

Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2

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Introduction

This recommended practice (RP) is under the joint jurisdiction of the API Exploration and Production (E&P) Department Committee on Production Equipment Standards, the API Manufacturing Distribution Marketing (MDM) Department, Committee on Refinery Equipment, and the Pipeline Operations Technical Committee. It is based upon a level of knowledge gained through experience and through the successful application of this practice in refining; drilling, and producing, and pipeline segments of the petroleum industry.

The first edition of API 505 was prepared as a supplement to the 1996 edition of the National Electrical Code (NEC), Article 505, with a scope limited to those petroleum facility locations classified as Class I, Zone 0, Zone 1, and Zone 2. It was issued in November 1997, reaffirmed in November 2013, and has been referenced in all issues of the NEC since the 1999 edition.

Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2

1 Scope

1.1 Purpose

1.1.1 The purpose of this recommended practice (RP) is to provide guidelines for classifying locations Class I, Zone 0, Zone 1, and Zone 2 at petroleum facilities for the selection and installation of electrical equipment. Basic definitions given in the 2014 edition of NFPA 70, the *National Electrical Code (NEC)*, have been followed in developing this RP. This publication is only a guide and requires the application of sound engineering judgment.

NOTE Recommendations for determining the degree and extent of classified locations Class I, Division 1, and Division 2 are addressed in API 500, *Recommended Practice for Classification of Electrical Installations at Petroleum Facilities Classified as Class I, Division 1, and Division 2*.

1.1.2 Electrical installations in areas where flammable liquids, gases, or vapors are produced, processed, stored, or otherwise handled can be suitably designed if the locations of potential sources of release and accumulation are clearly defined. Once a location has been classified, requirements for electrical equipment and associated wiring shall utilize applicable publications that apply this document such as NFPA 70 (*NEC*), CSA C22.1 (*Canadian Electrical Code*), or API 14FZ.

NOTE There are other publications that establish area classification criteria that may differ from those in this document. Refer to those documents for installation requirements, protection techniques, and wiring methods that align with the area classification criteria applied.

1.2 Application

1.2.1 This RP applies to the classification of locations for both temporarily and permanently installed electrical equipment. It is intended to be applied where there may be a risk of ignition due to the presence of flammable gases, flammable liquid produced vapors, or combustible liquid produced vapors mixed with air under normal atmospheric conditions. Normal atmospheric conditions are defined as conditions that vary above and below reference levels of 101.3 kPa (14.7 psia) and 20 °C (68 °F) provided that the variations have a negligible effect on the explosion properties of the flammable materials.

The following items are beyond the scope of this document:

- a) piping systems used for odorized natural gas used as fuel for cooking, heating, air conditioning, laundry, and similar appliances;
- b) catastrophes such as well blowouts or process vessel ruptures—such extreme events are not predictable and require emergency measures at the time of occurrence;
- c) the suitability of locations for the placement of non-electrical incendiary equipment;
- d) classification for locations containing combustible dust, ignitable fibers, or flyings;
- e) installations underground in mines;
- f) areas for the processing and manufacture of explosives; and
- g) areas where the presence of flammable mist may give rise to an unpredictable risk and that require special consideration.

1.2.2 Recommendations for determining the degree and extent of classified locations for specific examples of situations commonly encountered in petroleum facilities are given in Section 8 through Section 14. While it is important for area classifications at refineries, production and drilling facilities, and pipeline facilities to agree to some extent, there are differences in production, drilling, transportation, and refining facilities. Some differences include the process conditions, types and quantities of products handled, the physical size of typical facilities, and varying housing and sheltering practices.

1.2.3 Section 8 includes applications that are common to several of the facility types described in Section 9 through Section 14.

1.2.4 Section 9 is applicable to locations in which flammable petroleum gases and vapors and volatile flammable liquids are processed, stored, loaded, unloaded, or otherwise handled in petroleum refineries.

1.2.5 Section 10 is applicable to locations surrounding oil and gas drilling and workover rigs and production facilities on land and on marine fixed (bottom-founded, non-floating) platforms where flammable petroleum gas and volatile liquids are produced, processed (e.g. compressed), stored, transferred (e.g. pumped), or otherwise handled prior to entering the transportation facilities.

1.2.6 Section 11 is applicable to locations on Mobile Offshore Drilling Units (MODUs).

1.2.7 Section 12 is applicable to locations surrounding oil and gas drilling and workover rigs and production facilities on floating production units (FPUs) such as, but not limited to, tension leg platforms (TLPs), floating production systems (FPSs), floating production storage and offloading (FPSOs), single-anchor leg mooring buoys (SALMs), caisson structures, spars, and other floating structures where flammable petroleum gas and volatile liquids are produced, processed (e.g. compressed), stored, transferred (e.g. pumped), or otherwise handled prior to entering the transportation facilities.

1.2.8 Section 13 is reserved for future use.

1.2.9 Section 14 is applicable to onshore and offshore facilities handling the delivery of flammable or combustible petroleum liquids or flammable gases. Pipeline facilities may include pump and compressor stations, storage facilities, manifold areas, valve sites, and pipeline right-of-way areas.

2 Normative References

2.1 General

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.2 Industry Codes, Guides, and Standards

Various organizations have developed numerous codes, guides, and standards that have substantial acceptance by industry and governmental bodies. Codes, guides, and standards useful in the classification of locations and in the design and installation of electrical systems are listed below. These references are not to be considered a part of this recommended practice except for those specifically referenced. Additional Codes, Guides, and Standards that are useful, but not specifically identified in the normative text can be found in the Bibliography.

API Recommended Practice 14C, *Recommended Practice for Analysis, Design, Installation, and Testing of Safety Systems for Offshore Production Platforms*

API Recommended Practice 14FZ, *Recommended Practice for Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1, and Zone 2 Locations*

API Recommended Practice 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*

API Publication 4589, *Fugitive Hydrocarbon Emissions from Oil and Gas Production Operations*

ANSI/ISA 60079-10-1 ¹, (12.24.01)-2014, *Explosive atmosphere—Part 10-1: Classification of areas—Explosive gas atmospheres*

ANSI/ISA-60079-11 (12.02.01)-2014, *Explosive atmospheres—Part 11: Equipment protection by intrinsic safety “i”* (Edition 6.2)

ANSI/ISA-60079-29-1 (12.13.01)-2013, *Explosive atmospheres—Part 29-1: Gas detectors—Performance requirements of detectors for flammable gases*

ANSI/ISA-60079-29-2 (12.13.02)-2012, *Explosive atmospheres—Part 29-2: Gas detectors—Selection, installation, use and maintenance of detectors for flammable gases and oxygen*

ASHRAE ², *ASHRAE Handbook—Fundamentals*, Chapter 22, 1985

ASTM D323 ³, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*

ASTM D2880, *Standard Specifications for Gas Turbine Fuel Oil*

CSA C22.1 ⁴, *Canadian Electrical Code, Part I: Safety Standard for Electrical Installations*

IMO I810E ⁵, *Code for the Construction and Equipment of Mobile Offshore Drilling Units*, 2009

IP 15, *Institute of Petroleum: Area Classification Code for Petroleum Installations—Part 15*, First Edition

EI 15 ⁶, *Energy Institute, Part 15; Area Classification Code for Installations Handling Flammable Fluids*, Third Edition (formerly IP 15)

MIL-F-16884J, *Military Specification, Fuel, Naval Distillate*

NATO F-76, *Fuel Naval Distillate*

NFPA 30 ⁷, *Flammable and Combustible Liquids Code*

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*

NFPA 69, *Standard on Explosion Prevention Systems*

NFPA 70, *National Electrical Code*

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*

NFPA 497, *Recommended Practice for Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations For Electrical Installations In Chemical Process Areas*

2.3 Government Codes, Rules, and Regulations

Federal regulatory agencies have established certain requirements for the design, installation, and operation of petroleum facilities. These requirements may influence the design, installation and operation of the electrical

¹ American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, New York 10036, www.ansi.org.

² American Society of Heating, Refrigeration, and Air-Conditioning Engineers, 1791 Tullie Circle, N.E. Atlanta, GA 30329, www.ashrae.org.

³ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

⁴ CSA Group, 178 Rexdale Boulevard, Toronto, Ontario, M9W 1R3, Canada, www.csagroup.org.

⁵ International Maritime Organization, 4 Albert Embankment, London, United Kingdom, www.imo.org.

⁶ Energy Institute, 61 New Cavendish Street, London W1G 7AR, United Kingdom, www.energyinst.org.

⁷ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

systems. In addition to federal regulations, certain state, municipal, and local regulations may be applicable. The documents identified below may pertain to petroleum operations and shall be referenced when applicable.

DOI BSEE, *Code of Federal Regulations*⁸, Part 250, *Oil and Gas and Sulphur Operations in the Outer Continental Shelf*

DOT 49, *Code of Federal Regulations*⁹, Parts 190, 191, 192, 193, and 195, *Pipeline Safety Regulations*

OSHA 29, *Code of Federal Regulations*¹⁰, Part 1910, 119, *Process Safety Management of Highly Hazardous Chemicals*

OSHA 29, *Code of Federal Regulations*, Part 1910, *Subpart S—Electrical*

OSHA 29, *Code of Federal Regulations*, Part 1926, *Subpart K—Electrical Construction*

USCG 33, *Code of Federal Regulations*¹¹, Parts 140–147, *Subchapter N, Outer Continental Shelf Activities*

USCG 46, *Code of Federal Regulations*, Parts 107–108, *Shipping Subchapter I-A, Mobile Offshore Drilling Units*

USCG 46, *Code of Federal Regulations*, Parts 110–113, *Shipping Subchapter J, Electrical Engineering*

3 Terms, Definitions, and Acronyms

3.1 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1.1

approved

Acceptable to the authority having jurisdiction.

3.1.2

area

See “location.”

3.1.3

autoignition temperature

AIT

The lowest temperature of a heated surface that, under specified conditions, will ignite a flammable substance in the form of a gas or vapor mixture with air. (ANSI/ISA 60079-10-1)

3.1.4

barrier, vaportight

A wall or other obstruction that will limit the passage of gas or vapor at atmospheric pressure, thus preventing the accumulation of vapor-air or gas-air mixtures in concentrations above 25 % of their lower flammable limit (LFL).

⁸ Bureau of Safety and Environmental Enforcement. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, DC 20402. www.govinfo.gov.

⁹ Department of Transportation. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402. www.govinfo.gov.

¹⁰ U.S. Department of Labor, Occupational Safety and Health Administration. The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402. www.govinfo.gov.

¹¹ U.S. Coast Guard Marine Safety Center (part of DOT). The *Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402. www.govinfo.gov.

NOTE Barrier, non-vaportight applies to any wall or other obstruction that will not meet the criteria for barrier, vaportight. (ANSI/ISA 60079-10-1)

3.1.5

boiling point

The temperature of a liquid boiling at an ambient pressure of 101.3 kPa (14.7 psia). (ANSI/ISA 60079-10-1)

3.1.6

building, purged

See “enclosure”, “purged”, and “pressurized.”

3.1.7

Classification

See 3.1.7.1 through 3.1.7.6.

3.1.7.1

Class I, Zone 0: A Class I, Zone 0 location

A location:

- 1) in which ignitable concentrations of flammable gases or vapors are present continuously; or
- 2) in which ignitable concentrations of flammable gases or vapors are present for long periods of time.

3.1.7.2

Class I, Zone 1: A Class I, Zone 1 location

A location:

- 1) in which ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or
- 2) in which ignitable 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 that are of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of flammable gases or vapors and could also cause simultaneous failure of electrical equipment in a mode so 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 ignitable 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.

3.1.7.3

Class I, Zone 2: A Class I, Zone 2 location

A location:

- 1) in which ignitable 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 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; or
- 3) in which ignitable 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 ignitable 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.

NOTE Within this document, “Zone 0”, “Zone 1”, and “Zone 2” are understood to be preceded by “Class I”.

3.1.7.4

material groups

For purposes of testing, approval, and area classification, various air mixtures (not oxygen enriched) are grouped as in 3.1.7.4.1 and 3.1.7.4.2.

3.1.7.4.1

Group I

A term used by ANSI/ISA 60079-10 to describe atmospheres containing firedamp (a mixture of gases, composed mostly of methane, found underground, usually in mines). Since this RP does not apply to installations underground in mines, this term is not used further in this document.

3.1.7.4.2

Group II

The group used to describe gases found aboveground and is subdivided into IIA, IIB, and IIC.

3.1.7.4.2.1

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 (35 mils) or a minimum igniting current ratio (MIC ratio) greater than 0.80. (NFPA 497)

3.1.7.4.2.2

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 a maximum experimental safe gap (MESG) value greater than 0.50 mm (20 mils) and less than or equal to 0.90 mm (35 mils) or a minimum igniting current ratio (MIC ratio) greater than 0.45 and less than or equal to 0.80. (NFPA 497)

3.1.7.4.2.3

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 (20 mils) or a minimum igniting current ratio (MIC ratio) less than or equal to 0.45. (NFPA 497)

3.1.7.5

hazardous (classified) location

A location where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings. Unless specifically indicated otherwise, locations containing combustible dust, ignitable fibers or flyings are outside the scope of this RP.

3.1.7.6

unclassified location (non-hazardous location)

A location not classified as Class I, Zone 0, Zone 1, or Zone 2.

3.1.8

combustible liquid (Class II, IIIA, and IIIB Liquids)

Any liquid that has a closed-cup flash point at or above 37.8 °C (100 °F), as determined by the test procedures and apparatus outlined in NFPA 30. Combustible liquids are subdivided as follows.

3.1.8.1

Class II liquids

Liquids having flash points at or above 37.8 °C (100 °F) and below 60 °C (140 °F).

3.1.8.2

Class IIIA liquids

Liquids having flash points at or above 60 °C (140 °F) and below 93 °C (200 °F).

3.1.8.3

Class IIIB liquids

Liquids having flash points at or above 93 °C (200 °F).

3.1.9

density of a gas or a vapor, relative

The density of a gas or a vapor relative to the density of air at the same pressure and at the same temperature (air is equal to 1.0). (ANSI/ISA 60079-10-1)

3.1.10

drilling areas

Those areas in which wells are being drilled, recompleted, or reworked for the purpose of exploring for or producing oil or gas. Wells meeting any of the conditions of the above are referred to as “drilling wells.” The term “drilling wells” does not include wells on which wireline work is being performed through a lubricator or wells into which, or from which, pumping equipment is being installed or removed.

3.1.11

enclosed area (room, building, or space)

A three-dimensional space enclosed by more than two-thirds ($2/3$) of the possible projected plane surface area and of sufficient size to allow the entry of personnel. For a typical building, this would require that more than two-thirds ($2/3$) of the walls, ceiling, and floor be present.

3.1.12

enclosure, electrical

The case or housing of electrical apparatus provided to prevent personnel from accidentally contacting energized parts and to protect the equipment from physical damage. Certain enclosures also serve to prevent electrical equipment from being a source of ignition of flammable mixtures outside the enclosure.

3.1.13

enclosure, explosion-proof

An enclosure that is capable of withstanding an explosion of a specific gas or vapor within it and of preventing the subsequent ignition of a flammable gas or vapor that may surround it, and that operates at such an external temperature that a surrounding flammable gas or vapor will not be ignited.

3.1.14

enclosure, flameproof

An enclosure that will withstand an internal explosion of a flammable mixture that has penetrated into the interior, without suffering damage and without causing ignition, through any joints or structural openings in the enclosure, of an external flammable or explosive gas atmosphere consisting of one or more of the gases or vapors for which it is designed.

3.1.15

enclosure, purged

An enclosure or building supplied with clean air or an inert gas at sufficient flow and positive pressure to reduce the concentration of any flammable gases or vapors initially present to an acceptably safe level and to maintain this safe level by positive pressure with or without continuous flow (reference NFPA 496). See “purged” and “pressurized.”

3.1.16**explosive gas atmosphere**

Mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapor, which, after ignition, permits self-sustaining flame propagation.

3.1.17**flammable gas atmosphere**

Mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapor that is capable of igniting easily, burning intensely, or spreading flame rapidly.

NOTE 1 Although a mixture that has a concentration above the upper flammable limit (UFL) is not a flammable gas atmosphere, it can readily become so and, in certain cases for area classification purposes, it is advisable to consider it as a flammable gas atmosphere.

NOTE 2 There are some gases that are explosive with the concentration of 100 %. (ANSI/ISA 60079-10-1)

3.1.18**flammable, highly volatile liquid**

See “highly volatile liquid.”

3.1.19**flammable limits or explosive limits**

The lower and upper percentages by volume of concentration of gas in a gas–air mixture that will form an ignitable mixture (reference NFPA 497). The upper limit is typically expressed as UFL or UEL and the lower limit is expressed as LFL or LEL.

The term “LEL” and the term “LFL” are sometimes used interchangeably. For the purposes of area classification, the lower value should be used. For example, the LEL for hydrogen is 9% yet the LFL is 4%. (ANSI/UL 60079-10-1)

The term “UEL” and the term “UFL” are sometimes used interchangeably. For the purposes of area classification, the higher value should be used. For example, the UEL for methane is 15% yet the UFL is 17%. (ANSI/UL 60079-10-1)

NOTE The upper and lower explosive limits, UEL and LEL, are narrower than the upper and lower flammable limits, UFL and LFL, and therefore the explosive limits are not used in this standard. Explosive limits are determined by material properties plus other factors such as igniter energy and enclosure geometry, whereas flammable limits are determined by material properties only.

3.1.20**flammable liquid (Class I liquid)**

Any liquid that has a closed-cup flash point below 37.8 °C (100 °F), as determined by the test procedures and apparatus specified in NFPA 30. Flammable (Class I) liquids are subdivided into Classes IA, IB, and IC. (NFPA 30)

3.1.21**flash point**

The minimum temperature of a liquid at which sufficient vapor is given off to form an ignitable mixture with air, near the surface of the liquid or within the vessel used, as determined by the test procedure and apparatus specified in NFPA 30.

3.1.22**floor area**

The maximum area of any horizontal plane intersecting an enclosed area.

3.1.23

fugitive emissions

Continuous flammable gas and vapor releases that are relatively small compared to releases due to equipment failures. These releases occur during normal operation of closed systems from components such as pump seals, valve packing, and flange gaskets.

3.1.24

gases, heavier-than-air

Gases with a specific gravity greater than 1.0. See 7.2.2.

3.1.25

gases, lighter-than-air

Gases with a specific gravity less than 1.0. See 5.4 and 7.2.2.

3.1.26

grades of release

There are three basic grades of release, as listed below in order of decreasing frequency and likelihood of the flammable or explosive gas atmosphere being present:

- a) continuous grade,
- b) primary grade,
- c) secondary grade.

A source of release may give rise to any one of these grades of release or to a combination of more than one. (ANSI/ISA 60079-10-1)

3.1.26.1

grade of release, continuous

A release that is continuous or is expected to occur for long periods.

3.1.26.2

grade of release, primary

A release that can be expected to occur periodically or occasionally during normal operation.

3.1.26.3

grade of release, secondary

A release that is not expected to occur in normal operation and, if it does occur, is likely to do so only for short periods.

3.1.27

high temperature device

A device whose maximum operating temperature exceeds 80 % of the autoignition temperature, expressed in degrees Celsius (°C), of the gas or vapor involved or whose maximum operating temperature exceeds 100 % of the autoignition temperature, expressed in degrees Celsius (°C), of the gas or vapor involved when listed or labeled or otherwise approved by the authority having jurisdiction.

3.1.28

highly volatile liquid

HVL

A liquid whose vapor pressure exceeds 276 kPa (40 psia) at 37.8 °C (100 °F). See 5.3.

3.1.29

ignitable (flammable) mixture

A gas-air mixture that is capable of being ignited by an open flame, electric arc, spark, or a device operating at or above the autoignition temperature of the gas air mixture. See 3.1.19

3.1.30**location**

Throughout this RP, reference is made to areas, spaces, and locations. These terms should be considered interchangeable terms designating a three-dimensional space.

3.1.31**maximum experimental safe gap****MESG**

The maximum gap of the joint between the two parts of the interior chamber of a test apparatus that, when the internal gas mixture is ignited and under specified conditions, prevents ignition of the external gas mixture by flame propagation through a 25 mm (984 mils) long joint for all concentrations of the tested gas or vapor in air.

3.1.32**minimum ignition current****MIC**

The minimum current that, in a specified spark test apparatus and under specified conditions, is capable of igniting the most easily ignitable mixture of a gas or vapor.

3.1.33**minimum igniting current ratio****MIC ratio**

The ratio of the minimum current required from an inductive spark discharge to ignite the most easily ignitable 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. (NFPA 497)

3.1.34**minimum ignition energy****MIE**

The minimum energy required from a capacitive spark discharge to ignite the most easily ignitable mixture of a gas or vapor. (NFPA 497)

3.1.35**mist, flammable (flammable mist)**

Droplets of flammable liquid dispersed in air so as to form a flammable or explosive gas atmosphere. (ANSI/ISA 60079-10-1)

3.1.36**non-hazardous location**

Unclassified location (non-hazardous location). See 3.1.7.6.

3.1.37**normal operation**

The situation when the equipment is operating within its design parameters. (ANSI/ISA 60079-10-1)

3.1.38**petroleum refinery**

A facility within which petroleum liquids or vapors are continuously processed at temperatures and pressures to create both chemical and physical changes.

3.1.39**pipeline transportation facility**

A facility handling the delivery of flammable or combustible petroleum liquids or flammable gases; may include pump and compressor stations, storage facilities, manifold areas, valve sites, and pipeline right-of-way areas.

3.1.40

production areas

Those areas where flammable petroleum gas and volatile liquids are produced, processed (e.g. compressed), stored, transferred (e.g. pumped), or otherwise handled prior to entering the transportation facilities

3.1.41

protected fired vessel

Any fired vessel that is provided with equipment (such as flame arresters, stack temperature shutdowns, forced draft burners with safety controls, insulation/cladding, and spark arresters) designed to eliminate the air intake, high surface temperatures, and exhaust as sources of ignition.

3.1.42

purged and pressurized

The process of 1) purging—supplying an enclosure with a protective gas at a sufficient flow and positive pressure to reduce the concentration of any flammable gas or vapor initially present to an acceptable level; and 2) pressurization—supplying an enclosure with a protective gas with or without continuous flow at sufficient pressure to prevent the entrance of a flammable gas or vapor.

3.1.43

source of release

A point or location from which a gas, vapor, mist, or liquid may be released into the atmosphere so that a flammable or explosive gas atmosphere could be formed. (ANSI/ISA 60079-10-1)

3.1.44

release rate

The quantity of flammable gas, vapor, mist, or liquid emitted per unit time from the source of release. (ANSI/ISA 60079-10-1)

3.1.45

space

See “location”.

3.1.46

unclassified location

See “classification”.

3.1.47

vapor pressure

The pressure, measured in pounds per square inch absolute (psia), exerted by a liquid, as determined by ASTM D323, *Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method)*.

3.1.48

vaportight barrier

See “barrier, vaportight”.

3.1.49

ventilation

Movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial means (for example, fans or extractors). (ANSI/ISA 60079-10-1)

3.1.50

ventilation, adequate

Ventilation (natural or artificial) that is sufficient to prevent the accumulation of significant quantities of vapor-air or gas-air mixtures in concentrations above 25 % of their lower flammable limit (LFL). See also 6.6.2.

3.1.51**ventilation, inadequate**

Ventilation that is less than adequate. See 6.6.3.

3.1.52**volatile flammable liquid**

A flammable liquid whose temperature is above its flash point, or a Class II combustible liquid having a vapor pressure not exceeding 276 kPa (40 psia) at 37.8 °C (100 °F) whose temperature is above its flash point.

3.1.53**wireline work areas**

Those areas in which wireline work is being performed on a well through a lubricator.

3.2 Acronyms

ACT	automatic custody transfer
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASTM	ASTM International
BOP	blowout preventer
BSEE	Bureau of Safety and Environmental Enforcement
DOT	Department of Transportation
FPSO	floating production storage and offloading
HVL	highly volatile liquid
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Institute of Petroleum (Energy Institute)
IMO	International Maritime Organization
ISA	International Society of Automation
LEL	lower explosive limit
LFL	lower flammable limit
MESG	maximum experimental safe gap
MIC	minimum ignition current
MODU	mobile offshore drilling unit
NEC	<i>National Electrical Code</i>
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
TFL	through flow line
TLP	tension leg platform
UEL	upper explosive limit
UFL	upper flammable limit
UL	UL, LLC (formerly Underwriters Laboratories, Inc.)
USCG	United States Coast Guard

4 Basic Conditions for a Fire or Explosion

Three basic conditions are required for a fire or explosion to occur as a result of an electrical installation.

- 1) A flammable gas or vapor is present. In classifying a particular location, the likelihood of the presence of a flammable gas or vapor is a significant factor in determining the zone classification. The decision is

based principally on whether the flammable mixture may be present 1.) under normal conditions; or 2.) only under abnormal conditions (including equipment breakdown).

- 2) The gas or vapor is mixed with air or oxygen in the proportions and quantities required to produce a flammable or ignitable mixture. This condition is important in determining the limit or extent of the classified location. The quantity of the substance that might be liberated, its physical characteristics, the operating pressure, and the natural tendency of gases and vapors to disperse in the atmosphere should be considered.
- 3) The mixture is ignited. When classifying locations, the potential source of ignition is understood to be an electrical installation operating at energy levels or at temperatures sufficient to cause ignition.

5 Flammable and Combustible Liquids, Gases, and Vapors

5.1 General

Substances handled by petroleum facilities include flammable and combustible liquids, flammable highly volatile liquids (HVLs), and flammable gases and vapors. When classifying locations for electrical installations, the appropriate gas Group(s) (IIA, IIB, or IIC) should be determined for all flammable liquids, gases, and vapors present.

5.2 Flammable and Combustible Liquids

5.2.1 General

Refer to NFPA 497 for properties of specific flammable liquids and flammable gases. Flammable and combustible liquids vary in volatility and are defined in NFPA 30. Flammable (Class I) liquids, such as gasoline, are defined in 3.1.20. Combustible (Class II and Class III) liquids, such as kerosene and diesel fuel, are defined in 3.1.8.

Classes as used here to identify flammable and combustible liquids should not be confused with the classes in the National Electrical Code that identify specific types of flammable or explosive gas atmospheres. See 5.5 and definitions in Section 3.

5.2.2 Class I Liquids

5.2.2.1 Class I liquids usually are handled at temperatures above the liquids' flash points and, consequently, may produce a flammable atmosphere. Where released in appreciable quantities to the atmosphere, they may produce large volumes of vapor. This is particularly true for the more volatile Class I liquids. The less volatile Class I liquids release vapors more slowly at normal temperatures and are ignitable only near the surfaces of the liquids. At elevated temperatures, however, these heavier liquids give off large volumes of vapor that can spread. These vapors, even when evolved rapidly, have a natural tendency to disperse into the atmosphere and thus rapidly become diluted to concentrations below their lower flammable limit. This tendency is greatly accelerated by air movement.

5.2.2.2 The density of an atmosphere saturated with vapors of flammable liquids at ordinary atmospheric temperatures is usually heavier than air. However, when these vapors are diluted with sufficient air to create a flammable mixture, the density of the mixture approaches that of air.

5.2.3 Class II Liquids

5.2.3.1 With Class II liquids, the probability of an ignitable vapor–air mixture is low because the liquids typically are handled at temperatures below their flash point, where they do not produce sufficient vapors to form an ignitable mixture. When these liquids are heated above their flash point, additional vapors are generated, and the probability of ignition is increased.

5.2.3.2 The chance of ignition of vapors of Class II liquids is not as great as ignition of the vapors of Class I liquids. Their vapors normally do not travel as far as the vapors of Class I liquids. Normally, except near points of release, Class II liquids do not produce vapors of sufficient quantity to be considered for electrical classification purposes.

5.2.3.3 Where combustible liquids are processed or stored at temperatures at or above their flash point, they shall be treated as flammable liquids. Some Class II liquids may have flash points lower than those listed in standard material property tables. For example various grades of diesel or fuel oils are available. These grades may meet various specifications, such as ASTM D975, *Standard Specification for Diesel Fuel Oils*, No. 2, with grades of minimum flash points from 38 °C (100.4 °F) to 52 °C (125.6 °F) or ASTM D2069, *Standard Specifications for Marine Fuels, DMS through DMC*, which have a range of minimum flash points from 43 °C (109.4 °F) to 60 °C (140.0 °F). Knowledge of the different grades and flash points and the actual temperatures at which these materials are processed or stored is necessary in order to properly classify these areas.

5.2.4 Class III Liquids

Class III liquids normally do not produce vapors of sufficient quantity to be considered for electrical classification purposes. If heated above their flash points, Class III liquids will release vapor in the flammable range at their surfaces but the extent of the classified location ordinarily will be very small and near the point of release.

5.2.5 Crude Oils

A specific classification for crude oil is not possible since crude oil is a mixture of hydrocarbons of widely varying composition. Some crude oils may include volatiles (e.g. butane, propane, or natural gasoline). However, crude oil usually is classified as a Class I flammable liquid, and its flash point generally is accepted as -6.7 °C to 32.2 °C (20 °F to 90 °F).

5.3 Flammable Highly Volatile Liquids

5.3.1 Highly volatile liquids (HVLs) include liquids such as butane, ethane, ethylene, propane, propylene, liquefied natural gas, natural gas liquids, and similar mixtures. Vapor pressures of these liquids exceed 276 kilopascals (40 psia) at 37.8 °C (100 °F).

5.3.2 Highly volatile liquids vaporize at low temperatures (have low flash points). When released to the atmosphere, these liquids vaporize—creating large volumes of cooled gases whose densities exceed that of air. HVLs should be treated very conservatively in considering the extent of the area affected, especially when released at or near ground level. Under such conditions, the heavy gases can travel along the ground for great distances if air currents do not assist dispersion. When HVLs are released at higher elevations, or are directed upward at substantial velocity, diffusion and dilution of the upper-air mixture are faster, and the distance from the point of release where lower flammable limit (LFL) concentrations are present is less.

5.4 Flammable Lighter-than-air Gases

5.4.1 Petroleum facilities frequently handle lighter-than-air natural gases (methane or mixtures of methane and small quantities of low-molecular-weight hydrocarbons).

5.4.2 Lighter-than-air gases released from an opening often will disperse rapidly because of their relatively low density and usually will not affect as extensive an area as the vapors of flammable liquids or heavier-than-air gases. Lighter-than-air gases seldom produce large volumes of ignitable mixtures in open locations close to grade where most electrical installations are made; however, ignitable mixtures can accumulate inside enclosed spaces.

5.4.3 Hydrogen shall be given special consideration because of its properties of wide flammable mixture range, high flame-propagation velocity, low vapor density, low minimum ignition energy level, and relatively high autoignition temperature [520 °C (968 °F)].

5.5 National Electrical Code Grouping of Atmospheric Mixtures

5.5.1 Equipment shall be selected, tested, and approved for the specific flammable material involved because maximum explosive pressures and other characteristics vary widely. For purposes of testing, approval, and area classification, various atmospheric mixtures (not oxygen enriched) are grouped in the *National Electrical Code* (NEC) on the basis of their flammability characteristics. A partial listing follows; for a more complete listing refer to NFPA 497.

Group I is intended for use in describing atmospheres containing firedamp (a mixture of gases, composed mostly of methane, found underground, usually in mines). This RP does not apply to installations underground in mines.

Group II is subdivided into IIA, IIB, and IIC.

The gas and vapor subdivision as described above is based on the maximum experimental safe gap (MESG), minimum igniting current (MIC), or both. Test equipment for determining the MESG is described in, ANSI/ISA 60079-1A-1975, Amendment No. 1, (1993) *Construction and Verification Tests of Flameproof Enclosures of Electrical Apparatus* and UL Technical Report No. 58 (1993). The test equipment for determining MIC is described in ANSI/ISA 60079-11-1999, *Electrical apparatus for explosion gas atmospheres – Part 11: Intrinsic safety “i.”* The classification of gases or vapors according to their maximum experimental safe gaps and minimum igniting currents is described in ANSI/ISA 60079-12-1978, *Classification of mixtures of gases or vapours with air according to their maximum experimental safe gaps and minimum igniting currents.*

It is necessary that the meanings of the different equipment markings and Group II classifications be carefully observed to avoid confusion with Class I, Divisions 1 and 2, Groups A, B, C, and D.

a) Group IIC. Atmospheres containing acetylene, hydrogen, or gases or vapors of equivalent hazard.

NOTE Group IIC is equivalent to a combination of Class I, Group A and Class I, Group B, as described in NEC Sections 500.6(A)(1) and (A)(2). See 3.1.7.4.2.3.

b) Group IIB. Atmospheres containing acetaldehyde, ethylene, or gases or vapors of equivalent hazard.

NOTE Group IIB is equivalent to Class I, Group C, as described in NEC Section 500.6(A)(3). See 3.1.7.4.2.2.

c) Group IIA. Atmospheres containing acetone, ammonia, ethyl alcohol, methane, propane, or gases or vapors of equivalent hazard.

NOTE Group IIA is equivalent to Class I, Group D as described in NEC Section 500.6(A)(4). See 3.1.7.4.2.1.

5.5.2 The flammable characteristics of mixtures of gases or vapors and air vary with the specific material(s) involved. For Class I locations (Groups IIA, IIB, and IIC), the classification involves determinations of maximum explosion pressure, maximum safe clearance between parts of a clamped joint in an enclosure, and other characteristics of the atmospheric mixture. The results of the tests on many materials are found in NFPA 497. The materials were grouped based on comparison of maximum experimental safe gap (MESG) or minimum igniting current ratio (MIC ratio) to standard reference test materials for each group. NFPA 497 gives the pertinent data.

5.5.3 Most petroleum products are placed in Group IIA. However, ethylene production, catalytic reforming, ammonia synthesis, and other processes may involve other groups, particularly Group IIB.

5.5.4 Locations with rechargeable batteries that can discharge hydrogen to the atmosphere should be reviewed for possible Group IIC classification. See 8.2.6.

5.5.5 In mixtures of hydrogen sulfide and natural gas, it is recommended that the mixture be considered Group IIA if the hydrogen sulfide constitutes less than 25 % of the mixture (by volume).

5.5.6 In mixtures of manufactured gases, the mixture should be considered Group IIC if the gases contain more than 30 % hydrogen by volume.

5.5.7 Table 1 presents an approximate comparison of the NEC “Division” Grouping with “Zone” Grouping.

Table 1—Approximate Comparison of Zone and Division Gas Groups

NEC Article 505 Group Designation	NEC Article 500 Group Designation	Typical Gas
IIC	A B	Acetylene Hydrogen
(IIB + H ₂)*	B	Hydrogen
IIB	C	Ethylene
IIA	D	Propane
* (IIB + H₂) is not an NEC 505 Gas Group. As Type of Protection flameproof ‘d’ does not permit the use of flange joint apparatus in atmospheres containing acetylene, this designation is commonly used for such apparatus to designate that it can be used in Group IIB atmospheres and hydrogen atmospheres. This is generally representative of IIC atmospheres that do not include acetylene.		

6 Classification Criteria

6.1 General

6.1.1 The decision to classify a location is based on the likelihood that flammable gases or vapors may be present. Possible sources of release include vents, flanges, control valves, drains, pump and compressor seals, fittings, and floating roof seals. It is noted that the occurrence of flammable material liberation from some of the above apparatus is so infrequent and at such a small rate, that it is not necessary to consider it as a source or to classify adequately ventilated non-enclosed areas containing such apparatus. Factors described in Section 5 through Section 14 should be used in that determination. Having decided that a location should be classified, and having designated the gas or vapor as Group IIA, IIB, or IIC, the next step is to designate the location as Zone 0, Zone 1, or Zone 2. This latter step shall be determined by the likelihood of whether a flammable gas or vapor release may occur in sufficient quantities to be ignitable during normal operations, or only as a result of an unusual occurrence or abnormal condition.

6.1.2 Documentation shall include 1) the extent of all areas that are classified; 2) the Class; 3) the Zone; 4) the gas or gas group(s); and 5) the maximum permissible surface temperature for the electrical equipment in the area. The identification of Zone 0, Zone 1, and Zone 2 locations shall utilize the symbols in Annex C except for additions or modifications to existing documentation that may use the symbols of the existing documentation. See E.7 for additional documentation considerations.

6.1.3 Mists may form or be present at the same time as flammable vapors. This may affect the way flammable material disperses and the extent of any hazardous areas. The strict application of area classification for gases and vapors may not be appropriate because the flammability characteristics of mists are not always predictable. Although it can be difficult to decide upon the type and extent of zones, the criteria applicable to gases and vapors will, in most cases, give a safe result. However, special consideration should always be given to the danger of ignition of flammable mists. (ANSI/ISA 60079-10-1)

6.2 Sources of Release (ANSI/ISA 60079-10-1)

6.2.1 The basic elements for establishing the hazardous zone types are the identification of the source of release and the determination of the grade of release.

6.2.2 Since a flammable or explosive gas atmosphere can exist only if a flammable gas or vapor is present with air, it is necessary to decide if any of these flammable materials can exist in the area concerned. Generally speaking, such gases and vapors (and flammable liquids and solids that may give rise to them) are contained within equipment and piping, which may or may not be totally enclosed. It is necessary to identify where a release of flammables could occur from such equipment or piping.

6.2.3 Each item of process equipment should be considered as a potential source of release of flammable material. If the item cannot contain flammable material, it clearly will not necessitate a hazardous (classified) area around it. The same will apply if the item contains a flammable material but is not likely to release it into the atmosphere (see 6.5.9).

If it is established that flammable material may be released into the atmosphere, it first is necessary to determine the grade of release in accordance with the definitions, by establishing the likely frequency and duration of the release. It should be recognized that the opening of parts of enclosed process systems (for example, during filter changing) also should be considered as sources of release when developing the area classification. By means of this procedure, each release will be graded either “continuous,” “primary,” or “secondary.”

Having established the grade of the release, it then is necessary to determine the release rate and other factors (including ventilation) that may influence the type and extent of the zone.

6.3 Zone Designation (ANSI/ISA 60079-10-1)

The likelihood of the presence of a flammable or explosive gas atmosphere, and hence the zone designation, depends mainly on the grade of release and the ventilation.

NOTE A continuous grade of release normally leads to a Class I, Zone 0 designation; a primary grade to a Class I, Zone 1 designation; and a secondary grade to a Class I, Zone 2 designation.

6.4 Extent of Zone (ANSI/ISA 60079-10-1)

6.4.1 Where the source of release is situated outside an area or in an adjoining area, the penetration of a significant quantity of flammable gas or vapor into the area can be prevented by suitable means such as:

- a) physical barriers;
- b) maintaining a static overpressure in the area relative to the adjacent hazardous areas, so preventing the ingress of the hazardous atmosphere; and
- c) purging the area with a significant flow of air, so ensuring that the air escapes from all openings where the hazardous gas or vapor may enter.

6.4.2 The extent of the zone is mainly affected by the following chemical and physical parameters, some of which are intrinsic properties of the flammable material; others are specific to the process. For simplicity, the effect of each parameter listed below assumes that the other parameters remain unchanged.

6.4.2.1 Release Rate of Gas or Vapor

The greater the release rate, the larger the extent of the classified location. The release rate depends itself on other parameters, namely the following.

- a) Geometry of the Source of Release:

This is related to the physical characteristics of the source of release—for example, an open surface.

b) Release Velocity:

For a given source of release, the release rate increases with the release velocity. In the case of a product contained within process equipment, the release velocity is related to the process pressure and the geometry of the source of release. The size of a cloud of flammable gas or vapor is determined by the rate of flammable vapor release and the rate of dispersion. Gas and vapor flowing from a leak at high velocity will develop a cone-shaped jet that will entrain air and will be self-diluting. The extent of the flammable or explosive gas atmosphere will be almost independent of wind velocity. If the release is at low velocity or if its velocity is destroyed by impingement on a solid object, it will be carried by the wind and its dilution and extent will depend on wind velocity.

c) Concentration:

The release rate increases with the concentration of flammable vapor or gas in the released mixture.

d) Volatility of a Flammable Liquid:

The volatility of a flammable liquid is related principally to the vapor pressure and to the heat of vaporization. If the vapor pressure is not known, the boiling point and flashpoint can be used as a guide.

A flammable or explosive gas atmosphere cannot exist if the flashpoint is above the relevant maximum temperature of the flammable liquid. The lower the flashpoint, the greater may be the extent of the zone. If a flammable material is released in a way that forms a mist (for example, by spraying) a flammable or explosive gas atmosphere may be formed below the flashpoint of the material.

NOTE 1 Flashpoints of flammable liquids are not precise physical quantities, particularly where mixtures are involved.

NOTE 2 Some liquids (for example, certain halogenated hydrocarbons) do not possess a flashpoint although they are capable of producing a flammable or explosive gas atmosphere. In these cases, the equilibrium liquid temperature that corresponds to the saturated concentration at the lower flammable limit (LFL) is compared with the relevant maximum liquid temperature.

e) Liquid Temperature:

The vapor pressure increases with temperature, thus increasing the release rate due to evaporation.

NOTE The temperature of the liquid after it has been released may increase—for example, by a hot surface or by a high ambient temperature.

6.4.2.2 Ventilation

With increased ventilation, the extent of the classified location will be reduced. Obstacles that impede the ventilation may increase the extent of the classified location. On the other hand, some obstacles (for example, dikes, walls, and ceilings) may limit the extent.

6.4.2.3 Relative Density of the Gas or Vapor When It Is Released

If the gas or vapor is significantly lighter than air, it will tend to move upwards. If significantly heavier, it will tend to accumulate at ground level. The horizontal extent of the classified location at ground level will increase with increasing relative density, and the vertical extent above the source will increase with decreasing relative density.

For practical applications, a gas or vapor that has a relative density below 0.8 is regarded as being lighter than air. If the relative density is above 1.2, it is regarded as being heavier than air. Between these values, both of these possibilities should be considered.

Experience has shown that ammonia is hard to ignite, and a gas release will dissipate rapidly in the open air, so any flammable or explosive gas atmosphere will be of negligible extent.

Consideration should always be given to the possibility that a gas that is heavier than air may flow into areas below ground level (for example, pits and depressions) and that a gas that is lighter than air may be retained at high level (for example, in a roof space).

6.4.2.4 Other Parameters to be Considered

Other parameters to be considered include:

- a) climatic conditions and
- b) topography.

6.4.2.5 Effects of Parameters

Some ways in which the above parameters affect the vapor or gas release-rate, and hence the extent of the classified locations, are given below.

a) *Source of release: open surface of liquid*

In most cases, the liquid temperature will be below the boiling point and the vapor release rate will depend principally on the following parameters:

- 1) liquid temperature;
- 2) vapor pressure of the liquid at its surface temperature; and
- 3) dimensions of the evaporation surface.

b) *Source of release: virtually instantaneous evaporation of a liquid (for example, from a jet or spray)*

Since the discharged liquid vaporizes virtually instantaneously, the vapor release rate is equal to the liquid flow rate, and liquid flow rate depends on the following parameters:

- 1) liquid pressure; and
- 2) geometry of the source of release.

Where the liquid is not instantaneously vaporized, the situation is complex because droplets, liquid jets, and pools may create separate sources of release.

c) *Source of release: leakage of a gas mixture*

The gas release rate is affected by the following parameters:

- 1) pressure within the equipment that contains the gas;
- 2) geometry of the source of release; and
- 3) concentration of the flammable gas in the released mixture.

6.5 Classification Criteria and Considerations

6.5.1 NEC Classifications

6.5.1.1 General

The following basic definitions concerning the classifications of areas are the same as those contained in Article 505 of NFPA 70, the *National Electrical Code*, except for a few editorial changes for clarity and deletion of some subject matter not relevant to petroleum operations.

6.5.1.2 Class I Locations

6.5.1.2.1 Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations include the following.

6.5.1.2.2 *Class I, Zone 0.* A Class I, Zone 0 location is a location 1) in which ignitable concentrations of flammable gases or vapors are present continuously; or 2) in which ignitable concentrations of flammable gases or vapors are present for long periods of time.

This classification usually includes locations inside vented tanks or vessels containing volatile flammable liquids; inside inadequately vented spraying or coating enclosures, where volatile flammable solvents are used, between the inner and outer roof sections of a floating roof tank containing volatile flammable liquids; inside open vessels, tanks, and pits containing volatile flammable liquids; the interior of an exhaust duct that is used to vent ignitable concentrations of gases or vapors; and inside inadequately ventilated enclosures containing normally venting instruments utilizing or analyzing flammable fluids and venting to the inside of the enclosures.

NOTE As a further guide in determining when flammable gases or vapors are present continuously or for long periods of time, also refer to ANSI/ISA 60079-10-1 and EI 15.

6.5.1.2.3 *Class I, Zone 1.* A Class I, Zone 1 location is a location:

- a) in which ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or
- b) in which ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or
- c) 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 ignitable 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
- d) that is adjacent to a Class I, Zone 0 location from which ignitable 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.

NOTE Normal operation is considered the situation when plant equipment is operating within its design parameters. Minor releases of flammable material may be part of normal operations. Minor releases include the releases from mechanical packings on pumps. Failures that involve repair, urgent repair, or shutdown (such as the breakdown of pump seals and flange gaskets, and spillage caused by accidents) are not considered normal operation.

This classification usually includes 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; adequately ventilated drying rooms or compartments for evaporation of flammable solvents; adequately ventilated locations containing fat and oil extraction equipment using volatile flammable solvents; portions of cleaning and dyeing plants where volatile flammable liquids are used; adequately ventilated gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids.

interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers; and other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operation, but not classified Zone 0.

6.5.1.2.4 Class I, Zone 2. A Class I, Zone 2 location is a location:

- a) in which ignitable 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
- b) 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 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; or
- c) in which ignitable 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
- d) that is adjacent to a Class I, Zone 1 location, from which ignitable 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.

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

6.5.2 Class I, Zone 0 Considerations

Zone 0 locations include areas that are likely to have ignitable concentrations of flammable gases or vapors present continuously or for long periods of time. For instance, the continuous presence of flammable gases inside a tank storing flammable fluids is normal and requires a Zone 0 classification.

6.5.3 Class I, Zone 1 Considerations

6.5.3.1 Zone 1 locations include areas that are likely to have ignitable concentrations of flammable gases or vapors present under normal conditions. For instance, the presence of flammable gases in the immediate vicinity of an atmospheric vent from a Zone 1 area, such as the roof vent depicted by Figure 16, is normal and requires a Zone 1 classification. However, “normal” does not necessarily mean the situation that prevails when everything is working properly. For instance, a process might be so sensitive to control that relief valves frequently open, which could be considered normal. If these valves release flammable liquids or gases to the atmosphere, the location adjacent to the point of release should be classified Zone 1. However, if the operation of the relief valves occurs infrequently under usual conditions, it is not to be considered normal. Normal conditions in this context also cover frequent routine events. For example, opening a scraper barrel for inserting or removing a scraper is a normal condition.

6.5.3.2 There may be cases in which frequent maintenance and repair are necessary. When these cases are viewed as normal, and if significant quantities of flammable liquids or gases are released as a result of the maintenance and repair, the location should be classified Zone 1. However, if the maintenance and repairs are required infrequently, the work is to be considered abnormal.

6.5.3.3 The Zone 1 classification also applies to the “transition zone” that normally exists between a Zone 0 location and a Zone 2 location. Obviously, flammable gases or vapors cannot be present on one side of an imaginary line and never be present on the opposite side. There should be a Zone 1 “transition zone” surrounding locations where flammable gases or vapors may be present continuously or for long periods of time. A vaportight barrier can be used, however, to prevent the gas or vapor from spreading. In such cases there would not be a transition zone and the other side of the barrier could be unclassified. Also, as discussed

in 6.5.1.2.3, adequate positive-pressure ventilation from a source of clean air can be used to eliminate the transition zone if effective safeguards against ventilation failure are provided.

6.5.3.4 When an enclosed area is classified Zone 0 “to the extent of the enclosed area”, a Zone 1 transition zone shall be included adjacent to all non-vaportight walls and other openings (e.g. hatches, doors and windows). If no specific transition zone is recommended by Section 8 through Section 14 (as applicable), the Zone 1 area should extend as follows:

- a) in the case of a Zone 0 area surrounding a specific item of equipment, the same distance from the Zone 0—Zone 1 boundary as the Zone 0 area extends from the specific equipment in question; or
- b) in the case of an enclosed area classified Zone 0 to the extent of the enclosed area, 3 m (10 ft) from the non-vaportight wall or opening.

6.5.4 Class I, Zone 2 Considerations

6.5.4.1 Zone 2 locations are likely to have flammable gases or vapors present only under abnormal conditions. As an example, consider an adequately ventilated location containing a process pump with a mechanical shaft seal that releases flammable gases or vapors only under abnormal conditions. In this case, there is no Zone 1 classification. To release gases or vapors, the seal would have to leak, which would be abnormal. Thus, the area surrounding the pump is classified as Zone 2.

6.5.4.2 Petroleum handling equipment does not fail frequently. Furthermore, the NEC requirements for electrical installations in Zone 2 locations allow that a source of ignition may occur in the event of an electrical equipment failure. The probability of a simultaneous failure of electrical equipment and a release of ignitable materials is very small. This consideration often justifies a Zone 2 (versus Zone 1) classification.

NOTE For example, assuming the electrical and petroleum handling equipment each fail at the rate of one hour every 8000 hours (approximately once per year). The probability that both types of equipment will fail during the same hour is only 1 in 64 million. This is considered conservative as the time for these assumed failure rates are deliberately long because the failures usually would occur during a time interval shorter than one hour.

6.5.4.3 The Zone 2 classification also applies to the “transition zone” that normally exists between a Zone 1 location and an unclassified location. Obviously, flammable gases or vapors cannot be present on one side of an imaginary line and never be present on the opposite side. There should be a “transition zone” where flammable gases or vapors may be present under abnormal conditions. These abnormal conditions might be, for example, unfavorable air currents or an abnormally large release of flammable material. A vaportight barrier can be used, however, to prevent the gas or vapor from spreading. In such cases there would not be a transition zone and the other side of the barrier would be unclassified. Also, as discussed in 6.5.1.2.4, adequate positive-pressure ventilation from a source of clean air can be used to eliminate the transition zone if effective safeguards against ventilation failure are provided.

6.5.4.4 When a building (or similar enclosed area) is classified Zone 1 “to the extent of the building” due to specific oil or gas handling equipment enclosed by the building, a Zone 2 transition zone shall be included adjacent to all non-vaportight walls and other openings (e.g. doors and windows). If no specific transition zone is recommended by Section 8 through Section 14 (as applicable), the Zone 2 area should extend as follows.

- a) In the case of a Zone 1 area surrounding a specific item of equipment, the same distance from the Zone 1—Zone 2 boundary as the Zone 1 area extends from the specific equipment in question; or
- b) in the case of a building (or similar enclosed area) classified Zone 1 to the extent of the building, 3 m (10 ft) from the non-vaportight wall or opening.

6.5.4.5 When a building (or similar enclosed area) is classified Zone 2 “to the extent of the building” due to specific oil or gas handling equipment enclosed by the building, it is not necessary to extend the Zone 2 area beyond the building due to non-vaportight walls or other openings (e.g. doors and windows) except when specific equipment inside the building requires classification for distances beyond the openings. However, since

these openings occasionally may provide communication for flammable gases or vapors, for enhanced safety it generally is recommended that arcing or high temperature electrical equipment not be installed immediately adjacent to such openings.

6.5.4.6 In unattended and unmonitored facilities, a gas release within a building (or similar enclosed area) may go undetected for an extended period of time. Such facilities are typically classified as a Zone 1 location because the gas release or a loss of ventilation cannot be limited to a short time as per 6.5.1.2.4 (a). The use of gas detection in accordance with 6.8.2 with remote notification may be used to allow a response that will limit the facility's exposure to a flammable gas atmosphere to a short time as required for a Zone 2 classification.

6.5.5 Vent Openings

6.5.5.1 Certain openings are designed specifically to vent or exhaust potentially flammable gases or vapors from buildings (or similar enclosed areas)—e.g. ridge vents and forced ventilation system exhausts. Such openings in buildings should be considered as vents and classified accordingly.

- Where such openings are from a Class I, Zone 0 location, this requires a Class I, Zone 0 classification (Zone 0 for 1.5 m [5 ft] past the openings unless otherwise specified in Section 8 through Section 14) surrounded by an adjacent Zone 1 transition zone unless otherwise specified in Section 8 through Section 14, as applicable.
- Where such openings are from a Class I, Zone 1 location, this requires a Class I, Zone 1 classification (Zone 1 for 1.5 m [5 ft] past the openings unless otherwise specified in Section 8 through Section 14) surrounded by an adjacent Zone 2 transition zone unless otherwise specified in Section 8 through Section 14, as applicable.
- The area outside such openings in buildings that are classified Zone 2 should be considered Zone 2 for 1.5 m (5 ft) past the openings unless otherwise specified in Section 8 through Section 14, as applicable.

6.5.5.2 Consider the case of a non-enclosed source that releases flammable gas or vapor during normal operations. The classified area around the source normally would appear as a Zone 1 concentric circle around the source, surrounded by a concentric Zone 2 circle. The Zone 2 area is the “transition zone”. In some cases, the classified area around the source would appear as a Zone 0 concentric circle around the source, surrounded by concentric Zone 1 and Zone 2 circles.

6.5.6 Dual Classification

A Class I, Zone 2 location is allowed to abut, but not overlap, a Class I, Division 2 location. A Class I, Zone 0 or Zone 1 location is not allowed to abut a Class I, Division 1 or Division 2 location.

6.5.7 Classification Restrictions

A location may be classified in accordance with either the Zone or the Division concept provided all of the space that is classified because of a single source of release is classified using either the Zone or the Division concept, but not both.

6.5.8 Relationship Between Grade of Release and Zone Classification

6.5.8.1 Although many guidelines relate the percent of time a location contains an ignitable concentration to the Zone classification, certain locations should be classified Zone 1 even though they seldom (time-wise) contain an ignitable concentration. A room designated to spray items with flammable paint is one example of such a location. This room shall be designated Zone 1 whether one paints once a day or once a month. The room's designated use dictates that an ignitable mixture will be present under normal conditions. That is, it is normal to have an ignitable mixture in the room when it is used for its designated purpose without equipment failure. In the petroleum industry, an example of a location that should be considered Zone 1 is the space adjacent to the cover of a ball or pig launching or receiving installation. Although this location may seldom

contain ignitable concentrations of gas, one should anticipate ignitable mixtures when the cover is opened to remove or insert a ball or pig, which are normal conditions for use of the equipment.

6.5.8.2 How frequently a flammable material may be present is applicable, however, to one of the NEC conditions that dictate a Zone 1 classification: “(2) in which ignitable concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage.”

Although there is no firm rule relating the time that flammable mixtures occur with Zone 0, Zone 1, Zone 2, and unclassified locations, many (e.g. Section 1.6.4. of Third Edition of EI 15) use the rule-of-thumb provided in Table 2 to relate grade of release to the presence of flammable mixtures.

Table 2—Showing the Relationship Between Grade of Release and the Presence of Flammable Mixtures

Grade of Release	Flammable Mixture Present
Continuous	1000 or more hours/year
Primary	10 hours/year to 1000 hours/year
Secondary	less than 10 hours/year

6.5.8.3 In most cases, under open air conditions, there is a direct relationship between the Grade of Release and Zone classification. Continuous grades of release normally lead to a Zone 0 classification. Primary grades of release normally lead to a Zone 1 classification. Secondary grades of release normally lead to a Zone 2 classification. However, it should be noted that the terms “Grade of Release” and “Zone” are not synonymous. Although continuous, primary, and secondary grade releases normally will result in Zones 0, 1, and 2 classifications, respectively, this may not always be true. For example, poor ventilation may result in a more stringent classification while, with high ventilation provisions, the converse will be true. Also some sources may be considered to have a dual grade of release with a small continuous or primary grade and a larger secondary grade.

6.5.9 Unclassified Locations

6.5.9.1 Experience has shown that certain locations may be unclassified regardless of the ventilation rate since the occurrence of flammable gas or vapor liberation from some apparatus is so infrequent. Examples of such locations include the following:

6.5.9.1.1 Locations where flammable substances are contained in:

- a) all-welded closed piping systems without valves, flanges or similar devices; or
- b) continuous metallic tubing without valves, fittings, flanges, or similar devices.

6.5.9.1.2 Locations where flammable liquids, gases, or vapors are transported or stored in certain containers or vessels (refer to NFPA recommendations and Department of Transportation (DOT) regulations specifying containers for flammable liquids and gases).

6.5.9.2 Adequately ventilated locations surrounding equipment that has continuous flame sources (e.g. unprotected fired vessels and flare tips) need not be classified solely by reason of the fuel gas being considered as a source of release.

NOTE 1 It may be prudent to classify portions of these locations. For example, electrical equipment may be exposed to flammable gas during a purge cycle of a fired heater or furnace.

NOTE 2 The lack of classification around unprotected fired vessels and flare tips does not imply the safe placement of fired vessels and flare tips in the proximity to other sources of release because unprotected fired vessels and flare tips are themselves sources of ignition. The decision of whether or not it is safe to install the unprotected fired vessel or flare tip at the location is outside the scope of this document.

6.5.9.3 The practice of not classifying locations where non-electrical ignition sources (e.g. the open flame of an unprotected fired vessel or flare tip) exist has been utilized in previous issues of API RP 500 and RP 505. It is recommended that the application of this practice be limited to unprotected fired vessels or flare tips and that the resulting unclassified locations be restricted to their immediate vicinity. Electrical equipment located in these unclassified locations typically is de-energized for the majority of the time that the flame source is not present.

NOTE Although from a practical view, when an open flame is present, a spark from electrical equipment in the immediate area of the flame would not likely be the initiator of combustion, the location of sources of ignition is not a criteria for the classification of locations. Classification is, by definition, based on the likelihood of the presence of flammable mixtures. It is not the intent of this document to recommend the creation of an unclassified location in which one can locate general purpose electrical devices that are not directly associated with the combustion or ignition systems of unprotected fired vessels or flare tips.

6.5.9.4 Other locations that contain hydrocarbon handling apparatus may be unclassified. See Section 8 through Section 14, as applicable.

NOTE The examples listed in Section 8 through Section 14 consider only the specific equipment discussed and do not take into account the possible influence of adjacent areas classified due to other equipment.

6.6 Ventilation

6.6.1 General

6.6.1.1 The decision to classify a location as Zone 0, Zone 1, Zone 2, or unclassified, depends in part on the degree of ventilation of the location.

Gas or vapor released into the atmosphere can be diluted by dispersion or diffusion into the air until its concentration is below the lower flammable limit (LFL). Ventilation, i.e. air movement leading to replacement of the atmosphere in a volume around the source of release by fresh air, will promote dispersion. Suitable ventilation rates can also minimize the persistence of a flammable or explosive gas atmosphere, thus influencing the type of zone. (ANSI/ISA 60079-10-1)

6.6.1.2 Providing ventilation to allow the reclassification of an enclosed area from classified to unclassified is not allowed in enclosed areas containing a potential source of release. The following equipment, locations, and applications are excluded.

- a) Equipment as described by 6.5.9.1.
- b) Hydrocarbon-fueled prime movers with fuel gas pressure at 125 psig or less as provided for in 8.2.5.
- c) Laboratory and analyzer applications as provided for in 8.2.8.

6.6.1.3 Fixed open louvers, open grating, and the like, may be considered the same as open floors, roofs, or walls. Adjustable louvers that can be closed should be considered the same as closed floors, roofs, or walls for ventilation purposes. Adjustable louvers that are closed only during abnormal conditions (such as during a fire or fire suppressant release) and are closed only automatically can be considered the same as open floors, roofs, or walls for ventilation purposes. It is realized that floors, roofs, and walls will contain structural members.

columns, and the like that are not equivalent to open grating and louvers; when such obstructions constitute less than 15 % of the total area, they may be disregarded for ventilation degree determination.

6.6.1.4 In general, a naturally ventilated location (building, room, or space) should be substantially open and free from obstruction to the natural passage of air through it, vertically and horizontally. Such locations may be roofed or partially closed on the sides, or both.

6.6.1.5 The ventilation methodologies given in ANSI/ISA 60079-10-1, Appendix B may be used as an alternate method for determining the area classification. Utilizing this alternate method shall be applied in its entirety and shall not be mixed with other classification methods.

6.6.2 Adequate Ventilation

6.6.2.1 Adequate ventilation is defined as ventilation (natural or artificial) that is sufficient to prevent the accumulation of significant quantities of vapor-air or gas-air mixtures in concentration above 25 % of their lower flammable limit, LFL.

6.6.2.2 The source of air used for ventilation should not be from an area classified as Zone 0 or Zone 1. If practical, the source of air should be from an unclassified area. Air from a Zone 2 area may be used to reduce the classification of a space to Zone 2 that would otherwise be Zone 1.

6.6.2.3 In determining adequate ventilation, the gas or vapor concentration can be considered to be homogeneous, although it is recognized that there may be small "pockets" of higher concentrations near sources of release.

6.6.2.4 Achieving adequate ventilation is described below.

6.6.2.4.1 Several methods of achieving adequate ventilation are listed below. The list is not intended to be all-inclusive. Any method utilized is required to satisfy both (a) and (b) below, as applicable.

- a) For flammable liquids with heavier-than-air vapors, ventilation shall be arranged to ventilate all areas (particularly floor areas) where flammable vapors might collect (see 7.2.2).
- b) For lighter-than-air gases, roof or wall openings shall be arranged to ventilate all areas (particularly ceiling areas) where gases might collect.

6.6.2.4.2 Enclosed areas (rooms, buildings, or spaces) that are provided with at least six (6) air changes per hour can be considered as adequately ventilated. This ventilation rate can be accomplished by either natural or mechanical means. Loss of mechanical ventilation should be indicated by an alarm or other means to initiate corrective action.

6.6.2.4.3 Recirculation of inside air is an acceptable means of achieving adequate ventilation in enclosed areas if:

- a) the recirculated air is monitored continuously with a gas detection system meeting the requirements of 6.8.2a through 6.8.2h, and
- b) the gas detection system is designed to automatically modify recirculation, introduce additional dilution air, provide an alarm (audible or visual, or both, as most appropriate for the area), and provide exhaust (at a minimum rate as described in 6.6.2.4.2) to the outside if vapor-air mixtures in concentration over 20 % of their LFL are detected.

Dilution air shall be added to the space in question to ensure that the concentration of flammable gas or vapor is maintained below 25 % of the LFL for normal conditions.

6.6.2.4.4 For naturally ventilated enclosed areas (e.g. buildings), air flow due to thermal forces (stack effect) provides adequate ventilation if the inlet and outlet ventilation openings are properly sized and located. When

determining adequate ventilation for enclosed areas using the mathematical analysis below, a safety factor of two should be used, which increases the minimum calculated air flow rate required to 12 air changes per hour. The minimum area for inlet and outlet openings in buildings to obtain a complete change of air each five minutes (12 air changes per hour) can be calculated from Equation 1 and Equation 2 if there is no significant building internal resistance, and the inlet and outlet openings are vertically separated and on opposite walls. It is recommended that this method of calculating adequate ventilation be limited to enclosed areas (e.g. buildings) of approximately 30 m³ (1000 ft³) or less.

6.6.2.4.5 Provisions need to be made for the introduction of air in a manner to properly distribute ventilation; that is, air should not be permitted to flow directly from the air inlet to the air outlet (short-circuited) without removing air previously within the enclosed area, or from the air outlet back into the air inlet.

NOTE The specific equations below will determine the minimum area for inlet and outlet openings to provide a complete change of air each five minutes as recommended above. If a different time to exchange the inside air is desired, Equation 1 can be adjusted in an inverse linear manner; for example openings half as large would be required for a complete change of air each ten minutes. As T_i approaches T_o the stack effect is reduced.

$$A = \frac{V}{1200 \sqrt{h(T_i - T_o)/T_i}} \quad (1)$$

where

A is the free area of inlet (or outlet) opening(s), in square feet (includes a 50 % effectiveness factor);

V is the volume of building to be ventilated in cubic feet;

h see Equation 2;

T_i is the temperature of indoor air in degrees Rankine (degrees Fahrenheit plus 460);

T_o is the temperature of outdoor air in degrees Rankine;

Equation 1 was derived from the 1985 *ASHRAE Handbook of Fundamentals*, Chapter 22, using Equation (5) and Equation (10), assuming an air change every five minutes. Reference the above *Handbook*, Chapter 22, for additional information on naturally ventilated buildings.

Equation 1 applies when $T_i > T_o$. If $T_i < T_o$, replace T_i with T_o and replace T_o with T_i .

The free area (A) determined in Equation 1 assumes that the free area of the inlet is equal to the free area of the outlet. If the areas are not equal, use the smaller of the two areas and refer to Figure 7, Chapter 22, of the 1985 *ASHRAE Handbook of Fundamentals*, reproduced below as Figure 1. The area of the openings (A) as determined from Equation 1 can be reduced by the same percentage as the "increase in percent" obtained from Figure 1.

$$h = \frac{H}{1 + [(A_1/A_2)^2 (T_i/T_o)]} \quad (2)$$

where

h is the height from the center of the louver opening to the neutral pressure level (NPL) in feet. The NPL is the point on the vertical surface of a building where the interior and exterior pressures are equal.

A_1 is the free area of lower opening in square feet;

A_2 is the free area of upper opening in square feet;

H is the vertical distance (center-to-center) between A_1 and A_2 in feet;

Equation 2 applies when $T_i > T_o$. If $T_i < T_o$, the ratio T_i/T_o should be inverted.

A sample calculation for determining the minimum number of louvers required for adequate ventilation in a building (using Equation 1 and Equation 2) is given in Annex A.

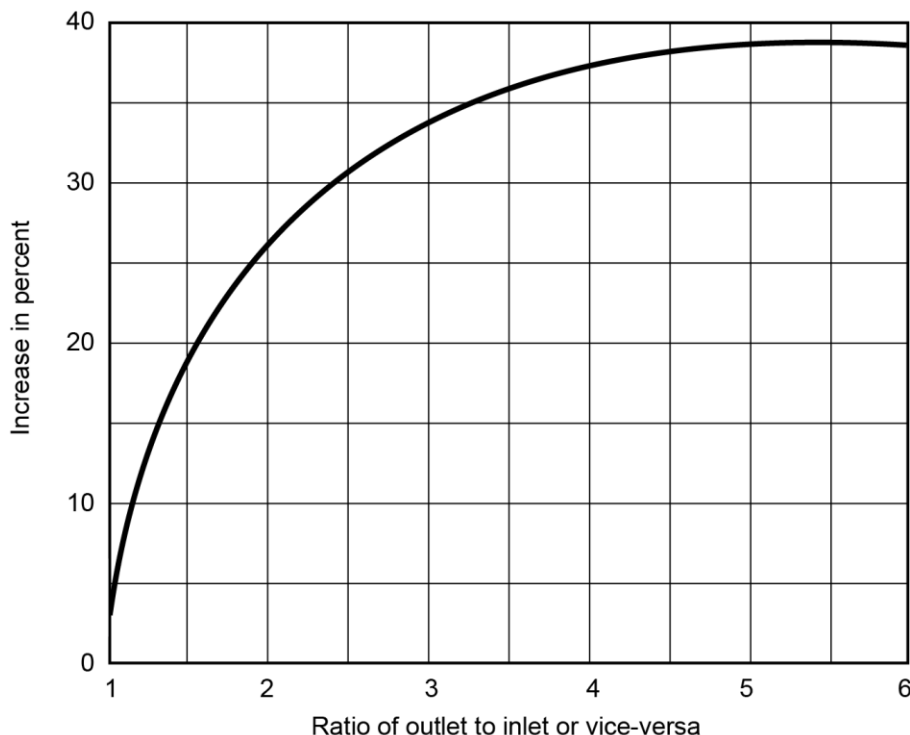


**Figure 1—Increase in Flow Caused by Excess of One Opening Over Another
(See 6.6.2.4.5)**

6.6.2.4.6 Buildings or other enclosed or partially enclosed areas are considered adequately ventilated because of their construction characteristics if they comply with both 6.6.2.4.1 and one of the following:

- a building or area having a roof or ceiling with walls comprising 50 % or less vertical wall area than the total wall area possible is considered to be adequately ventilated (regardless of the type of floor);
- a building or area is considered to be adequately ventilated provided it has neither a floor (for example, the floor is grating) nor a roof or ceiling;
- a building or area is considered to be adequately ventilated provided it is without a roof or ceiling, and provided that there are no walls for a minimum of 25 % of its perimeter.

6.6.2.4.7 Enclosed areas can be considered as adequately ventilated if the ventilation rate provided is at least four times the ventilation rate required to dilute the anticipated fugitive emissions to below 25 % LFL, determined by detailed calculations as per Annex B. If the ventilation rate provided is less than three air changes per hour, it is recommended that continuous monitoring with fixed gas detectors be provided to assure that less than 25 % LFL is maintained. This ventilation rate can be accomplished by either natural or mechanical means. Loss of mechanical ventilation should be indicated by an alarm or other means to initiate corrective action.

Recirculation of inside air is permitted in accordance with 6.6.2.4.3.

6.6.3 Inadequately Ventilated Areas

6.6.3.1 Inadequately ventilated areas are defined as rooms, buildings, or spaces that do not have a natural or a mechanical ventilation system providing for adequate ventilation as defined in 6.6.2.

6.6.3.2 It is possible to have portions of enclosed areas (e.g. buildings) adequately ventilated while other portions are inadequately ventilated. For example, the lower portion of a compressor building (shed) without walls (from the floor) might be adequately ventilated, while the upper portion of the shed (particularly if without ridge vents or the like) might be inadequately ventilated.

6.7 Adjacent Areas

6.7.1 A non-enclosed adequately ventilated area that is adjacent to a classified area, and that is not separated from the classified area by a vaportight barrier, should be classified to the extent designated by Section 8 through Section 14, as applicable. See Figure 2.

6.7.2 An enclosed area that is adjacent to a classified area, and that is separated from the classified area by a vaportight barrier, is unclassified, considering only the external source. See Figure 3.

6.7.3 An enclosed area that is adjacent to a classified area, and that is not separated from the classified area by a vaportight barrier, should be classified the same as the highest classification included. See Figure 4 and Figure 5.

6.7.4 It may be possible to reduce the classification of an enclosed area adjacent to a classified area if the enclosed area is purged in accordance with NFPA 496.

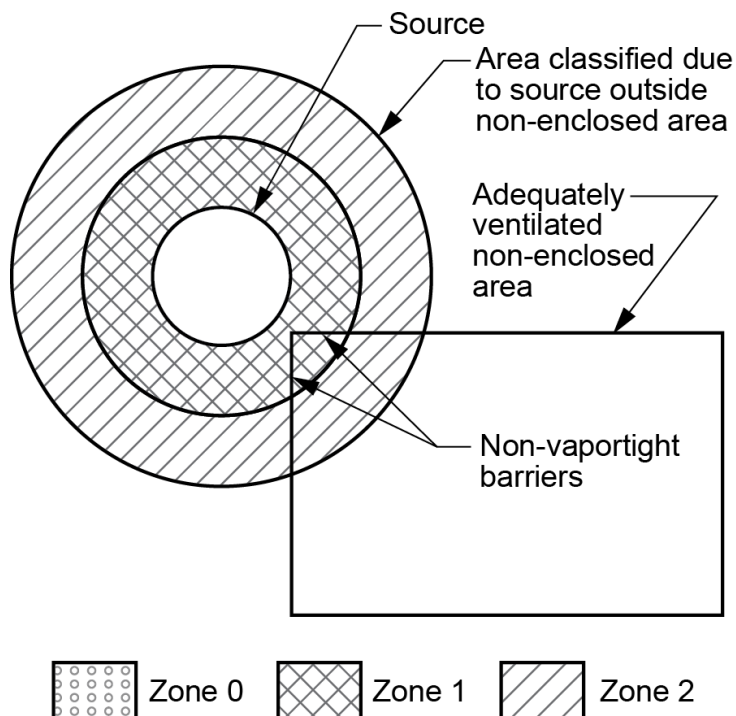


**Figure 2—Adequately Ventilated Non-enclosed Area Adjacent to a Classified Area
(See 6.7.1)**

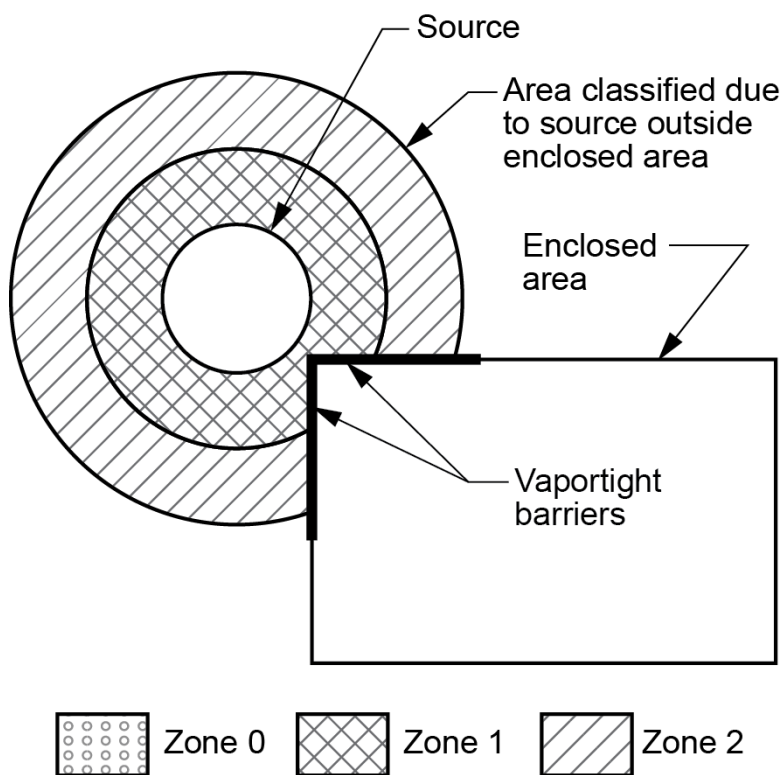


Figure 3—Enclosed Area Adjacent to a Classified Area
(See 6.7.2)

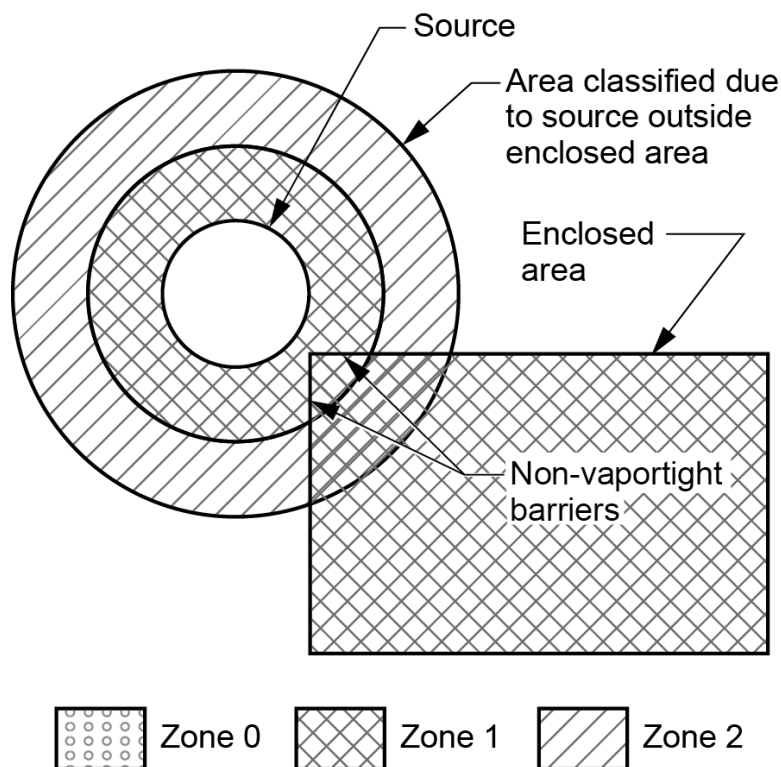


Figure 4—Enclosed Area Adjacent to a Classified Area
(See 6.7.3)

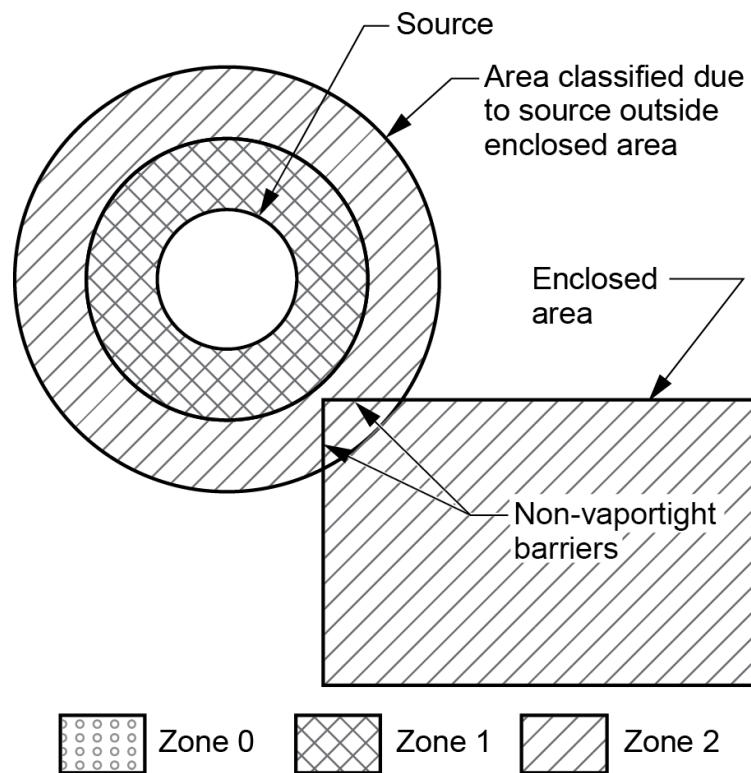


Figure 5—Enclosed Area Adjacent to a Classified Area
(See 6.7.3)

6.8 Use of Combustible Gas Detection Equipment

6.8.1 Provided the conditions of 6.8.2 are met, the installation of combustible gas detection equipment can be a basis for the following.

- a) An inadequately ventilated Zone 1 area containing equipment that could release flammable gas or vapor can be designated as suitable for Zone 2 electrical equipment. Documentation of the area classification shall include the basis for installing electrical equipment suitable for Zone 2 in the Zone 1 area.

NOTE 1 If an area contains equipment that may release flammable gases or vapors within the area during normal operations, gas detectors are not a feasible alternative unless some degree of ventilation is provided since frequent alarms or equipment shutdowns, or both, are likely to occur.

NOTE 2 For Class I, Zone 0 locations, the installation of gas detectors is not feasible as very frequent alarms or equipment shutdowns, or both will occur.

- b) The interior of a building (or similar area) that does not contain a source of flammable gas or vapor can be designated as suitable for electrical equipment for unclassified locations, even though a door or similar pierced portion or all of the outside of the building is located in a Zone 2 area, provided the building is of a type construction that is essentially vaportight; that is, the building will not allow the entry of significant quantities of outside atmospheric pressure gas or vapor. Buildings made of fiberglass (molded fiberglass or fiberglass sprayed over wood) or seal welded steel plate normally are used to meet this criteria, but other construction methods may be equally satisfactory. Penetrations should be minimized—normally limited to a personnel entry door(s), electrical cable entries, air conditioning unit(s), and the like. The buildings should contain no windows that can be opened, and the personnel entry door(s) should be provided with adequate gaskets or weather stripping. Openings for air conditioning units and windows should be adequately caulked or otherwise made vaportight. Air conditioning equipment should not introduce outside air into the building. Entries for cables and other services should be made in a vaportight manner. Documentation of the area

classification shall include the basis for installing electrical equipment suitable for unclassified locations in the Zone 2 area.

6.8.2 The criteria for use of combustible gas detection equipment to meet the objectives of 6.8.1 follow.

- a) The gas detectors are stationary type and permanently mounted. Portable gas detectors or open path combustible gas detection (line-of-sight) will not satisfy this requirement.
- b) The gas detection equipment is of a type listed or approved by a nationally recognized testing laboratory (NRTL) as gas detection equipment. Combustible gas detectors that have been evaluated for explosions in Class I hazardous atmospheres and the risk of fire and electric shock shall also include performance testing for the specific gas listed and safe operation of the instrument in the presence of flammable or explosive mixtures of representative gases with air. It is recommended that equipment meet ANSI/ISA-60079-29-1.

NOTE Combustible gas detection equipment available with other types of NRTL labels are not acceptable substitutes for the type identified in 6.8.2b, as performance testing is not a requirement for labeling. These include:

- classified gas or vapor detection enclosures—combustible gas detectors in this category have only been evaluated for explosions and fires in Class I hazardous atmospheres; and
 - classified gas or vapor detection equipment—combustible gas detectors in this category have only been evaluated for explosions in Class I hazardous atmospheres and the risk of fire and electric shock.
- c) An adequate number of sensors is installed to ensure the sensing of flammable gas or vapor in the building (or similar area) in all areas where such gas might accumulate.

NOTE For offshore production and drilling operations, refer to API 14C.

- d) Sensing a gas concentration of 20 % LFL (or less) should activate a local alarm (audible or visual, or both, as most appropriate for the location).

It is recommended that remedial action be initiated at this level to avoid reaching the 40 % LFL level, which requires power disconnection for 6.8.1b) applications as detailed in 6.8.2e.

- e) Sensing a gas concentration of 40 % LFL has different requirements for applications of 6.8.1a) or 6.8.1b) as follows.
 - For applications of 6.8.1 a) where all equipment is required to be suitable for Zone 2, sensing a gas concentration of 40 % LFL (maximum) or a gas detector system malfunction should activate an alarm (audible or visual, or both, as most appropriate for the area).
 - For applications of 6.8.1b), sensing a gas concentration of 40 % LFL (maximum) or a gas detector system malfunction should both activate an alarm (audible or visual, or both, as most appropriate for the area) and initiate automatic disconnection of power from all electrical devices in the area that are not suitable for Zone 2. The power disconnecting device(s) should be suitable for Class I, Zone 1 if located inside the building (or similar area); if the disconnecting device(s) is located outside the building (or similar area), it should be suitable for the area in which it is located. Redundant or duplicate components (such as sensors) may be installed to avoid disconnecting electrical power when single component malfunctions are indicated. When automatic shutdown could introduce additional or increased hazard, this technique of reducing the equipment suitability requirements as given in 6.8.1a) or 6.8.1b) should not be used.
 - In applying 6.8.1a) or 6.8.1b), the case of sensing 40 % LFL or a gas detection system malfunction, corrective action to reduce the gas concentration should be initiated immediately.

- f) The gas detectors should be calibrated at a frequency in accordance with the manufacturer's recommendations, but at least once every three months. Calibration should be performed by actual

exposure of the sensor to a known mixture (nominal 50 % LFL recommended) of diluent and methane or other gas anticipated, in accordance with the manufacturer's recommendations.

- g) User-provided systems bypassing the disconnecting or other "corrective action" devices (but not audible or visual alarm devices) to allow calibration and maintenance are permitted, provided the bypass system is utilized only during calibration or maintenance operations, and only while the area is manned by personnel who are qualified to take corrective action should there be a malfunction in process, storage, transfer, or similar equipment that potentially might release flammable gas or vapor into the area. Any systems in the bypass mode shall be made continuously obvious (audibly or visually) to facility personnel.
- h) The building (or similar area) contains no electrically heated parts or components (not enclosed in explosion-proof or flameproof enclosures or otherwise suitable for Zone 1 applications) that may operate at a temperature equal to or above 80 % of the autoignition temperature (expressed in degrees C) of the gas or vapor involved unless the component has been verified by a NRTL to operate below the autoignition temperature of the gas or vapor.

NOTE Electrically heated parts and components could remain at or above the autoignition temperature for some time after de-energization.

6.8.3 It is recommended that gas detectors be installed, operated, and maintained in accordance with ANSI/ISA-60079-29-2.

7 Extent of a Classified Location

7.1 General

7.1.1 Locations are classified solely for the selection, design, and installation of electrical equipment.

Although electrical area classification drawings may be useful to assist in determining designated welding areas, smoking areas, and the like, they do not contain all the information that is necessary for making decisions for designating such locations. It should not be implied that it is safe to have non-electrical sources of ignition in unclassified locations.

7.1.2 The volume, temperature, and volatility of liquid or gas that could be released, the nature of the leak source, and the rate at which it could be released, are of extreme importance in determining the extent of a classified location. Sound engineering judgment is required to properly determine the extent of classified locations.

7.1.3 In most petroleum facilities, there are sources of ignition in addition to those associated with electrical equipment (for example, piping systems and engine manifolds operated at elevated temperatures and unprotected fired vessels). The extent of classified locations is determined only by the location of potential sources of release of flammable liquids, gases, and vapors, and not by the location of sources of ignition—electrical or non-electrical.

7.2 Outdoor Locations

7.2.1 In the absence of walls or other barriers, and in the absence of air currents or similar disturbing forces, it should be assumed that a gas or vapor will disperse uniformly in all directions, as governed by the gas or vapor density and velocity (that is, heavier-than-air vapors principally downward and outward; lighter-than-air gases principally upward and outward).

7.2.2 For heavier-than-air vapors released at or near grade level, the locations where potentially ignitable concentrations are most likely to be found are below grade; those at grade are next most likely; and as the height above grade increases, the potential decreases. In open locations away from the immediate point of release, freely drifting heavier-than-air vapors from a source near grade seldom are above the lower flammable limits at elevations more than a few feet above grade. For lighter-than-air gases the opposite is true; there is little potential of an ignitable mixture below grade, and greater potential above grade.

Gases, vapors, and combinations of gases and vapors should be carefully analyzed to determine whether they are heavier- or lighter-than-air under all operating conditions. Mixtures often contain both lighter-than-air and heavier-than-air components.

7.2.3 Elevated or below grade sources of gas or vapor release, or release of gas or vapor under pressure, may substantially alter the outline of the limits of the classified location. Also, low velocity movement (e.g. movement caused by a mild breeze) may extend these limits in the direction of air movement. However, higher velocity air movement (e.g. a stronger breeze) can so accelerate the dispersion of gases or vapors that the extent of the classified location would be greatly reduced. The nature of the release (that is, whether it is a high pressure spray-type mist or a low velocity stream or drip) also has a significant impact on the extent of the classified location. Thus, dimensional limits recommended for Zone 0, Zone 1, and Zone 2 locations are based on experience, as well as theoretical diffusion of gases or vapors of the types prevalent in petroleum operations. There are several techniques available to aid in the analysis of gas and vapor dispersion, including specific plant experience and computer simulation programs. These techniques may be used with good engineering judgment to modify standard area classification boundaries for specific applications.

NOTE Reference Annex D for one such technique. Annex D considers the volatility of material and predicted release rates to determine the extent of classification boundaries. Use of Annex D typically requires a more rigorous engineering analysis and requires the collection and analysis of material data, equipment design data and process conditions not normally required for area classification assessments. For more volatile materials and larger release rates, use of this method may result in the extent of classified areas equal to or greater than those derived from the conventional methods presented in this document. For less volatile materials and smaller release rates this method may result in a reduction of the extent of the classified area. The alternate method may be used to verify/validate the classification of existing facilities and upgrades to existing facilities, but is not typically used to classify new “grassroot” facilities because the level of detailed information necessary to apply the method is not available when the area classification is determined.

7.2.4 Air currents, quantity of release, nature of release, and volatility combine to affect the extent of a classified location. Vapors are rapidly dispersed in a well-ventilated location. For this reason, outdoor locations and locations having ventilation equivalent to normal outdoor conditions often can be classified as Zone 2 or unclassified. However, where ventilation is inadequate, vapor-air and gas-air mixtures are more likely to reach flammable limits, and the situation should justify a change in the degree or extent of the classified area.

7.3 Enclosed Locations

Some enclosed locations (e.g. buildings) used for petroleum operations have mechanical ventilation provided. Also, construction design may permit a substantial degree of natural ventilation that, when coupled with such factors as volumetric content of the enclosed location, floor area, lineal dimensions of walls, and ceiling height could justify considering that enclosed location as adequately ventilated. If adequate ventilation is provided, mechanically or naturally, many enclosed locations may be classified Zone 2 instead of Zone 1, and some locations may be classified Zone 1 instead of Zone 0. A careful evaluation of prior experience with the same or similar types of installations, including the temporary use of tarpaulins or similar devices as windbreaks, should be a part of the classification criteria.

8 Recommendations for Determining Degree and Extent of Classified Locations—Common Applications

8.1 General

8.1.1 This section presents guidelines for classifying locations for electrical installations common in many petroleum facilities. The examples have been developed by experience in industry and are applicable to most petroleum facilities. Section 9 through Section 14 provide guidance for classifying locations within specific refining, production, and transportation facilities.

8.1.2 Specific examples listed consider only the item discussed and do not take into account the possible influence of adjacent areas classified due to other equipment. Application of these examples to similar, though not identical, situations should be made with sound engineering judgment, employing information presented in this RP and other publications.

8.2 Recommendations for Areas Surrounding Specific Equipment

8.2.1 Storage Tanks

Appurtenances added to the storage tank walls can affect the area classification surrounding the storage tank. By adding screwed fittings or flanges to the storage tank walls, the fittings or flanges can be an additional source of flammable vapor.

8.2.1.1 Fixed Roof Flammable Liquid Storage Tanks

8.2.1.1.1 Areas in and around flammable liquid storage tanks in non-enclosed adequately ventilated areas are classified as shown in Figure 6. Reference 5.2 for a discussion of “Flammable Liquids.”

8.2.1.1.2 Areas surrounding fixed roof flammable liquid storage tanks in adequately ventilated enclosed areas are classified as shown in Figure 6, but with the remainder of the enclosed area designated as Zone 2, provided all vents are extended to the outside of the enclosed area and there are no hatches or similar devices inside the enclosed area.

8.2.1.1.3 Areas inside fixed roof flammable liquid storage tanks in inadequately ventilated enclosed areas are classified Zone 0 and areas surrounding the tank Zone 1 to the extent of the enclosed area provided all vents are extended to the outside of the enclosed area and there are no hatches or similar devices inside the enclosed area.

8.2.1.2 Open-top Floating Roof Flammable Liquid Storage Tanks

8.2.1.2.1 Areas in and around open-top floating roof flammable liquid storage tanks in non-enclosed adequately ventilated areas are classified as shown in Figure 7. Reference 5.2 for a discussion of “Flammable Liquids.”

8.2.1.2.2 Areas in and around open top floating roof flammable liquid storage tanks in adequately ventilated enclosed areas are classified as shown in Figure 7, but with the remainder of the enclosed area designated as Zone 2, provided all vents are extended to the outside of the enclosed area and there are no hatches or similar devices inside the enclosed area.

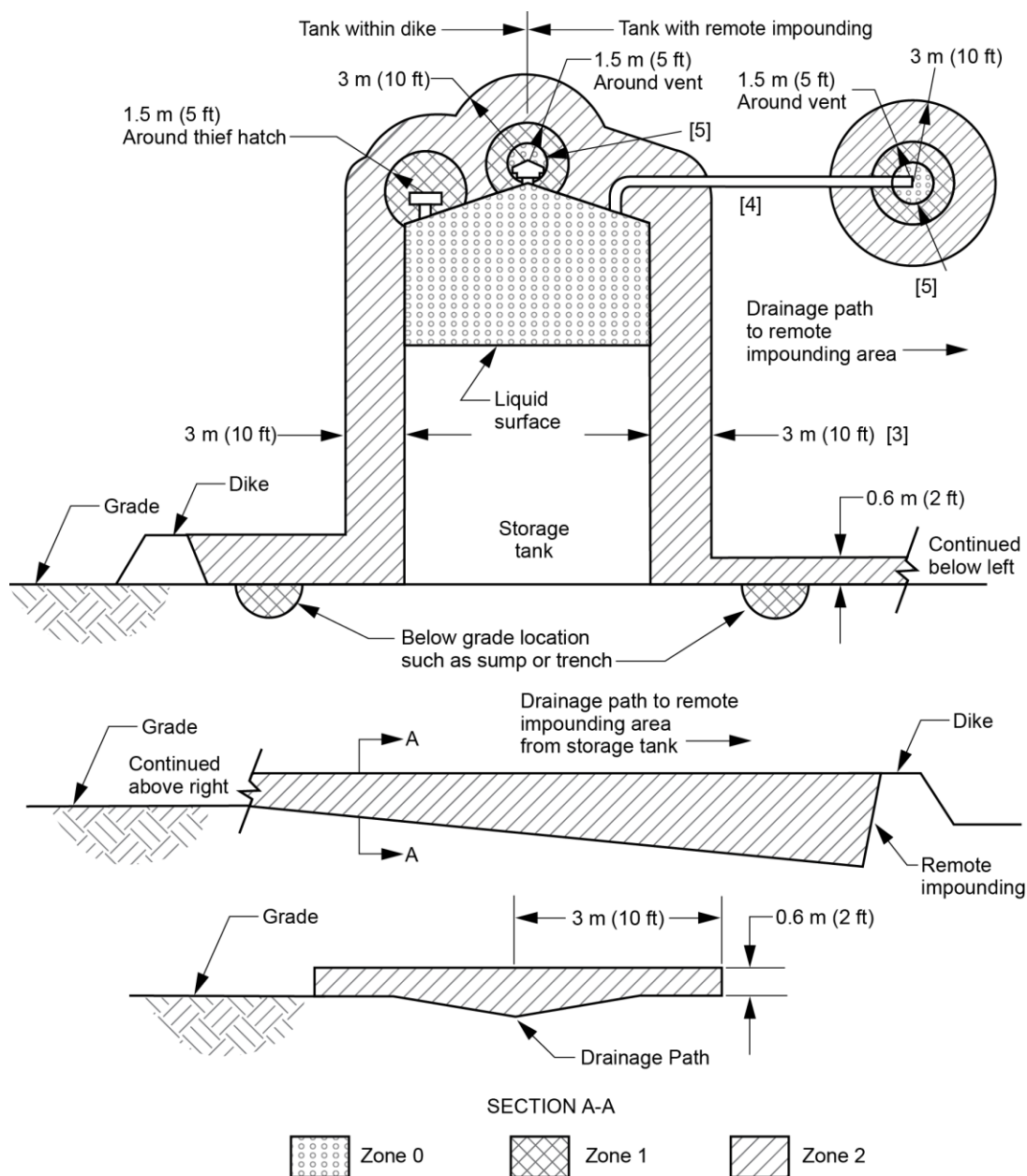
8.2.1.2.3 Areas in and around open top floating roof flammable liquid storage tanks in inadequately ventilated enclosed areas are classified Zone 0 inside the tank as shown in Figure 7, but also Zone 0 outside the tank to the extent of the enclosed area.

8.2.1.3 Combustible Liquid Storage Tanks

8.2.1.3.1 Unheated storage tanks for combustible liquids (e.g. diesel fuel and Jet A fuel) in non-enclosed adequately ventilated areas are classified as shown in Figure 8. Reference 5.2 for a discussion of “Combustible Liquids.”

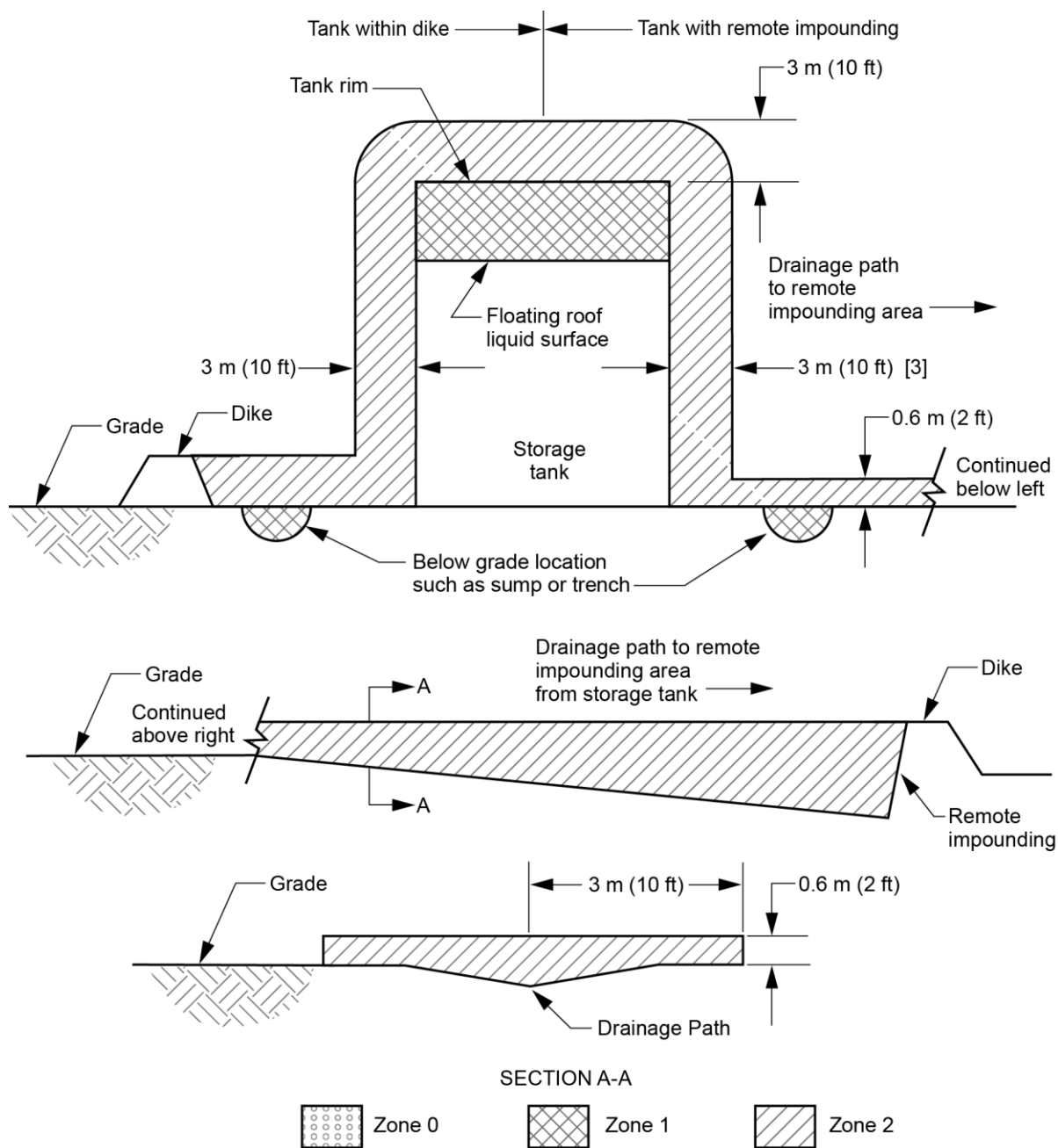
8.2.1.3.2 Enclosed areas containing unheated storage tanks for combustible liquids are unclassified provided all vents are extended to the outside of the enclosed area.

8.2.1.3.3 The area surrounding the vents is classified to allow for the possibility that the surface of the liquid might be heated above its flash point by the ambient. The area surrounding the vents need not be classified if the liquid will be handled and stored below its flash point.



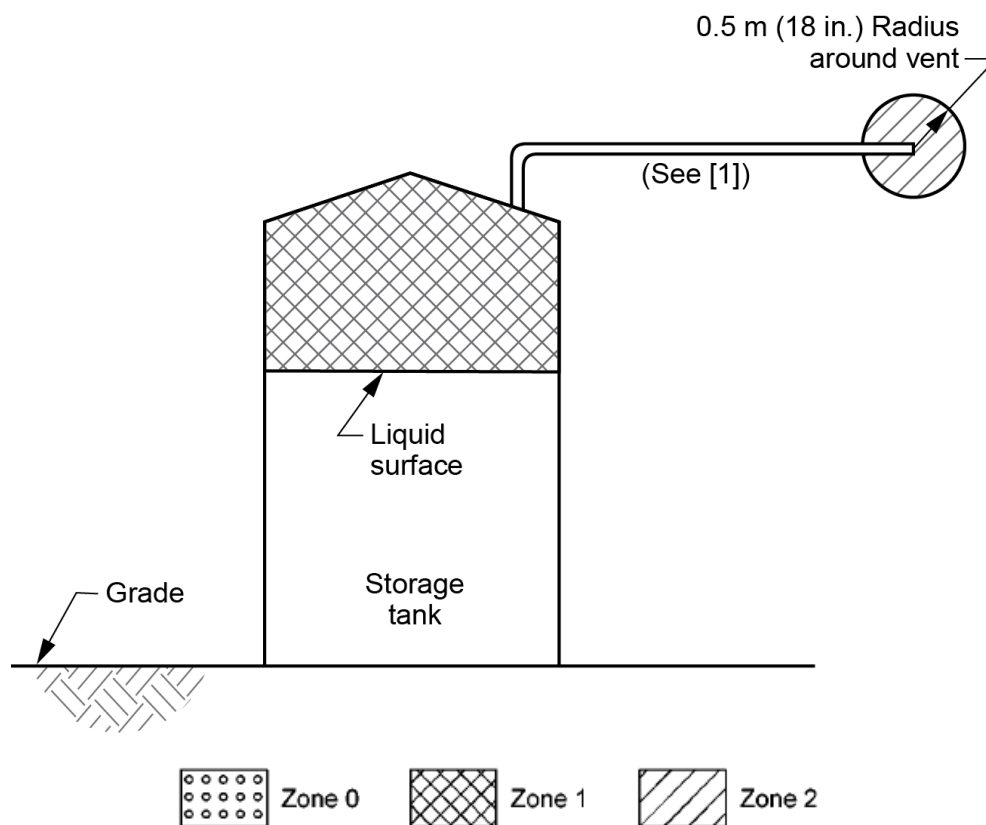
- [1] High filling rates or blending operations involving Class 1 flammable liquids may require extending the boundaries of classified areas.
- [2] Distances given are for typical petroleum facilities; they shall be used with judgment, with consideration given to all factors discussed in the text.
- [3] If there is no dike or no remote impounding, the Zone 2 area only extends 3 m (10 ft) horizontal distance from the tank shell.
- [4] The interior of the vent piping is Zone 0. Cross hatching has been omitted for drawing clarity.
- [5] An area 0.5 m (18 in.) around vents is classified Zone 0.

Figure 6—Fixed-roof Flammable Liquid Storage Tank in a Non-enclosed, Adequately Ventilated Area (See 8.2.1.1.1)



- [1] High filling rates or blending operations involving Class 1 flammable liquids may require extending the boundaries of classified areas.
- [2] Distances given are for typical petroleum facilities: they shall be used with judgment, with consideration given to all factors discussed in the text.
- [3] If there is no dike or no remote impounding, the Zone 2 area only extends 3 m (10 ft) horizontal distance from the tank shell.

Figure 7—Open Top Floating Roof Flammable Liquid Storage Tank in a Non-enclosed, Adequately Ventilated Area (See 8.2.1.2)



[1] The interior of the vent piping is Zone 1. Cross hatching has been omitted for drawing clarity.

Figure 8—Combustible Liquid Storage Tank in a Non-enclosed, Adequately Ventilated Area
(See 8.2.1.3)

8.2.2 Tank Cars and Tank Trucks

8.2.2.1 Locations where tank cars or tank trucks are loaded or unloaded via closed systems, transferring liquefied gas, compressed gas, or cryogenic liquid only through the dome are classified as shown in Figure 9.

8.2.2.2 Locations where tank cars or tank trucks are loaded or unloaded via closed systems, transferring flammable liquids only through the dome are classified as shown in Figure 10.

8.2.2.3 Locations where tank cars or tank trucks are loaded or unloaded via closed systems, transferring flammable liquid only through the bottom are classified as shown in Figure 11.

8.2.2.4 Locations where tank cars or tank trucks are loaded or unloaded via open systems, transferring flammable liquid through the top or the bottom are classified as shown in Figure 12.