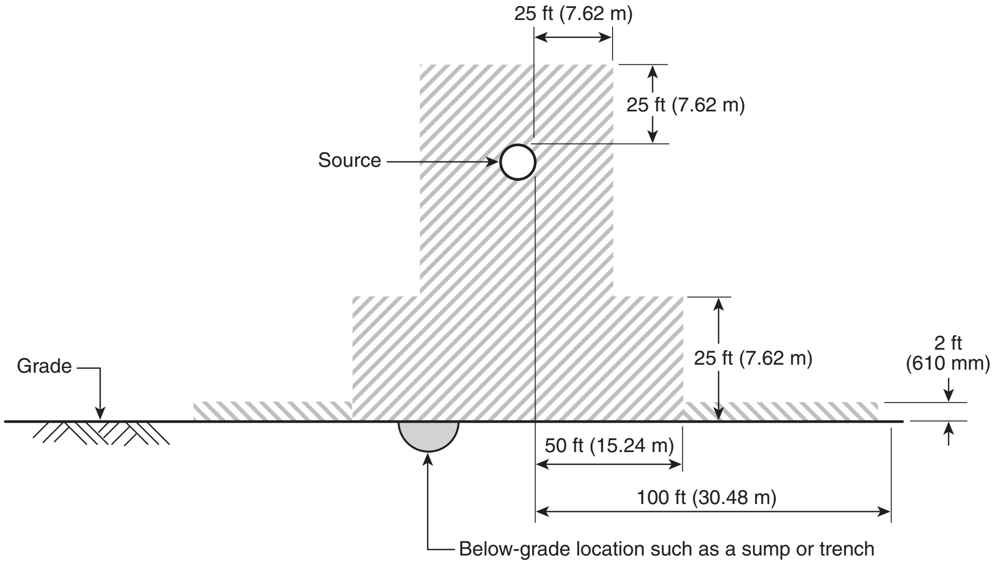
	Small/low	Moderate	Large/high
Process equipment size			X
Pressure		X	X
Flow rate			X

Division 1

Division 2

Additional Division 2 location. Use extra precaution where large release of volatile products may occur.

FIGURE 5.9.1(g) Leakage Located Outdoors, at Grade. The material being handled is a flammable liquid.



Material: Flammable liquid

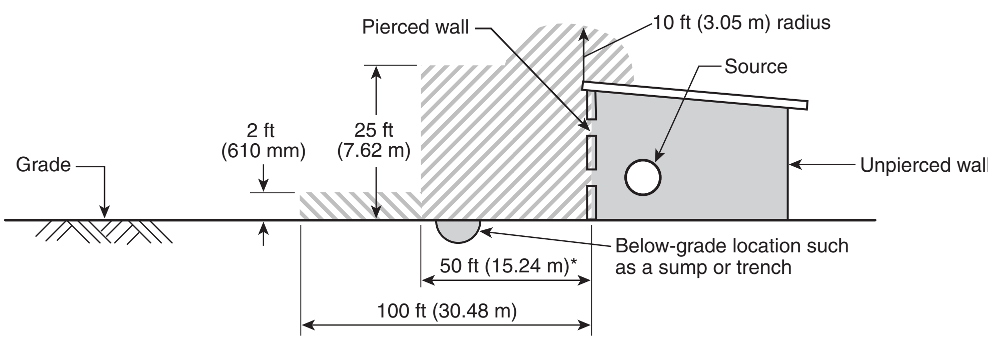
	Small/low	Moderate	Large/high
Process equipment size			X
Pressure		X	X
Flow rate			X

Division 1

Division 2

Additional Division 2 location. Use extra precaution where large release of volatile products may occur.

FIGURE 5.9.1(h) Leakage Located Outdoors, above Grade. The material being handled is a flammable liquid.



* "Apply" horizontal distances of 50 ft from the source of vapor or 10 ft beyond the perimeter of the building, whichever is greater, except that beyond unpierced vaportight walls the area is unclassified.

Material: Flammable liquid

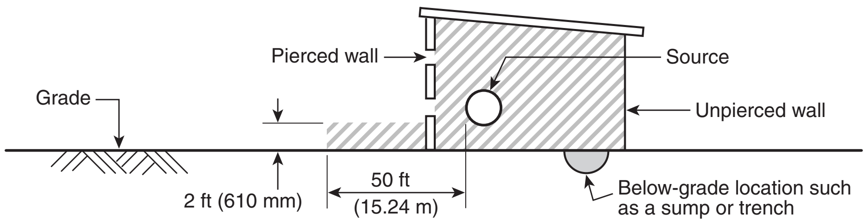
	Small/low	Moderate	Large/high
Process equipment size		X	X
Pressure			X
Flow rate		X	X

Division 1

Division 2

Additional Division 2 location. Use extra precaution where large release of volatile products may occur.

FIGURE 5.9.1(i) Leakage Located Indoors, Adjacent to an Opening in an Exterior Wall. Ventilation is not adequate. The material being handled is a flammable liquid.



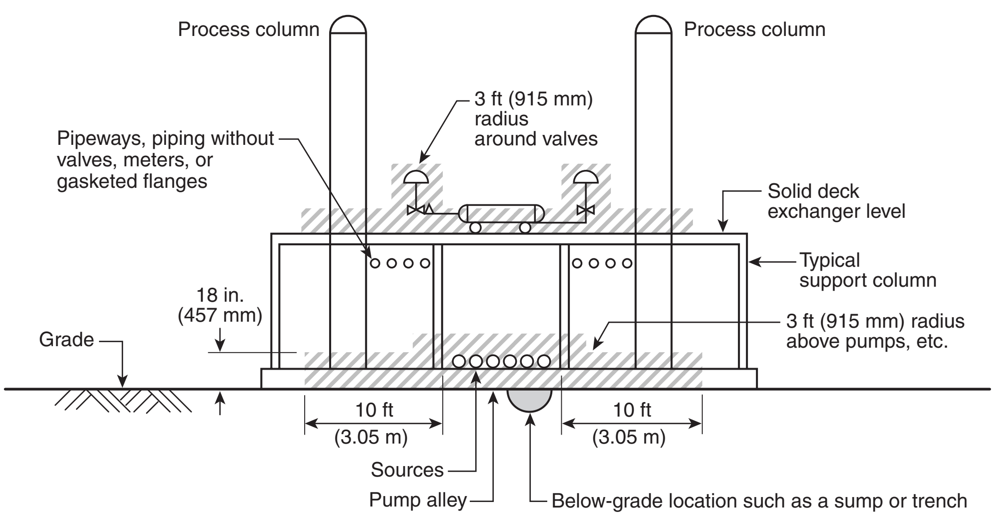
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size		X	X
Pressure			X
Flow rate		X	X

Division 1

Division 2

FIGURE 5.9.1(j) Leakage Located Indoors, Adjacent to an Opening in an Exterior Wall. Adequate ventilation is provided. The material being handled is a flammable liquid.



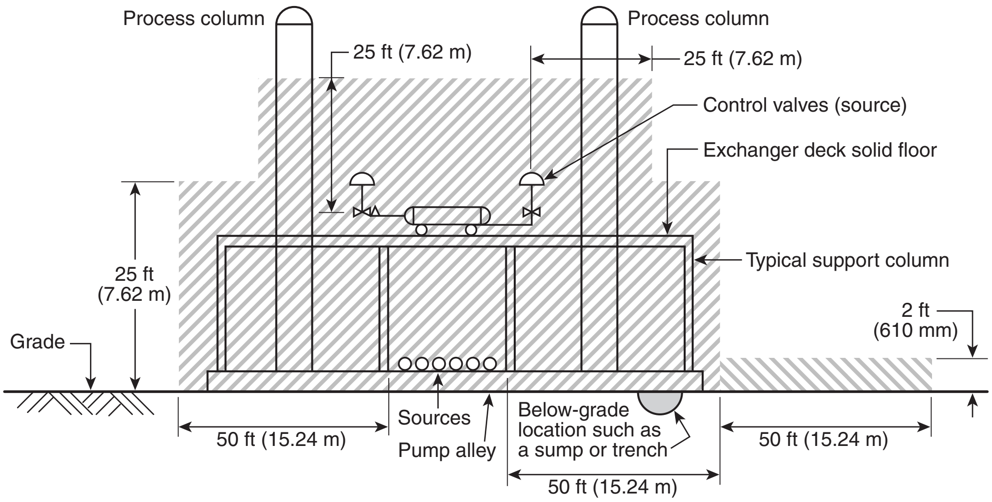
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Division 1

Division 2

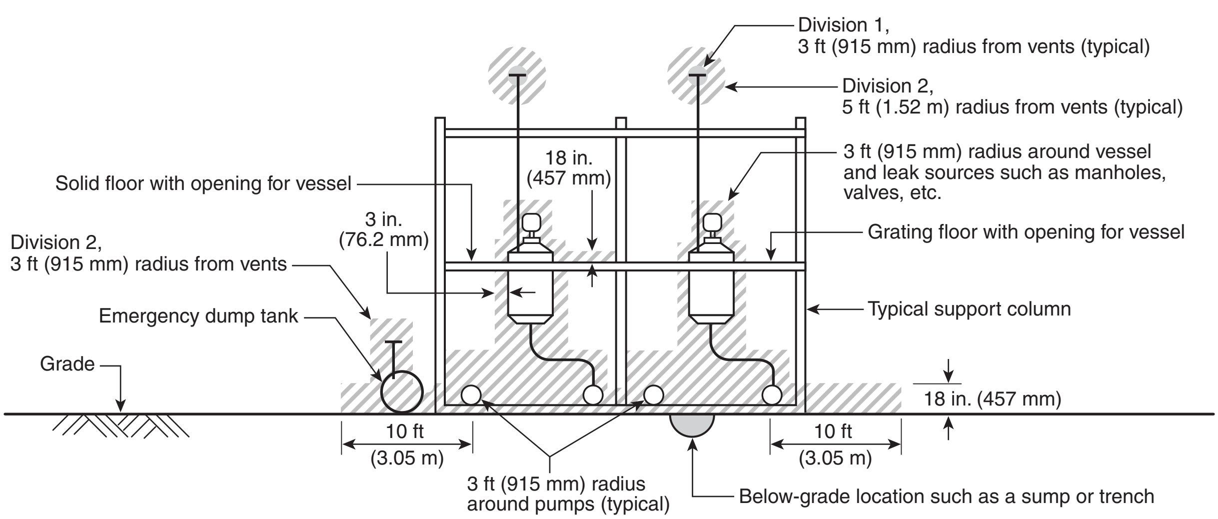
FIGURE 5.9.1(k) Leakage, Located Both at Grade and above Grade, in an Outdoor Process Area. The material being handled is a flammable liquid.



Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size		X	X
Pressure		X	X
Flow rate		X	X

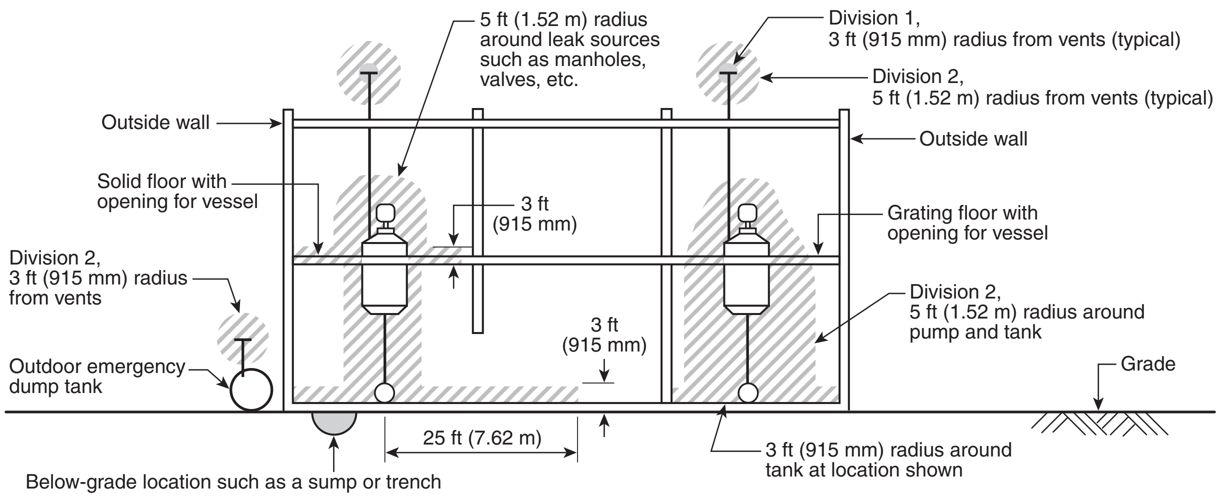
FIGURE 5.9.1(l) Multiple Sources of Leakage, Located Both at Grade and above Grade, in an Outdoor Process Area. The material being handled is a flammable liquid.



Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

FIGURE 5.9.1(m) Multiple Sources of Leakage, Located Both at and above Grade, in an Outdoor Process Area. The material being handled is a flammable liquid.



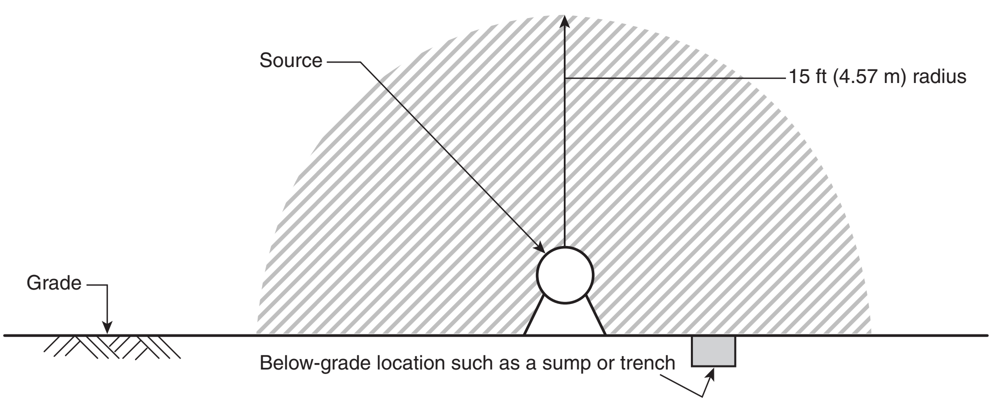
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Division 1

Division 2

FIGURE 5.9.1(n) Multiple Sources of Leakage, Located Both at and above Floor Level, in an Adequately Ventilated Building. The material being handled is a flammable liquid.



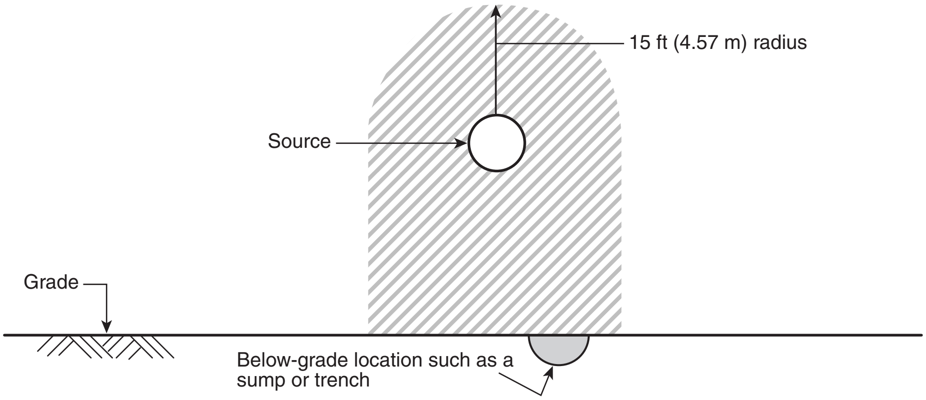
Material: Flammable liquid, liquefied flammable gas, compressed flammable gas, and cryogenic liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure		X	X
Flow rate	X	X	

Division 1

Division 2

FIGURE 5.9.2(a) Leakage Located Outdoors, at Grade. The material being handled could be a flammable liquid, a liquefied or compressed flammable gas, or a flammable cryogenic liquid.

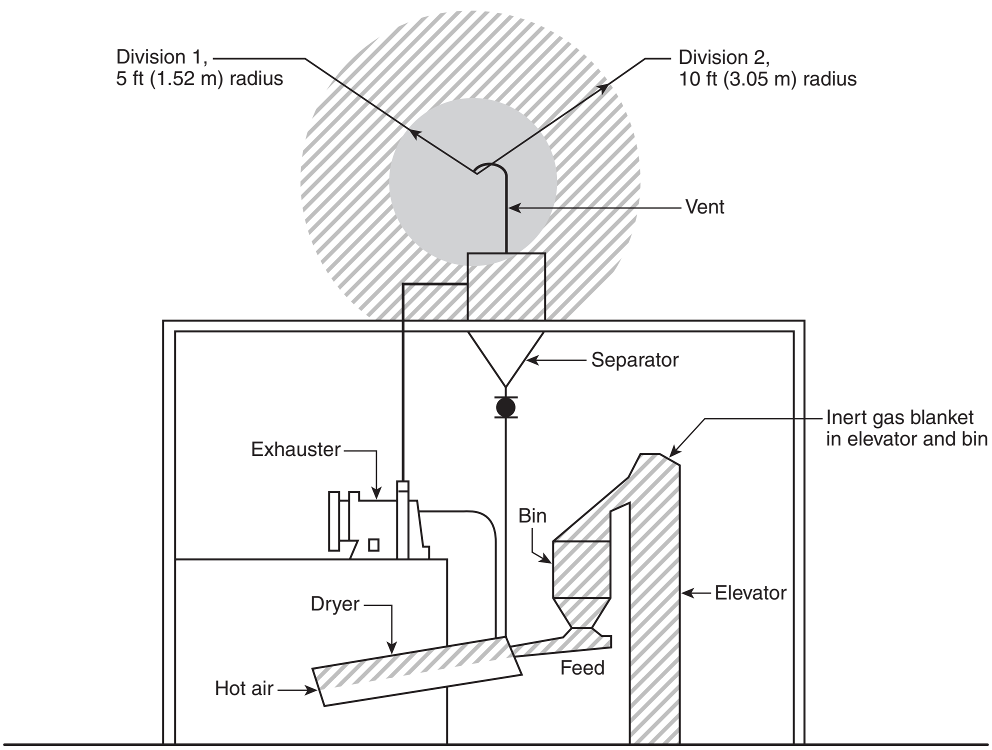


Material: Flammable liquid, liquefied flammable gas, compressed flammable gas, and cryogenic liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure		X	X
Flow rate	X	X	

Division 1
Division 2

FIGURE 5.9.2(b) Leakage Located Outdoors, above Grade. The material being handled could be a flammable liquid, a liquefied or compressed flammable gas, or a flammable cryogenic liquid.



Material: Solids wet with flammable liquid   Division 1   Division 2

FIGURE 5.9.3(a) Product Dryer Located in an Adequately Ventilated Building. The product dryer system is totally enclosed. The material being handled is a solid wet with a flammable liquid.

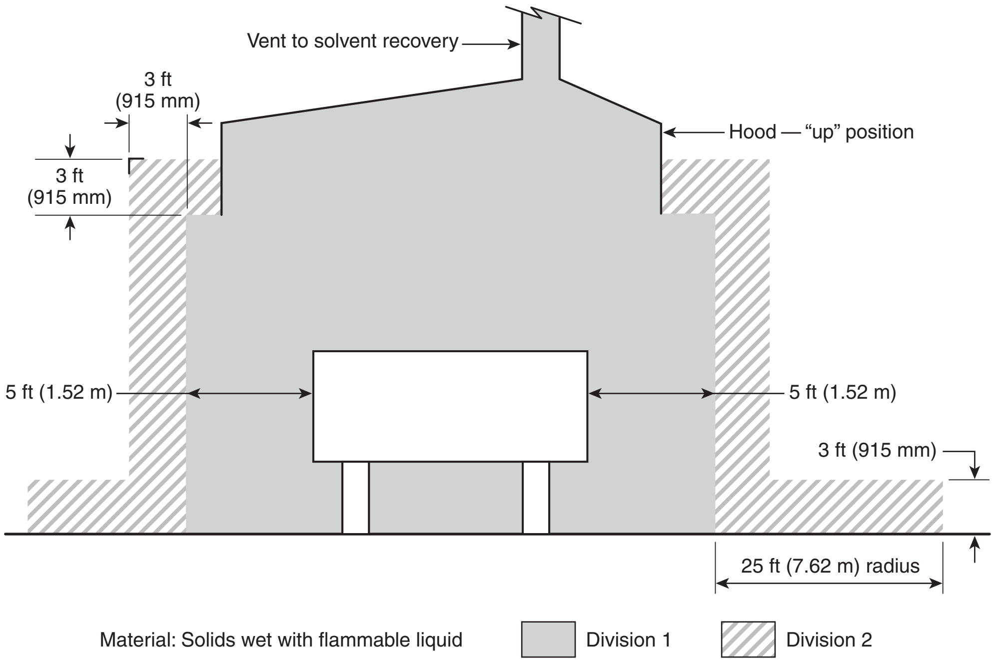
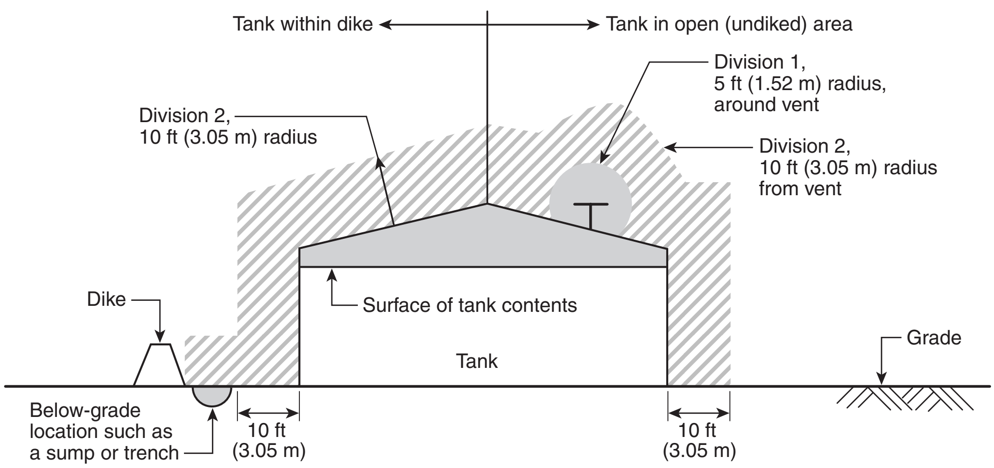


FIGURE 5.9.3(b) Plate and Frame Filter Press. Adequate ventilation is provided. The material being handled is a solid wet with a flammable liquid.



Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size		X	X
Pressure			X
Flow rate		X	X

Division 1

Division 2

FIGURE 5.9.4(a) Product Storage Tank Located Outdoors, at Grade. The material that is being stored is a flammable liquid.

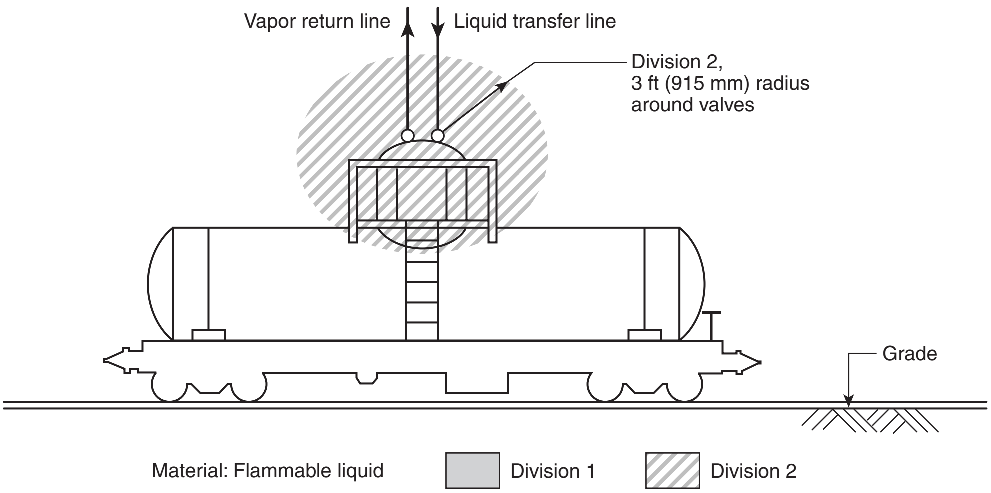


FIGURE 5.9.4(b) Tank Car Loading and Unloading via a Closed Transfer System. Material is transferred only through the dome. The material being transferred is a flammable liquid.

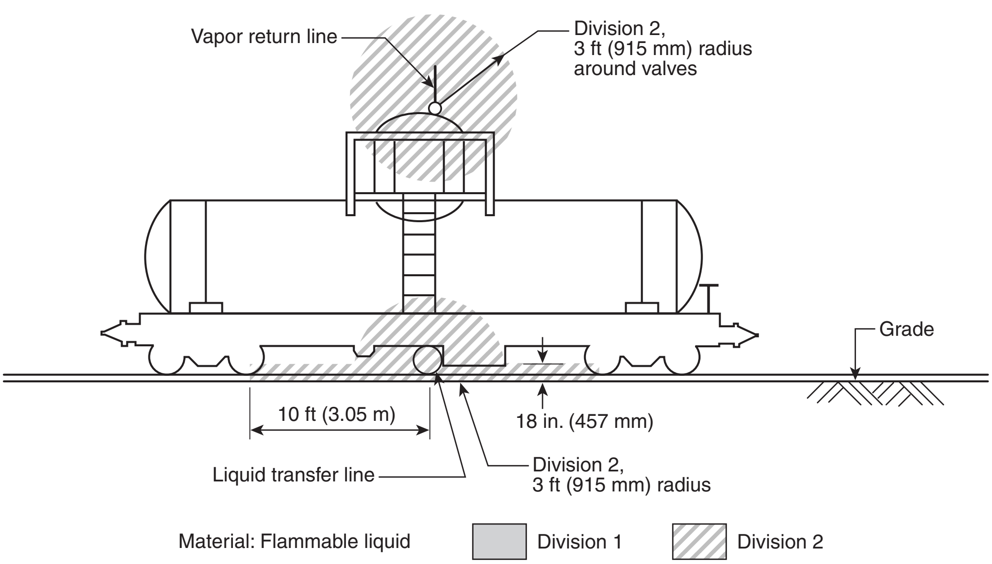


FIGURE 5.9.4(c) Tank Car Loading and Unloading via a Closed Transfer System. Material is transferred through the bottom fittings. The material being transferred is a flammable liquid.

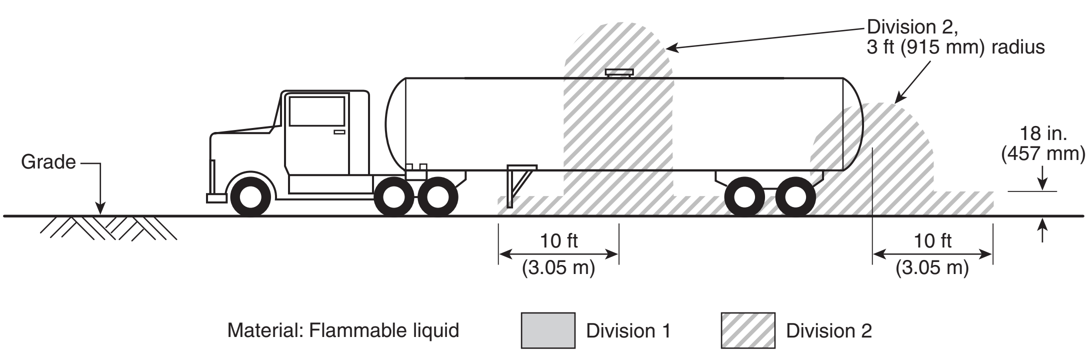


FIGURE 5.9.4(d) Tank Truck Loading and Unloading via a Closed Transfer System. Material is transferred through the bottom fittings. The material being transferred is a flammable liquid.

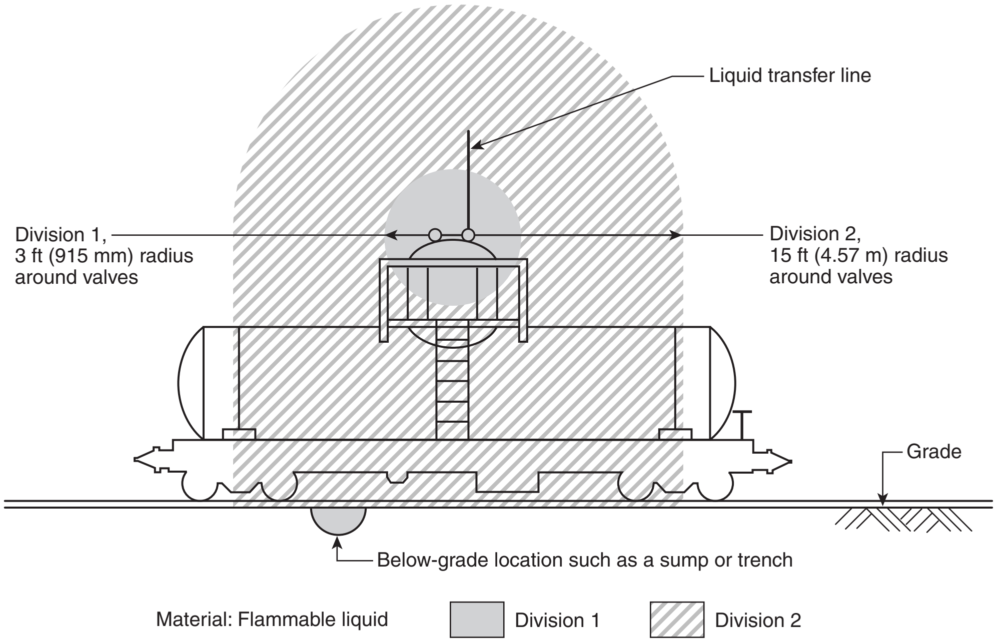


FIGURE 5.9.4(e) Tank Car (or Tank Truck) Loading and Unloading via an Open Transfer System. Material is transferred either through the dome or the bottom fittings. The material being transferred is a flammable liquid.

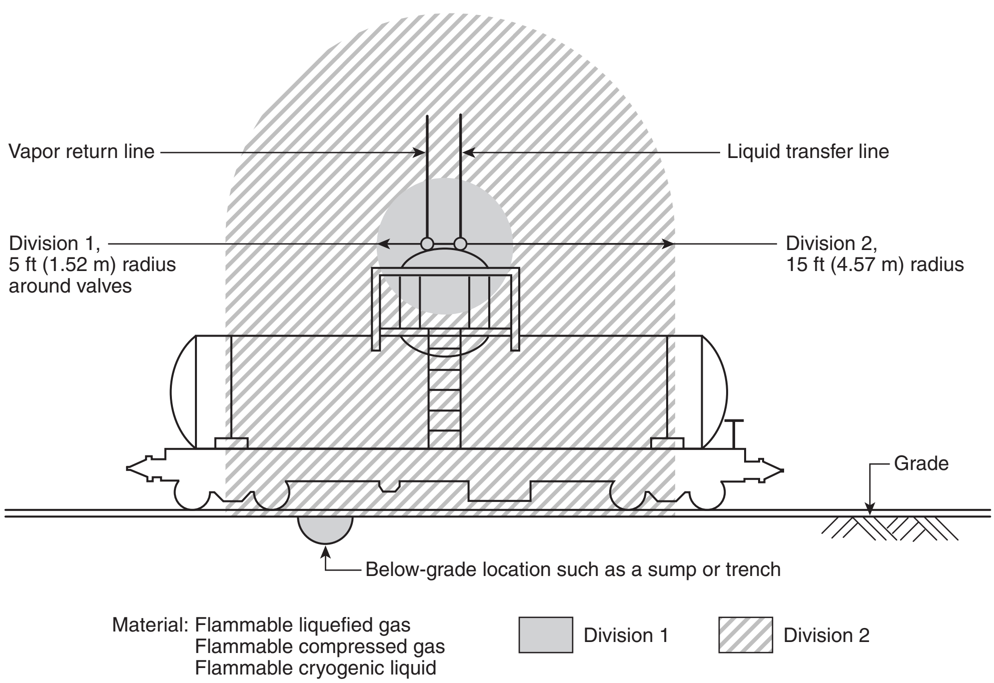


FIGURE 5.9.5 Tank Car (or Tank Truck) Loading and Unloading via a Closed Transfer System. Material is transferred only through the dome. The material being transferred may be a liquefied or compressed flammable gas or a flammable cryogenic liquid.

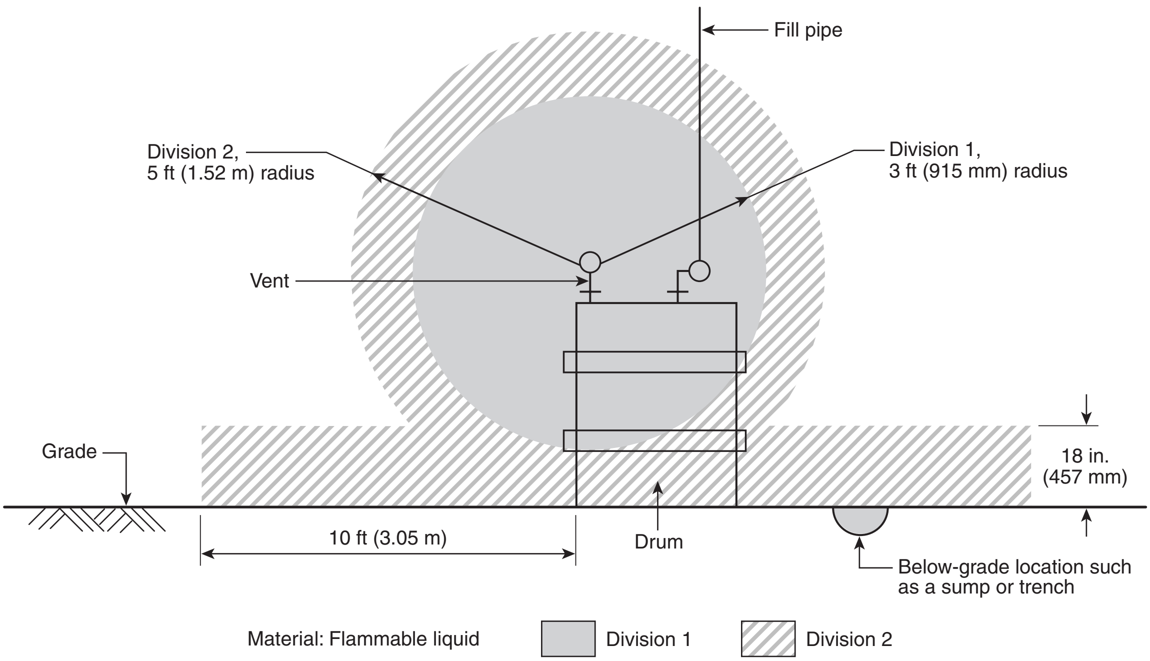


FIGURE 5.9.6 Drum Filling Station Located Either Outdoors or Indoors in an Adequately Ventilated Building. The material being handled is a flammable liquid.

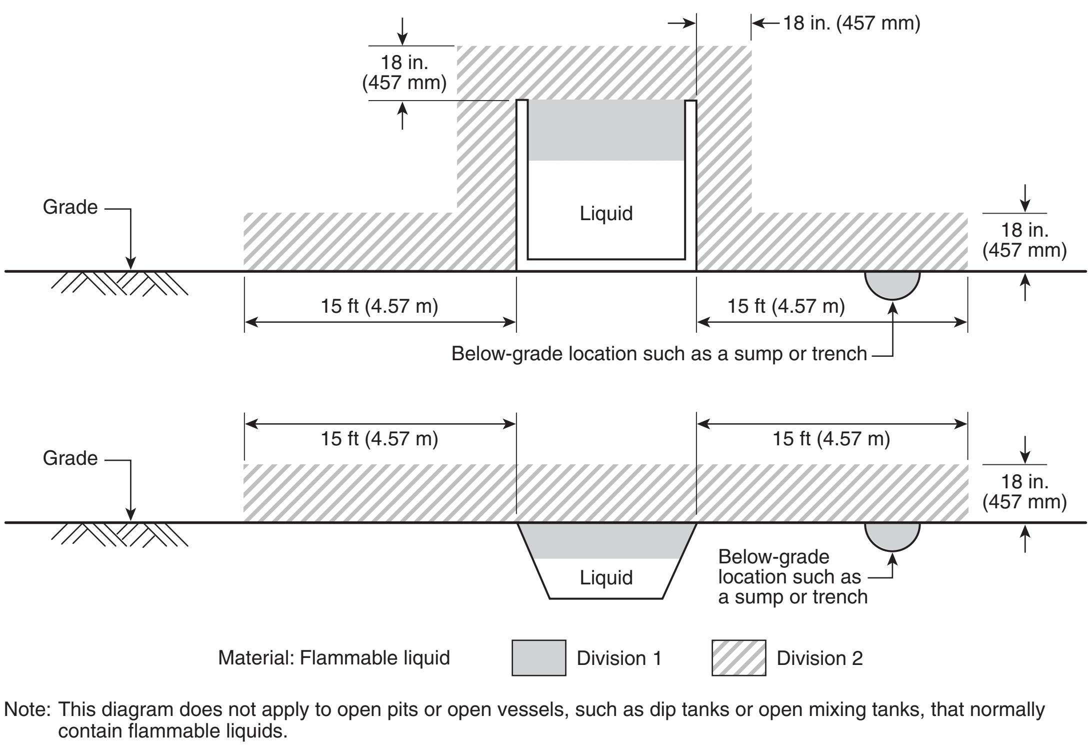


FIGURE 5.9.7 Emergency Impounding Basin or Oil/Water Separator and an Emergency or Temporary Drainage Ditch or Oil/Water Separator. The material being handled is a flammable liquid.

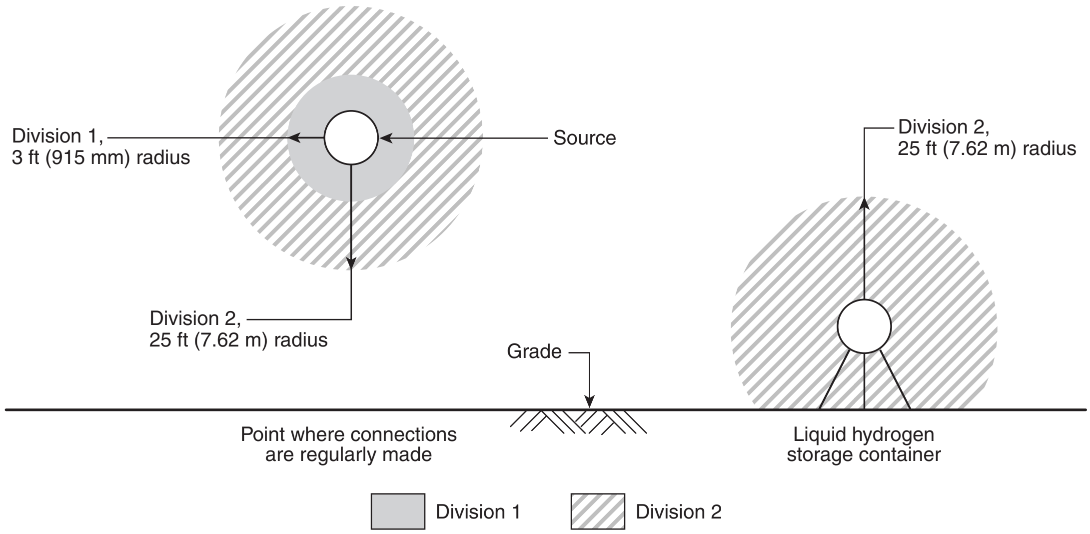


FIGURE 5.9.8(a) Liquid Hydrogen Storage Located Outdoors or Indoors in an Adequately Ventilated Building. This diagram applies to liquid hydrogen only.

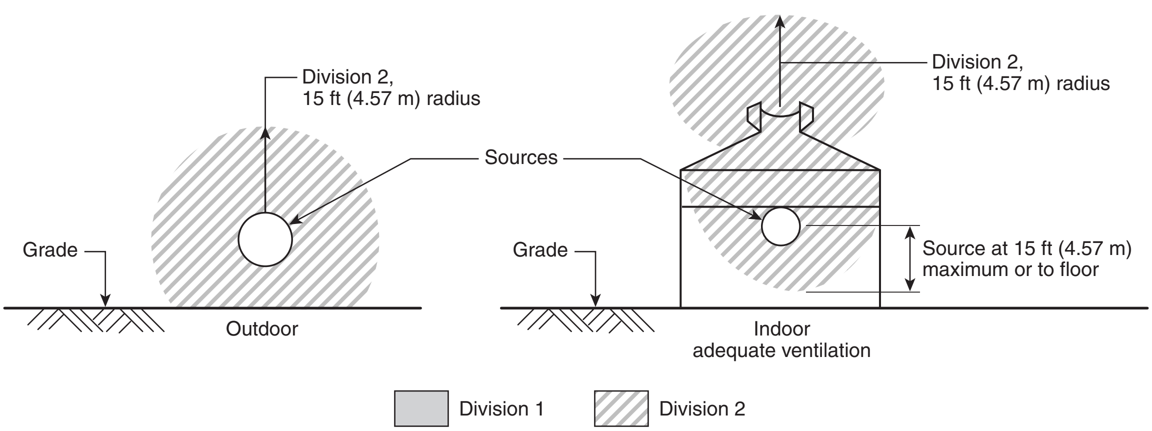


FIGURE 5.9.8(b) Gaseous Hydrogen Storage Located Outdoors or Indoors in an Adequately Ventilated Building. This diagram applies to gaseous hydrogen only.

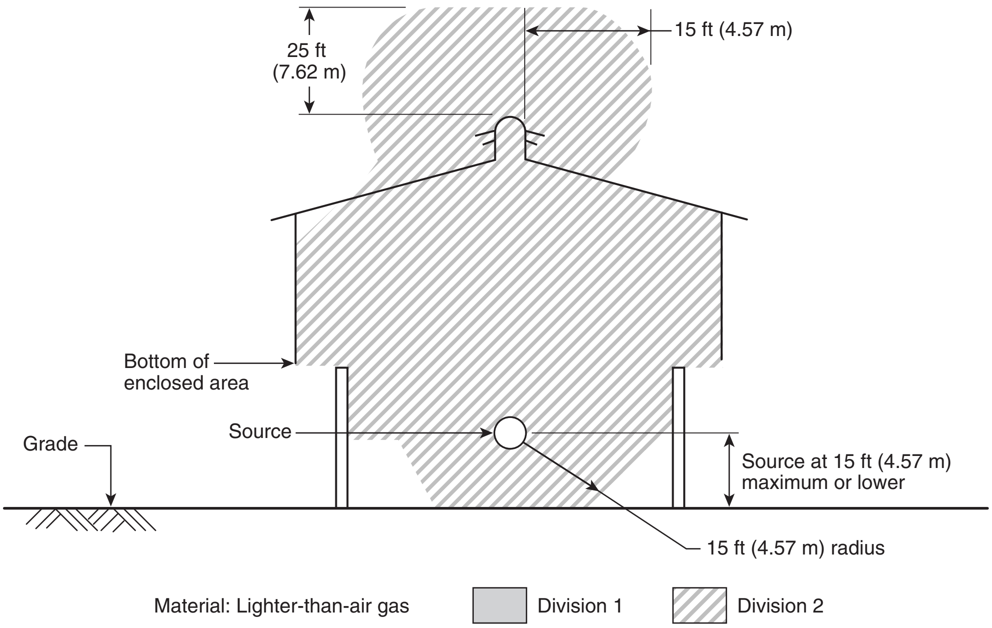


FIGURE 5.9.9(a) Adequately Ventilated Compressor Shelter. The material being handled is a lighter-than-air gas.

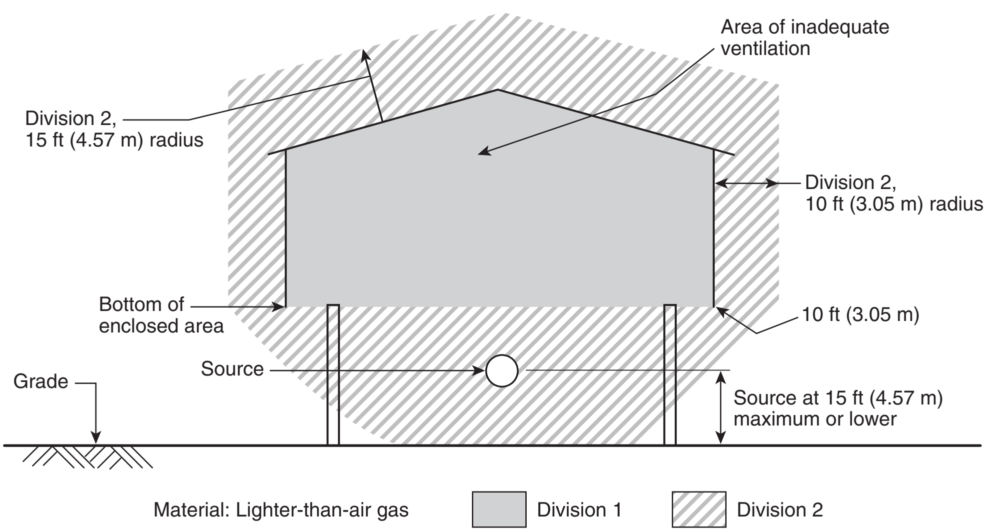


FIGURE 5.9.9(b) Inadequately Ventilated Compressor Shelter. The material being handled is a lighter-than-air gas.

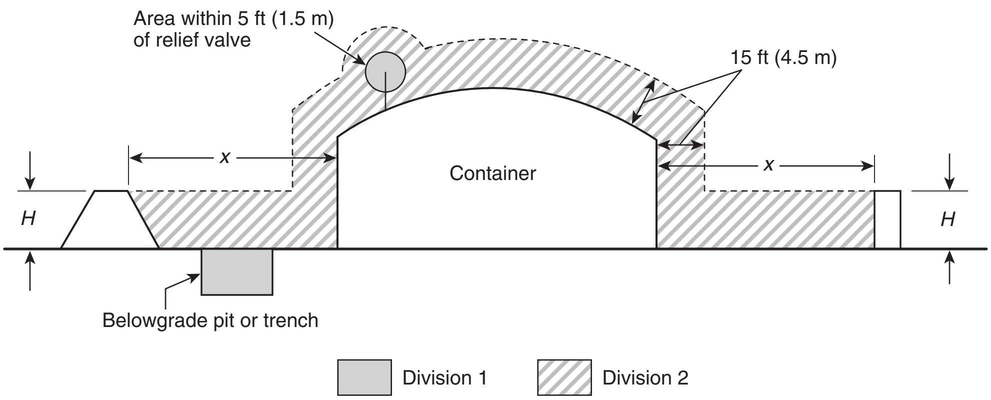


FIGURE 5.9.10(a) Tank for the Storage of Cryogenic and Other Cold Liquefied Flammable Gases. Dike height less than distance from container to dike ($H < x$). [59A: Figure A.10.6.2(a).]

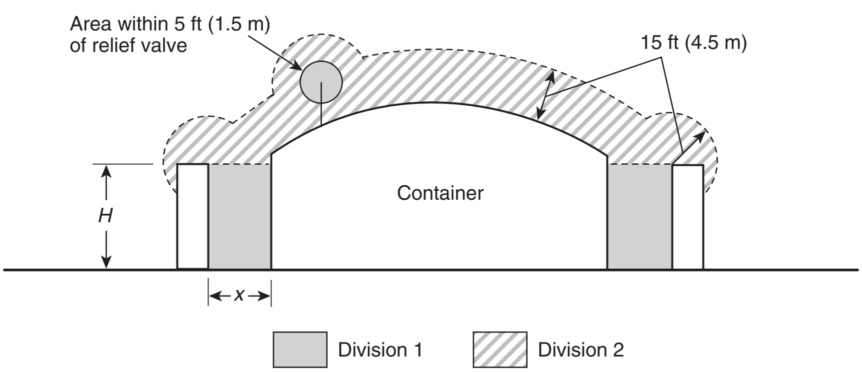


FIGURE 5.9.10(b) Tank for the Storage of Cryogenic and Other Cold Liquefied Flammable Gases. Dike height greater than distance from container to dike ($H > x$). [59A: Figure A.10.6.2(b)]

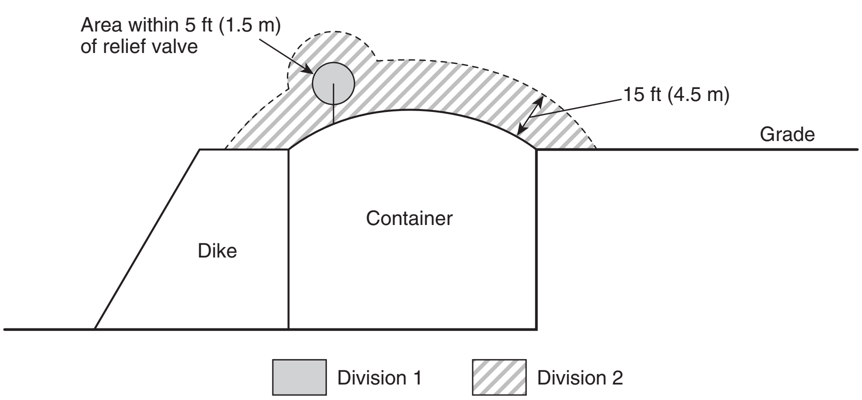


FIGURE 5.9.10(c) Tank for the Storage of Cryogenic and Other Cold Liquefied Flammable Gases. Container with liquid level below grade or top of dike. [59A: Figure A.10.6.2(c).]

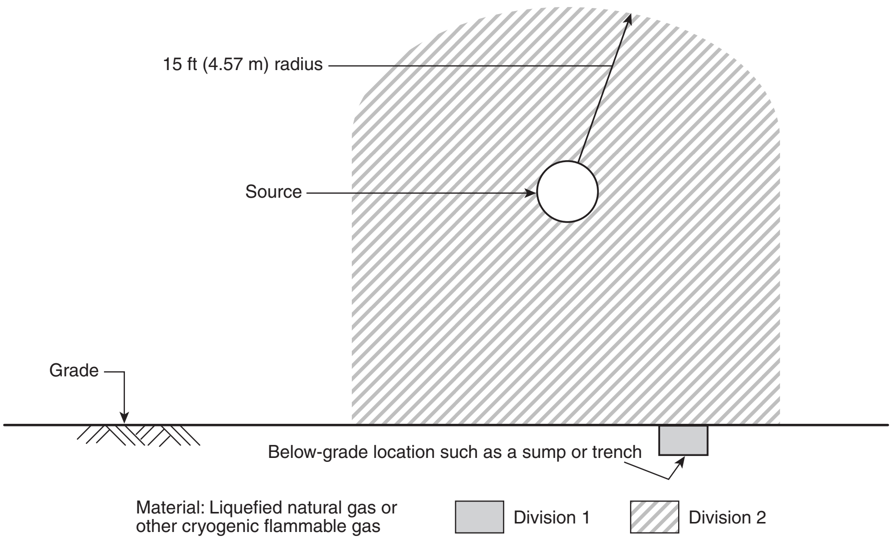


FIGURE 5.9.11 Source of Leakage from Equipment Handling Liquefied Natural Gas or Other Cold Liquefied Flammable Gas and Located Outdoors, at or above Grade.

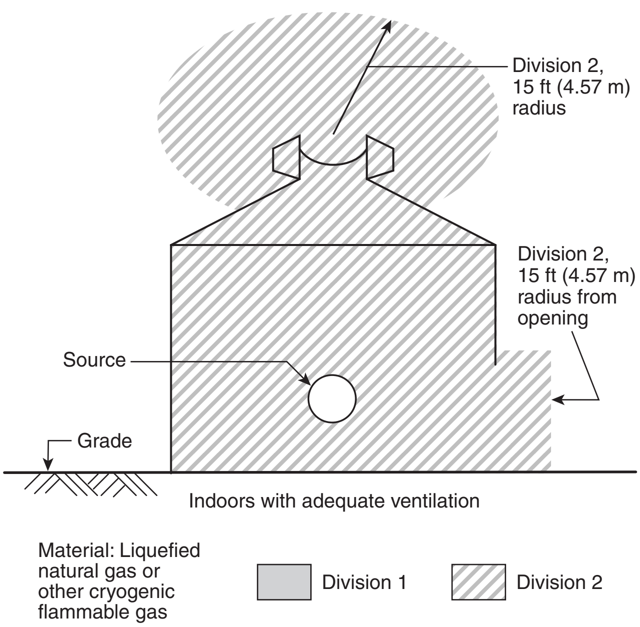


FIGURE 5.9.12 Source of Leakage from Equipment Handling Liquefied Natural Gas or Other Cold Liquefied Flammable Gas and Located Indoors in an Adequately Ventilated Building.

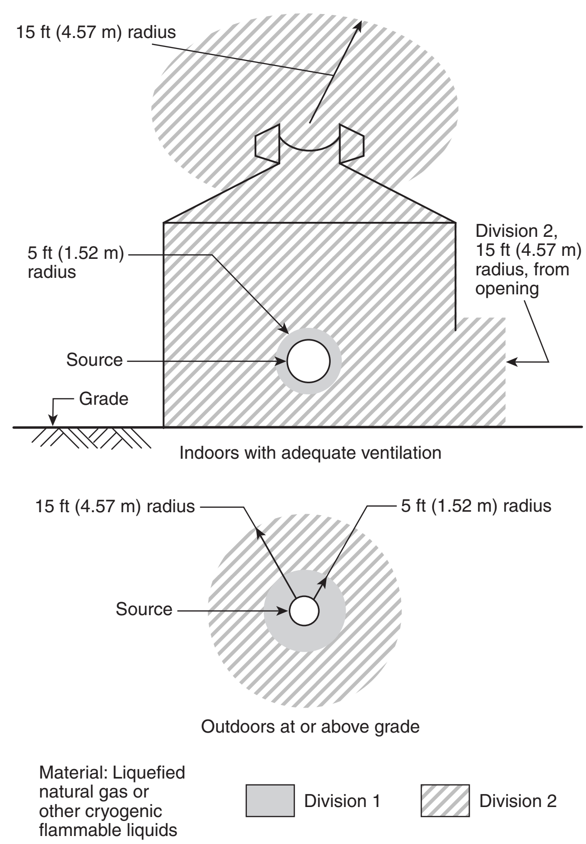
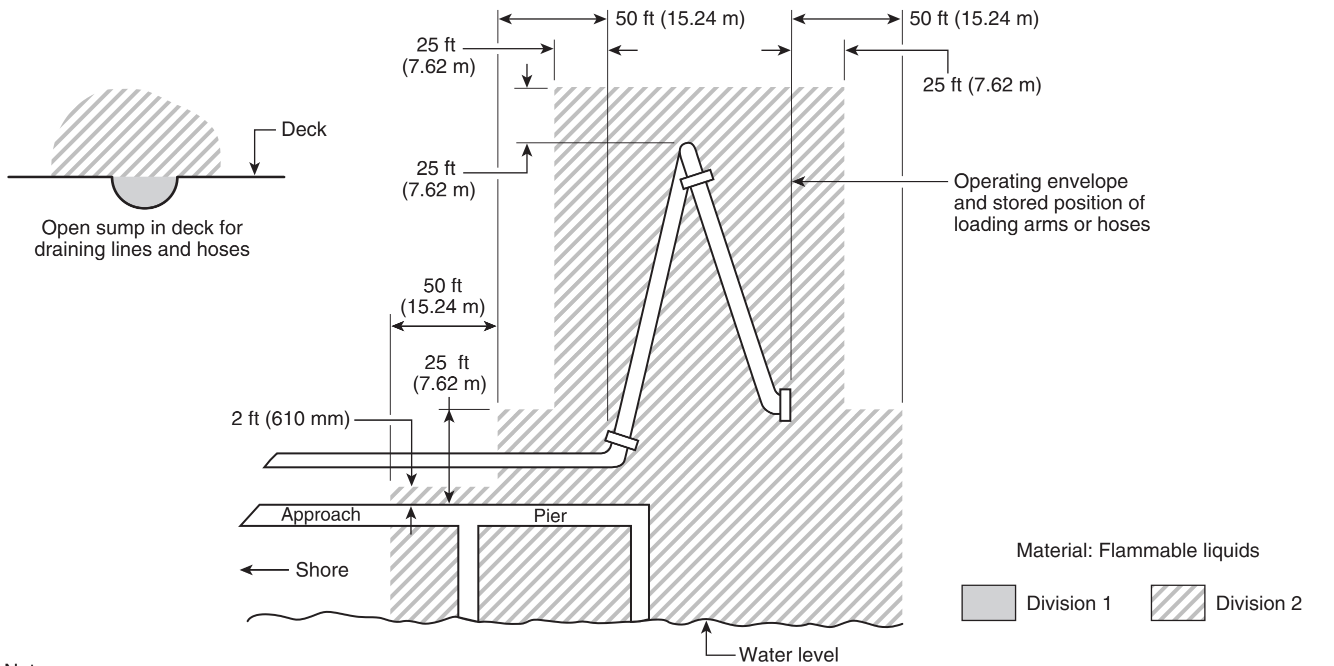


FIGURE 5.9.13 Classified Zones around Liquefied Natural Gas Routinely Operating Bleeds, Drips, Vents, and Drains Both Outdoors, at or above Grade, and Indoors, in an Adequately Ventilated Building. This diagram also applies to other cold liquefied flammable gases. (Source: Table 10.6.2 of NFPA 59A.)



Notes:
1. The "source of vapor" is the operating envelope and stored position of the outboard flange connection of the loading arm (or hose).
2. The berth area adjacent to tanker and barge cargo tanks is to be Division 2 to the following extent:
   (a) 25 ft (7.62 m) horizontally in all directions on the pier side from that portion of the hull containing cargo tanks.
   (b) From the water level to 25 ft (7.62 m) above the cargo tanks at their highest position.
3. Additional locations may have to be classified as required by the presence of other sources of flammable liquids or by Coast Guard or other regulations.

FIGURE 5.9.14 Classified Locations at a Marine Terminal Handling Flammable Liquids; Includes the Area Around the Stored Position of Loading Arms and Hoses.

5.10 Classification Diagrams for Class I, Zones. Class I, Zone diagrams include Figure 5.10.1(a) through Figure 5.10.1(n). Table 5.9 provides a summary of where each diagram is intended to apply.

5.10.1 Indoor and Outdoor Process — Flammable Liquids. *[See Figure 5.10.1(a), Figure 5.10.1(b), Figure 5.10.1(c), Figure 5.10.1(d), Figure 5.10.1(e), Figure 5.10.1(f), Figure 5.10.1(g), Figure 5.10.1(h), Figure 5.10.1(i), Figure 5.10.1(j), Figure 5.10.1(k), Figure 5.10.1(l), Figure 5.10.1(m), and Figure 5.10.1(n).]*

5.10.2 Outdoor Process — Flammable Liquid, Flammable Gas, Compressed Flammable Gas, or Cryogenic Liquid. *[See Figure 5.10.2(a) and Figure 5.10.2(b).]*

5.10.3 Product Dryer and Plate and Frame Filter Press — Solids Wet with Flammable Liquids. *[See Figure 5.10.3(a) and Figure 5.10.3(b).]*

5.10.4 Storage Tanks and Tank Vehicles — Flammable Liquids. *[See Figure 5.10.4(a), Figure 5.10.4(b), Figure 5.10.4(c), Figure 5.10.4(d), and Figure 5.10.4(e).]*

5.10.5 Tank Vehicle — Flammable Liquefied Gas, Flammable Compressed Gas, or Flammable Cryogenic Liquid. *(See Figure 5.10.5.)*

5.10.6 Indoor or Outdoor Drum Filling Station— Flammable Liquids. *(See Figure 5.10.6.)*

5.10.7 Emergency Impounding Basins, Emergency Drainage Ditches, or Oil/Water Separators — Flammable Liquids. *(See Figure 5.10.7.)*

5.10.8 Storage of Liquid or Gaseous Hydrogen. *[See Figure 5.10.8(a) and Figure 5.10.8(b).]*

5.10.9 Compressor Shelters — Lighter-than-Air Gas. *[See Figure 5.10.9(a) and Figure 5.10.9(b).]*

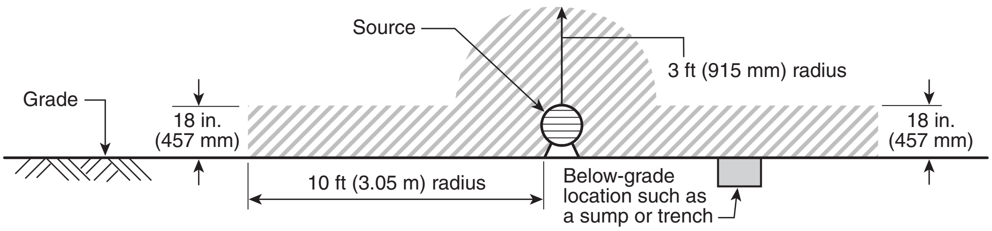
5.10.10 Storage Tanks for Cryogenic Liquids. *[See Figure 5.10.10(a), Figure 5.10.10(b), and Figure 5.10.10(c).]*

5.10.11 Outdoor Handling — Liquefied Natural Gas or Other Cryogenic Flammable Gas. *(See Figure 5.10.11.)*

5.10.12 Indoor Handling — Liquefied Natural Gas or Other Cryogenic Flammable Gas. *(See Figure 5.10.12.)*

5.10.13 Routinely Operating Bleeds — Liquefied Natural Gas or Other Cryogenic Flammable Gas. *(See Figure 5.10.13.)*

5.10.14 Marine Terminal — Flammable Liquids. *(See Figure 5.10.14.)*

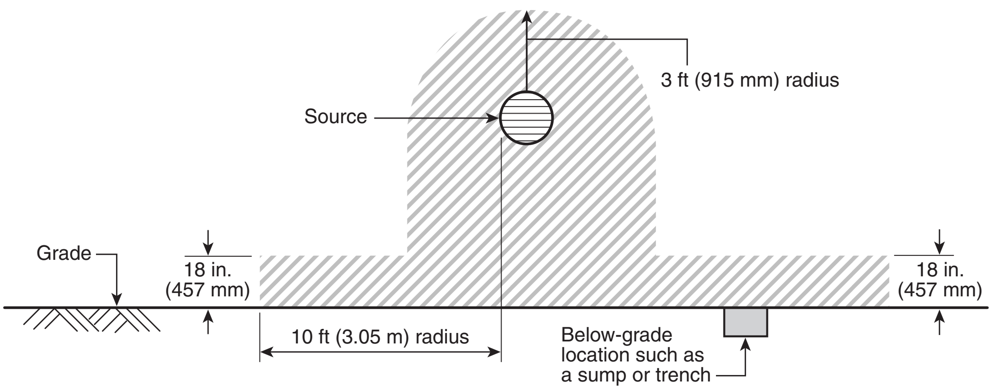


Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Zone 1
Zone 2

FIGURE 5.10.1(a) Leakage Located Outdoors, at Grade. The material being handled is a flammable liquid.

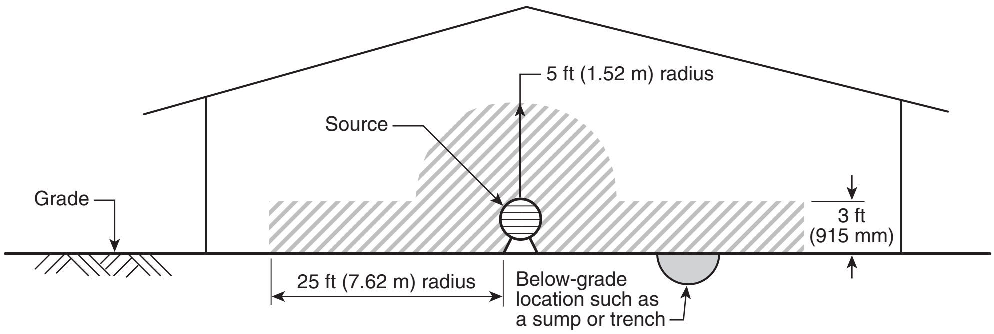


Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

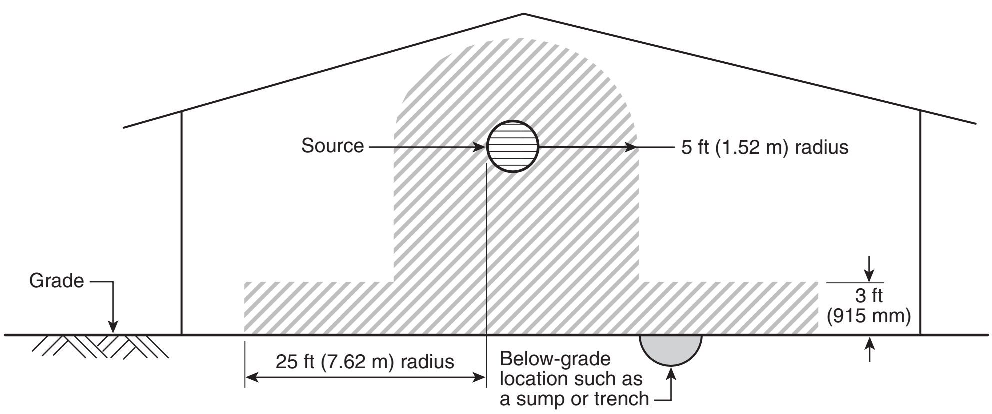
Zone 1
Zone 2

FIGURE 5.10.1(b) Leakage Located Outdoors, above Grade. The material being handled is a flammable liquid.



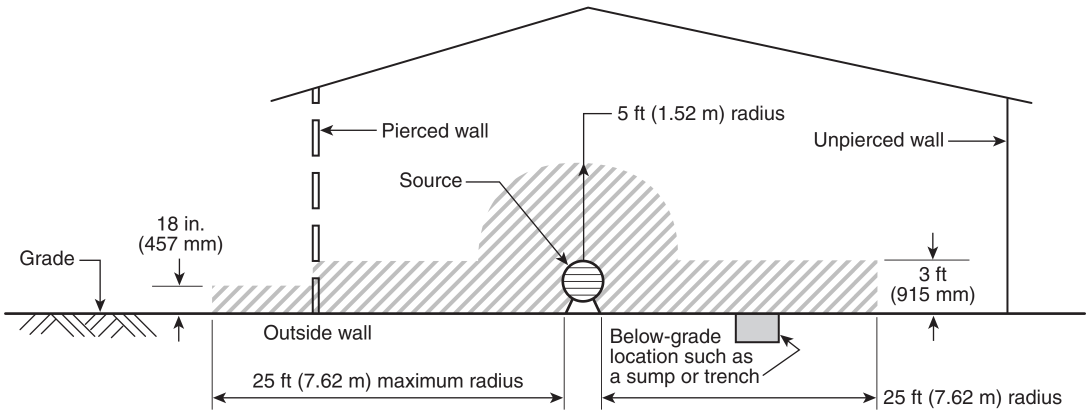
	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

FIGURE 5.10.1(c) Leakage Located Indoors, at Floor Level. Adequate ventilation is provided. The material being handled is a flammable liquid.



	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

FIGURE 5.10.1(d) Leakage Located Indoors, above Floor Level. Adequate ventilation is provided. The material being handled is a flammable liquid.



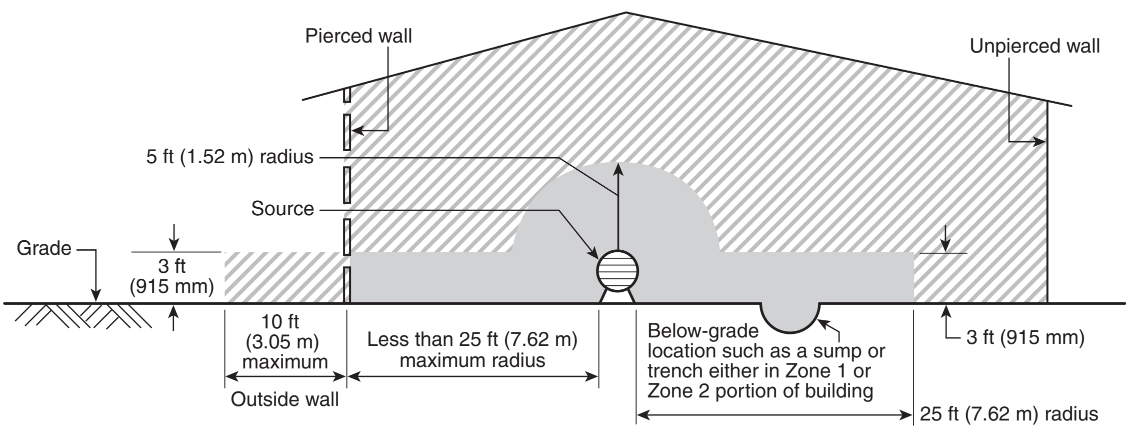
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Zone 1

Zone 2

FIGURE 5.10.1(e) Leakage Located Indoors, at Floor Level, Adjacent to an Opening in an Exterior Wall. Adequate ventilation is provided. The material being handled is a flammable liquid.



Note: If building is small compared to size of equipment, and leakage can fill the building, the entire building interior is classified Zone 1.

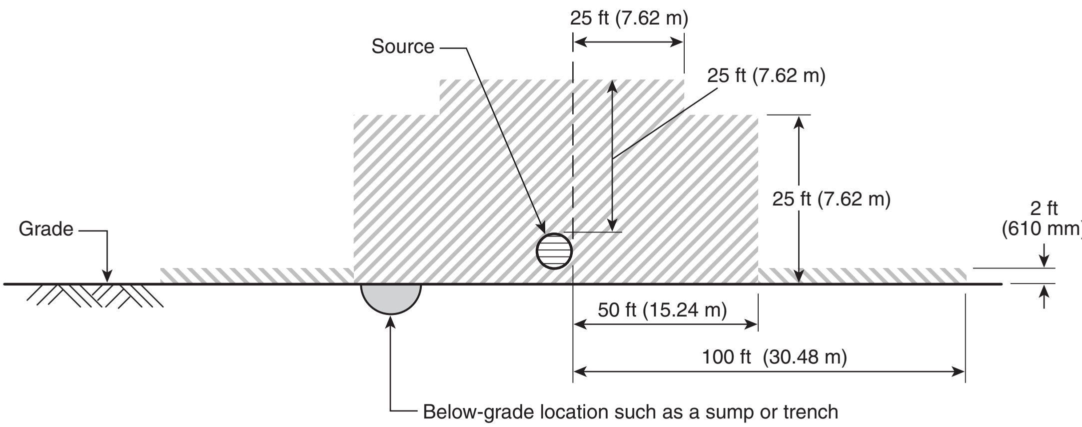
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Zone 1

Zone 2

FIGURE 5.10.1(f) Leakage Located Indoors, at Floor Level, Adjacent to an Opening in an Exterior Wall. Ventilation is not adequate. The material being handled is a flammable liquid.



Material: Flammable liquid

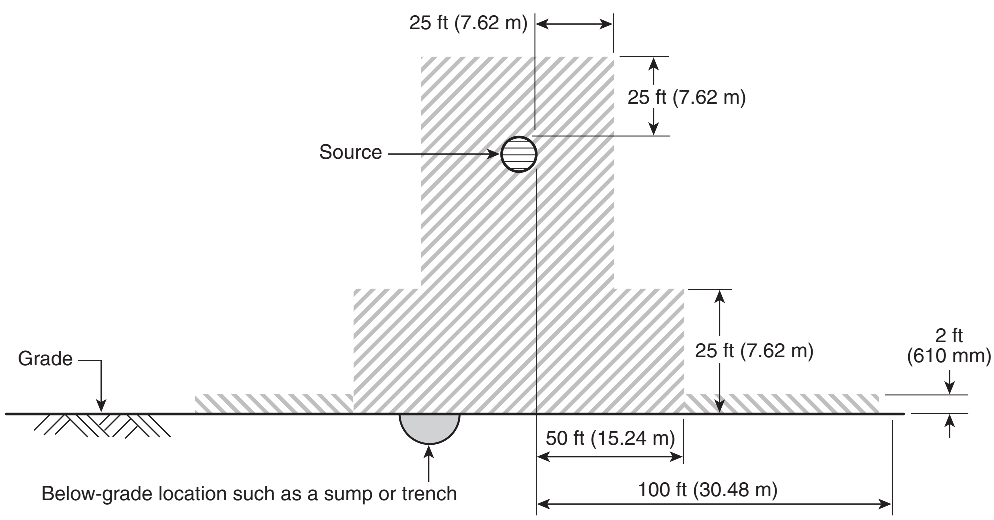
	Small/low	Moderate	Large/high
Process equipment size			X
Pressure		X	X
Flow rate			X

Zone 1

Zone 2

Additional Zone 2 location. Use extra precaution where large release of volatile products may occur.

FIGURE 5.10.1(g) Leakage Located Outdoors, at Grade. The material being handled is a flammable liquid.



Material: Flammable liquid

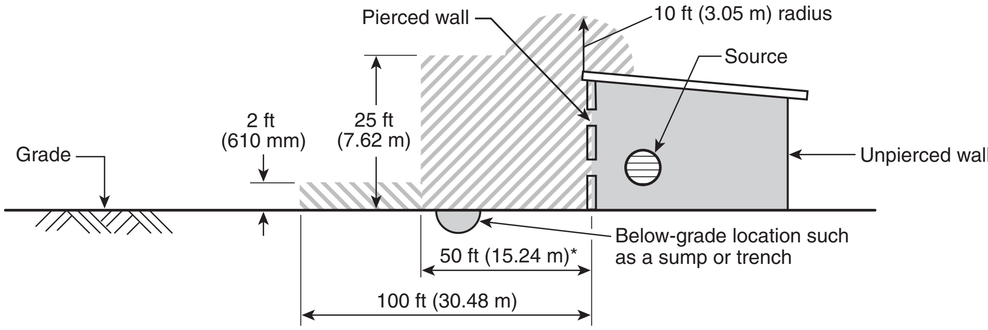
	Small/low	Moderate	Large/high
Process equipment size			X
Pressure		X	X
Flow rate			X

Zone 1

Zone 2

Additional Zone 2 location. Use extra precaution where large release of volatile products may occur.

FIGURE 5.10.1(h) Leakage Located Outdoors, above Grade. The material being handled is a flammable liquid.



* "Apply" horizontal distances of 50 ft from the source of vapor or 10 ft beyond the perimeter of the building, whichever is greater, except that beyond unpierced vaportight walls the area is unclassified.

Material: Flammable liquid

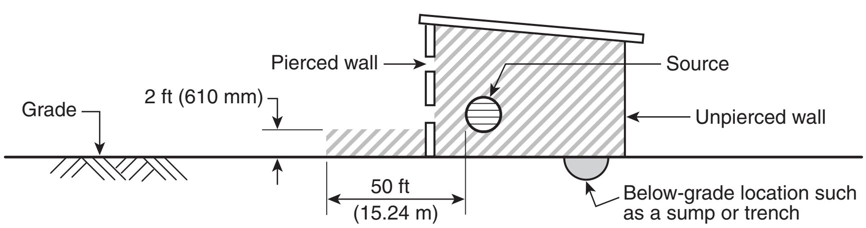
	Small/low	Moderate	Large/high
Process equipment size		X	X
Pressure			X
Flow rate		X	X

Zone 1

Zone 2

Additional Zone 2 location. Use extra precaution where large release of volatile products may occur.

FIGURE 5.10.1(i) Leakage Located Indoors, Adjacent to an Opening in an Exterior Wall. Ventilation is not adequate. The material being handled is a flammable liquid.



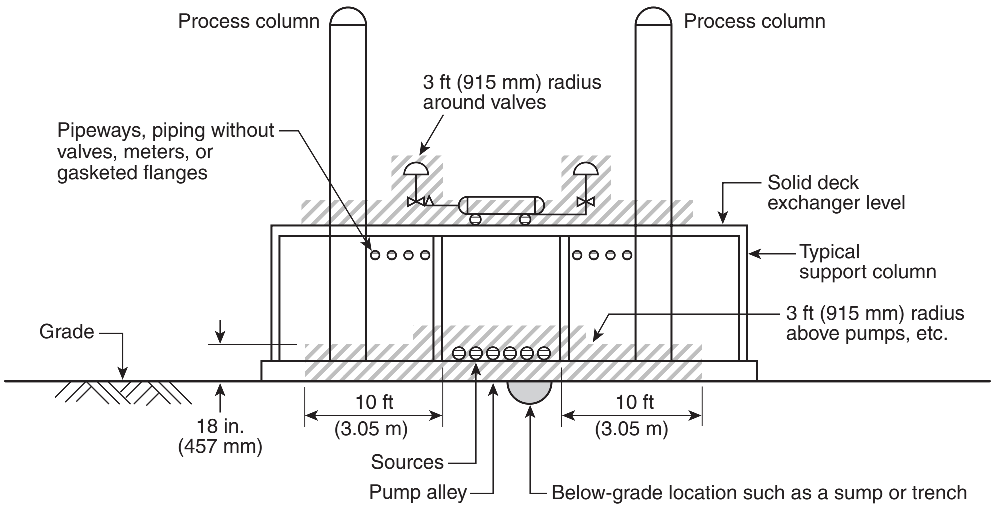
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size		X	X
Pressure			X
Flow rate		X	X

Zone 1

Zone 2

FIGURE 5.10.1(j) Leakage Located Indoors, Adjacent to an Opening in an Exterior Wall. Adequate ventilation is provided. The material being handled is a flammable liquid.



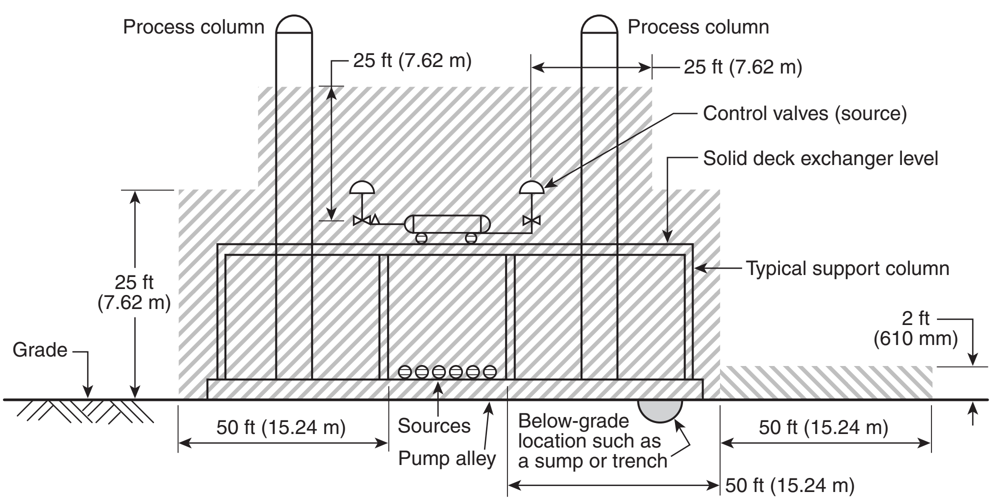
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Zone 1

Zone 2

FIGURE 5.10.1(k) Leakage, Located Both at Grade and above Grade, in an Outdoor Process Area. The material being handled is a flammable liquid.



Material: Flammable liquid

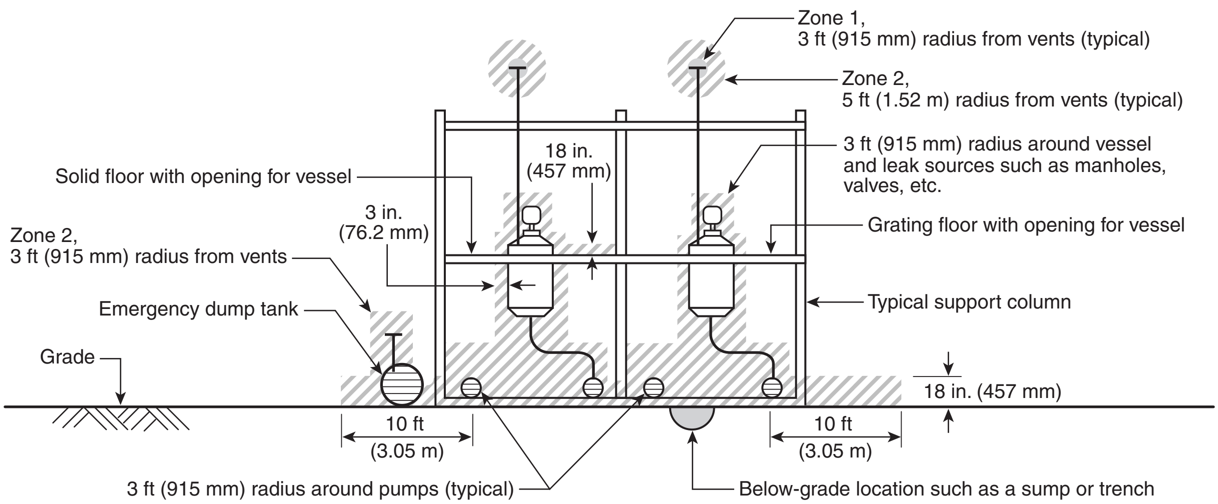
	Small/low	Moderate	Large/high
Process equipment size		X	X
Pressure		X	X
Flow rate		X	X

Zone 1

Zone 2

Additional Zone 2 area where release may be large

FIGURE 5.10.1(l) Multiple Sources of Leakage, Located Both at Grade and above Grade, in an Outdoor Process Area. The material being handled is a flammable liquid.



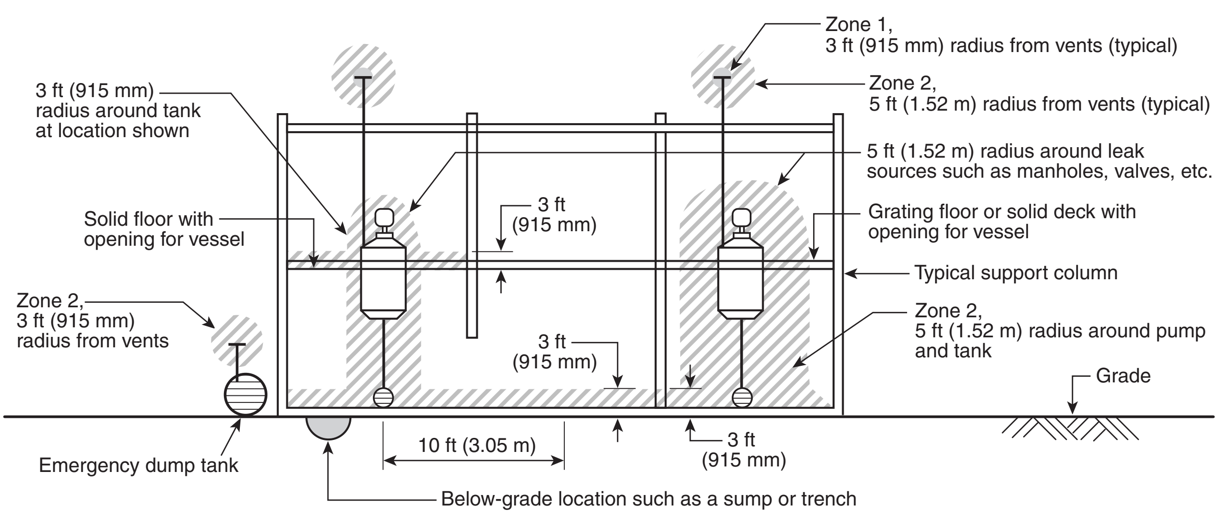
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Zone 1

Zone 2

FIGURE 5.10.1(m) Multiple Sources of Leakage, Located Both at and above Grade, in an Outdoor Process Area. The material being handled is a flammable liquid.



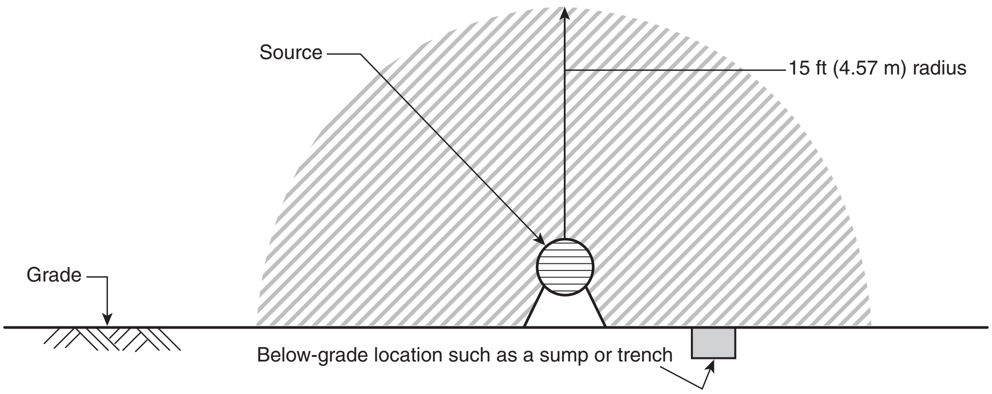
Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure	X	X	
Flow rate	X	X	

Zone 1

Zone 2

FIGURE 5.10.1(n) Multiple Sources of Leakage, Located Both at and above Floor Level, in an Adequately Ventilated Building. The material being handled is a flammable liquid.



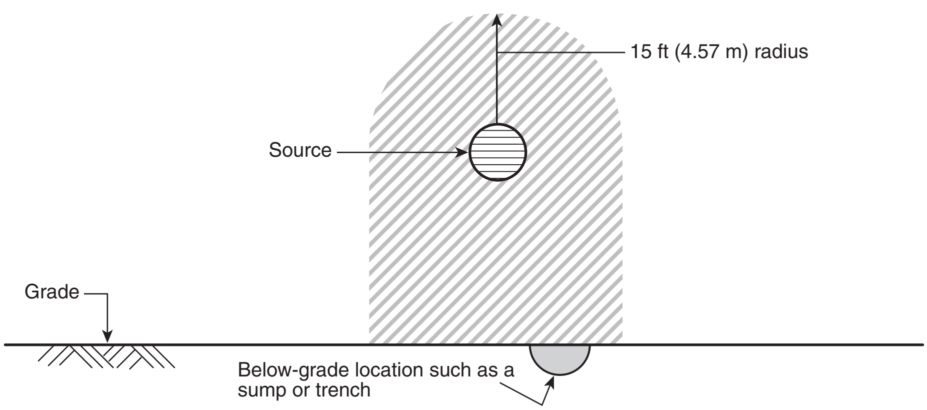
Material: Flammable liquid, liquefied flammable gas, compressed flammable gas, and cryogenic liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure		X	X
Flow rate	X	X	

Zone 1

Zone 2

FIGURE 5.10.2(a) Leakage Located Outdoors, at Grade. The material being handled could be a flammable liquid, a liquefied or compressed flammable gas, or a flammable cryogenic liquid.



Material: Flammable liquid, liquefied flammable gas, compressed flammable gas, and cryogenic liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure		X	X
Flow rate	X	X	

Zone 1

Zone 2

FIGURE 5.10.2(b) Leakage Located Outdoors, above Grade. The material being handled could be a flammable liquid, a liquefied or compressed flammable gas, or a flammable cryogenic liquid.

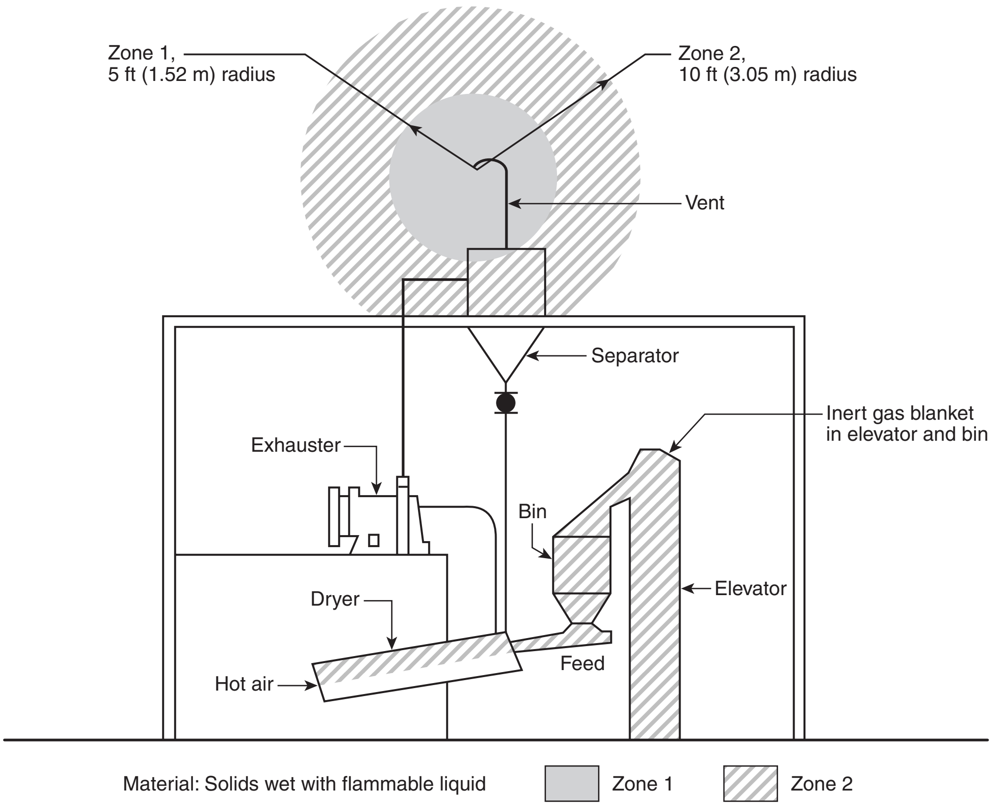


FIGURE 5.10.3(a) Product Dryer Located in an Adequately Ventilated Building. The product dryer system is totally enclosed. The material being handled is a solid wet with a flammable liquid.

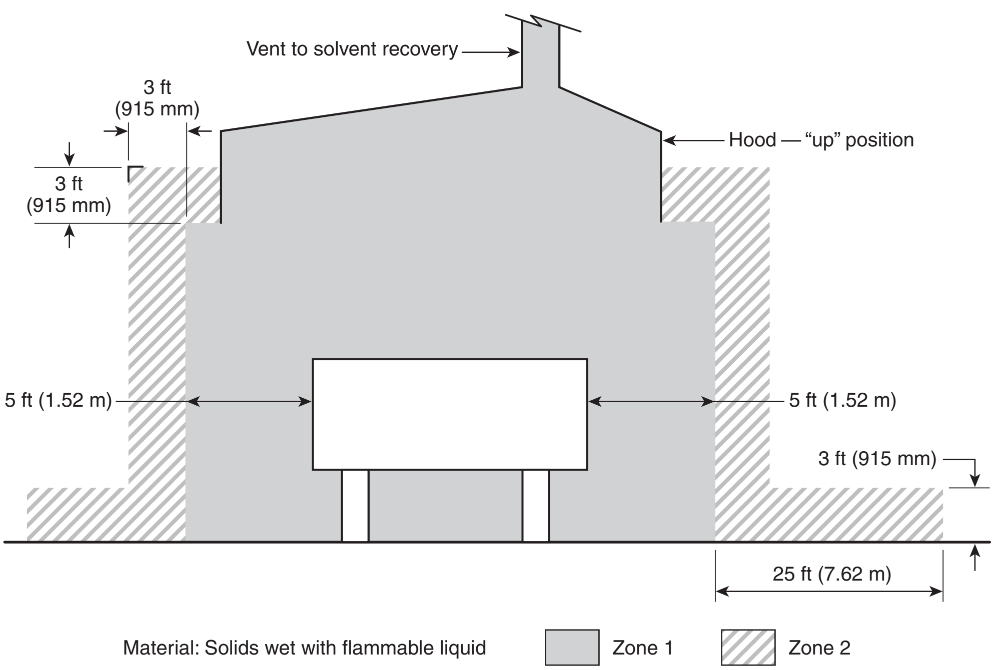
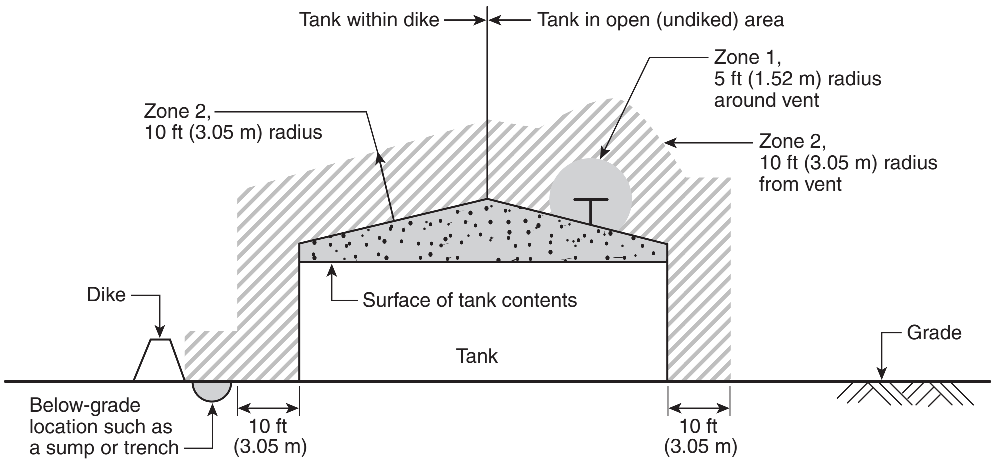


FIGURE 5.10.3(b) Plate and Frame Filter Press. Adequate ventilation is provided. The material being handled is a solid wet with a flammable liquid.



Material: Flammable liquid

	Small/low	Moderate	Large/high
Process equipment size		X	X
Pressure			X
Flow rate		X	X

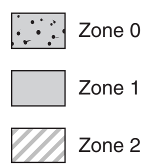


FIGURE 5.10.4(a) Product Storage Tank Located Outdoors, at Grade. The material being stored is a flammable liquid.

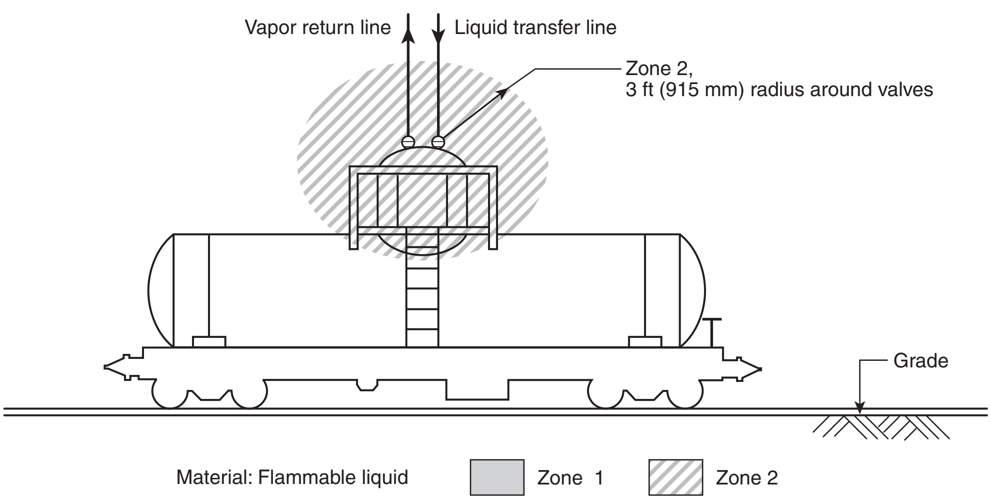


FIGURE 5.10.4(b) Tank Car Loading and Unloading via a Closed Transfer System. Material is transferred only through the dome. The material being transferred is a flammable liquid.

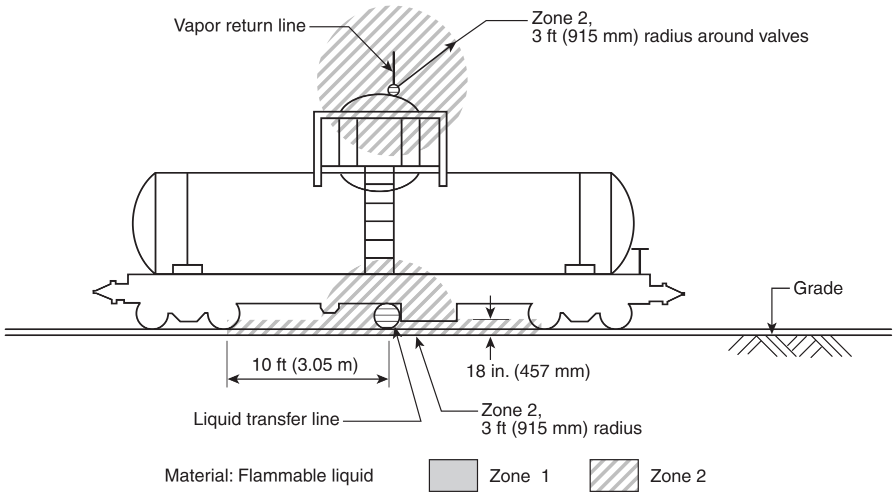


FIGURE 5.10.4(c) Tank Car Loading and Unloading via a Closed Transfer System. Material is transferred through the bottom fittings. The material being transferred is a flammable liquid.

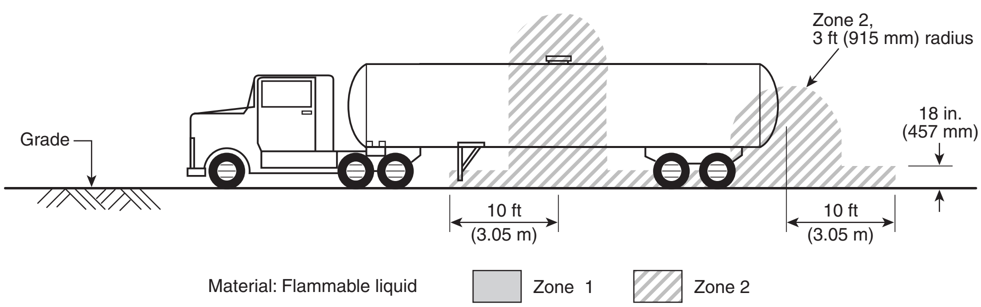


FIGURE 5.10.4(d) Tank Truck Loading and Unloading via a Closed Transfer System. Material is transferred through the bottom fittings. The material being transferred is a flammable liquid.

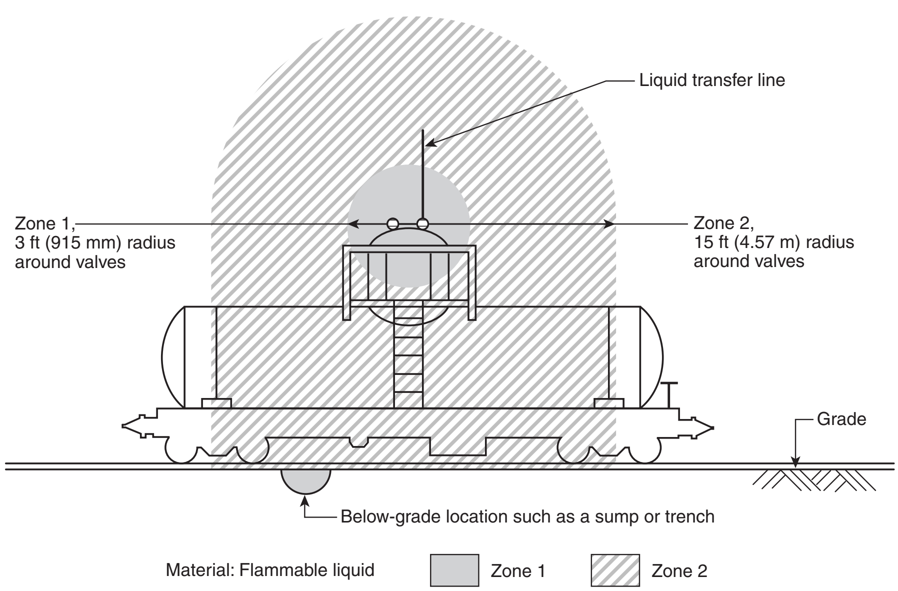


FIGURE 5.10.4(e) Tank Car (or Tank Truck) Loading and Unloading via an Open Transfer System. Material is transferred either through the dome or the bottom fittings. The material being transferred is a flammable liquid.