Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as 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 Zone 0, Zone 1, and Zone 2 at petroleum facilities for the selection and installation of electrical equipment. Basic definitions given in the 2023 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 13is 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.

1.2.9 Section 14 is applicable to facilities processing, handling, and storage of liquefied natural gas (LNG)

2 Normative References

2.1 General

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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

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*

NFPA 30 [4], *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*

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).

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

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 (normal or atmospheric)
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 "purged and pressurized."

3.1.7
Classification
See 3.1.7.1 through 3.1.7.6.

3.1.7.1
Zone 0
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
Zone 1
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 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
Zone 2
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 of 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 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.

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 can 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. See 3.1.7.5.

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 indicated in 3.1.8.1 through 3.1.8.3.

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 and pressurized
3.1.16 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."

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
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 and the lower limit is expressed as LFL.

NOTE: The terms "LEL" and "LFL" as well as the terms "UEL" and "UFL are sometimes used interchangeably; however, they are not the same. 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
Liquefied natural gas
LNG

A fluid in the cryogenic liquid state that is composed predominately of methane and that can contain minor quantities of ethane, propane, nitrogen, and other components normally found in natural gas. See 14.1

3.1.31
location
Throughout this RP, reference is made to areas, spaces, and locations. These terms should be considered interchangeable terms designating a three-dimensional space.

3.1.32
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.

3.1.33
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 3.1.7.6.

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

ABS	American Bureau of Shipping
ACT	automatic custody transfer
ANSI	American National Standards Institute
API	American Petroleum Institute
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASTM	ASTM International
BOP	blowout preventer
BSEE	Bureau of Safety and Environmental Enforcement
CSA	Canadian Standards Association
DOT	Department of Transportation
EI	Energy Institute (formerly IP, Institute of Petroleum)
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 (currently Energy Institute)
IMO	International Maritime Organization
ISA	International Society of Automation
LFL	lower flammable limit
LNG	liquefied natural gas
MESG	maximum experimental safe gap
MIC	minimum ignition current
MODU	mobile offshore drilling unit
NEC	*National Electrical Code*
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
TFL	through flow line
TLP	tension leg platform
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.

a) 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).

b) 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.

c) 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), liquefied natural gas (LNG), 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, and low minimum ignition energy level. Hydrogen operating at high and very high pressures requires additional considerations for the classification of areas.

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 ratio (MIC ratio), or both. Test equipment for determining the MESG and MIC ratio are described in,UL 80079-20-1: Material Characteristics for gas and vapour classification – Test methods and data. The classification of gases or vapors according to their maximum experimental safe gaps and minimum igniting currents is described in UL 80079-20-1: 2017 Explosive atmospheres – Part 20-1: Material Characteristics for gas and vapour classification – Test methods and data.

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 locations with Groups IIA, IIB, and IIC materials, 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 + H2)*	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:

a) the extent of all areas that are classified;

b) the Zone;

c) the gas or gas group(s); and

d) the maximum permissible surface temperature for the electrical equipment in the area.

6.1.3 The identification of Zone 0, Zone 1, and Zone 2 locations shall utilize the symbols in Annex F except for additions or modifications to existing documentation that may use the symbols of the existing documentation. See E.7 for additional documentation considerations.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 Zone 0 designation; a primary grade to a Zone 1 designation; and a secondary grade to a 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

NOTE: The term "Class I" was originally included as a prefix to Zone 0, Zone 1, and Zone 2 locations and references as an identifier for flammable gases, vapors, or liquids to differentiate from Class II and Class III locations. Zone 0, Zone 1, and Zone 2 only apply to flammable gases, vapors or liquids, so "Class I" prefix is redundant and therefore deleted. "Class I" on markings remains optional.

6.5.1.2 Classified Locations

6.5.1.2.1 Classified 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. Classified locations include the following.

6.5.1.2.2 *Zone 0.* A Zone 0 location is a location: a) in which ignitable concentrations of flammable gases or vapors are present continuously; or b) 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 *Zone 1.* A 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 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; the 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 *Zone 2.* A 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 of 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 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 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 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 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 Annex G 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 the equipment to meet 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.

a) Where such openings are from a Zone 0 location, this requires a 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.

b) Where such openings are from a Zone 1 location, this requires a 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.

c) 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 Zone 2 location is allowed to abut, but not overlap, a Class I, Division 2 location. A 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 1.5.4. of Fourth 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 instrument taps, 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. Since flammable gas may exist during the purge cycle of a fired heater or furnace or other process or maintenance operations, it may be prudent to classify portions of these locations. For fuel gas applications exceeding 861.8kpa (125 psi), see 8.2.5.4 and 8.2.5.5.

NOTE 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 gas atmosphere, thus influencing the classification of the area. . Annex C provides background on the development of adequate ventilation criteria.

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; and

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 Adequate ventilation is addressed in 6.6.2.4.1.

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 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 Annex G; 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 m^3 (1000 ft^3) 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.

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

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) from that publication, assuming an air change every five minutes. Reference the above *Handbook*, Chapter 22, for additional information on naturally ventilated buildings.

NOTE 1 Equation 1 applies when Ti > To. If Ti < To, replace Ti with To and replace To with Ti.

NOTE 2 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 as Figure 1 in this document. 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.

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

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 Ti > To. If Ti < To, the ratio Ti/To 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.

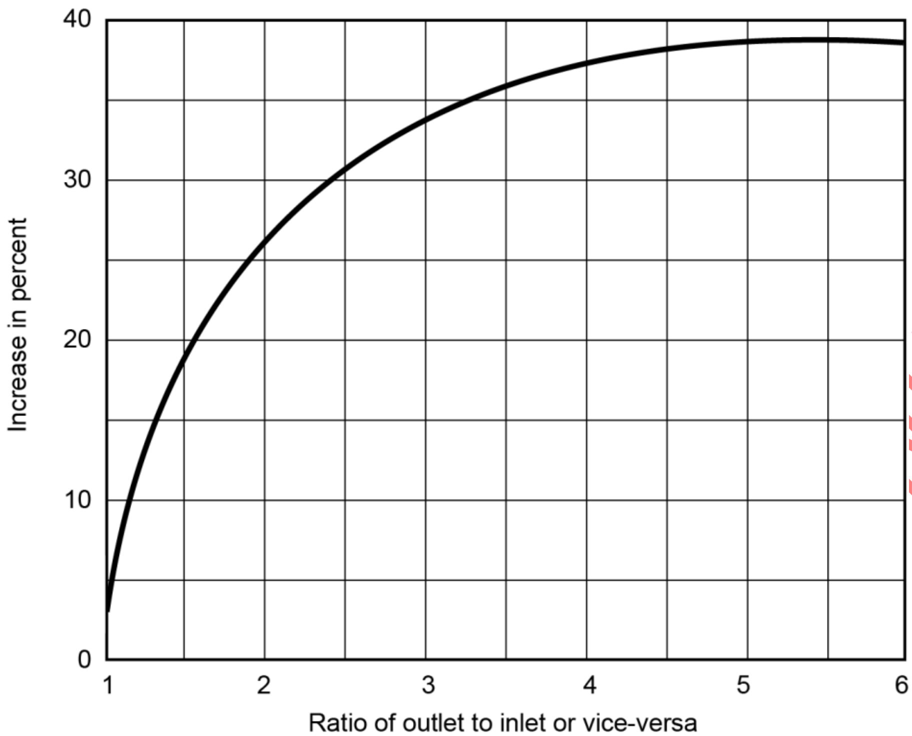


Figure 1—Increase in Flow Caused by Excess of One Opening Over Another (See 6.6.2.4.5)

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) 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);

b) 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;

c) 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 or 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, inadequately 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 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 pressurized in accordance with NFPA 496.

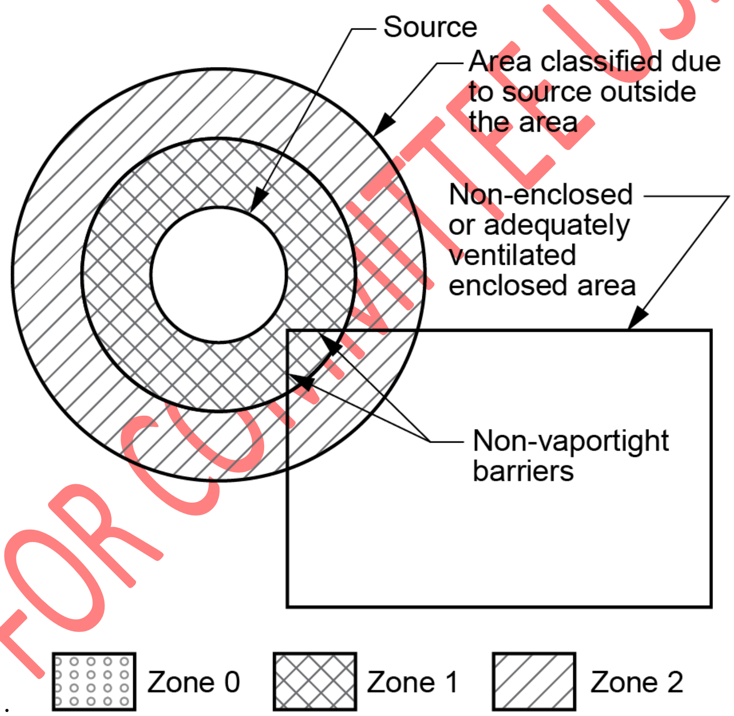


Figure 2—Non-enclosed or Adequately Ventilated Enclosed Area Adjacent to a Classified Area (See 6.7.1)

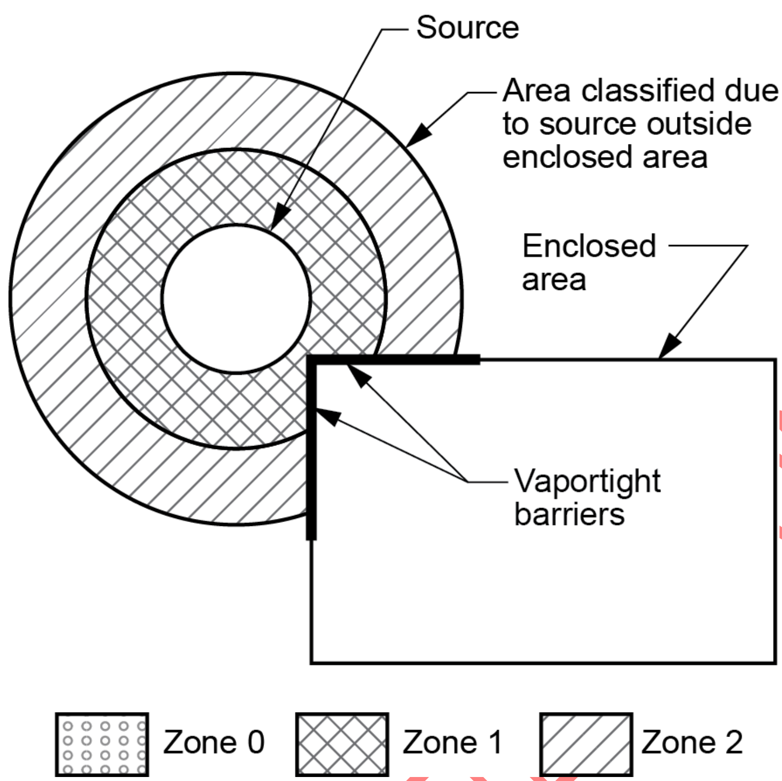


Figure 3—Enclosed Area Adjacent to a Classified Area (See 6.7.2)

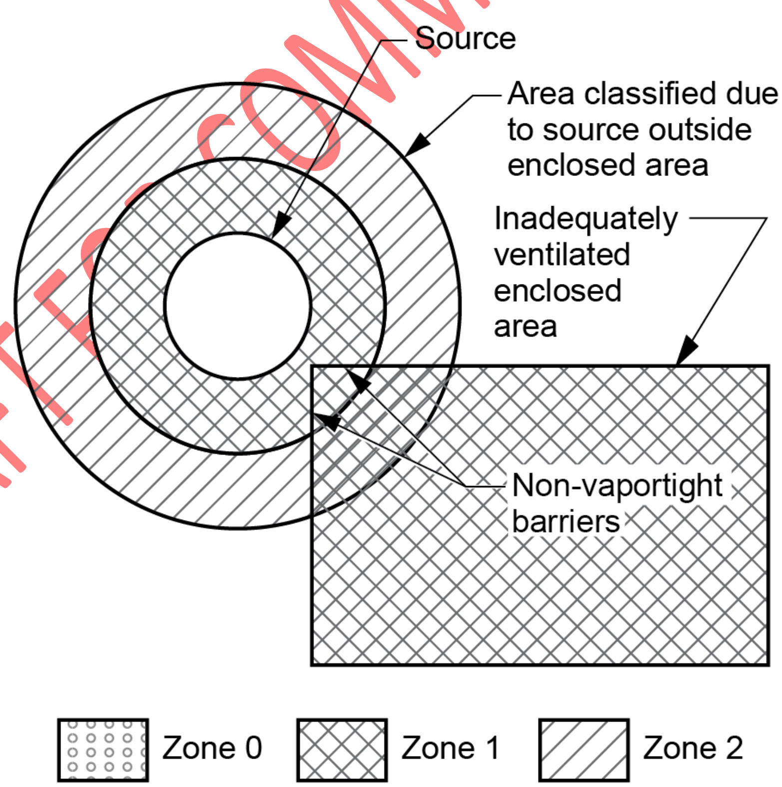


Figure 4—Inadequately Ventilated, Enclosed Area Adjacent to a Classified Area (See 6.7.3)

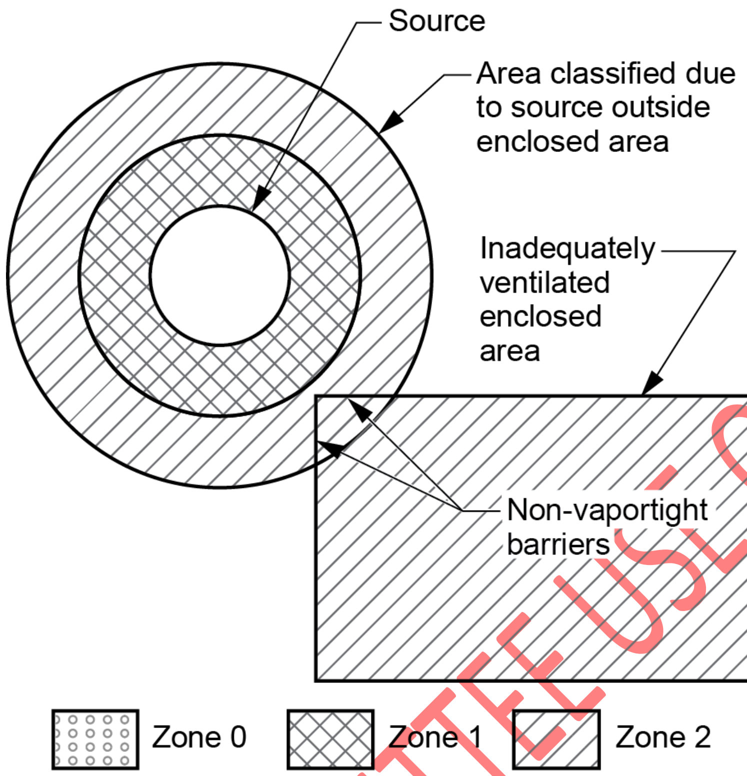


Figure 5—Inadequately Ventilated Enclosed Area Adjacent to a Classified Area (See 6.7.3)

6.8 Use of Combustible Gas Detection Equipment

The requirements for the use of combustible gas detection equipment as a method of protection for electrical equipment have been relocated to Annex G as these requirements are not used for the purpose of classifying areas.

While combustible gas detection cannot be the basis for classification of a location, it can be utilized as a protection method that augments other requirements that identify suitable electrical equipment for a location.

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.

NOTE: 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 mixtures of gases and vapors shall be analyzed to determine whether they are heavier- or lighter-than-air under all operating conditions.

NOTE: 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 sound 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 Containing Sources of Release

An enclosed location (such as a building or enclosure) that is inadequately ventilated and contains a source(s) of release is typically classified Zone 1 to the extent of the enclosure. Depending on the nature of the source of release, the Classification may be determined to be Zone 0 to the extent of the enclosure. The addition of adequate ventilation through mechanical or natural means can justify the reduction of the area classified as Zone 0 to Zone 1 or Zone 1 to Zone 2. For sources of release under normal operating conditions, the area immediately surrounding the source of release still requires a Zone 1 classification. For continuous sources of release, the area surrounding the source of release requires a Zone 0 classification. An 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

8.2.1.1 General

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.

8.2.1.2 Fixed Roof Flammable Liquid Storage Tanks

8.2.1.2.1 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.”

8.2.1.2.2 Areas in and around fixed roof flammable liquid storage tanks in enclosed adequately ventilated 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.

8.2.1.2.3 Areas in and around 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.

8.2.1.3 Open-top Floating Roof Flammable Liquid Storage Tanks

8.2.1.3.1 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.”

8.2.1.3.2 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.

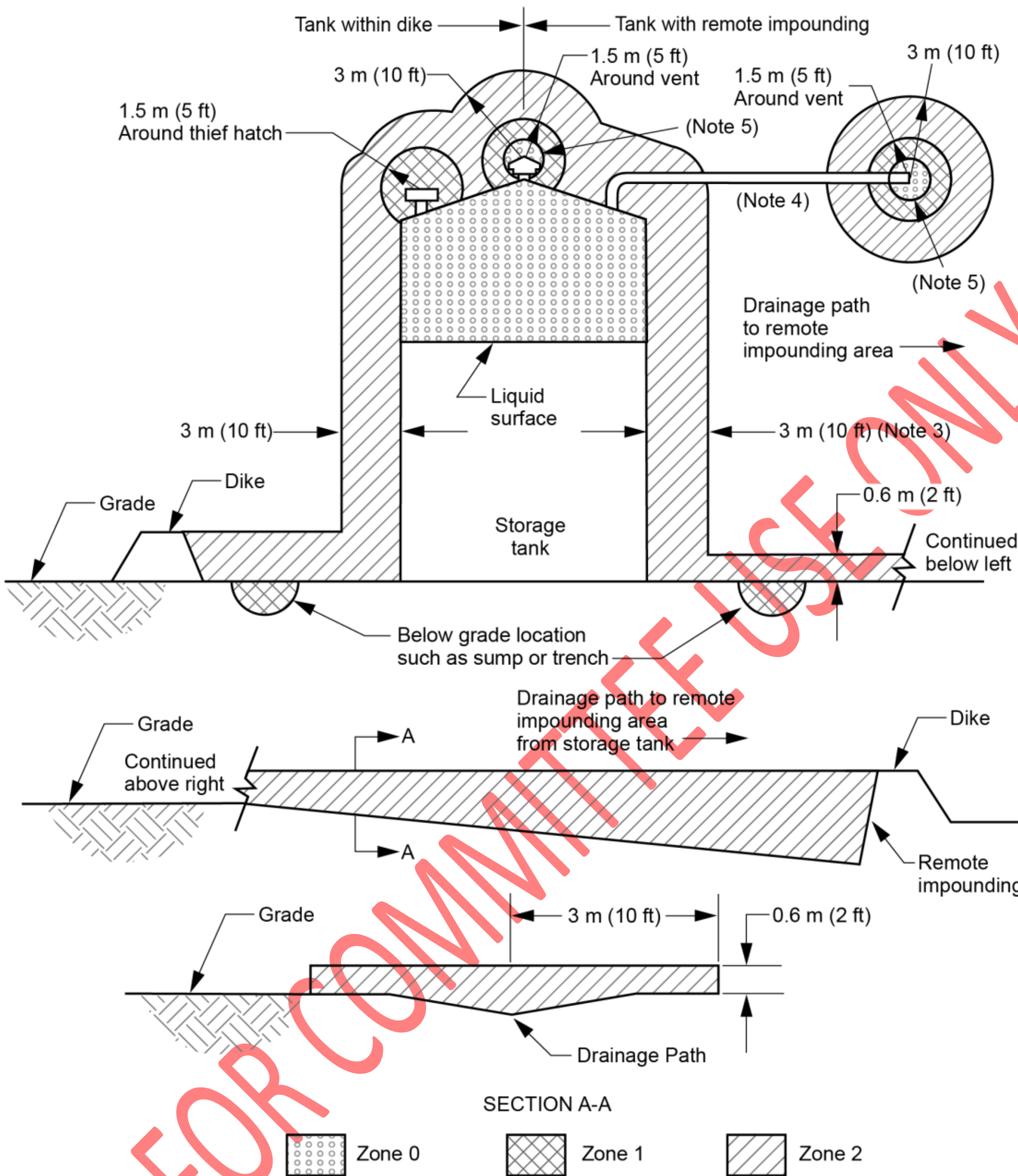
8.2.1.3.3 Areas in and around open top floating roof flammable liquid storage tanks in inadequately ventilated enclosed areas are classified Zone 0 inside the tank as shown in Figure 7, but also Zone 0 outside the tank to the extent of the enclosed area.

8.2.1.4 Combustible Liquid Storage Tanks

8.2.1.4.1 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."

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

8.2.1.4.3 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.



NOTE 1 High filling rates or blending operations involving Class I flammable liquids may require extending the boundaries of classified areas.

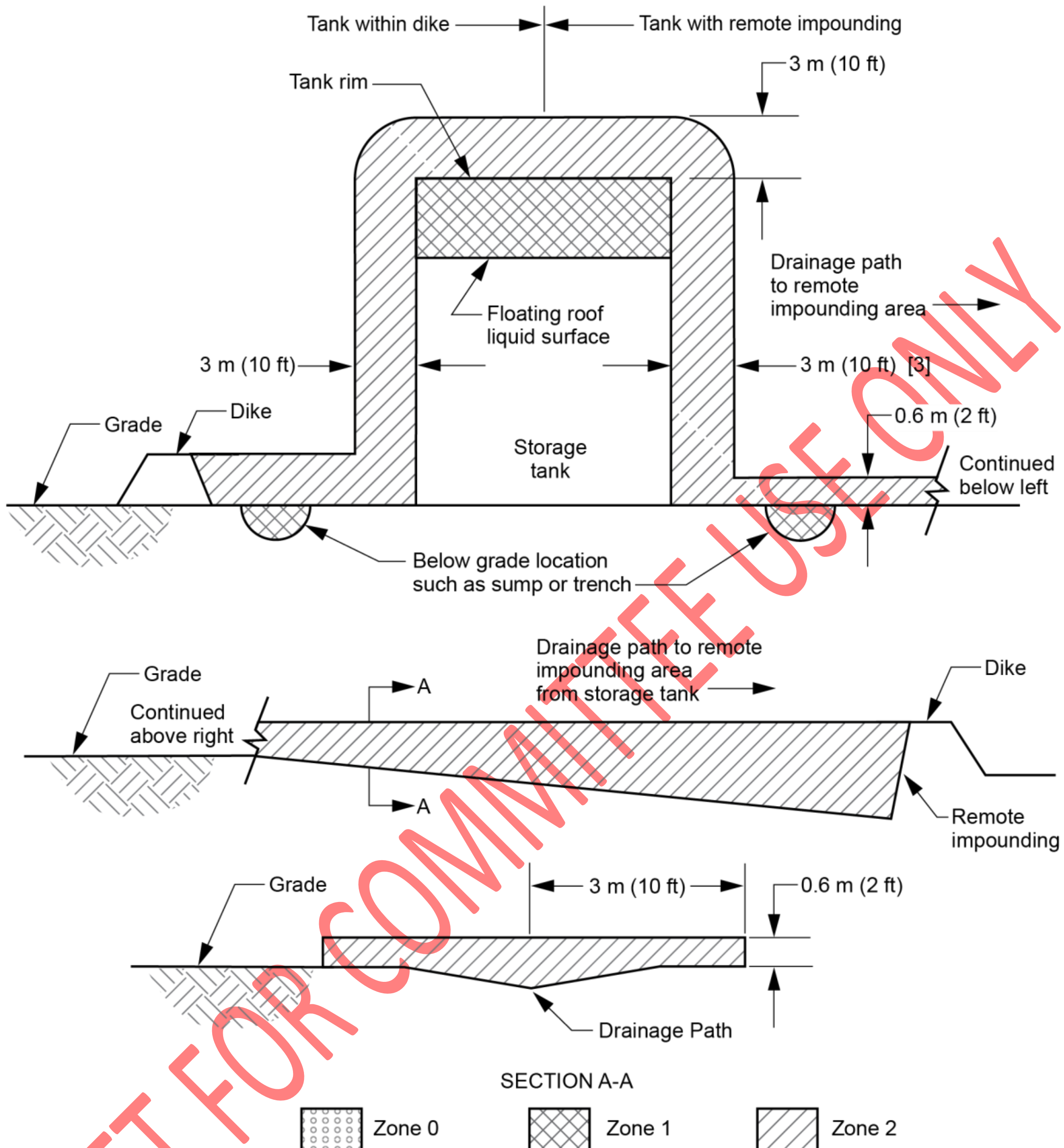
NOTE 2 Distances given are for typical petroleum facilities: they must be used with judgment, with consideration given to all factors discussed in the text.

NOTE 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.

NOTE 4 The interior of the vent piping is Zone 0. Cross hatching has been omitted for drawing clarity.

NOTE 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 8.2.1.2.1 and 8.2.1.2.2)

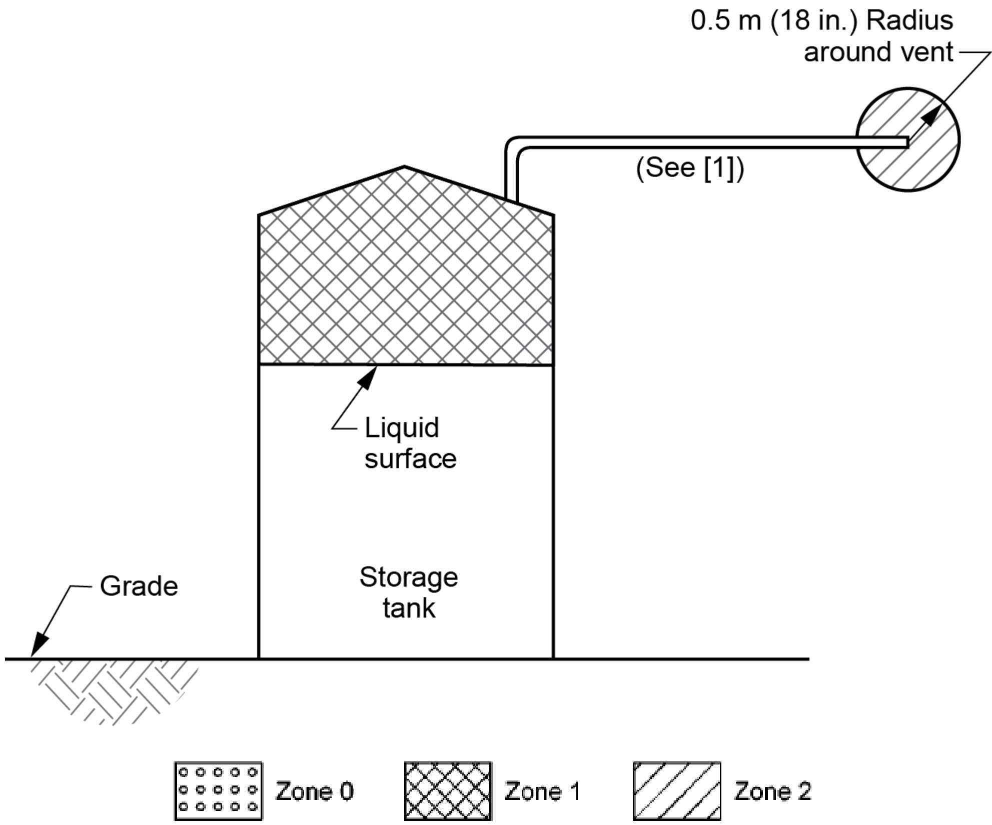


[1] High filling rates or blending operations involving Class I flammable liquids may require extending the boundaries of classified areas.

[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 8.2.1.3)



[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 8.2.1.4)

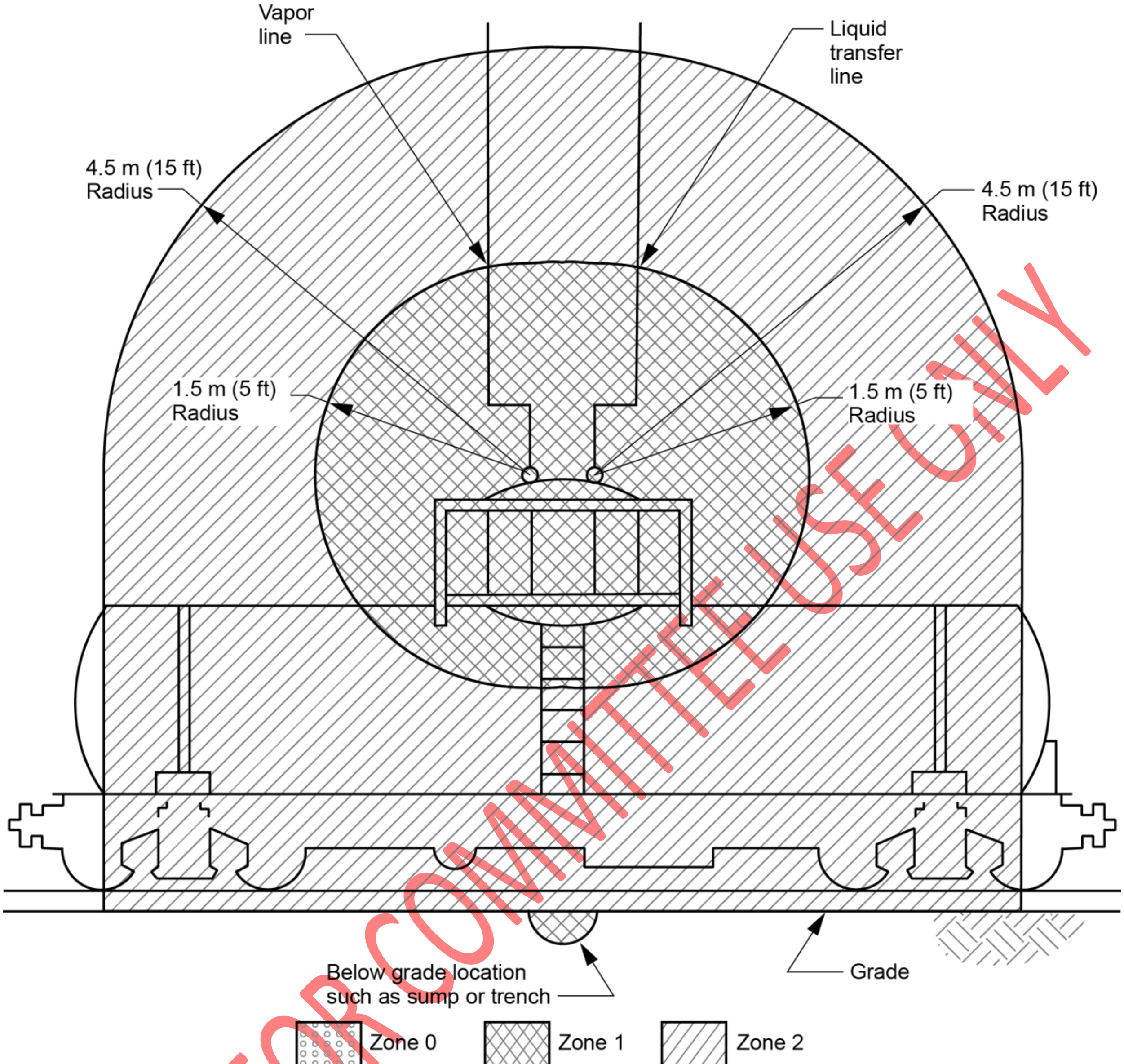
8.2.2 Tank Cars and Tank Trucks

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.



Material: Flammable liquid; for combustible liquid, see 8.2.2.6

Figure 9—Tank Car or Tank Truck Loading and Unloading via Closed System. Product Transfer Through Dome Only (See 8.2.2.1)

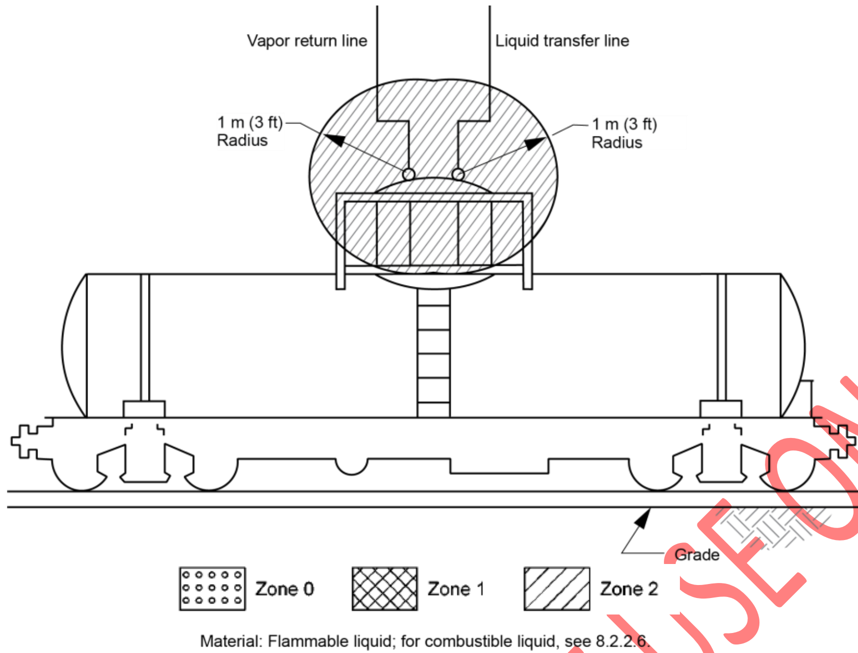


Figure 10—Tank Car or Tank Truck Loading and Unloading Via Closed System. Product Transfer Through Dome Only (See 8.2.2.2)

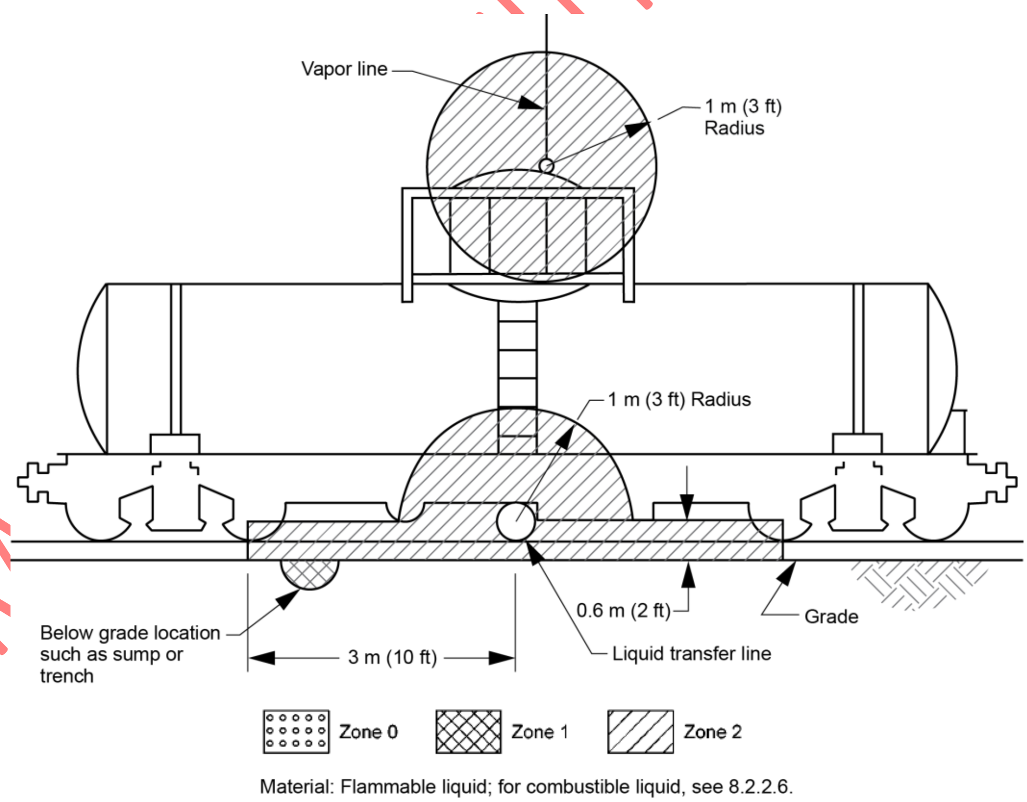


Figure 11—Tank Car or Tank Truck Loading and Unloading Via Closed System. Product Transfer Through Bottom Only (See 8.2.3)

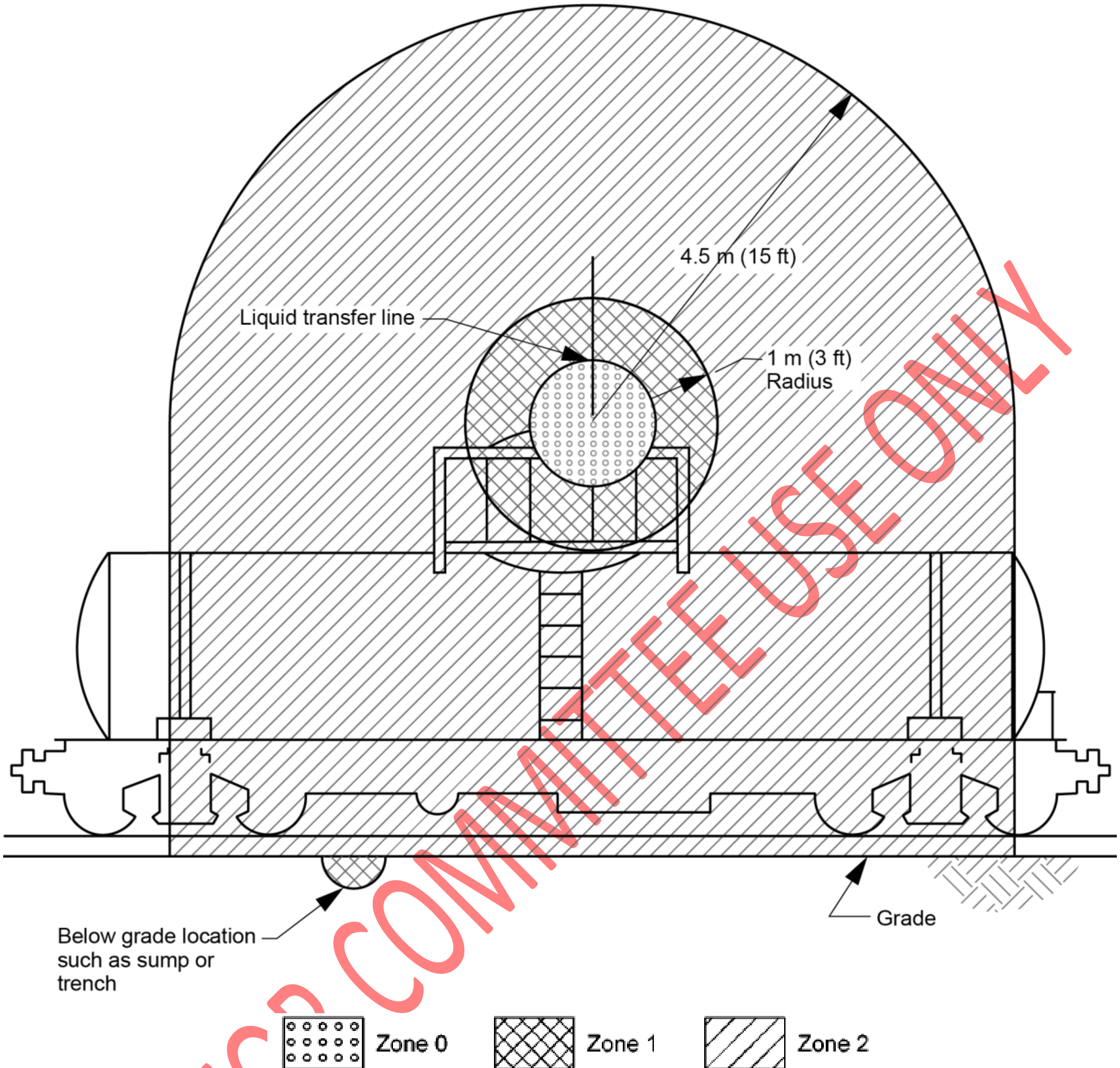


Figure 12—Tank Car or Tank Truck Loading and Unloading Via Open System. Product Transfer Through Top or Bottom (See 8.2.2.4)

8.2.2.5 Locations where tank cars or tank trucks are loaded or unloaded via closed systems, transferring liquefied gas, compressed gas, or cryogenic liquid only through bottom transfer are classified as shown in Figure 13.

8.2.2.6 Locations where tank cars or tank trucks are loaded or unloaded, transferring combustible liquids below their flash point are unclassified except for the area surrounding any vent opening that requires a 0.5 m (18 in.) Zone 2 classification. For combustible liquids transferred at or above their flash point, the equipment arrangement for loading and unloading of flammable liquids, Figure 10, Figure 11, or Figure 12 apply.

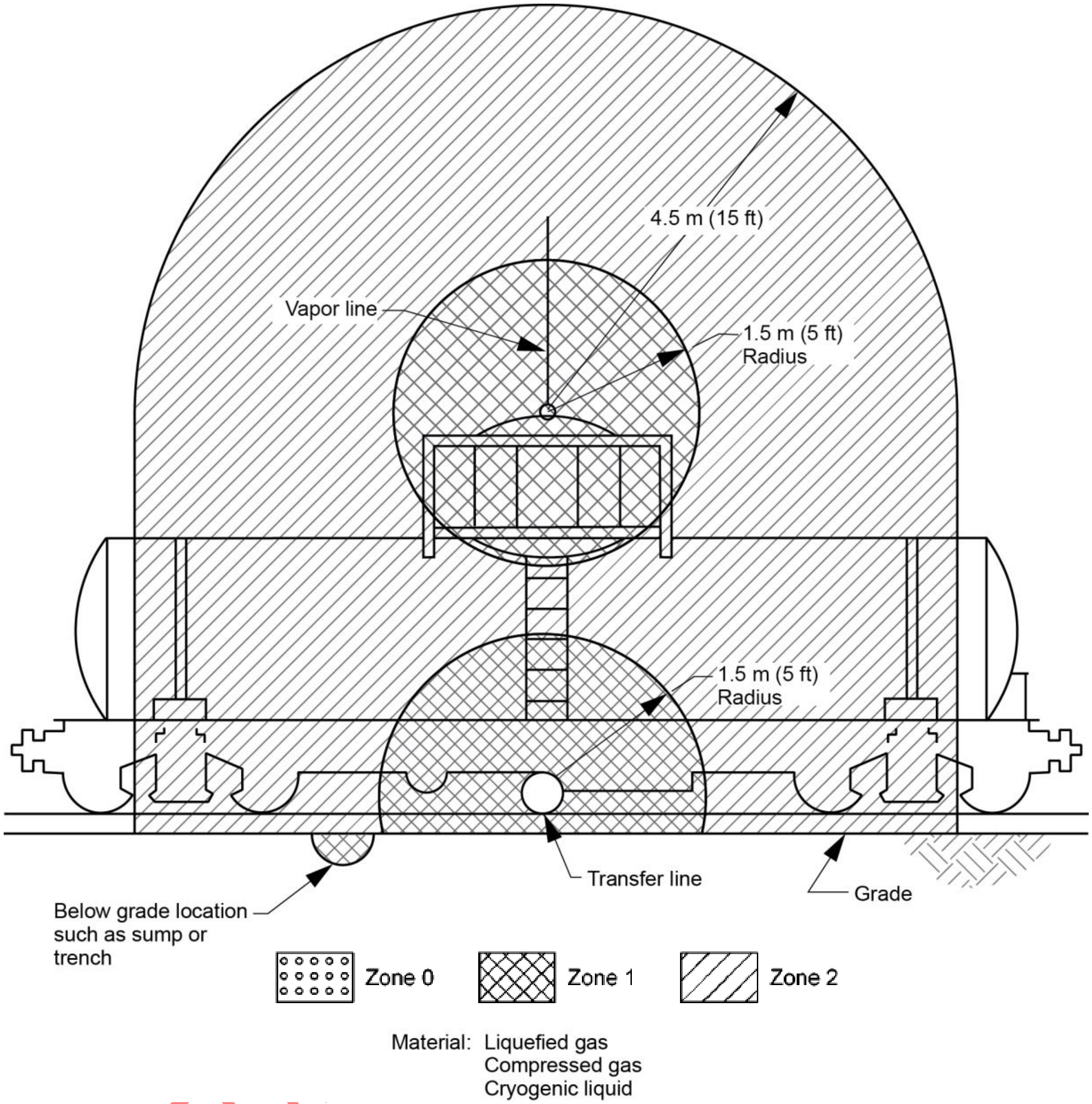


Figure 13—Tank Car or Tank Truck Loading and Unloading Via Closed System. Product Transfer Through Bottom Only (See 8.2.2.5)

8.2.3 Vents, Relief Valves, and Rupture Disks

8.2.3.1 Process Equipment Vents

8.2.3.1.1 The criteria affecting the extent of the classification of the areas around process equipment vents in non-enclosed areas are too diverse to specify distances. Sound engineering judgment is required for specific cases, but in no case should the classification be less than that shown by Figure 14.

8.2.3.1.2 Enclosed areas containing process equipment vents are classified Zone 0 or Zone 1 to the extent of the enclosed area dependent on ventilation and grade of release.

8.2.3.2 Instrument and Control Device Vents

8.2.3.2.1 Adequately ventilated non-enclosed areas containing vents from instruments and control devices utilizing flammable gas for control are classified as shown in Figure 15.

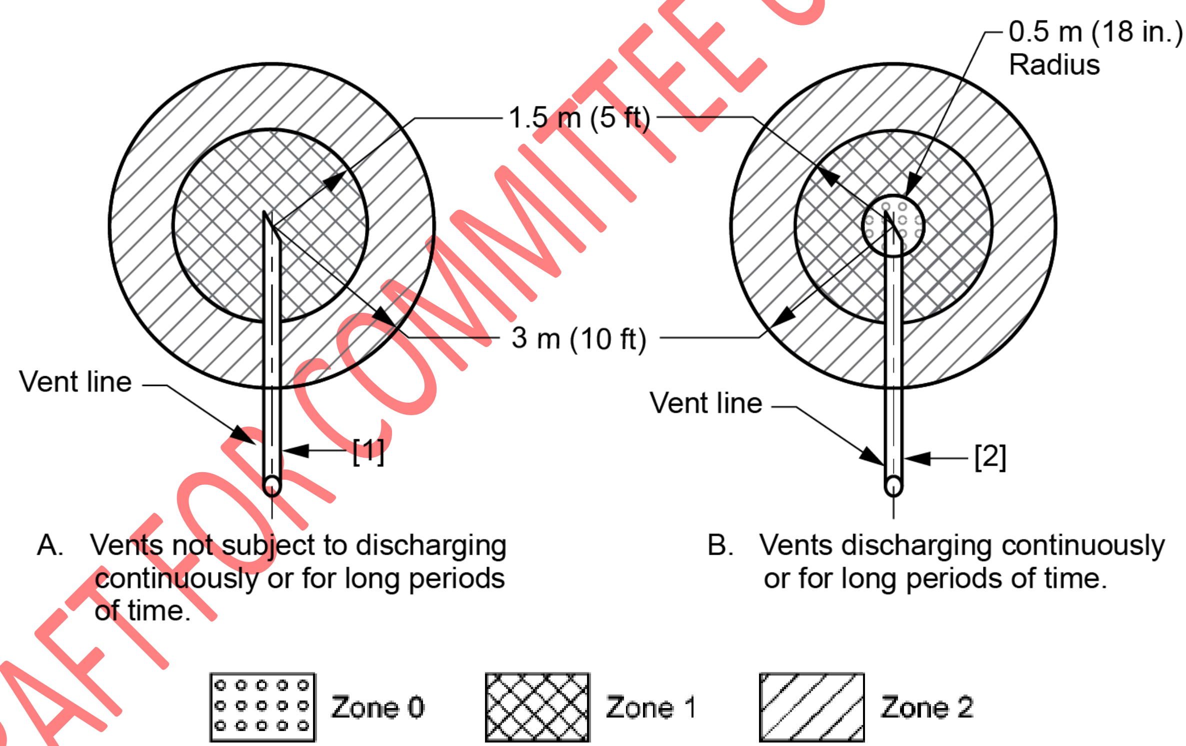
8.2.3.2.2 Enclosed areas containing vents from instruments and control devices utilizing flammable gas for control are classified Zone 0 to the extent of the enclosed area.

8.2.3.3 Atmospheric Vents

8.2.3.3.1 Atmospheric vents (e.g. atmospheric tank vents) venting from a Zone 0 area are classified in a manner shown in Figure 14B, they should be surrounded by a Zone 0 classification for a distance of 0.5 m (18 in.). The Zone 0 classification should be surrounded by a Zone 1 classification for a distance of 1 m (3 ft), which, in turn, should be surrounded by a Zone 2 classification of 1.5 m (5 ft).

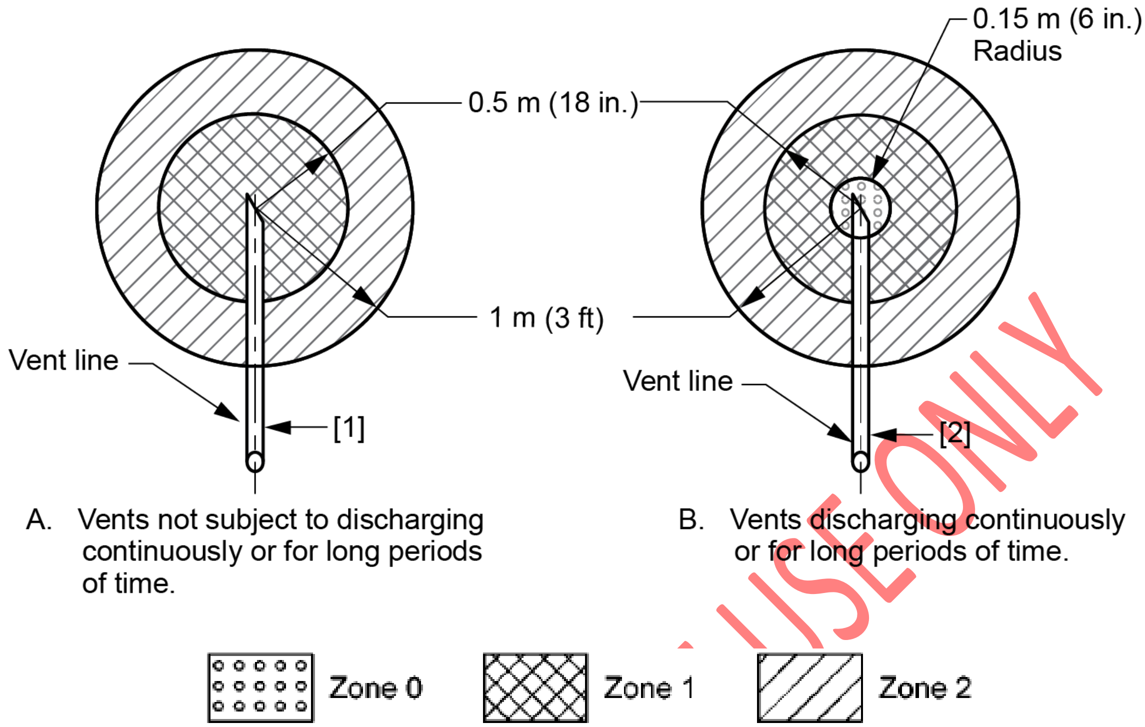
8.2.3.3.2 Atmospheric vents (e.g. building ridge vents, building roof vents, and atmospheric tank vents) are classified as shown in Figure 16 when they vent from a Zone 1 area.

8.2.3.3.3 Atmospheric vents (e.g. building ridge vents and building roof vents) are classified as shown in Figure 17 when they vent from a Zone 2 area.



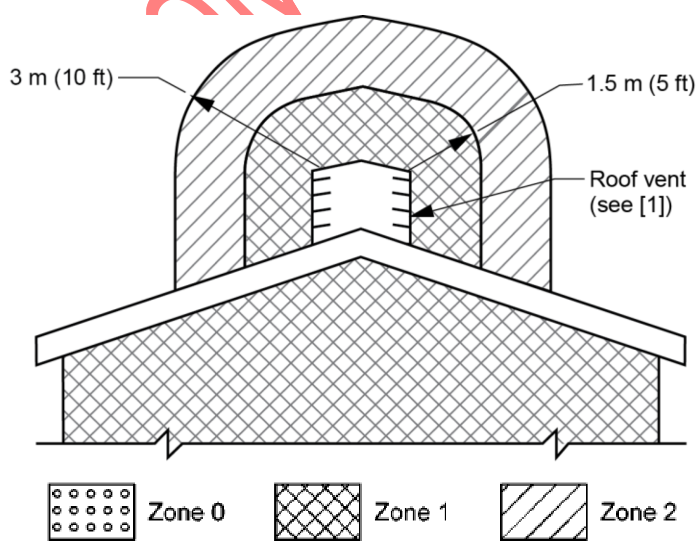
[1] The interior of the vent piping is Zone 1. Cross hatching has been omitted for drawing clarity.
[2] The interior of the vent piping is Zone 0. Cross hatching has been omitted for drawing clarity.

Figure 14—Process Equipment Vent in a Non-enclosed Adequately Ventilated Area (See 8.2.3.1)



[1] The interior of the vent piping is Zone 1. Cross hatching has been omitted for drawing clarity.
[2] The interior of the vent piping is Zone 0. Cross hatching has been omitted for drawing clarity.

Figure 15—Instrument or Control Device Vent in a Non-enclosed, Adequately Ventilated Area (See 8.2.3.2)



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

Figure 16—Atmospheric Vent From a Zone 1 Area (See 8.2.3.3.2)

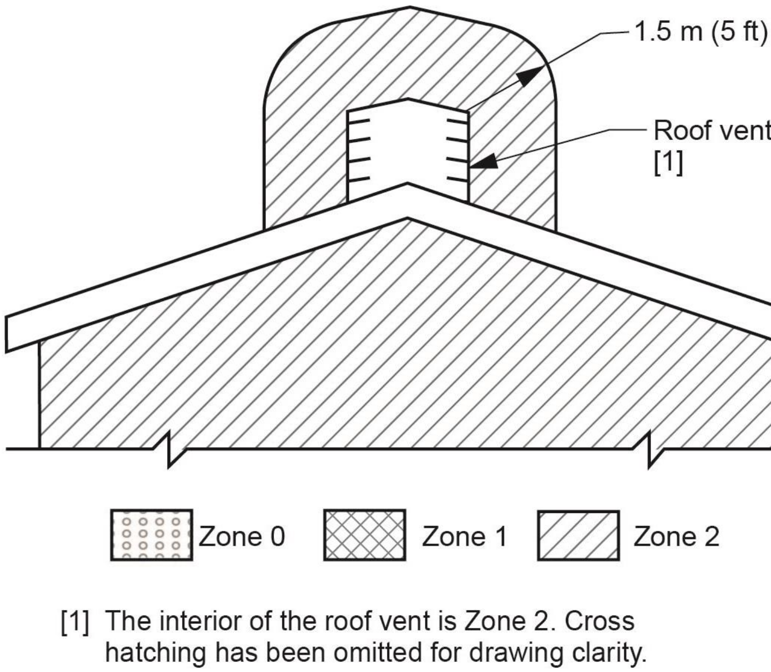


Figure 17—Atmospheric Vent From a Zone 2 Area (See 8.2.3.3.3)

8.2.3.4 Relief Valves and Rupture Disks

8.2.3.4.1 The criteria affecting the extent of the classification of the areas around relief valve vents in non-enclosed areas are too diverse to specify distances. Sound engineering judgment is required for specific cases, but in no case should the classification be less than that shown by Figure 18.

8.2.3.4.2 Enclosed areas containing relief valve vents are classified Zone 1 to the extent of the enclosed area.

8.2.3.4.3 Rupture disks should be considered the same as relief valves.

8.2.4 Marine Terminals Handling Flammable Liquids

Marine terminals handling flammable liquids are classified as shown in Figure 19. The source of gas is primarily from tanker (or barge) cargo tank vents and ullage (gauging and sampling) openings during loading and unloading. These criteria do not apply if flammable gases or vapors are not vented (for example, when unloading without cargo tank ballasting). The extent of the classified area is based on the longest tanker that the berth can accommodate. When water level changes may result in gases or vapors from cargo tank vents or ullage openings collecting underneath the berth deck, consideration should be given to classifying this space as Zone 1.

8.2.5 Hydrocarbon-fueled Prime Movers

8.2.5.1 Adequately ventilated enclosed areas containing gas-fueled engine/turbines with fuel pressures inside the enclosure exceeding 861.8 kPa (125 psi) should be classified Zone 2 to the extent of the enclosure. See Figure 54b. Adequately ventilated enclosed areas containing diesel-fueled or gas-fueled, 861.8 kPa (125 psi) or less engine/turbines need not be classified solely by reason of the engine/turbine fuel, provided the specific recommendations for the design and installation of the fuel piping systems for these prime movers meets the criteria established in NFPA 37. The pressure criteria applied to hydrocarbon prime movers is based on NFPA 37, is specific to this application, and is not applicable for other systems.

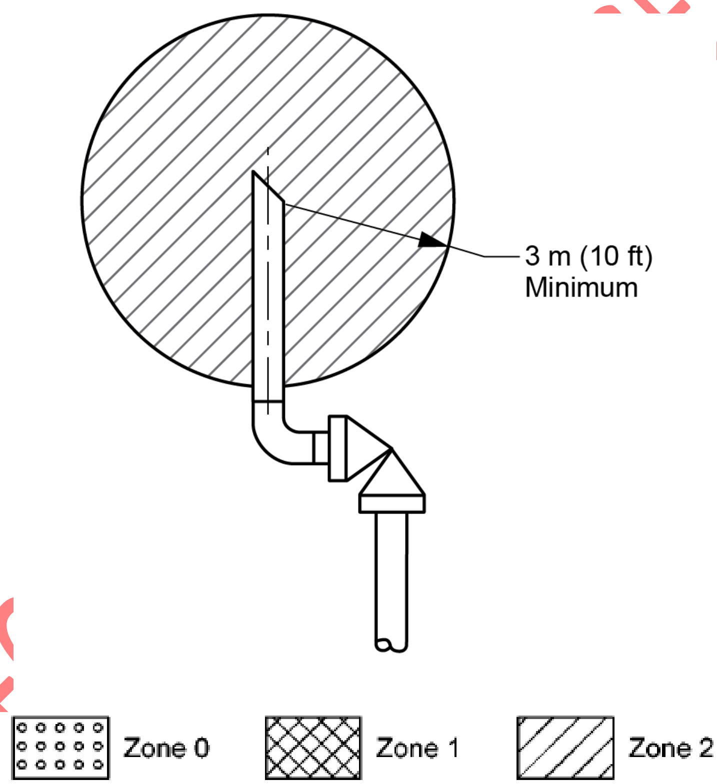
NOTE 1 NFPA 850, *Recommended Practice for Fire Protection for Fossil Fueled Steam Electric Generating Plants*, provides recommendations (not requirements) for fire prevention and fire protection for gas, oil, or coal-fired electric generating plants used for electric generation. NFPA 850 does not address the specific issue of area classification due to liquid or gaseous fuel. Both NFPA 37 and NFPA 850 provide safety recommendations when designing generating stations.

8.2.5.2 Associated non-fuel handling equipment shall be considered for area classification separately.

8.2.5.3 Pneumatic starters utilizing flammable gas for the power medium should be classified the same as flammable gas-operated instruments; see 10.11.3. The discharge of their vents should be considered the same as the discharge of process equipment vents; see 8.2.3.1.

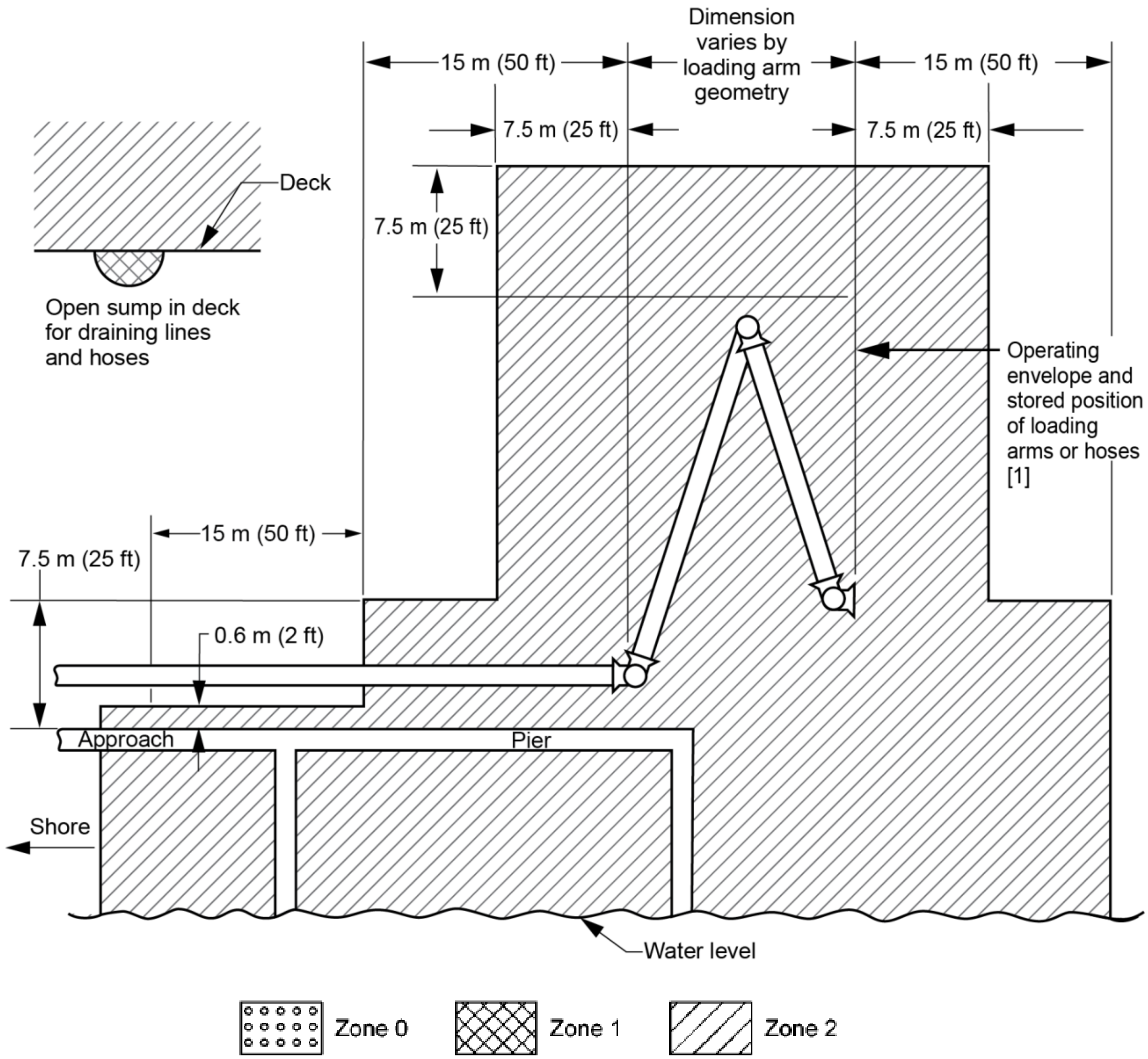
8.2.5.4 Gas pressure regulators, shutdown valves, and similar equipment in fuel service handling pressures exceeding 861.8 kPa (125 psi) should be classified according to the appropriate portions of Section 8 through Section 14.

8.2.5.5 Gas scrubbers in fuel service should be classified the same as hydrocarbon pressure vessels. Gas filter-separators in fuel service should be classified the same as launchers or receivers.



[1] The interior of the vent piping above the relief valve is Zone 2. Cross hatching has been omitted for drawing clarity.

Figure 18—Relief Valve in a Non-enclosed, Adequately Ventilated Area (See 8.2.3.4)



[1] The operating envelope and stored position of the outboard flange connection of the loading arm (or hose) should be considered the “source of release”.

[2] The berth area adjacent to tanker and barge cargo tanks is to be Zone 2 to the following extent:

a. 7.5 m (25 ft) horizontally in all directions on the pier side from that portion of the hull containing cargo tanks;

b. from the water level to 7.5 m (25 ft) above the cargo tanks at the highest position.

[3] Additional locations may have to be classified as required by the presence of oher sources of flammable liquids on the berth, or by the requirements of the Coast Guard or other authorities having jurisdiction.

Figure 19—Marine Terminal Handling Flammable Liquids
(See 8.2.4)

8.2.6 Batteries

8.2.6.1 This section presents guidelines for classifying locations where batteries are installed. Areas classified solely because they contain batteries are classified because of hydrogen evolution from the batteries and therefore require a Group IIC designation.

8.2.6.2 Areas containing non-rechargeable batteries do not require area classification solely due to the presence of the batteries.

8.2.6.3 Enclosed areas containing rechargeable batteries that have no vents do not require area classification solely due to the presence of the batteries when meeting 8.2.6.3 a), b) and c).

a) batteries are of the nickel-cadmium or nickel-hydride type;

b) have a total volume less than one-hundredth of the free volume of the enclosed area, and

c) have a capacity not exceeding 1.5 ampere-hours at a one hour discharge rate

NOTE For the purpose of area classification, battery vents include relief devices, such as valves that open to the atmosphere, as found in valve-regulated lead acid (VRLA) batteries.

8.2.6.4 Enclosed areas containing rechargeable batteries that have no vents do not require area classification solely due to the presence of the batteries when meeting 8.2.6.4 a) or 8.2.6.4 b).

a) have a total volume less than one-hundredth of the free volume of the enclosed area, or

b) have a charging system that has a rated output of 200 watts or less and that is designed to prevent inadvertent overcharging

8.2.6.5 A non-enclosed adequately ventilated location containing batteries is unclassified.

8.2.6.6 An enclosed location containing rechargeable batteries is unclassified provided all batteries are vented either directly or indirectly to the outside of the enclosed area.

8.2.6.6.1 Directly vented systems vent evolved hydrogen directly from the batteries to the outside utilizing vent tubing systems or similar apparatus.

8.2.6.6.2 Indirectly vented systems collect evolved hydrogen in battery boxes (electrical enclosures designed to enclose batteries), which, in turn, are vented outside of the enclosed area, or utilize systems such as hood vents (or other systems that perform similar functions) that collect evolved hydrogen and vent it to the outside of the enclosed area.

a) The interior of battery boxes should be unclassified provided:

   1) the battery boxes have vent(s) with a cross-sectional area of not less than 6.45 cm^2 (1 $in.^2$) for every 0.14 m^3 (5 ft^3) of battery box volume;

   2) the vent(s) is not more than 45° from vertical for any point except wall penetrations; and

   3) the vent(s) extends from the highest point of the battery box.

   Wall penetrations include penetrations through the walls of the battery boxes and through the walls of the buildings (or similar enclosed areas) in which the battery boxes are installed.

b) The interior of battery boxes should be unclassified, provided they are adequately ventilated in accordance with 6.6.2.

The method of ventilation should be carefully considered since some methods of ventilation may affect the classification of the area in which the battery boxes are installed.

c) The interior of battery boxes should be Zone 2 provided

1) the battery boxes have vent(s) with a cross-sectional area of less than 6.45 cm^2 (1 in.^{2}) but not less than 3.23 cm^2 (0.5 in.^{2}) for every 0.14 m^3 (5 ft^3) of battery box volume;

2) the vent(s) is not more than 45° from vertical for any point except wall penetrations;and

3) the vent(s) extends from the highest point of the battery box.

d) The interior of inadequately ventilated battery boxes not meeting the provisions of 8.2.6.6.2a, 8.2.6.6.2b, or 8.2.6.6.2c is classified Zone 1.

A Zone 0 or Zone 1 classification would normally prohibit the installation of batteries in the area. Check applicable requirements.

8.2.6.7 An enclosed, adequately ventilated location (excluding battery boxes, as provided for in 8.2.6.6.2) containing batteries is classified as follows.

8.2.6.7.1 Unclassified provided:

1) calculations verify that natural ventilation will prevent the accumulation in the enclosed location of hydrogen above 25 % of its LFL during normal float charge operations; and

2) the battery charging system is designed to prevent inadvertent overcharging.

8.2.6.7.2 Unclassified provided:

1) calculations verify that mechanical ventilation will prevent the accumulation in the enclosed location of hydrogen above 25 % of its LFL during normal float charge operations;

2) the battery charging system is designed to prevent inadvertent overcharging; and

3) effective safeguards against ventilation failure are provided.

8.2.6.7.3 Ventilation rates should be based on the maximum hydrogen evolution rate for the applicable batteries. Lacking specific data, the maximum hydrogen evolution rate for all batteries should be considered as 1.27 x 10-7 m^3/s (0.000269 ft^3/min) per charging ampere per cell at 25 °C, and standard pressure (101.325 kPa) with the maximum charging current available from the battery charger applied into a fully charged battery.

8.2.6.8 An enclosed, inadequately ventilated area containing batteries is classified as follows.

8.2.6.8.1 Zone 2, provided:

a) ventilation is at least 25 % that required for adequate ventilation; and

b) the battery charging system is designed to prevent inadvertent overcharging.

8.2.6.8.2 Zone 1, if the criteria specified by 8.2.6.8.1 is not met and therefore unsuitable for battery installations.

8.2.6.8.3 A Zone 0 classification would prohibit the installation of batteries in the area. Flammable and Combustible Paint Products—Storage and Usage Areas

8.2.7.1 General

8.2.7.1.1 This section addresses only the electrical classification of locations where flammable and combustible paint products (/for example, paints, lacquers, and paint solvents) are stored or used. It does not address safe practices for the storage or use of these products, a subject outside the scope of this document.

8.2.7.1.2 This section does not cover rooms and other areas specifically intended for spray painting and similar operations where flammable and combustible paint products are regularly or frequently applied during normal operations in the room or area. These areas are not unique to petroleum facilities and are adequately addressed in Article 516 of the *National Electrical Code*, to which the reader should refer. Due to the wide variety of conditions and application methods encountered, this section does not cover painting operations, which are not unique to petroleum facilities.

8.2.7.2 Storage Areas

8.2.7.2.1 This subsection covers non-enclosed and enclosed areas (e.g. rooms, cabinets, and lockers) where flammable and combustible paint products are stored.

8.2.7.2.2 This subsection does not cover areas where paint brushes are cleaned with flammable solvents, paint is mixed with solvents, and other similar operations or areas where cleaning rags containing solvents, open containers of paint products, and similar materials are present. Where such operations are performed or such materials are present, reference 8.2.7.3.

8.2.7.2.3 Non-enclosed and enclosed, adequately ventilated and inadequately ventilated areas where flammable and combustible paint products are stored in sealed containers (original containers or equivalent) are unclassified.

8.2.7.3 Usage Areas

8.2.7.3.1 This section covers areas where flammable and combustible paint products are used. “Used” is defined as operations such as cleaning paint brushes with flammable solvents and mixing paint with solvents where volatile gases or vapors will be given off to the atmosphere. Also included as “usage areas” are areas where cleaning rags containing solvents or open containers of paint products are present.

8.2.7.3.2 Most operations involving the use of paint products as described in the paragraph above are performed at random locations on an infrequent basis. Unless an area is specifically designated for such usage, it is not practicable to assign area classification. This does not preclude the necessity of following safe practices in these areas during such usage, but the subject is outside the scope of this document. If an area is specifically designated for such usage, the area should be classified as follows:

8.2.7.3.3 Non-enclosed, adequately ventilated areas where flammable and combustible paint products are used are unclassified.

8.2.7.3.4 Adequately ventilated enclosed areas where flammable and combustible paint products are used are classified Zone 2 to the extent of the area except as specified in a) and b).

a) Adequately ventilated enclosed areas where flammable and combustible paint products are used are unclassified if the quantities of open containers of paint are 20 liters (5 gallons) or less or if the quantities of open containers of solvent are 4 liters (1 gallon) or less.

b) Adequately ventilated enclosed areas where only combustible paint products are used are unclassified if the temperature is below their flashpoints.

8.2.7.3.5 Inadequately ventilated enclosed areas where flammable or combustible paint products are used are classified as Zone 1 to the extent of the area.

8.2.8 Laboratory Rooms, Laboratory Buildings, and Analyzer Buildings

8.2.8.1 General

8.2.8.1.1 This section addresses only the electrical classification of locations where flammable or combustible materials are analyzed (e.g. gas chromatographs, oil analysis, water cut determination, and other flammable material analysis methods). It also includes areas that are used for analysis purposes where flammable or combustible materials and chemicals or solvents (typically chemicals or solvents with a 2, 3, or 4 Flammability Hazard Rating as defined by NFPA 704) are utilized in the analysis process and are stored or used (e.g. toluene). Also see criteria in 5.2. This section does not address safe practices for the storage or use of these products, a subject outside the scope of this document.

8.2.8.1.2 Laboratory buildings and rooms that are designed and constructed to NFPA 45, *Standard On Fire Protection for Laboratories Using Chemicals*, are an acceptable alternative to the requirements of this section.

8.2.8.2 Rooms or Buildings Containing Process Streams of Flammable Liquid, Vapor, or Flammable Gas Piped into the Room or Building for Analysis

8.2.8.2.1 All laboratory and analyzer rooms or buildings with a source of small quantities of flammable or combustible gas or liquid for analysis should be classified as identified in 8.2.8.2.2, 8.2.8.2.3, or 8.2.8.2.4.

8.2.8.2.2 All buildings and rooms that are determined to be inadequately ventilated as per the requirements of 6.6 should have the interior classified as Zone 1.

8.2.8.2.3 All buildings and rooms that are determined to be adequately ventilated as per the requirements of 6.6 by mechanical means with a minimum of six air changes per hour should be classified as Zone 2.

8.2.8.2.4 All buildings and rooms that are determined to be adequately ventilated as per the requirements of 6.6 by mechanical means with a minimum of six air changes per hour, and provided with gas detection meeting all of the requirements of Annex G could utilize electrical equipment suitable for unclassified locations. In addition to the requirements of G.3e, the loss of ventilation should also initiate automatic disconnection of power from all electrical devices in the area that are not suitable for Zone 2. Special attention should be given to the locations of the gas detection sensors with respect to the potential sources of ignition and the release points of the gas to insure that localized gas accumulations are detected. Documentation of the area classification shall include the basis for installing electrical equipment suitable for unclassified locations in the Zone 2 area.

In addition to the de-energization of electrical equipment not suitable for Zone 2 upon the detection of gas or loss of mechanical ventilation, consideration should be given to automatic isolation of the process stream.

8.2.8.3 Rooms or Buildings where Samples of Flammable Liquid, Vapor, or Flammable Gas Materials are Brought into the Room or Building for Analysis in Containers of 4.0 Liters (1 Gallon) or Less

8.2.8.3.1 Locations or areas within rooms or buildings where samples of flammable liquid, vapor, or flammable gas materials are brought into the location or area for analysis or otherwise used in open containers totaling four liters (one gallon) or less should be classified as identified in 8.2.8.3.2 or 8.2.8.3.3. Where flammable or combustible chemicals or solvents are stored in these locations or areas, see 8.2.8.4 for additional requirements. Where flammable or combustible chemicals or solvents are used in these locations or areas, see 8.2.8.5 for additional requirements.

8.2.8.3.2 All locations or areas that are determined to be inadequately ventilated as per the requirements of 6.6 where the sample containers are open should have the interior classified as Zone 2. In locations or areas where samples of flammable liquid, vapor, or flammable gas materials are transferred, used, or analyzed under chemical fume hoods provided and installed as detailed in NFPA 45, the areas outside of the hood(s) should be unclassified.

8.2.8.3.3 All locations or areas that are determined to be adequately ventilated as per the requirements of 6.6 by mechanical means with a minimum of six air changes per hour where the sample containers are open may have the interior classified as unclassified where the loss of ventilation initiates an alarm for corrective action to prevent the presence of a flammable mixture or to disconnect all electrical equipment not suitable for Zone 2.

8.2.8.4 Laboratory or Analyzer Chemical Storage Areas

8.2.8.4.1 This section covers non-enclosed and enclosed areas (e.g. rooms, cabinets, and lockers) where flammable and combustible laboratory or analyzer chemicals are stored.

8.2.8.4.2 Non-enclosed and enclosed, adequately ventilated and inadequately ventilated areas where flammable and combustible chemicals for laboratory or analyzer use are stored in closed DOT approved containers (original containers or equivalent) are unclassified.

8.2.8.4.3 Enclosed, adequately ventilated, and inadequately ventilated areas where flammable and combustible chemicals for laboratory or analyzer use are stored in closed containers that are not DOT approved (original containers or equivalent) in quantities in excess of 4.0 liters (one gallon) shall have the interior classified as Zone 2. Areas where the total quantity is 4.0 liters (one gallon) or less are unclassified.

8.2.8.5 Other Usage Areas

8.2.8.5.1 This section covers areas where flammable and combustible chemicals are used, but have not been previously addressed. "Used" is defined as laboratory operations or analysis where samples are mixed with flammable solvents where volatile gases or vapors will be given off to the atmosphere. Also included as "usage areas" are areas where cleaning rags containing solvents or open containers of chemicals are present.

8.2.8.5.2 Non-enclosed, adequately ventilated areas where flammable and combustible chemicals for analyzer or laboratory operations are used are unclassified.

8.2.8.5.3 Adequately ventilated enclosed areas where flammable and combustible chemicals for analyzer or laboratory operations are used are classified Zone 2 to the extent of the area except as specified in a) and b).

a) Adequately ventilated enclosed areas where flammable and combustible chemicals for analyzer or laboratory operations are used are unclassified if the total quantities of open containers of chemicals are 4.0 liters (one gallon) or less.

b) Adequately ventilated enclosed areas where only combustible chemicals for analyzer or laboratory operations are used are unclassified if the temperature is below their flash points.

8.2.8.5.4 Inadequately ventilated enclosed areas where flammable materials or combustible chemicals for analyzer or laboratory operations are used are classified Zone 1 to the extent of the area.

8.2.8.5.5 Inadequately ventilated enclosed areas where flammable materials or combustible chemicals above their flashpoints and with a potential for continuous open sampling for analyzer or laboratory operations are Zone 0 to the extent of the area.

8.2.8.5.6 Inadequately ventilated enclosed areas where samples of flammable liquid, vapor, or flammable gas materials are transferred, used, or analyzed under chemical fume hoods provided and installed as detailed in NFPA 45, the areas outside of the hood(s) should be unclassified.

9 Recommendations for Determining Degree and Extent of Classified Locations in Petroleum Refineries

9.1 Introduction

9.1.1 This section presents guidelines for classifying locations for electrical installations at refinery facilities. The guidelines cover onshore refinery facilities handling flammable and combustible liquids and flammable gases and vapors.

9.1.2 The following recommendations for determining the degree and extent of classified locations have been developed by survey and analysis of the practices of a large segment of the petroleum refining industry, by use of available experimental data, and by careful weighing of pertinent factors such as the number of potential sources, the release rate and the volume of possible release. These recommended limits of classified locations for refinery installations may be more restrictive than are warranted for non-refining types of facilities handling hydrocarbons. In this sense, the recommendations are considered conservative.

9.1.3 Refinery processing facilities consist of specialized equipment within which liquids, gases, or vapors are continuously processed at high rates and at elevated temperatures and pressures. Both chemical and physical changes occur in these materials, and during abnormal conditions the composition and properties of stocks may change drastically. These conditions, together with considerations of operating continuity, dictate standards of refinery design that may not be warranted in other petroleum industry operations. However, although these recommendations are applicable primarily to refinery areas, it is recognized that a modern refinery includes facilities other than those traditionally associated with refining operations. Often petrochemical and chemical facilities are interrelated both physically and by process procedure with refining equipment. The practices recommended in this section can be applied to these additional facilities to the extent that such physical relationships or process similarities exist.

9.1.4 In setting limits of classified locations in refinery facilities, it generally is assumed that the flammable gases and vapors are heavier than air. Classification on this basis is normally conservative for lighter-than-air gases such as hydrogen. However, some modification of the limits may be necessary to accommodate certain situations involving lighter-than-air gases.

9.1.5 Experience has shown that the occurrence of flammable material liberation from some operations and apparatus is so infrequent that it is not necessary to classify the surrounding areas. An example of such an area is an adequately ventilated location where flammable substances are contained in suitable, well maintained closed process piping systems that include only the pipe, fittings, flanges, meters, and small valves.

9.1.6 The figures in 9.2 show classified locations surrounding typical sources of flammable liquids, vapors, and gases. The intended use of these diagrams is to develop area classification documentation used for the selection of and proper installation methods for electrical equipment. Area classification drawings or other documentation may be required by certain regulatory agencies. Elevations or sections may also be required where different classifications apply at different elevations.

9.1.7 It may be found that individual classification of a great number of sources in a location is not feasible or desirable. Classification of an entire location as a single area should be considered after evaluation of the extent and interaction of various sources and areas within, or adjacent to, the location.

9.2 Recommendations

9.2.1 Locations where heavier-than-air flammable gases are handled or stored should be classified in accordance with 9.2.1.1 and 9.2.1.2.

9.2.1.1 Within adequately ventilated locations containing closed systems, refer to Figure 20 and Figure 21.

NOTE Manholes and interconnecting raceways may collect flammable liquids or gases that can then be conducted to other locations unless prevented by proper sealing, purging, water flooding, or other methods.

9.2.1.2 Within inadequately ventilated locations containing closed systems, refer to Figure 22.

9.2.2 Locations where lighter-than-air flammable gases or vapors are handled should be classified in accordance with 9.2.2.1 and 9.2.2.2.

9.2.2.1 Within adequately ventilated locations containing closed systems, refer to Figure 23 and Figure 24.

9.2.2.2 Within inadequately ventilated refinery process areas containing closed systems, refer to Figure 25 and Figure 26.

9.2.3 In separators, dissolved air flotation units, biological oxidation units and enclosed sumps refer to Figure 27. For open sumps in adequately ventilated areas, refer to Figure 57.

9.2.4 In cooling towers, refer to Figure 28.

Cooling tower pump pits located in unclassified locations need not be classified since cooling tower pumps are not considered sources of release.

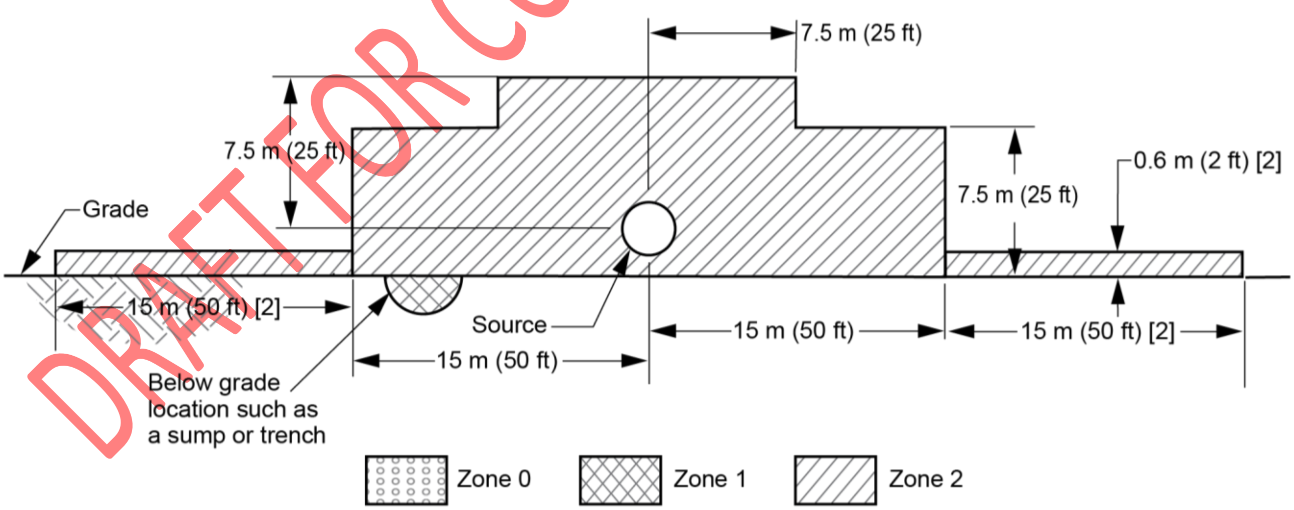
9.2.5 For marine terminals handling flammable liquids, refer to Figure 19.

9.2.6 For process control and block valves installed in adequately ventilated, non-enclosed locations that are not classified from other sources (such as utilizing 9.1.7), the extent of the classification of the areas is too diverse to specify distances for all cases. Sound engineering judgment is required for specific cases.

9.2.6.1 For heavier-than-air gas or vapors, the classification should be Zone 2 with a radius no less than 1 m (3 ft) from the valve packing.

9.2.6.2 For lighter-than-air gas or vapors, the classification should be Zone 2 with a radius no less than 3 m (10 ft) from the valve packing.

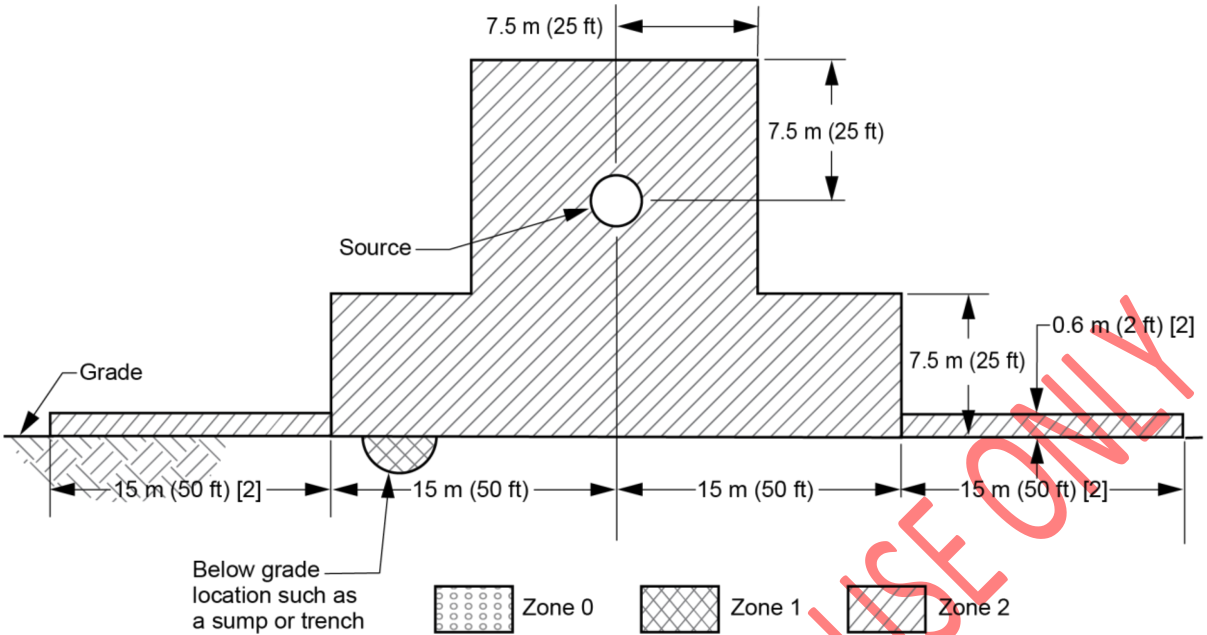
9.2.6.3 For HVLs, the Zone 2 classification should be a minimum radius of 1 m (3 ft) from the valve packing with an extension of 6 m (20 ft) to a height of 0.6 m (2 ft) above grade.



[1] Distances given are for typical refinery installations: they shall be used with judgment, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

[2] Additional distances of 15 m (50 ft) at 0.6 m (2 ft) suggested where HVLs or large releases of volatile products may occur.

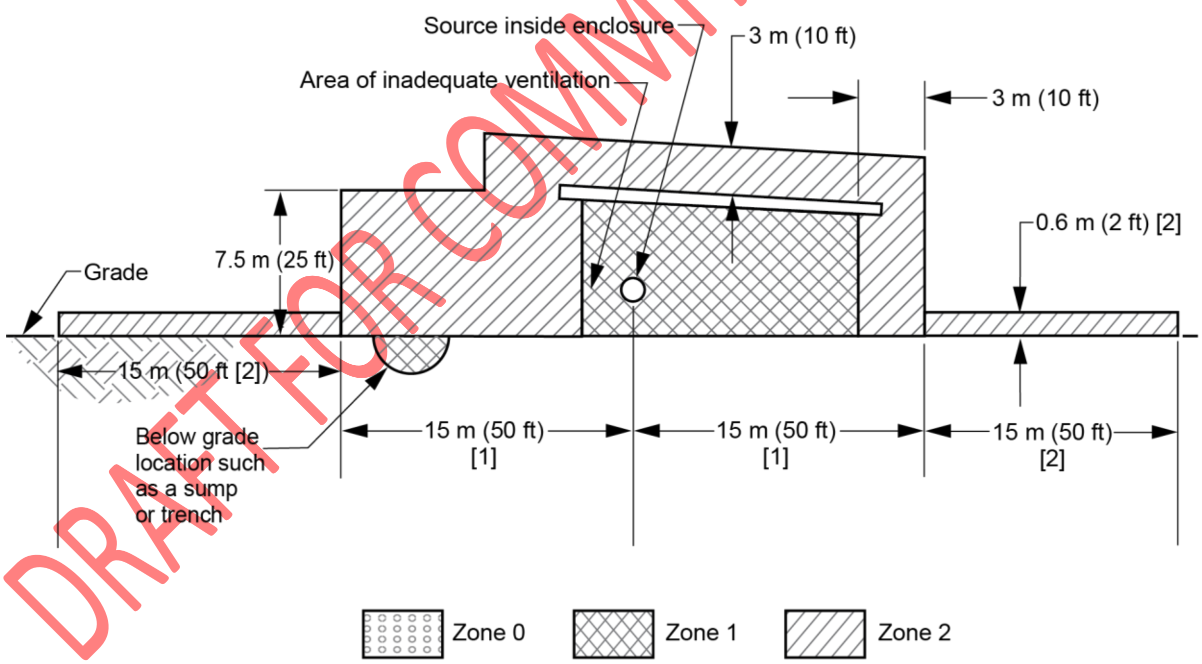
Figure 20—Adequately Ventilated Process Location with Heavier-than-air Gas or Vapor Source Located Near Grade (See 9.2.1.1)



[1] Distances given are for typical refinery installations: they shall be used with judgment, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

[2] Additional distances of 15 m (50 ft) at 0.6 m (2 ft) suggested where HVLs or large releases of volatile products may occur.

Figure 21—Adequately Ventilated Process Location with Heavier-than-air Gas or Vapor Source Located Above Grade (See 9.2.1.1)

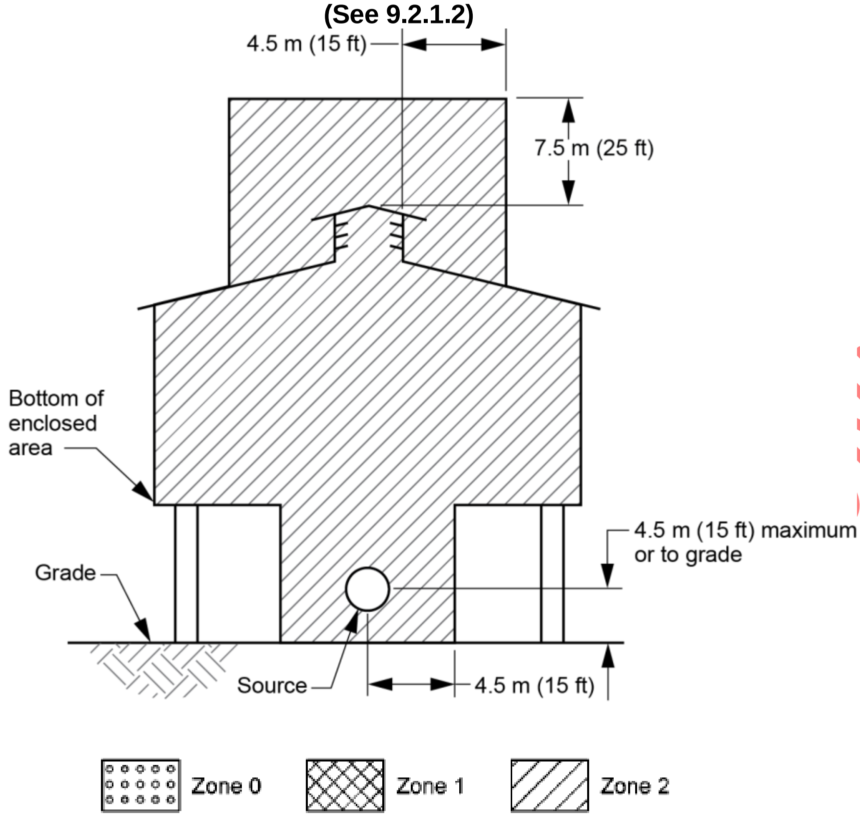


[1] Apply horizontal distances of 15 m (50 ft) from the source of gas or vapor or 3 m (10 ft) beyond the perimeter of the building, whichever is greater, except that beyond unpierced vaportight walls the area is unclassified.

[2] Additional distances of 15 m (50 ft) at 0.6 m (2 ft) suggested where HVLs or large releases of volatile products may occur.

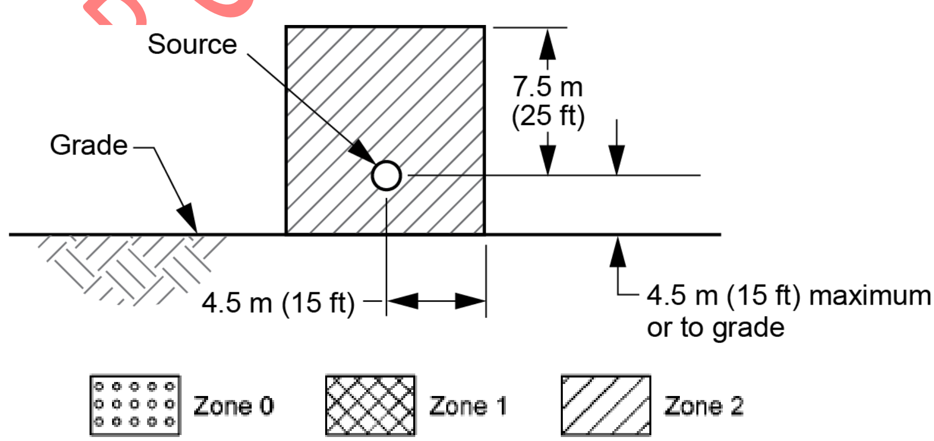
Figure 22—Inadequately Ventilated Process Location with Heavier-than-air Gas or Vapor Source

(See 9.2.1.2)



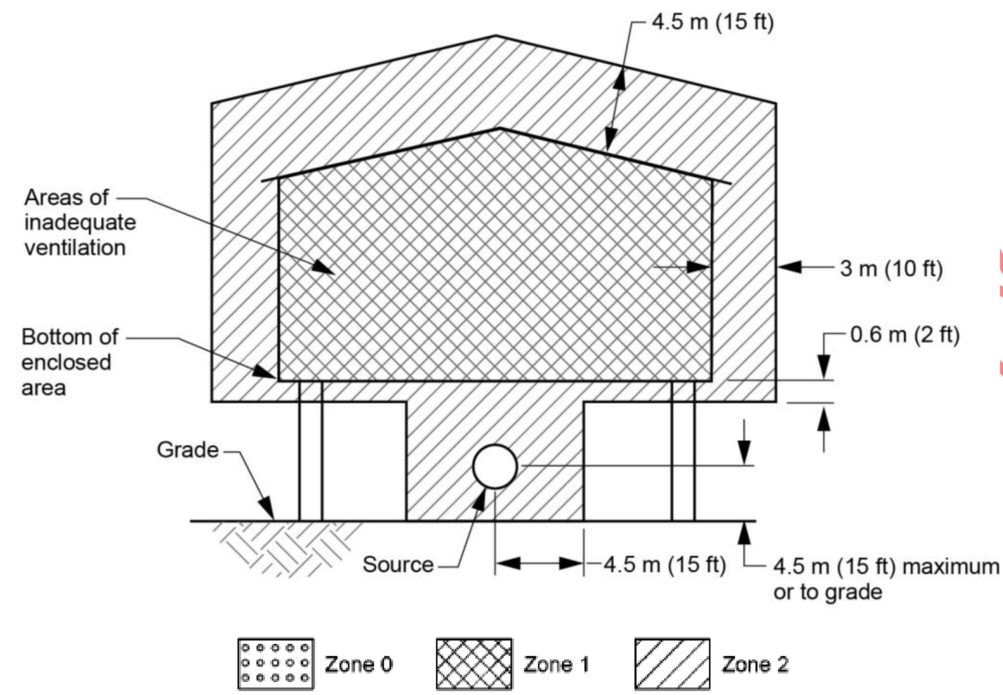
[1] Distances given are for typical refinery installations; they shall be used with judgment, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

Figure 23—Adequately Ventilated Compressor Shelter with Lighter-than-air Gas or Vapor Source
(See 9.2.2.1)



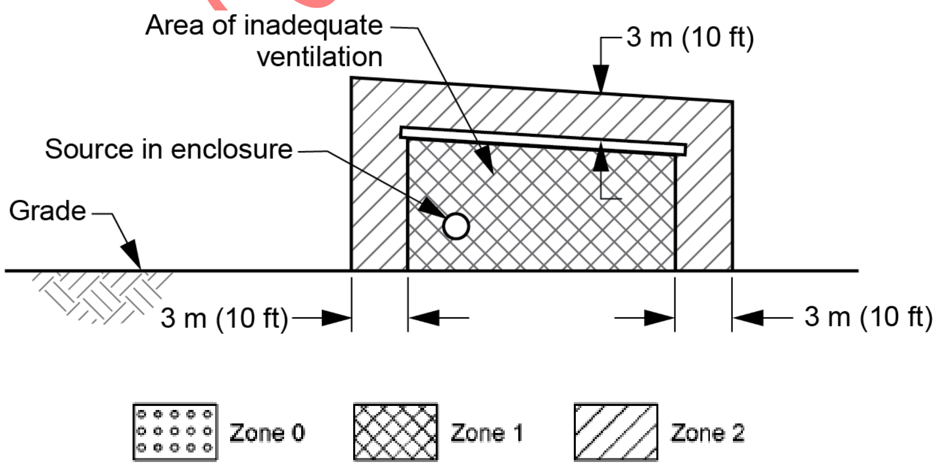
[1] Distances given are for typical refinery installations; they shall be used with judgment, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

Figure 24—Adequately Ventilated Process Location with Lighter-than-air Gas or Vapor Source
(See 9.2.2.1)



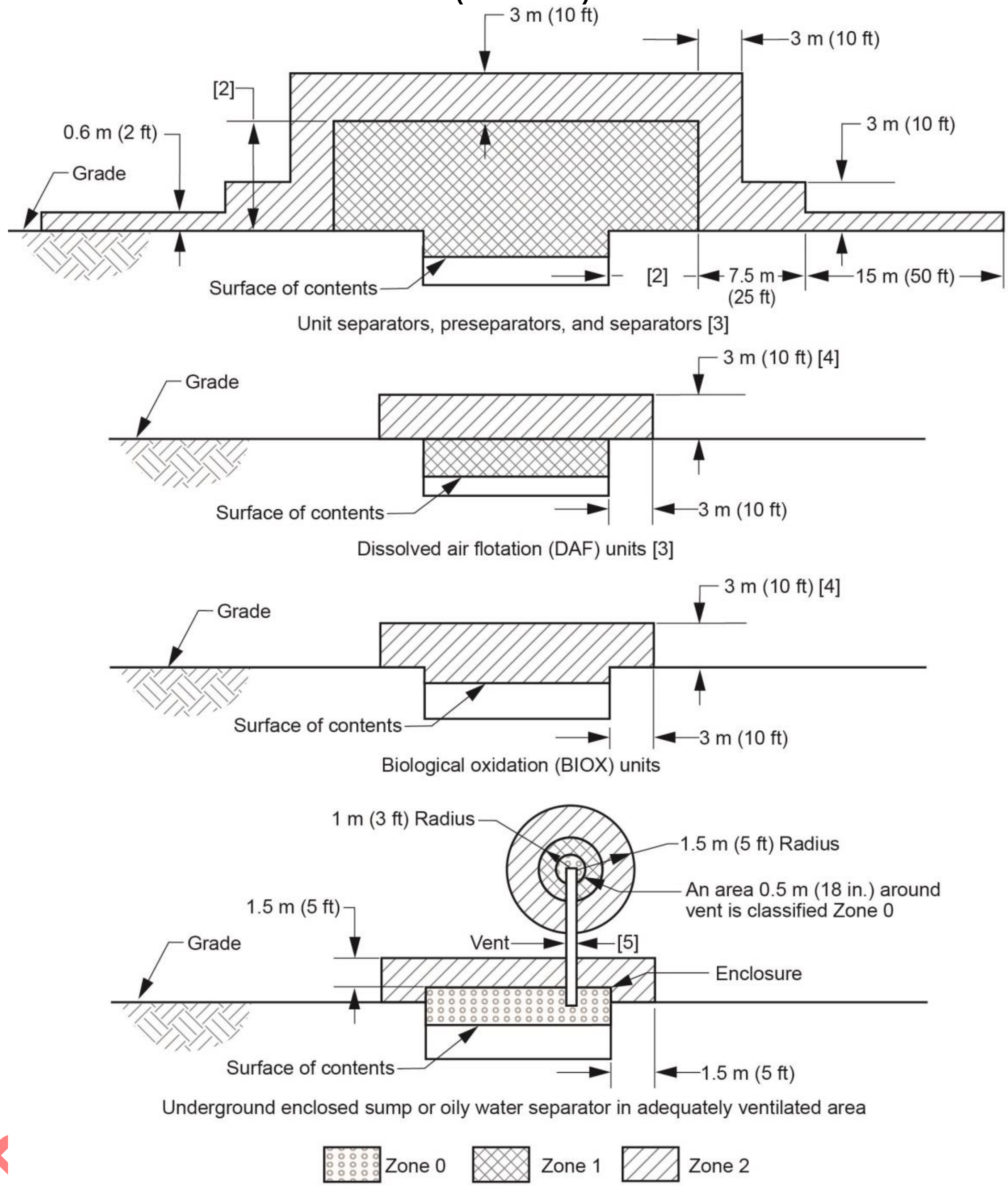
[1] Distances given are for typical refinery installations; they shall be used with judgment, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

Figure 25—Inadequately Ventilated Compressor Shelter with Lighter-than-air Gas or Vapor Source (See 9.2.2.2)



[1] Distances given are for typical refinery installations; they shall be used with judgment, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

Figure 26—Inadequately Ventilated Process Location with Lighter-than-air Gas or Vapor Source
(See 9.2.2.2)



[1] The extent of the classified areas shown shall be modified as required by the proximity of the other potential sources of release or of nearby obstructions, such as dikes or hills, that would impede dispersal of vapors. Distances given are for typical refinery installations; they shall be used with judgment, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

[2] The dimensions usually varies from 3 m (10 ft) to 7.5 m (25 ft) dependent on the volume of the volatiles.

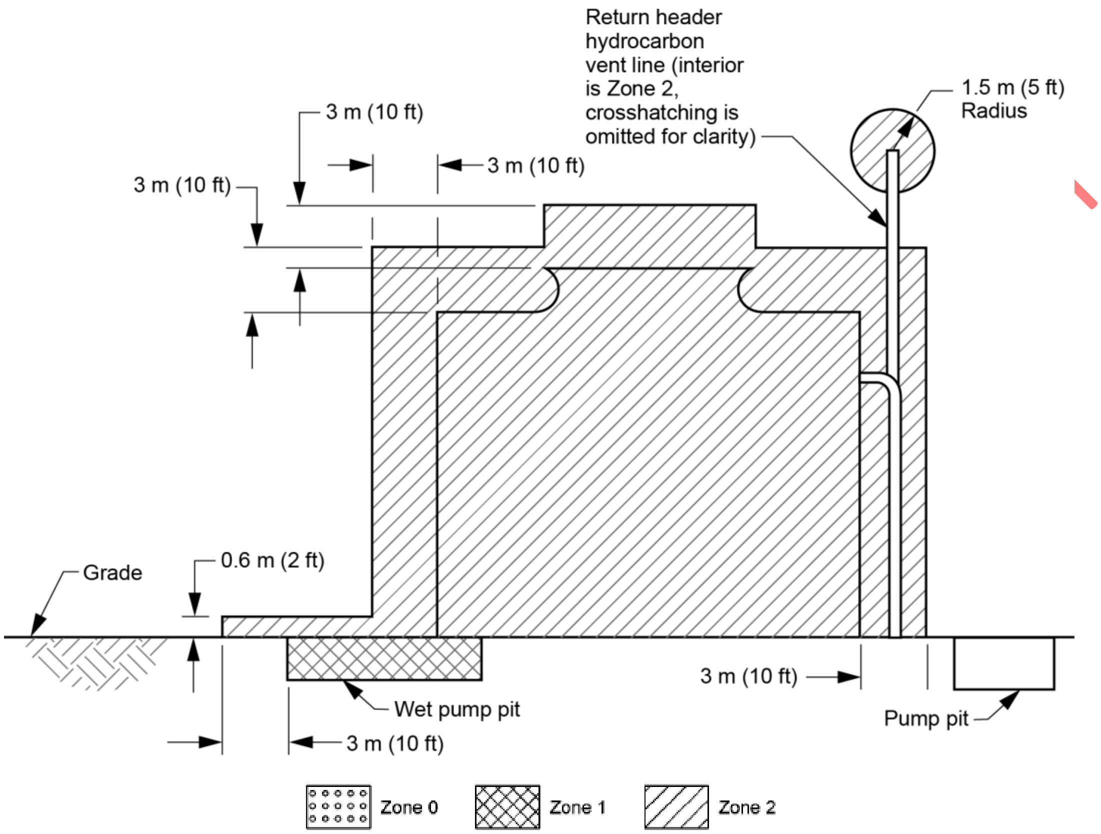
[3] Applies to open top tanks or basins. Classify closed tank units per Figure 6.

[4] Distances above top of basin or tank. Extend to grade for basins or tanks located above grade.

[5] The interior of the vent piping is Zone 0. Cross hatching has been omitted for clarity.

[6] Thief hatches, manways, and other openings to the enclosed sump may require Zone 1 classification boundary around the opening similar to those shown in Figure 6.

Figure 27—Separators, Dissolved Air Flotation (DAF) Units, Biological Oxidation (BIOX) Units, and Enclosed Sumps
(See 9.2.3)



[1] It is recommended that electrical equipment be located away from the vent area.

Figure 28—Mechanical Draft Cooling Tower Handling Process Cooling Water
(See 9.2.4)

10 Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Land and on Marine Fixed Platforms

10.1 General

10.1.1 This section presents guidelines for classifying locations for electrical installations at locations surrounding oil and gas drilling and workover rigs and facilities on land and on marine platforms where flammable petroleum gas and volatile liquids are produced, processed, stored, transferred, or otherwise handled prior to entering the transportation facilities. The requirements for MODUs, see section 11. For additional requirements for floating facilities, see section12.

10.1.2 The following recommendations for determining the degree and extent of classified locations are specific examples of situations commonly encountered in producing and drilling operations and have been developed by experience in the industry. Application of these examples to similar, though not identical, situations should be made with sound engineering judgment, employing material presented in this recommended practice and other publications. 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.

10.1.3 Higher operating pressures represent larger releases and possibly increased areas where a flammable mixture may exist after such a release is realized. Engineering judgment should be used whenever addressing high-pressure hydrocarbon streams. Table 3 indicates pressure adjustment factors for typical services that should be used with engineering judgement to determine the appropriate hazard radii or distance of all dimensions shown in the appropriate figure based on equipment operating within the indicated pressure range. To apply the factors, identify the type of equipment, determine the maximum operating pressure, use the appropriate figure for the equipment type, select the adjustment factor from Table 3, and multiply the adjustment factor times the hazard distances from the figure to establish the area classification hazard distances. For example, the area around a separator operating at 1500 psig would be classified in accordance with Figure 48. The hazard radii at 3 m (10 ft) illustrated in Figure 48 would be increased by the adjustment factor in Table 3 that would result in a hazardous radius of 7.5 m (25 ft).

Certain applications do not represent higher release risks at higher pressures due to the reduced dispersion capacity and the indicated pressure adjustment factors do not apply. These applications include:

— heavy oil production streams (14 API gravity or less);

— high-pressure/low volume applications (such as chemical injection systems);

— high water cut production streams;

— hydrocarbon mixtures with high carbon dioxide content; or

— other similar applications.

Table 3—Pressure Adjustment Factor

Description	Typical Services	Pressure Range (psig)	Adjustment Factor
Low pressure	LP separation, free water knock out, bad oil tank, vapor recovery unit, fuel system, etc.	0 to 740 (0 kPa to 5102 kPa) (Typical ANSI 300 Class flange and below rating at 100 °F)	1.0
Medium pressure	Intermediate pressure (IP) separation, gas compression, etc.	741 to 1440 (5109 kPa to 9928 kPa) (Typical ANSI 600 Class flange rating at 100 °F)	1.5
High pressure	HP separation, manifold, Flow Line, gas compression, dehydration, metering, export, etc.	> 1440 (9928 kPa) (Typical ANSI 900 Class and above flange ratings at 100 °F)	2.5
Very High Pressure	VHP separation, flow line, gas compression, metering, export, subsea processing, etc.	2221–3705 (15,313 kPa–25,545 kPa) (Typical ANSI 1500 Class)	3.5
Ultra-High Pressure [1]	UHP separation, flow line, gas compression, metering, export, subsea tie back, subsea processing, etc	3706–6170 (25,552 kPa–42,541 kPa) (Typical ANSI 2500 Class)	4.0

NOTE 1 The adjustment factors identified in Table 3 were based on user experiences and dispersion modeling methods described in *The Energy Institute Model Code of Safe Practice Part 15*.

NOTE 2 The pressure ranges given for the typical ANSI Class flange designations are from Table II-2-1.1,"Pressure-Temperature Ratings for Group 1.1 Materials at temperatures of 100 ^{0}F and below." In ASME B16.5-2017.

[1] For pressures greater than 6170 psig (42.541 kPa), sound engineering judgement should be used to determine if larger pressure adjustment factors are required.

10.2 Drilling Areas

Drilling areas considered for classification by this section include the following:

a) rig floor and substructure area;

b) mud tank;

c) mud ditch, trench, or pit;

d) mud pump;

e) shale shaker;

f) desander or desilter;

g) degasser;

h) diverter line vent;

i) blowout preventer (BOP);

j) choke manifold;

k) cement unit.

10.3 Production Facilities

Production facilities considered for classification by this section include the following.

a) Producing oil and gas wells:

   1) flowing wells;

   2) artificially lifted wells:

      a. beam pumping wells,

      b. mechanically driven, rotating, subsurface pumps,

      c. electric submersible pumping wells,

      d. hydraulic subsurface pumping wells,

      e. gas lift wells,

      f. plunger lift wells;

3) multi-well installations.

b) Oil and gas processing and storage equipment:

1) hydrocarbon pressure vessel;

2) header or manifold;

3) fired equipment;

4) launcher or receiver:

   a. ball or pig launcher or receiver,

   b. through flow line (TFL) tool launcher or receiver;

5) dehydrator, stabilizer, and hydrocarbon recovery unit;

6) automatic custody transfer (ACT) unit;

7) flammable gas–blanketed and produced water handling equipment;

8) gas compressor or pump handling volatile, flammable fluids;

9) instruments

   a. not operated by flammable gas,

   b. operated by flammable gas;

10) sumps;

11) drains;

12) screwed connections, flanges, valves and valve operators;

13) drip pans;

14) control panels;

15) gas meters.

10.4 Drilling Wells

10.4.1 General

Areas surrounding wells being drilled or being serviced by drilling rigs are classified as follows.

10.4.2 Rig Floor and Substructure Area

10.4.2.1 When the derrick is not enclosed or is equipped with a "windbreak" (open top and open "V" door) and the substructure is adequately ventilated, the areas are classified as shown in Figure 29.

NOTE 1 Derricks enclosed with a windbreak (open top and open V door) such as that depicted by Figure 29 are considered to satisfy the requirements of adequate ventilation through years of satisfactory experience with this practice.

NOTE 2 An open substructure such as that depicted by Figure 29 is classified Zone 2 for 3 m (10 ft) from the center of the wellbore because of well testing, well completion, and workover operations.

10.4.2.2 When the derrick is enclosed (open top) with adequate ventilation and the substructure is inadequately ventilated, the areas are classified as shown in Figure 30.

NOTE The enclosed substructure depicted by Figure 30 is classified Zone 1 because it contains the bell nipple, which can allow release of flammable gas during normal operations. The area above the top of the derrick enclosure is classified as Zone 2 as it is considered a vent.

10.4.2.3 For drilling rigs on offshore platforms with producing wells in an adequately ventilated location below the platform drilling deck, the locations are classified as shown in Figure 31. Reference Figure 29 or Figure 30 for classification of the drilling rig; the specific rig shown is as described by 10.4.2.1 or 10.4.2.2.

10.4.2.4 For drilling rigs on offshore platforms with producing wells in an inadequately ventilated location below the platform drilling deck, the areas are classified as shown in Figure 32. Reference Figure 29 or Figure 30 for classification of the drilling rig; the specific rig shown is as described by 10.4.2.1 or 10.4.2.2.

10.4.3 Mud Tank

10.4.3.1 The area around a mud tank located in a non-enclosed, adequately ventilated location is classified to the extent shown in Figure 33.

10.4.3.2 The area around a mud tank located in an adequately ventilated enclosed area is classified as illustrated by Figure 33, but Zone 2 for the remainder of the extent of the enclosed area.

10.4.3.3 The area around a mud tank located in an enclosed inadequately ventilated location is classified to the extent shown in Figure 34.

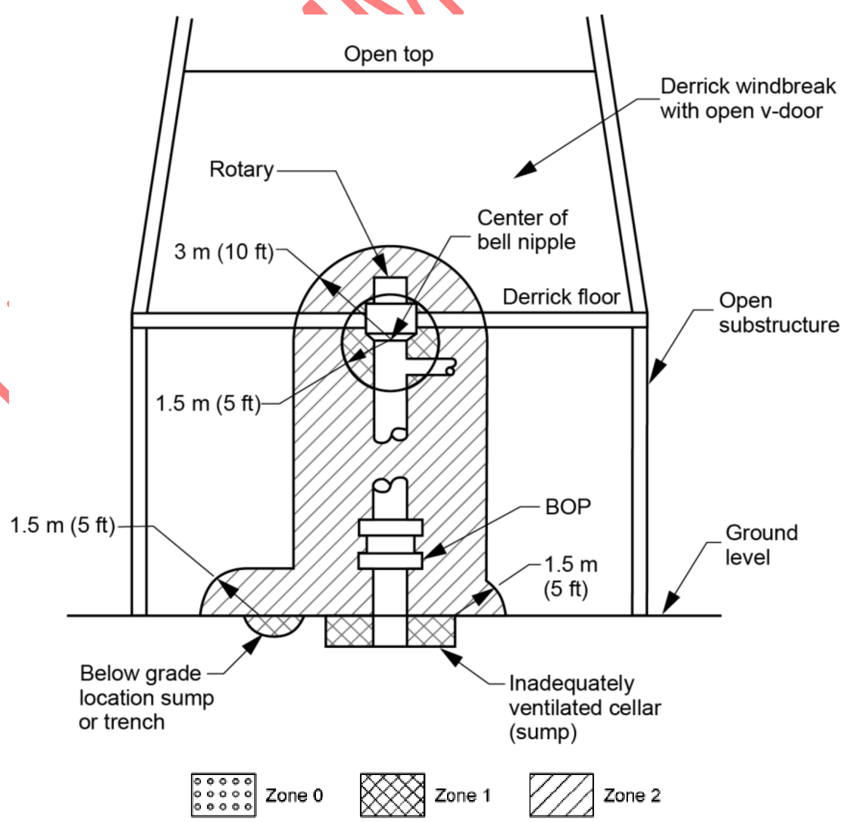


Figure 29—Drilling Rig, Adequate Ventilation in Substructure, and Derrick is Not Enclosed, but Is Equipped with a Windbreak, Open Top, and Open V-door (See 10.4.2.1)

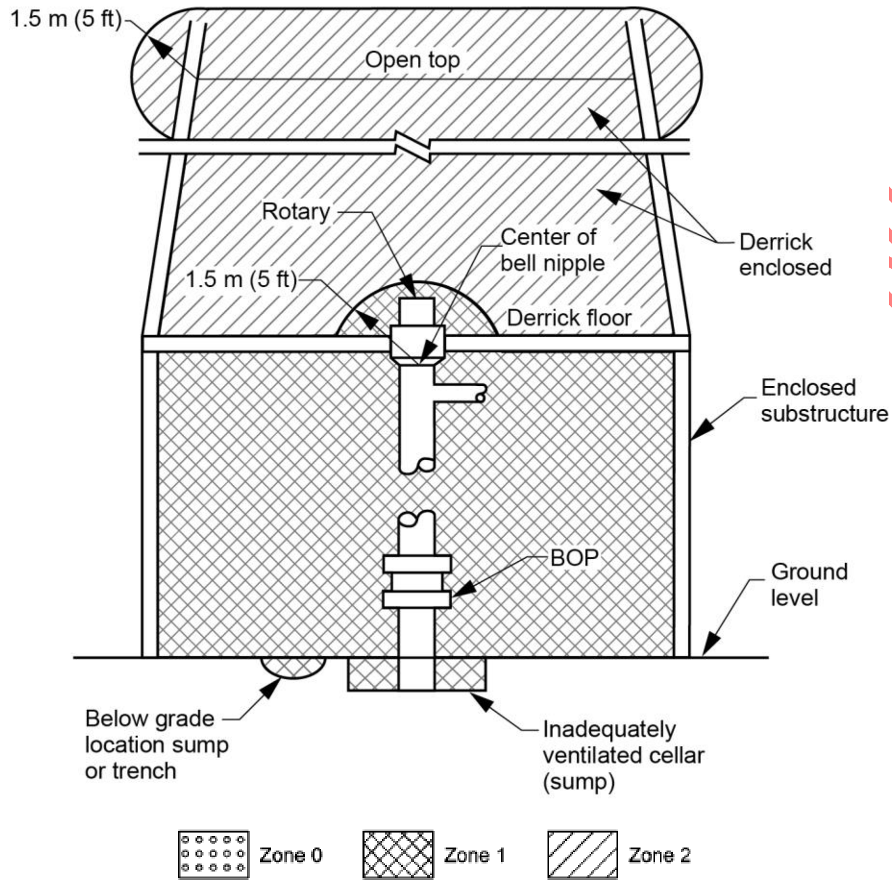


Figure 30—Drilling Rig, Adequate Ventilation in Enclosed Derrick (Open Top), and Inadequately Ventilated Substructure (See 10.4.2.2)

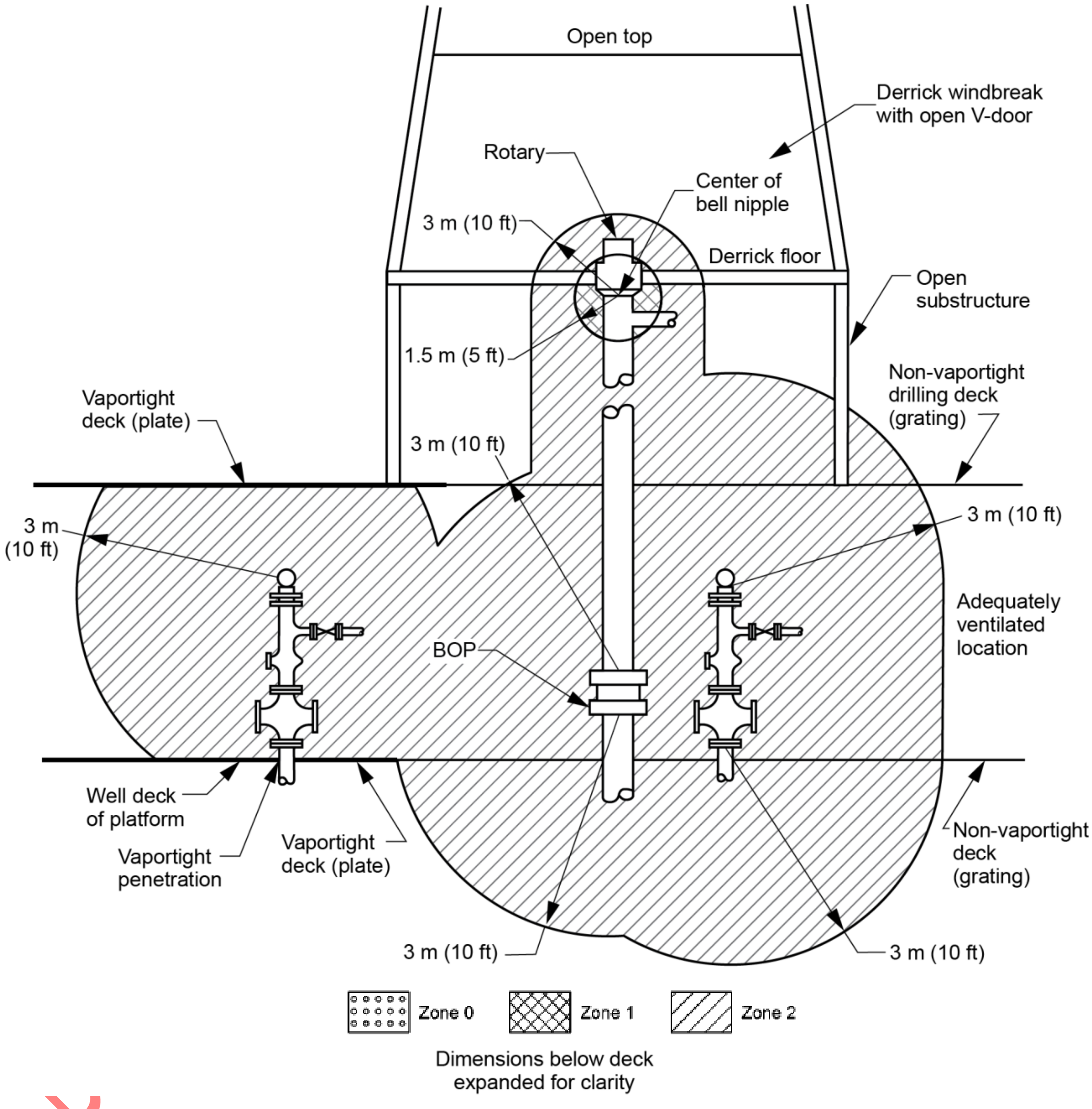


Figure 31—Platform Drilling Rig, Adequately Ventilated in Substructure and Inside Derrick, Several Producing Wells Beneath in an Adequately Ventilated Area (See 10.4.2.3)

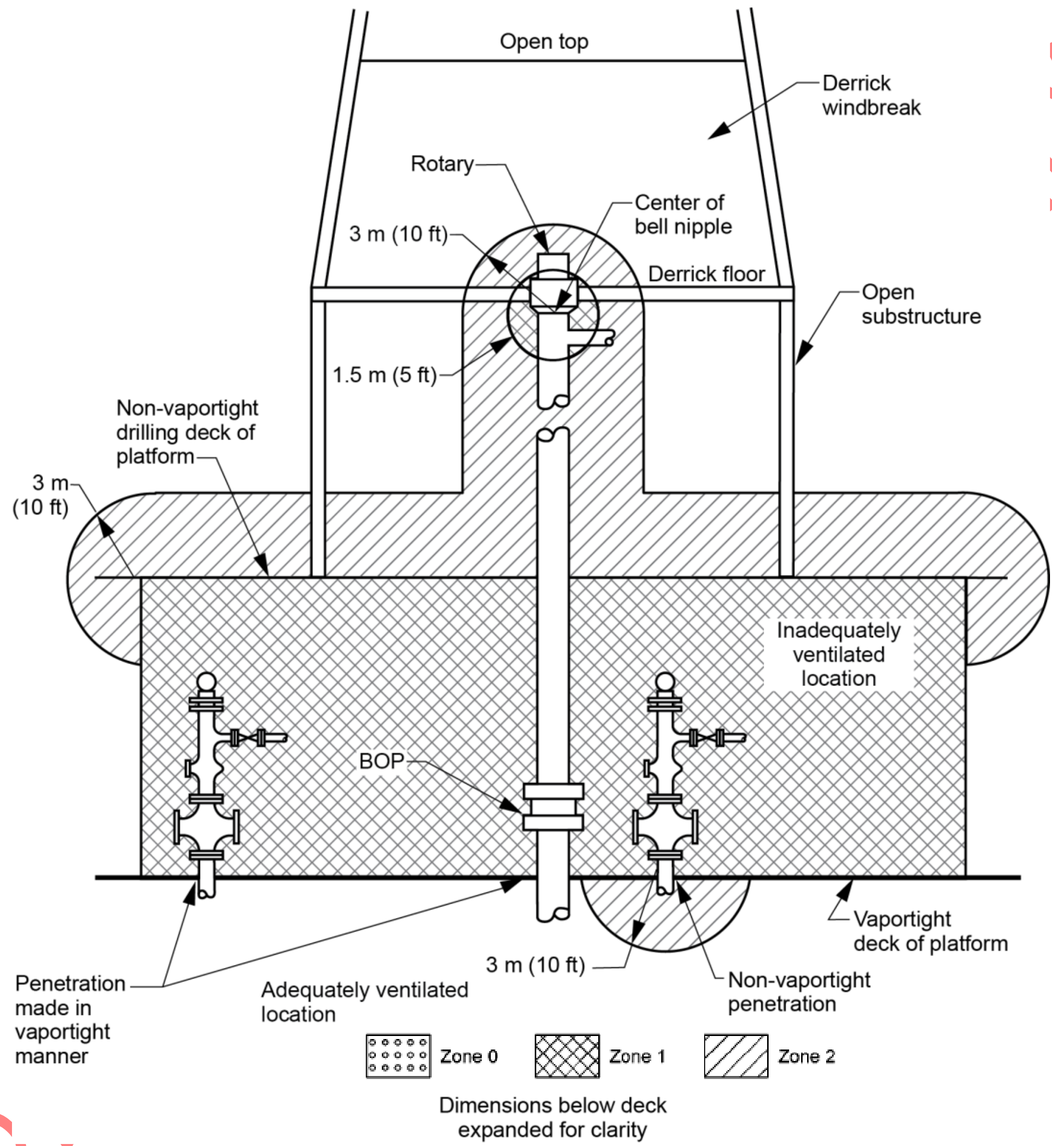


Figure 32—Platform Drilling Rig, Adequate Ventilation in Substructure and Inside Derrick, Several Producing Wells Beneath in an Inadequately Ventilated Location (See 10.4.2.4 and 10.5.2.4)

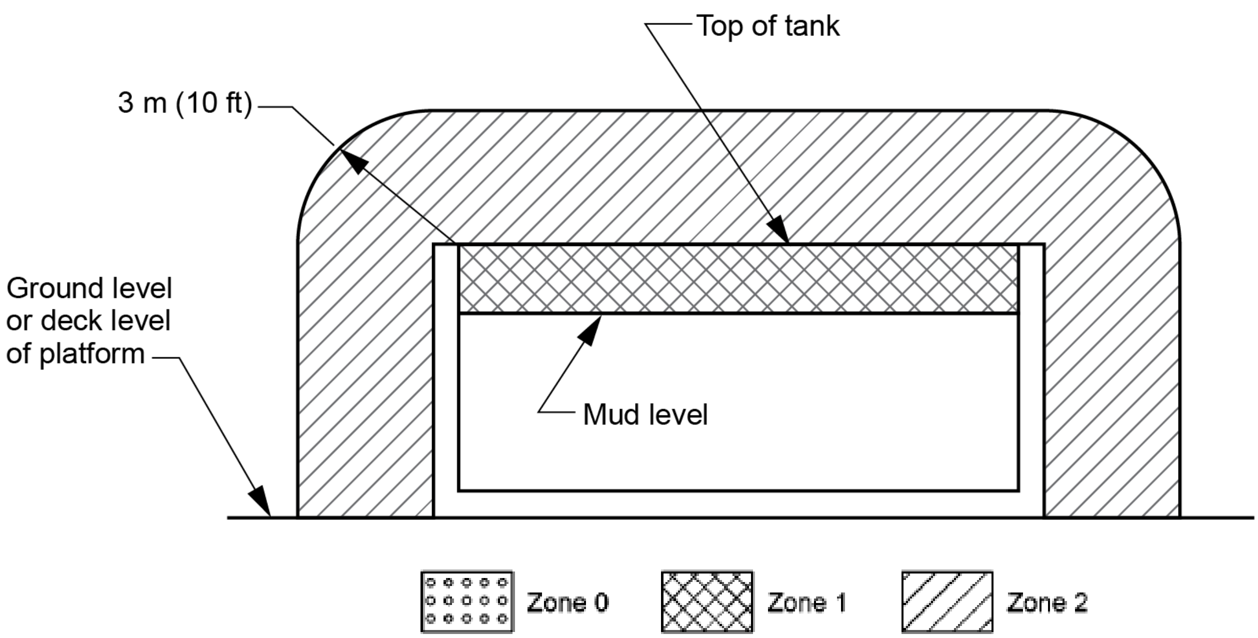


Figure 33—Mud Tank in a Non-enclosed, Adequately Ventilated Area (See 10.4.3.1, 10.4.3.2, 10.4.4.1, and 10.4.4.2)

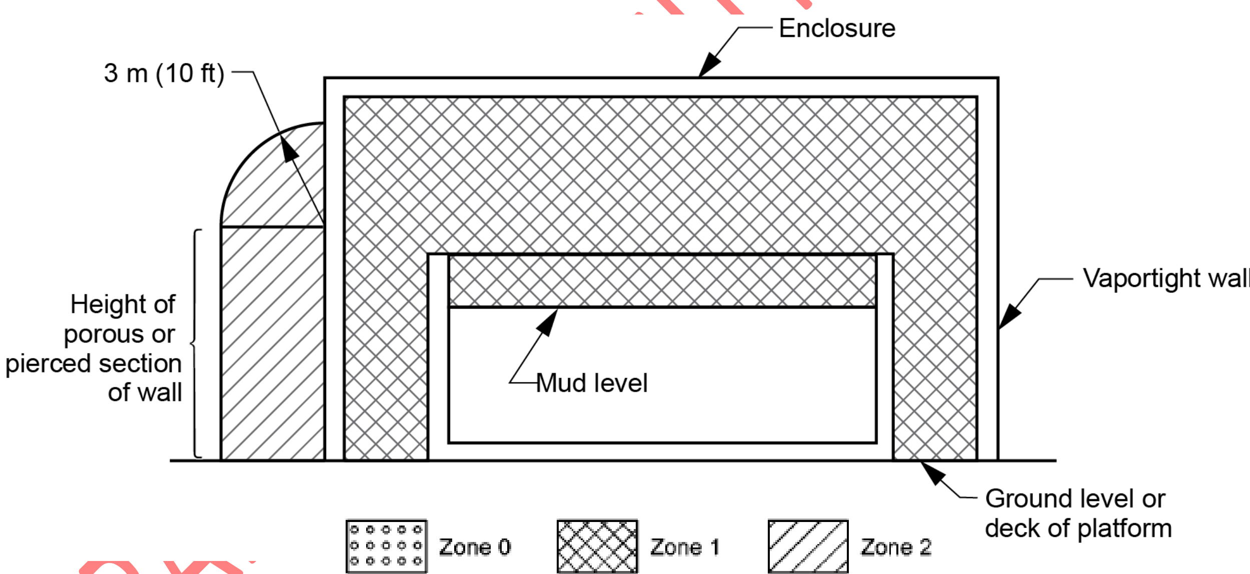


Figure 34—Mud Tank in an Enclosed Inadequately Ventilated Area (See 10.4.3.3, 10.4.4.3, and 10.12.4)

10.4.4 Mud Ditch, Trench, or Pit

10.4.4.1 The area around an open ditch or trench used to connect between mud tanks and open active mud pits located in non-enclosed adequately ventilated areas is classified the same as illustrated for mud tanks in Figure 33.

10.4.4.2 The area around an open ditch or trench used to connect between mud tanks and open, active mud pits located in adequately ventilated enclosed areas is classified the same as illustrated for mud tanks in Figure 33, but Zone 2 for the remainder of the extent of the enclosed area.

10.4.4.3 The area around an open ditch or trench used to connect between mud tanks and open, active mud pits located in inadequately ventilated areas is classified the same as illustrated for mud tanks in Figure 34.

10.4.5 Mud Pump

10.4.5.1 The area surrounding a mud pump in a non-enclosed or enclosed adequately ventilated location is unclassified.

10.4.5.2 The area surrounding a mud pump in an inadequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.4.6 Shale Shaker

10.4.6.1 The location surrounding a shale shaker located in a non-enclosed, adequately ventilated area is classified as shown in Figure 35.

10.4.6.2 The location surrounding a shale shaker located in an adequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.4.6.3 The location surrounding a shale shaker located in an inadequately ventilated enclosed area is classified Zone 0 to the extent of the enclosed area.

10.4.7 Desander or Desilter

10.4.7.1 The location surrounding a desander or desilter located in a non-enclosed adequately ventilated location is classified as shown in Figure 36.

10.4.7.2 The location surrounding a desander or desilter located in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area as in Figure 37.

10.4.7.3 The location surrounding a desander or desilter located in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

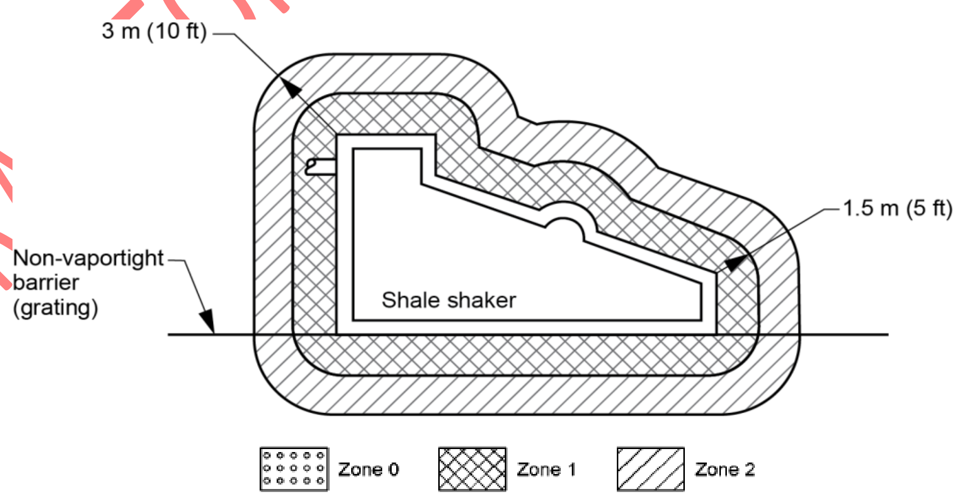


Figure 35—Shale Shaker in a Non-enclosed, Adequately Ventilated Area (See 10.4.6.1)

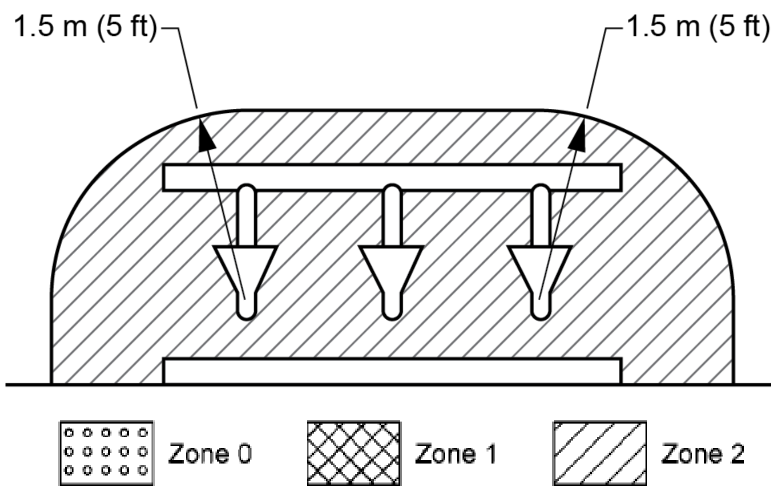


Figure 36—Desander or Desilter in a Non-enclosed, Adequately Ventilated Area (See 10.4.7.1)

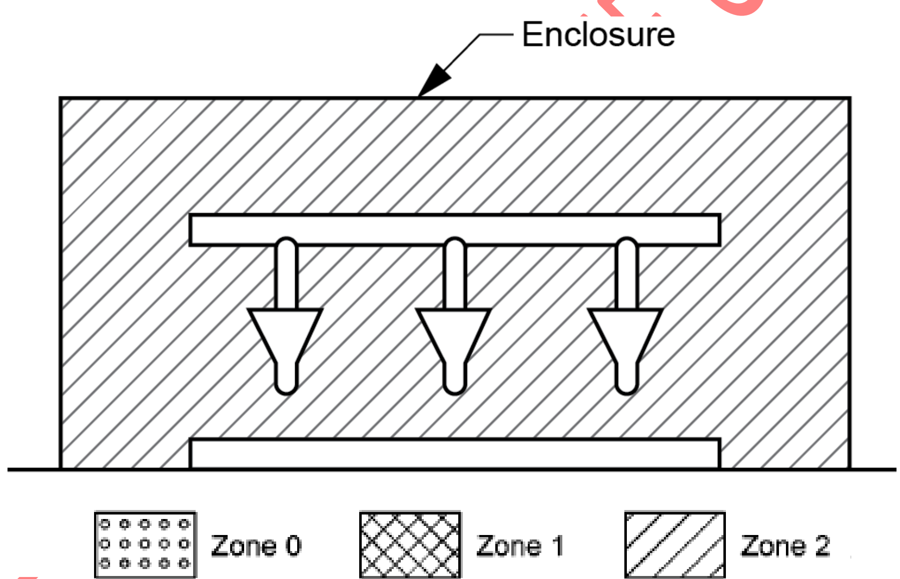


Figure 37—Desander or Desilter in an Adequately Ventilated Enclosed Area (See 10.4.7.2)

10.4.8 Degasser

10.4.8.1 The area surrounding a degasser located in a non-enclosed, adequately ventilated location is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the degasser.

10.4.8.2 The area surrounding a degasser located in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.4.8.3 The area surrounding a degasser located in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.4.8.4 The area surrounding the vent from a degasser is classified as shown in Figure 38.

10.4.9 Blowout Preventer (BOP)

10.4.9.1 The area surrounding a BOP in a non-enclosed, adequately ventilated location is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the BOP.

NOTE The pressure adjustment factors in Table 3 apply to the operating pressure and not the equipment pressure rating.

10.4.9.2 The area surrounding a BOP in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.4.9.3 The area surrounding a BOP in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.4.10 Choke Manifold

10.4.10.1 The area surrounding a choke manifold in a non-enclosed, adequately ventilated location is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the choke manifold.

NOTE The pressure adjustment factors in Table 3 apply to the operating pressure and not the equipment pressure rating.

10.4.10.2 The area surrounding a choke manifold in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.4.10.3 The area surrounding a choke manifold in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

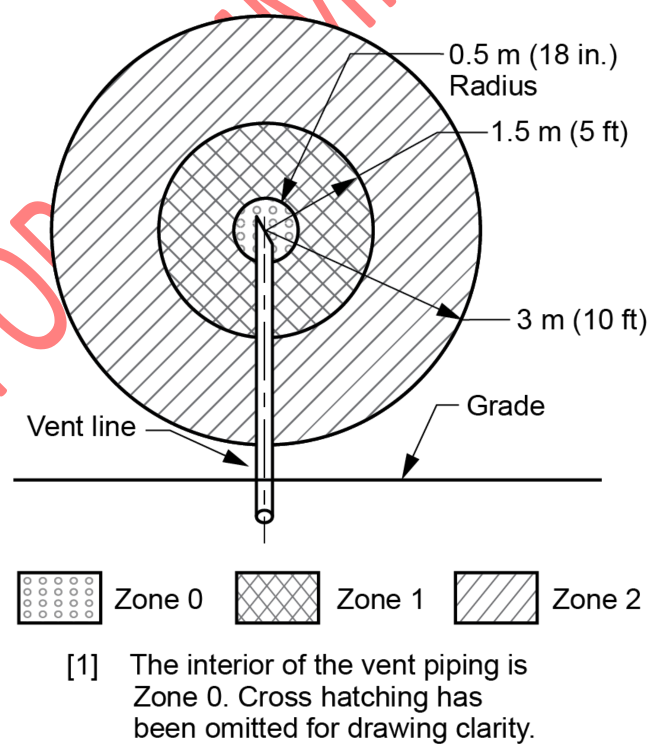


Figure 38—Degasser Vent in Non-enclosed, Adequately Ventilated Area (See 10.4.8.4)

10.4.11 Cement Unit

10.4.11.1 The area surrounding a mixing/holding tank for a cement unit in a non-enclosed, adequately ventilated location is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the mixing/holding tank.

10.4.11.2 The area surrounding a mixing/holding tank for a cement unit in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.4.11.3 The area surrounding a mixing/holding tank for a cement unit in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.5 Producing Oil and Gas Wells

10.5.1 General

Areas adjacent to producing oil and gas wells are classified as follows.

10.5.2 Flowing Well

10.5.2.1 The area around a flowing well located in a non-enclosed, adequately ventilated location where a cellar or below grade sump is not present is classified as shown by Figure 39.

10.5.2.2 The area around a flowing well located in a non-enclosed, adequately ventilated location with an inadequately ventilated cellar or below grade sump is Zone 1 below grade and Zone 2 above grade to the extent shown in Figure 40.

10.5.2.3 A flowing well located in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.5.2.4 A flowing well located in an inadequately ventilated enclosed area (such as a wellhead room) is classified Zone 1 to the extent of the enclosed area as shown in Figure 32 and Figure 41.

10.5.2.5 For surface safety valves, see 10.15.3.

10.5.2.6 For sample valves, instrument drain valves, gauge valves, and similar devices, see 10.15.4.

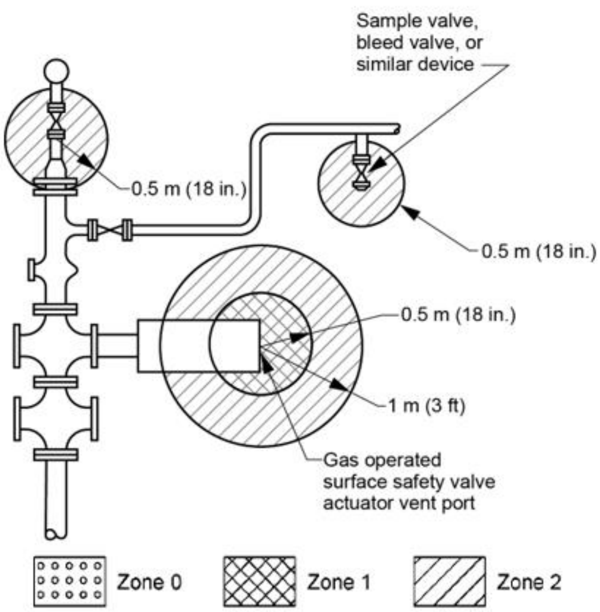


Figure 39—Flowing Well in a Non-enclosed, Adequately Ventilated Area and Without a Cellar or Below-grade Sump (See 10.5.2.1 and 10.15.4.2)

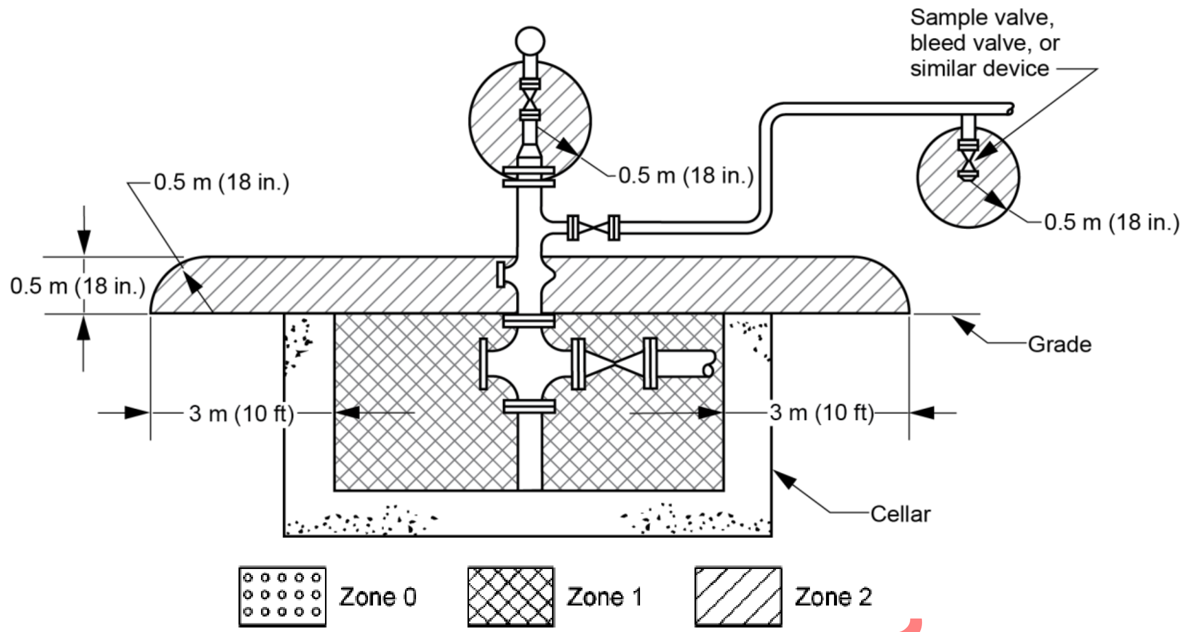


Figure 40—Flowing Well in a Non-enclosed, Adequately Ventilated Area with an Inadequately Ventilated Cellar or Below-grade Sump (See 10.5.2.2 and 10.15.4.2)

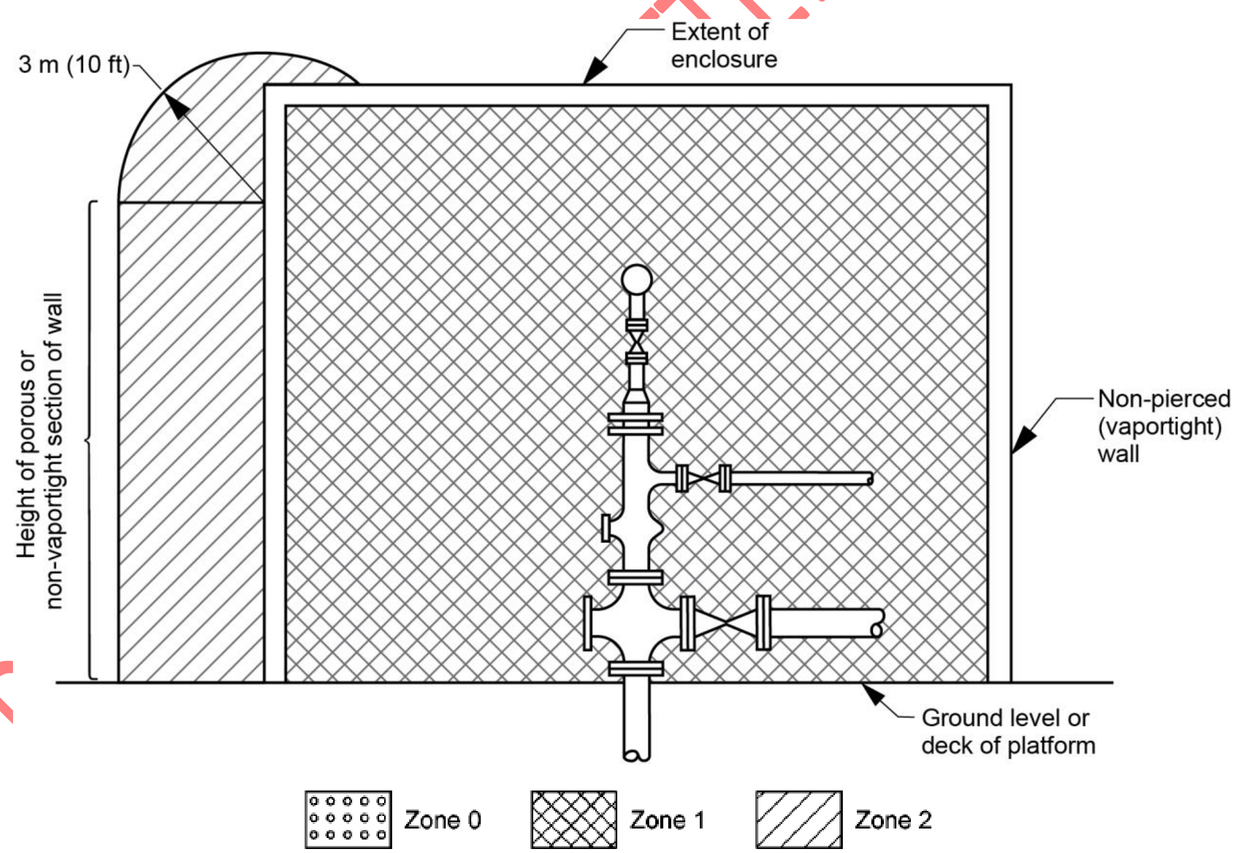


Figure 41—Flowing Well in an Inadequately Ventilated Enclosed Area (See 10.5.2.4)

10.5.3 Artificially Lifted Wells

10.5.3.1 Beam Pumping Well

10.5.3.1.1 Where a cellar or below grade sump is not present, the area around a beam pumping well in a non-enclosed, adequately ventilated area is Zone 2 to the extent shown in Figure 42.

10.5.3.1.2 The area around a beam pumping well in a non-enclosed adequately ventilated area where an inadequately ventilated cellar or below grade sump is present is classified Zone 1 below grade and Zone 2 above grade to the extent shown in Figure 43.

10.5.3.1.3 The area around a beam pumping well in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.5.3.1.4 The area around a beam pumping well in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.5.3.2 Mechanically Driven, Rotating, Subsurface Pumps

The location around a well produced with a downhole pump, shaft driven by a surface mounted prime mover, (e.g. progressive cavity pump) is classified the same as the location around a beam pumping well. Reference 10.5.3.1.

10.5.3.3 Electric Submersible Pumping Well

10.5.3.3.1 Where a cellar or below grade sump is not present, the area around an electric submersible pump wellhead in a non-enclosed, adequately ventilated location is classified Zone 2 to the extent shown in Figure 44.

10.5.3.3.2 Where an inadequately ventilated cellar or below grade sump is present at a well produced with an electric submersible pump, the location is classified as shown in Figure 45.

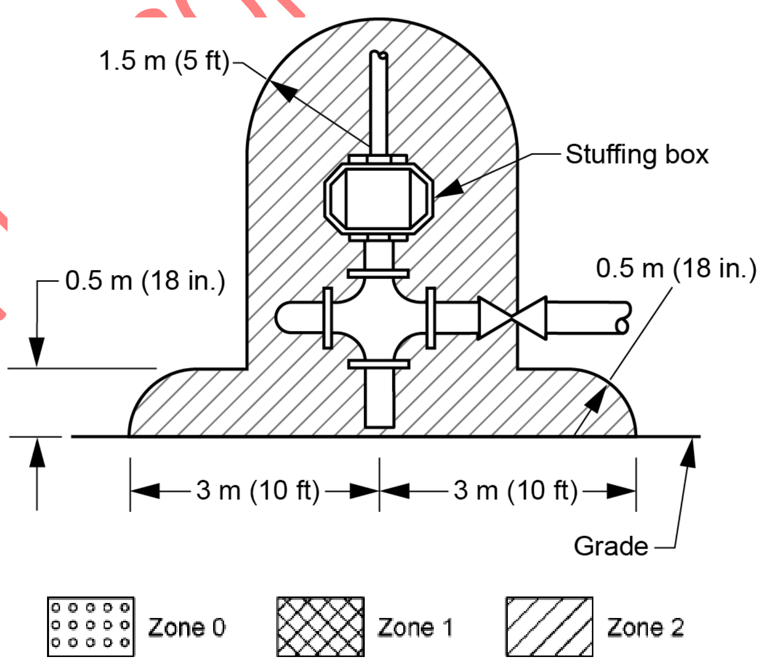


Figure 42—Non-enclosed Beam Pumping Well in an Adequately Ventilated Area Without a Cellar (See 10.5.3.1.1)

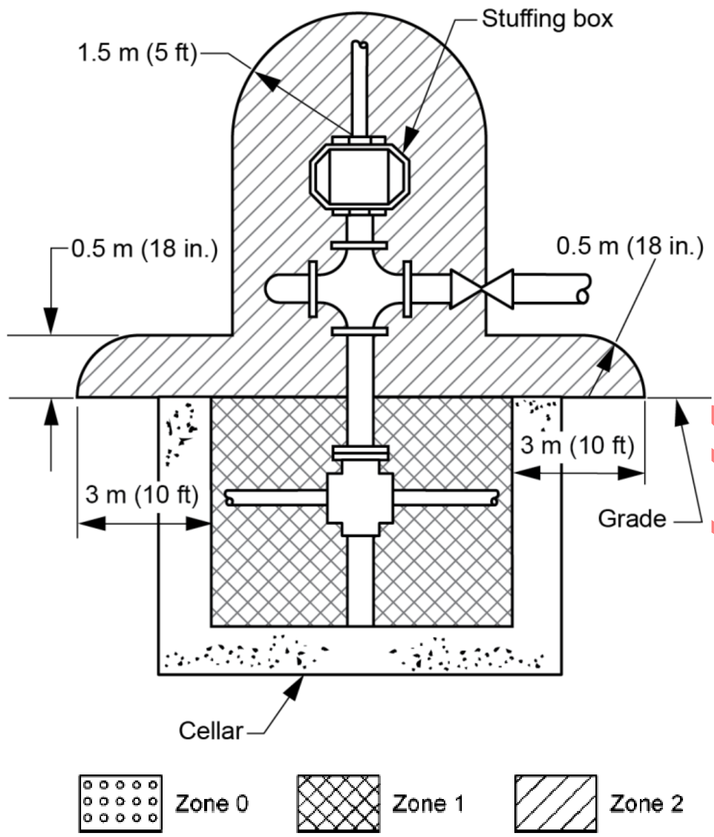


Figure 43—Non-enclosed Beam Pumping Well in an Adequately Ventilated Area with an Inadequately Ventilated Cellar (See 10.5.3.1.2)

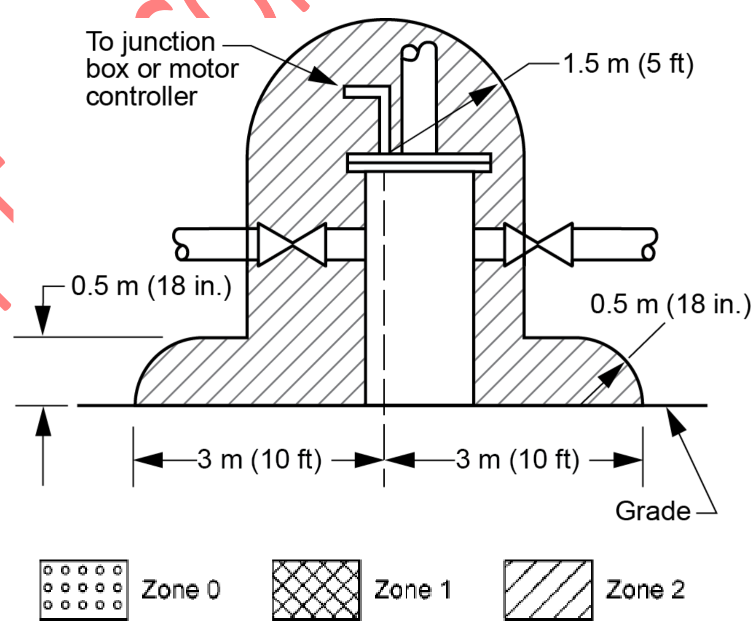


Figure 44—Electric Submersible Pumping Well in a Non-enclosed, Adequately Ventilated Area Without a Cellar (See 10.5.3.3.1)

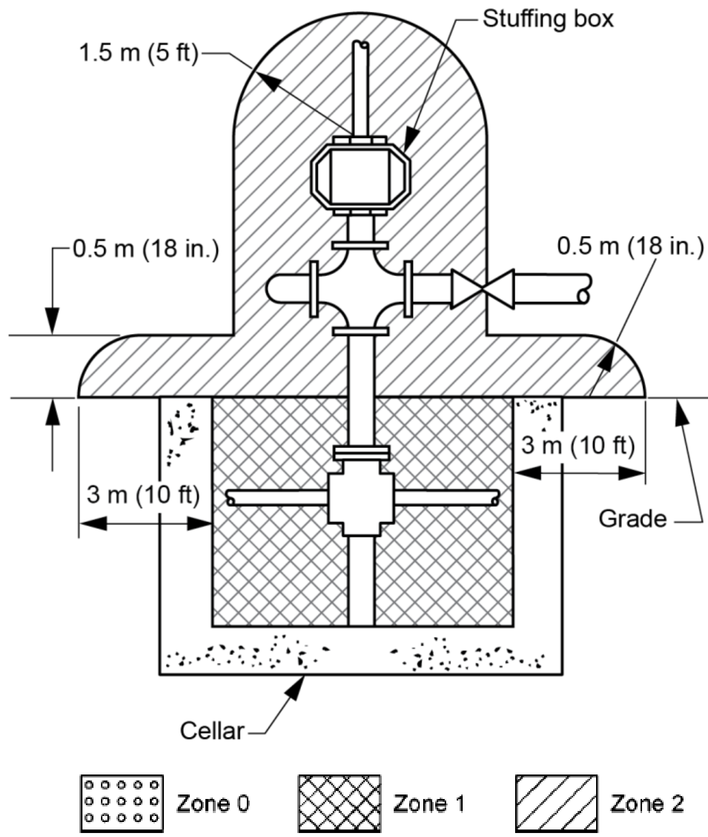


Figure 45—Electric Submersible Pumping Well in a Non-enclosed, Adequately Ventilated Area with an Inadequately Ventilated Cellar (See 10.5.3.3.2)

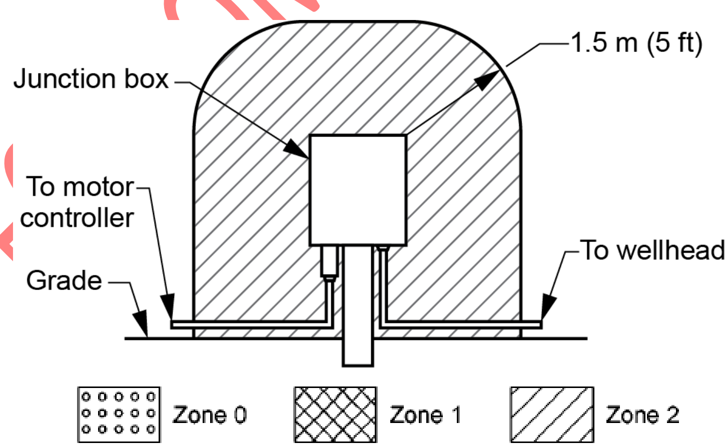


Figure 46—Junction Box in a Non-enclosed, Adequately Ventilated Area Connected to an Electric Submersible Pump (See 10.5.3.3.3)

10.5.3.3.3 The area surrounding a junction box connected directly to an electric submersible pump by a cable or conduit in a non-enclosed adequately ventilated location is classified as shown in Figure 46.

a) The interior of the junction box is classified Zone 2 if vented.

b) The interior of the junction box is classified Zone 1 if not vented.

10.5.3.3.4 The interior of a motor controller enclosure connected to an electric submersible pump through a vented junction box and sealing fitting by a cable or conduit is unclassified.

10.5.3.3.5 The interior of an adequately ventilated motor controller enclosure connected to an electric submersible pump through a vented junction box without an intervening sealing fitting by a cable or conduit is classified Zone 2.

10.5.3.3.6 The interior of an inadequately ventilated motor controller enclosure connected to an electric submersible pump through a vented junction box without an intervening sealing fitting by a cable or conduit is classified Zone 1.

10.5.3.3.7 The interior of a motor controller enclosure connected through a non-vented junction box or connected directly to an electric submersible pump by a cable or conduit in a non-enclosed, adequately ventilated location is classified Zone 1.

10.5.3.3.8 Enclosed adequately ventilated areas containing electric submersible pumping wells or associated junction boxes are classified Zone 2 to the extent of the enclosed area.

10.5.3.3.9 Enclosed inadequately ventilated areas containing electric submersible pumping wells or associated junction boxes are classified Zone 1 to the extent of the enclosed area.

10.5.3.4 Hydraulic Subsurface Pumping Well

The location around a well produced with a hydraulic subsurface pump is classified the same as the location around a flowing well. See 10.5.2.

10.5.3.5 Gas Lift Well

The area around a gas lift well is classified the same as the area around a flowing well. See 10.5.2.

10.5.3.6 Plunger Lift Well

The area around a plunger lift well is classified the same as the area around a flowing well. See 10.5.2.

10.5.4 Injection Wells

10.5.4.1 The area around a flammable gas or liquid injection well is classified the same as the area around a flowing well. See 10.5.2.

10.5.4.2 The area around a nonflammable gas or liquid injection well is unclassified, unless the well is connected to facilities that are connected to hydrocarbon-producing wells (flowing or artificially lifted) wherein an equipment malfunction or barrier leakage could cause backflow, exposing the associated injection equipment to hydrocarbons. In those cases, the classification should be as oil and gas producing equipment in accordance with 10.9. For example, injection equipment protected from backflow using only a check valve should be classified, since the associated injection equipment will be exposed to hydrocarbons during a check valve malfunction and hydrocarbon backflow.

10.5.5 Multi-well Installations

10.5.5.1 For a multi-well installation in a non-enclosed, adequately ventilated area with less than 7.5 m (25 ft) between wells (centerline to centerline), the area within a 3 m (10 ft) radius of the centerline of each well is classified Zone 2.

10.5.5.2 Multiple completions within a single casing are considered a single-well installation.

10.5.6 Wireline Lubricator

10.5.6.1 The area around the stuffing box on a wireline lubricator in a non-enclosed adequately ventilated location is classified as shown in Figure 47.

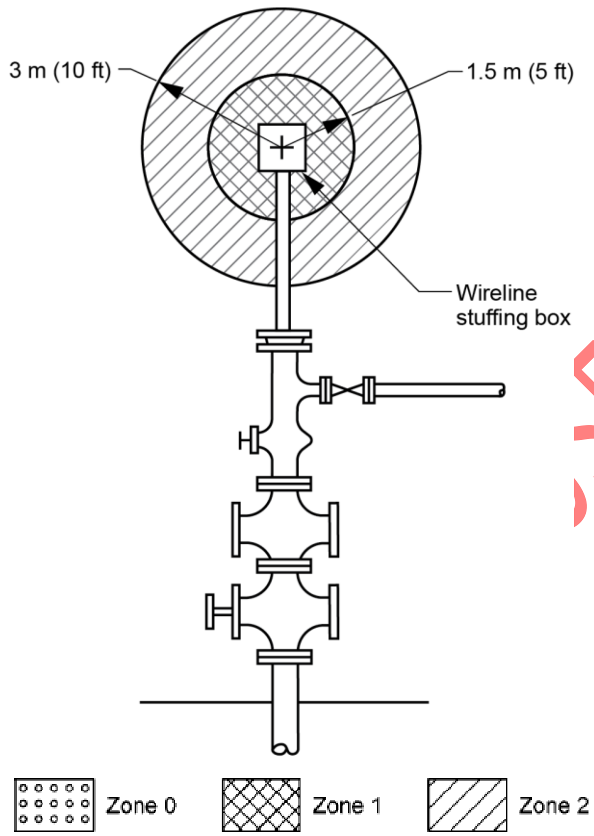


Figure 47—Non-enclosed, Adequately Ventilated Well on Which Wireline Work is Being Performed (See 10.5.6.1 and 10.5.6.2)

10.5.6.2 The area around the stuffing box on a wireline lubricator in an adequately ventilated enclosed area is classified Zone 1, as shown by Figure 47, and Zone 2 for the remainder of the extent of the enclosed area.

10.5.6.3 The area around the stuffing box on a wireline lubricator in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.6 Oil and Gas Processing and Storage Equipment

10.6.1 Flammable Liquid Storage Tank

See 8.2.1.2 or 8.2.13 as applicable.

10.6.2 Combustible Liquid Storage Tank

See 8.2.1.4.

10.6.3 Hydrocarbon Pressure Vessel

10.6.3.1 An all-welded, hydrocarbon pressure vessel does not create a classified area; however, valves and other appurtenances such as control valves, sample valves, drain valves, and instrumentation fittings connected to the vessel creates a classified area around the vessel. The area around the vessel should be classified as described in 10.6.3.2, 10.6.3.3, and 10.6.3.4.

For pressure vessels opened under normal conditions, such as the maintenance of filters or separators, the area around the opening should be classified in accordance with 10.6.6.

10.6.3.2 The area around a hydrocarbon pressure vessel (e.g. oil–gas separator, treater, and glycol contactor) in a non-enclosed, adequately ventilated area is classified as shown in Figure 48.

10.6.3.3 The area around a hydrocarbon pressure vessel in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area if all flammable gas vents, relief valve vents, and the like are extended to outside the enclosed area.

10.6.3.4 When a hydrocarbon pressure vessel is installed in an inadequately ventilated enclosed area, the area is classified Zone 1 to the extent of the enclosed area.

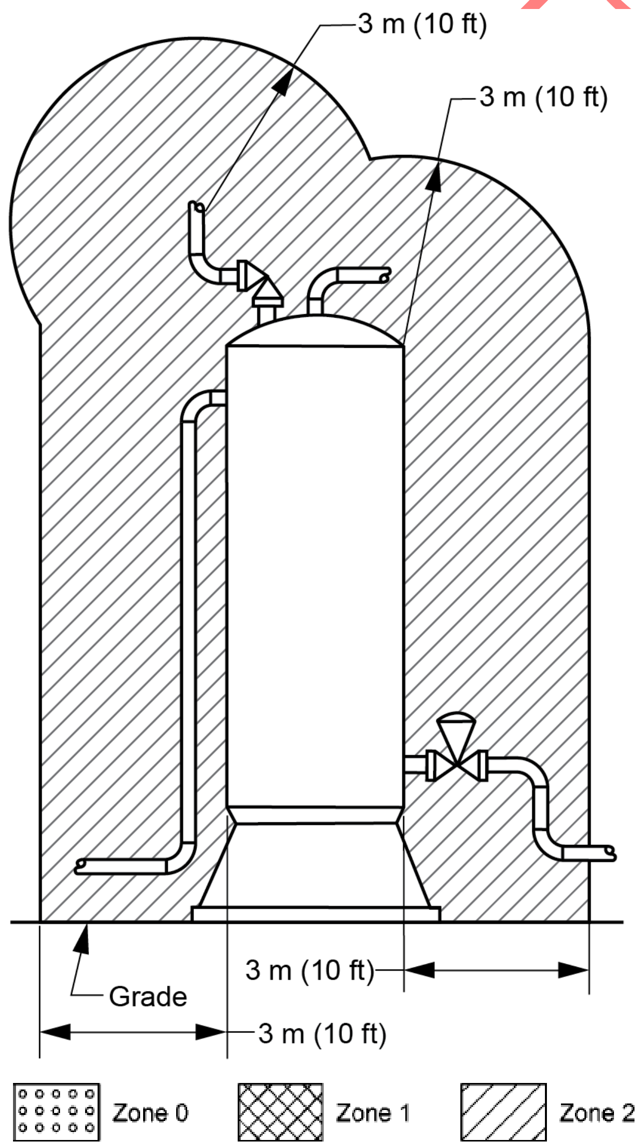


Figure 48—Hydrocarbon Pressure Vessel or Protected Fired Vessel in a Non-enclosed, Adequately Ventilated Area (See 10.6.3.2 and 10.6.7.1)

10.6.4 Header or Manifold

10.6.4.1 As utilized in this section, a header or manifold is an assembly comprised of pipe flanges, valves, and miscellaneous fittings used to collect or distribute a common fluid or gas to or from a multiple of flow lines.

10.6.4.2 The area around a non-enclosed header or manifold located in an adequately ventilated area is classified Zone 2 within 0.5 m (18 in) from the outside surface of the manifold assembly for low pressure applications. For medium and higher pressure applications, the minimum area is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the manifold assembly.

NOTE The pressure adjustment factors in Table 3 apply to the operating pressure.

10.6.4.3 The area around a header or manifold located in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.6.4.4 The area around a header or manifold located in an inadequately ventilated enclosure is classified Zone 1 to the extent of the enclosure.

10.6.4.5 Associated equipment (such as control valves) should be considered separately.

10.6.5 Protected Fired Vessels

A protected fired vessel and the surrounding area is classified the same as for a hydrocarbon pressure vessel (see 10.6.3).

10.6.6 Launcher or Receiver

Blowdown and drain valve vents should be classified the same as shown by Figure 14 for process equipment vents.

10.6.6.1 Ball or Pig Launcher or Receiver

10.6.6.1.1 The area around an installation for launching or receiving balls or pigs into or from a producing or gathering line in a non-enclosed, adequately ventilated area is classified as shown in Figure 49.

10.6.6.1.2 The area around such an installation in an adequately ventilated enclosed area is classified as shown in Figure 49, but Zone 2 for the remainder of the extent of the enclosed area.

10.6.6.1.3 The area around such an installation in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.6.6.2 Through Flow Line (TFL) Tool Launcher or Receiver

10.6.6.2.1 The area around a through flow line (TFL) tool launcher or receiver in a non-enclosed, adequately ventilated area is classified the same as illustrated in Figure 49 for a ball or pig launcher or receiver.

10.6.6.2.2 The area around such an installation in an adequately ventilated enclosed area is classified as shown in Figure 49, but Zone 2 for the remainder of the extent of the enclosed area.

10.6.6.2.3 The area around such an installation in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

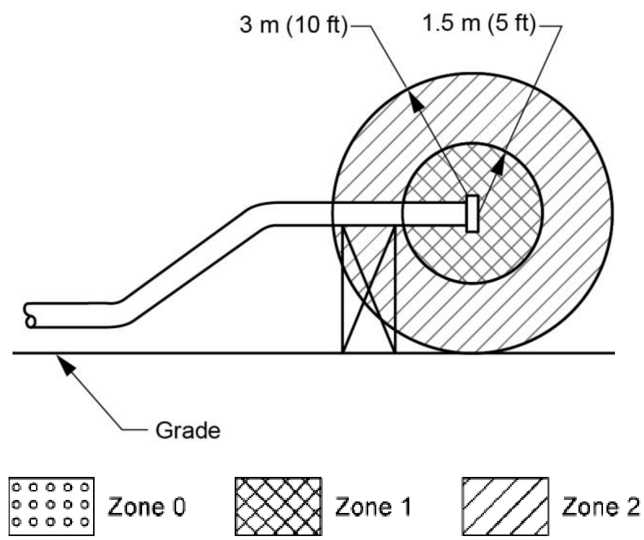


Figure 49—Ball or Pig Launching or Receiving Installation in a Non-enclosed, Adequately Ventilated Area (See 10.6.6.1.1, 10.6.6.1.2, 10.6.6.2.1, and 10.6.6.2.2)

10.6.7 Dehydrator, Stabilizer, and Hydrocarbon Recovery Unit

10.6.7.1 Areas around such equipment in non-enclosed, adequately ventilated areas are classified the same as shown in Figure 48 for hydrocarbon pressure vessels, except when an unprotected fire box or source of ignition is an integral part of such equipment. In this latter case, see 6.5.9.2 and 6.5.9.3.

10.6.7.2 Areas around such equipment in an adequately ventilated enclosed area are classified Zone 2 to the extent of the enclosed area.

10.6.7.3 Areas around such equipment in an inadequately ventilated enclosed area are classified Zone 1 to the extent of the enclosed area.

10.6.8 Vents and Relief Valves

See 8.2.3.

10.6.9 Hydrocarbon-fueled Prime Movers

See 8.2.5.

10.6.10 Batteries

See 8.2.6.

10.7 Automatic Custody Transfer (ACT) Units

For details concerning areas around automatic custody transfer (ACT) units, refer to appropriate sections of this recommended practice (e.g. pumps, tanks, etc.). Areas around positive displacement meters should be classified the same as areas around control valves (see 10.15.3). Areas around turbine meters should be classified the same as areas around block and check valves (see 10.15.2). Areas around sample containers should be classified Zone 2 within 1.5 m (5 ft) of the container; sample valves are included in 10.15.4.

10.8 Produced, Processed, or Injection Water Handling Equipment

10.8.1 Produced, processed, or /injection water is any water, regardless of its source, that in the course of use may contain or mix with flammable liquids, gases, or vapors.

10.8.1.1 This water can be divided into at least three categories:

10.8.1.1.2 10.8.1.1.1 *Water that can be considered non-flammable.* This water is usually the product of multiple stages of separation or filtration where a process upset would not result in the release of flammable concentrations of the materials. The area surrounding such water handling equipment need not be classified solely by reason of the produced, processed, or injection water.*Water that is likely to contain flammables due to process upset conditions, or that is gas-blanketed.* This water would usually be the product of one or more stages of separation or filtration where occasional process upsets might result in the release of small quantities of flammables for a short duration. Equipment for handling such water and flammable gas–blanketed equipment should be classified as described below.

a) Areas around flammable gas–blanketed equipment and produced, processed, injection water-handling equipment installed in non-enclosed adequately ventilated areas are unclassified as shown in Figure 50. For process equipment vents on this equipment, see 8.2.3.1.

b) The area around such equipment installed in an adequately ventilated enclosed area is classified as shown by Figure 50, but also Zone 2 for the remainder of the extent of the enclosed area if the equipment is vented to the outside of the enclosed area. If all equipment vents are not extended to the outside of the enclosed area, the entire enclosed area is classified Zone 1.

c) The area around such equipment installed in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.8.1.1.3 *Water that is likely to contain flammables on routine occasions or that could release sizable quantities of flammables for extended periods*. Equipment handling this type of water should be classified as process equipment handling flammables. See 10.6 for guidance. Such equipment might consist of installations where process upset conditions could result in significant quantities of flammables in the water stream and where such conditions could exist unnoticed for extended periods of time. Such equipment could also consist of separation equipment prone to frequent upsets where the water stream contains flammable concentrations.

10.8.1.2 Source/injection water equipment can be divided into the two following categories:

10.8.1.2.1 *Source/injection water that can be considered non-flammable.* This water is usually from a non-hydrocarbon source and is treated or filtered and where a process upset would not result in the exposure of equipment to flammable concentrations of hydrocarbons. The area surrounding such water injection equipment need not be classified.

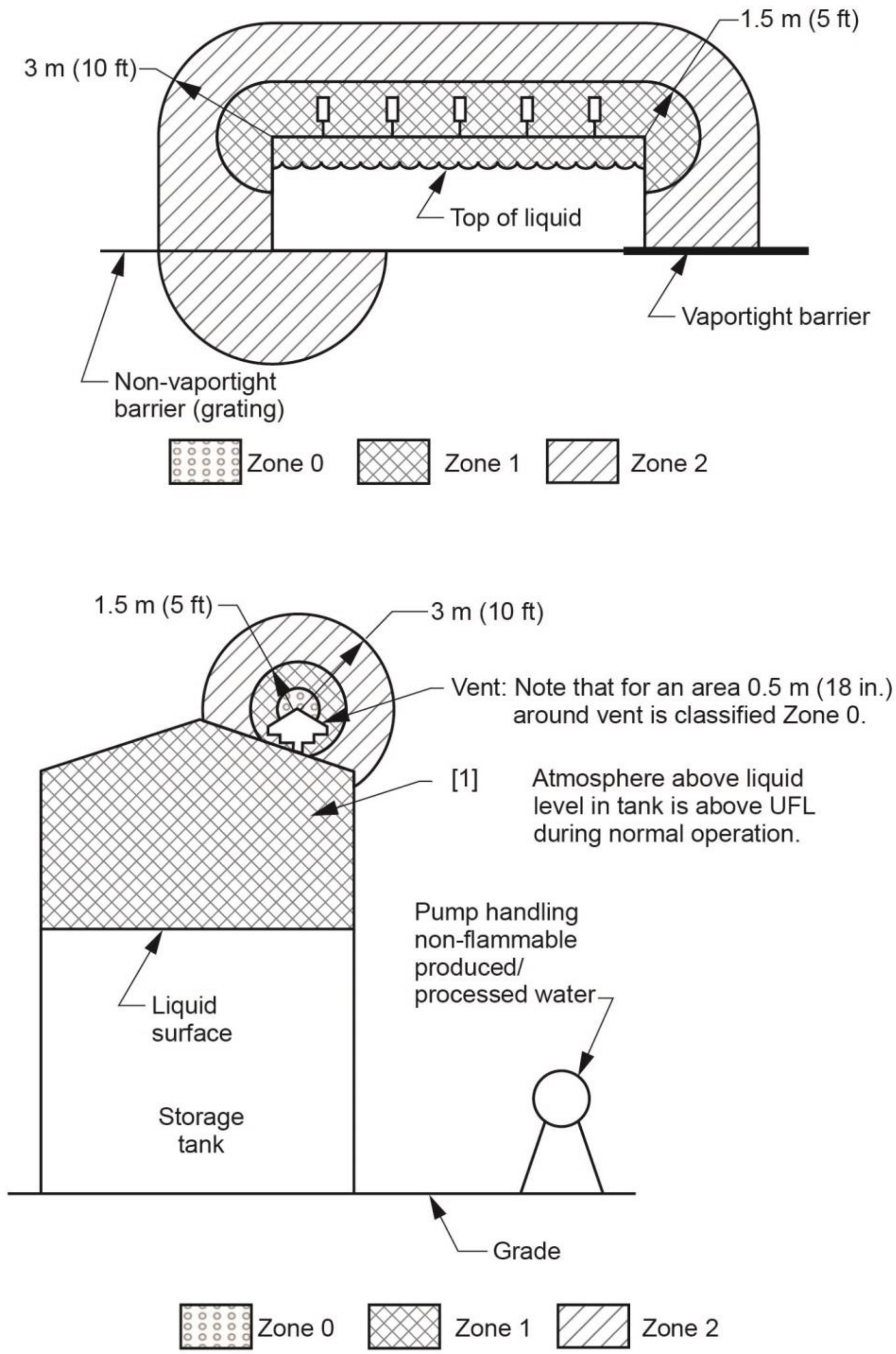
10.8.1.2.2 *Source/injection water that is likely to contain hydrocarbons due to process upset conditions or is flammable gas–blanketed.* This water is usually from a non-hydrocarbon source and is treated or filtered and where an equipment malfunction or barrier leakage could cause backflow, exposing the associated injection equipment to hydrocarbons, or is flammable gas–blanketed. Equipment for handling such water should be classified as described in 10.8.1.1.2a) and 10.8.1.1.2b).

10.8.2 For processed, produced, or injection water that is stored without gas blanketing, the interior of the storage tank shown in Figure 50 should be classified as Zone 0.

10.9 Compressor or Pump Handling Flammable Liquids, Gases, or Vapors

10.9.1 The area around a compressor or pump handling flammable liquids, gases, or vapors in a non-enclosed, adequately ventilated area is classified as shown in Figure 51 or Figure 52.

10.9.2 The area around a compressor or pump handling flammable liquids, gases, or vapors in an adequately ventilated enclosed area is classified as shown in Figure 53.



[1] For non-gas-blanketed tanks, see 10.8.2.

Figure 50—Flammable Gas–blanketed and Produced/Processed/Injected Water-handling Equipment [Tank (bottom) and Flotation Cell (top)] in a Non-enclosed, Adequately Ventilated Area
(See 10.8.1.1.2a, 10.8.1.1.2b, 10.8.2, and 10.12.6)

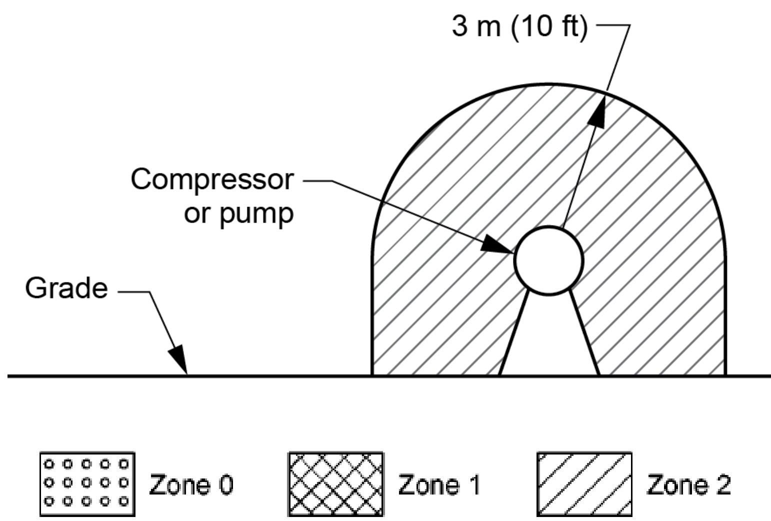


Figure 51—Compressor or Pump in an Adequately Ventilated Non-enclosed Area (See 10.9.1)

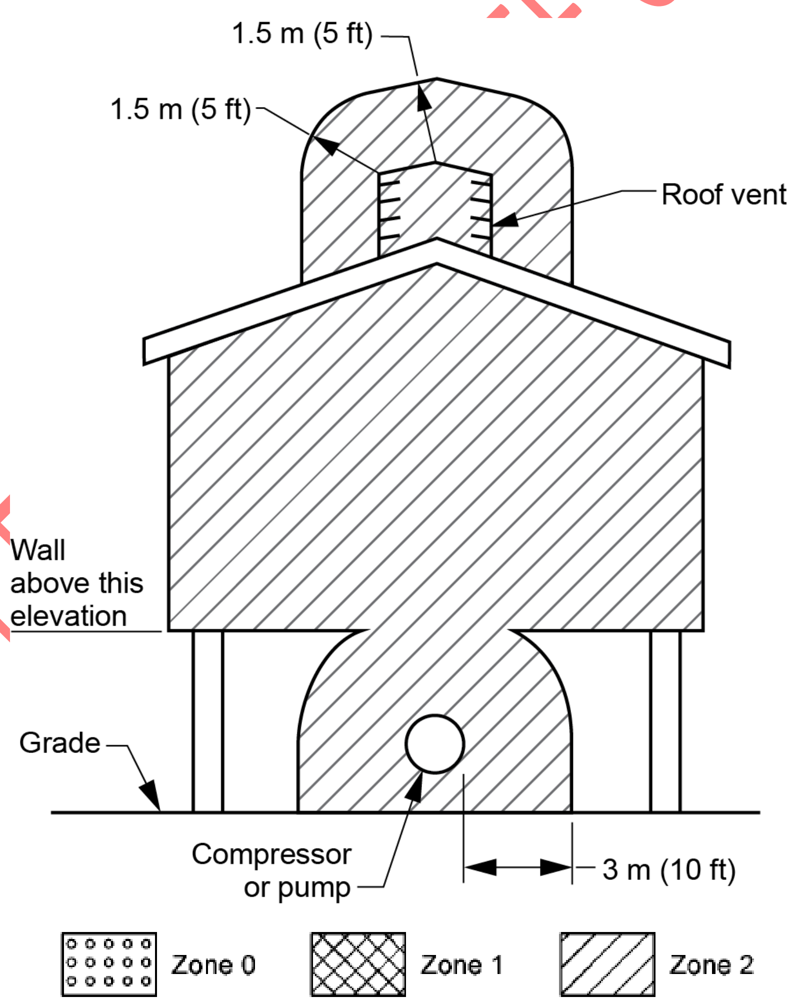


Figure 52—Compressor or Pump in an Adequately Ventilated Non-enclosed Area (See 10.9.1)

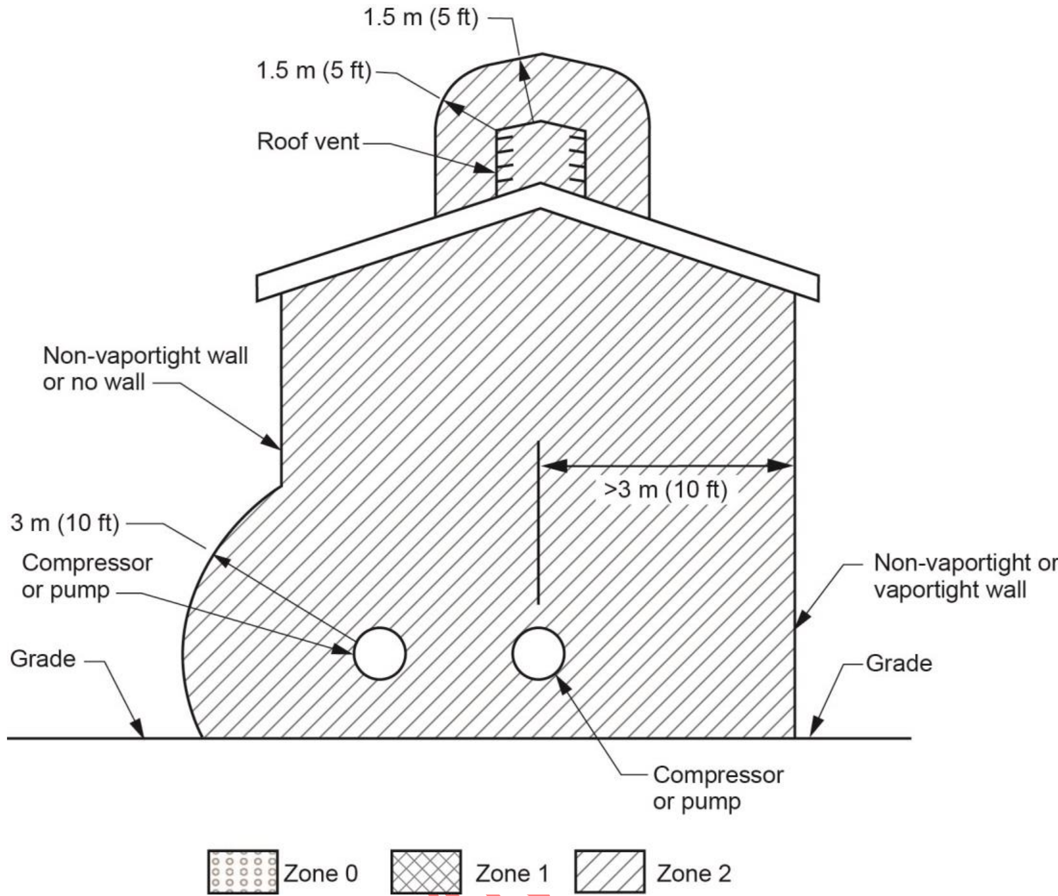


Figure 53—Compressor or Pump in an Adequately Ventilated Enclosed Area (See 10.9.2)

10.9.3 The area around a compressor or pump handling flammable liquids, gases, or vapors in an inadequately ventilated enclosed area is classified as shown in Figure 54a.

10.9.4 The area around a compressor or pump handling flammable liquids, gases, or vapors in an adequately ventilated non-enclosed area is classified as shown in Figure 54b.

10.10 Drip Pans

10.10.1 Included in this section are devices that, under abnormal operating conditions, collect and temporarily contain combustible or flammable liquids at atmospheric pressure.

10.10.2 Drip pans that collect and temporarily contain combustible liquids are unclassified if the liquid is handled and contained below its flash point.

10.10.3 Drip pans that collect flammable liquids are classified as follows:

10.10.3.1 Drip pans that are continually drained to a containment system should be classified the same as drains as described in 10.13.

10.10.3.2 Drip pans that are not continually drained to a containment section should be classified the same as sumps as described in 10.12. In non-enclosed, adequately ventilated locations, drip pans that contain flammable liquids only in case of mechanical equipment failure; are monitored routinely; are capable of containing 38 liters (10 gallons) or less; and have a maximum surface area of 0.6 m^2 (6 ft^2), should be classified Zone 1 inside the drip pan and Zone 2 for 0.5 m (18 in.) above and within 0.5 m (18 in.) of the perimeter of the drip pan.

10.11 Instruments

10.11.1 General

This section addresses non-enclosed areas and enclosed areas (enclosures) sufficient in size to allow the entry of personnel. See 10.16 for enclosed areas (enclosures) insufficient in size to allow the entry of personnel.

10.11.2 Instruments Not Operated by Flammable Gas

10.11.2.1 This section includes those instruments or other devices connected in hydrocarbon service (for example, devices used for flow, pressure, or level, analysis, measurement, or control) that do not utilize flammable gas for motive force. Valves (as opposed to valve operators) should be classified in accordance with 10.15.2, 10.15.3, and 10.15.4.

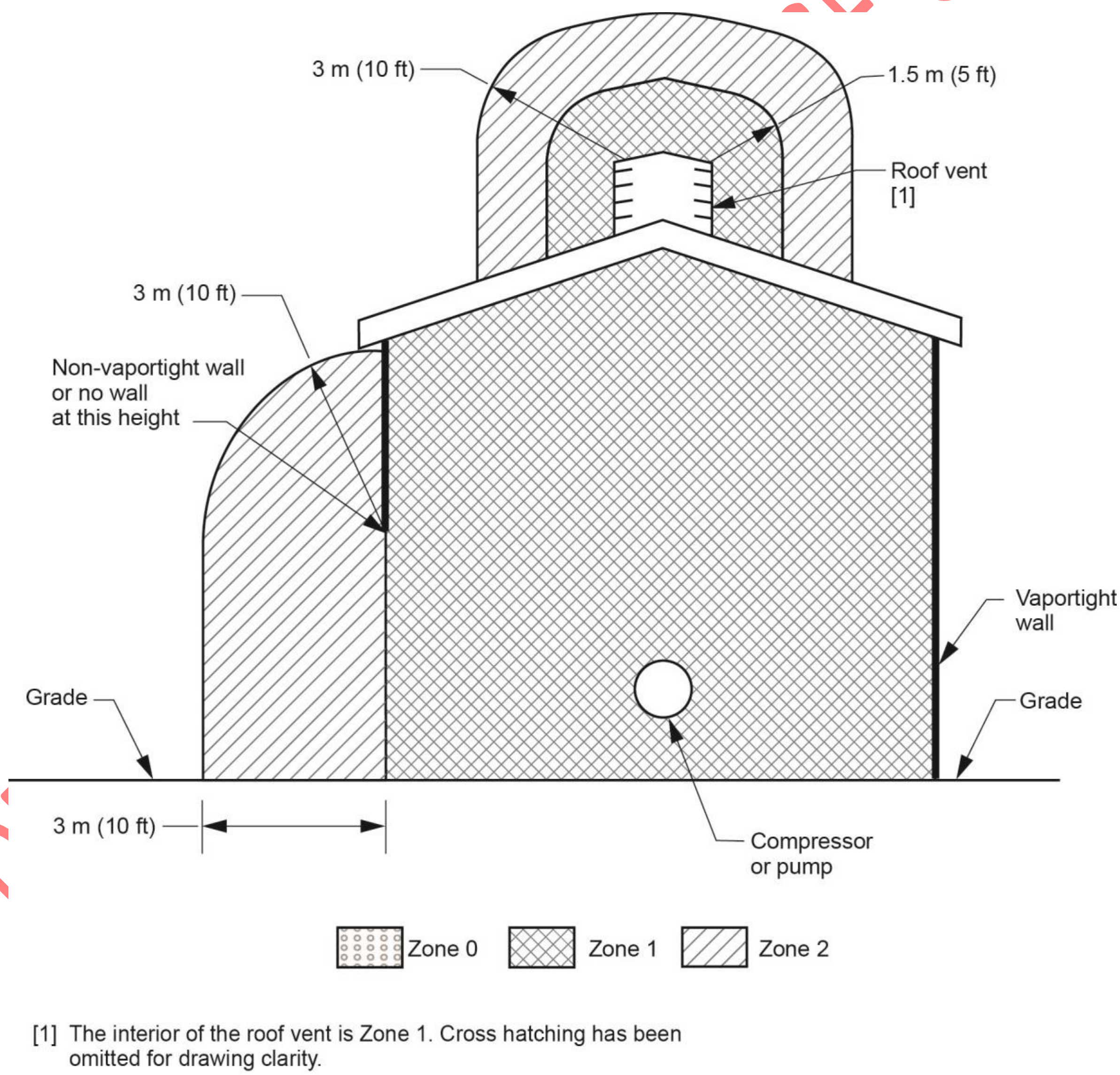
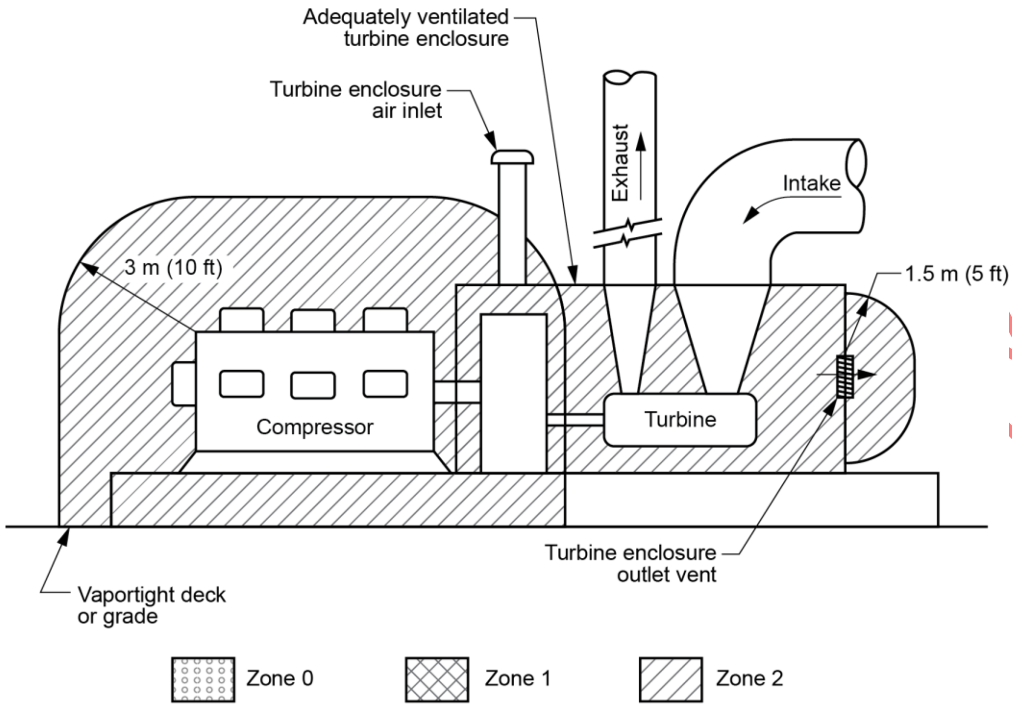


Figure 54a—Compressor or Pump in an Inadequately Ventilated Enclosed Area (See 10.9.3)



[1] Turbine enclosure classification as shown applies when turbine fuel gas pressure exceeds 861.8 kPa (125 psi) and enclosure is adequately ventilated. See 8.25 for additional requirements.

[2] Turbine enclosure is unclassified when adequately ventilated and turbine fuel gas pressure is 861.8 kPa (125 psi) or less. See 8.2.5 for additional requirements.

Figure 54b—Compressor or Pump in an Adequately Ventilated Non-enclosed Area (See 10.9.4 and 8.2.5.1)

10.11.2.2 The area surrounding such instruments (e.g. pressure switches and pressure transmitters) in a non-enclosed, adequately ventilated area is unclassified.

10.11.2.3 The area surrounding such instruments in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.11.2.4 The area surrounding such instruments in an inadequately ventilated enclosure is classified Zone 1 to the extent of the enclosure.

When evaluating small sources in large, enclosed areas, sound engineering judgment should be used. For example, locating a metering pump in a large warehouse would typically not require classification of the entire warehouse, but only an area surrounding the metering pump. Ventilation rate, process pressure, process volume, and the size of the enclosed area are all aspects of classification to be considered in these cases.

10.11.3 Instruments Operated by Flammable Gas

10.11.3.1 This section includes those instruments or other devices connected in hydrocarbon service (for example, for flow, pressure, or level analysis, measurement, or control) that utilize flammable gas for motive force. Valves (as opposed to valve operators) should be classified in accordance with 10.15.2, 10.15.3, and 10.15.4.

10.11.3.2 When pneumatic instruments operated by flammable gas are located in a non-enclosed, adequately ventilated area, the area is classified Zone 2 within 0.5 m (18 in.) of the surface of the instruments. Additionally, any vent(s) shall be classified in accordance with Figure 15.

10.11.3.3 When pneumatic instruments operated by flammable gas are located in an adequately ventilated enclosed area, the enclosed area is classified as shown by Figure 55 provided all devices are vented to outside the enclosed area. If all devices are not vented to outside the enclosed area, the enclosed area is classified Zone 1 to the extent of the enclosed area.

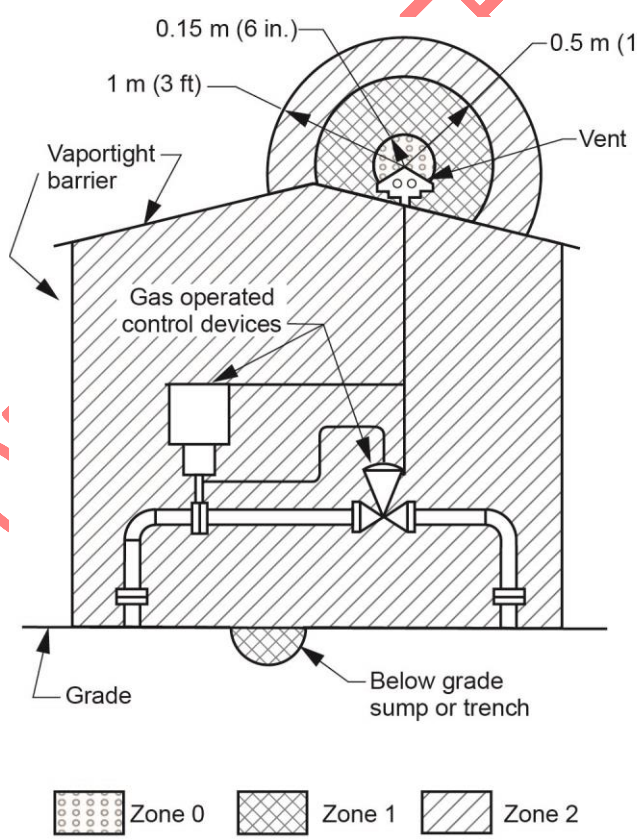
10.11.3.4 When pneumatic instruments operated by flammable gas are located in an inadequately ventilated enclosed area, the enclosed area is classified as shown by Figure 56 provided all devices are vented to outside the enclosed area. If all devices are not vented to outside the enclosed area, the enclosed area is classified Zone 0 to the extent of the enclosed area.

10.12 Sumps

10.12.1 This section includes equipment intended to collect and contain flammable fluids at atmospheric pressure.

10.12.2 The area surrounding an open sump that can contain flammable liquid and is located in a non-enclosed, adequately ventilated area is classified as shown by Figure 57.

10.12.3 The location surrounding an open sump that can contain flammable liquid and is located in an adequately ventilated enclosed area is classified as shown by Figure 57, but Zone 2 for the remainder of the extent of the enclosed area.



[1] For vents, see 8.2.3.2.

Figure 55—Flammable Gas–operated Instruments in an Adequately Ventilated Enclosed Area with All Devices Vented to the Outside (See 10.11.3.3)

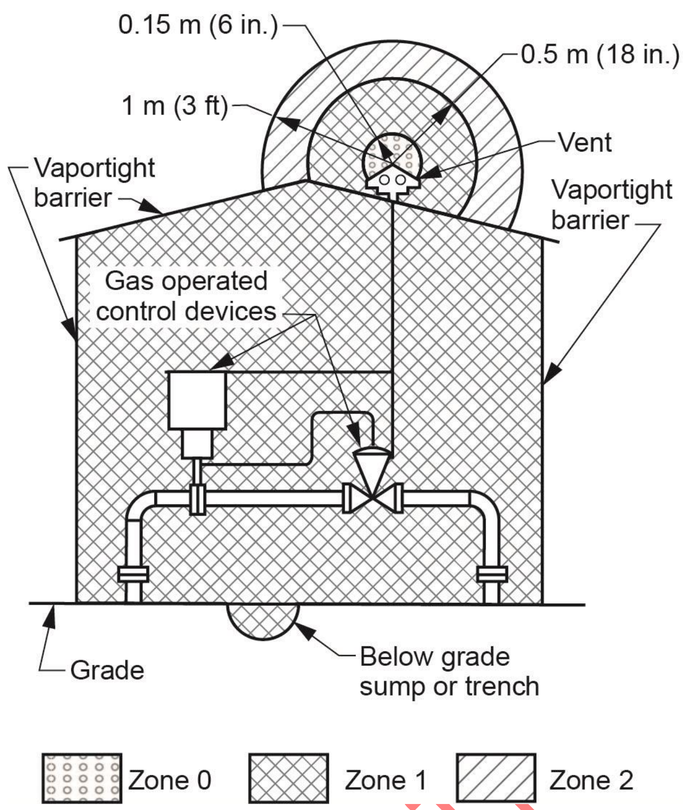


Figure 56—Flammable Gas–operated Instruments in an Inadequately Ventilated Enclosed Area (See 10.11.3.4)

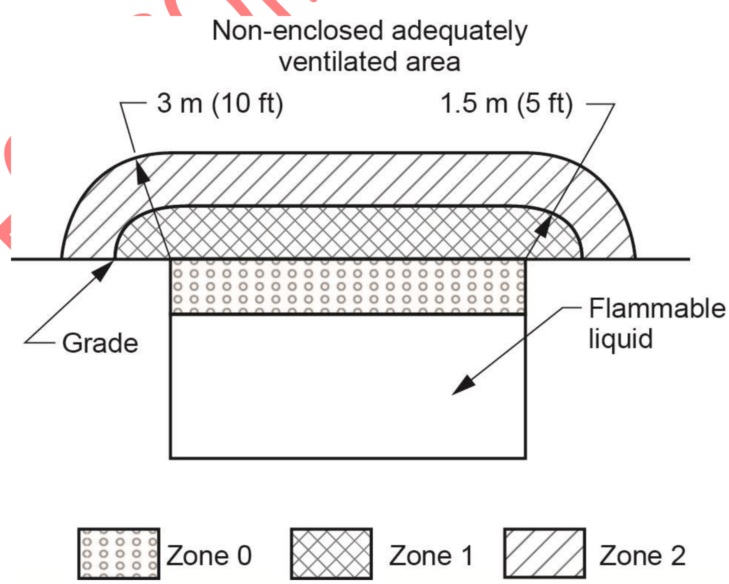


Figure 57—Open Sump in Non-enclosed, Adequately Ventilated Area (See 9.2.3, 10.12.2, 10.12.3, and 10.13.2c)

10.12.4 The area surrounding an open sump that can contain flammable liquid and is located in an inadequately ventilated area is classified as illustrated for mud tanks in Figure 34.

10.12.5 Closed sumps that can contain flammable liquid should be classified the same as shown by Figure 27.

10.12.6 Gas-blanketed closed sumps that can contain flammable liquid should be classified the same as shown by Figure 50 for flammable gas–blanketed and produced water–handling equipment.

10.13 Drains

10.13.1 General

Included in this section are devices intended to collect and remove, but not continuously contain, flammable liquids. Included also are devices intended to collect and remove, but not continuously contain, combustible liquids if their temperatures are above their flashpoints.

10.13.2 Definitions

The following definitions apply to this section.

a) An **open drain** is defined as a drain that is open to the atmosphere before ts discharge enters a sump, pit, or other containment device.

b) A **closed drain** is defined as a drain that is piped to a sump or other closed containment device without being open to the atmosphere, whether the containment device is at atmospheric or elevated pressure.

c) An **open containment system** is defined as a system open to the atmosphere. See Figure 57.

d) A **drain opening** is defined as an opening in the drain system where the drained fluid enters the drain piping from the atmosphere.

e) A **drain entry** is defined as an open fluid collection system, such as a trough or gutter, that routes the drained fluid to the drain opening.

f) A **liquid trap** is defined as a device that is designed and maintained to prevent gases and vapors from a containment system from being vented through a drain opening in the opposite direction for which it is designed.

10.13.3 Type 1 Open Drains

10.13.3.1 Type 1 open drains are designed to be operated in such a manner to prevent flammables from entering or exiting the drain system.

10.13.3.2 Non-enclosed areas and enclosed areas without heavier-than-air flammable sources:

a) with Type 1 open drains including only open fluid collection systems (i.e. drain entries) designed to collect only non-flammable fluids; and

b) without drains connected to drain or containment systems designed to collect or contain flammable fluids are classified in accordance with Figure 58.

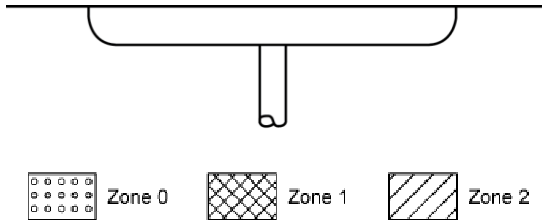


Figure 58—Type 1 Open Drain System
(See 10.13.3.2 and 10.13.3.3)

10.13.3.3 Non-enclosed areas and enclosed, adequately ventilated areas without heavier-than-air flammable sources:

a) with Type 1 open drains including only open fluid collection systems (i.e. drain entries) designed to collect only non-flammable fluids; and

b) connected to, but properly isolated from (e.g. with liquid traps), drain systems designed to collect or contain flammable fluids that gravity drain those fluids to open containment areas (e.g. pits) are classified in accordance with Figure 58.

10.13.4 Type 2 Open Drains

10.13.4.1 Type 2 open drains do not allow an accumulation of flammables above grade. Flammables may accumulate below grade due to flammable liquids or heavier-than-air flammable vapors settling into low spot(s) created by the drain or drain piping.

10.13.4.2 Non-enclosed areas and enclosed areas with heavier-than-air flammable sources:

a) with Type 2 open drains including only open fluid collection systems (i.e. drain entries) designed to collect only non-flammable fluids; and

b) without drains connected to drain or containment systems designed to collect or contain flammable fluids are classified in accordance with Figure 59.

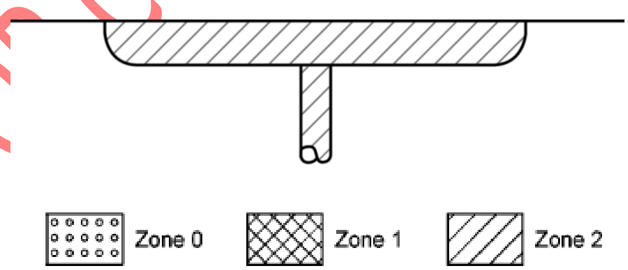


Figure 59—Type 2 Open Drain System
(See 10.13.4.2)

10.13.5 Type 3 Open Drains

10.13.5.1 Type 3 open drains can allow releases (through drain openings) of lighter-than-air flammable gases or vapors at atmospheric pressure.

10.13.5.2 Adequately ventilated, non-enclosed areas:

a) with Type 3 open drains including only open fluid collection systems designed for flammable or non-flammable fluids; and

b) with drains connected to drain systems designed to contain flammable fluids only for brief periods of time while gravity drains these fluids to open containment areas are classified in accordance with Figure 60.

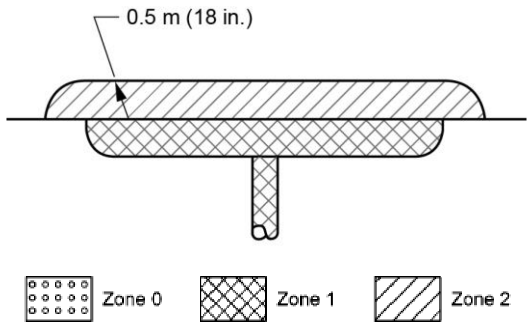


Figure 60—Type 3 Open Drain System in Non-enclosed Area (See 10.13.5.2 and 10.13.5.3)

10.13.5.3 Adequately ventilated, non-enclosed areas:

a) with Type 3 open drains including only open fluid collection systems designed for flammable fluids; and

b) with drains connected to, but properly isolated from (e.g. with liquid traps) closed containment system(s) designed to contain flammable fluids are classified in accordance with Figure 60.

10.13.5.4 Adequately ventilated, enclosed areas:

a) containing Type 3 open drains including only open fluid collection systems designed for flammable or non-flammable fluids; and

b) with drains connected to drain systems designed to contain flammable fluids only for brief periods of time while gravity drains these fluids to open containment areas are classified in accordance with Figure 61.

10.13.5.5 Adequately ventilated, enclosed areas:

a) with Type 3 open drains including only open fluid collection systems designed for flammable fluids; and

b) with drains connected to, but properly isolated from (e.g. with liquid traps) closed containment system(s) designed to contain flammable fluids are classified in accordance with Figure 61.

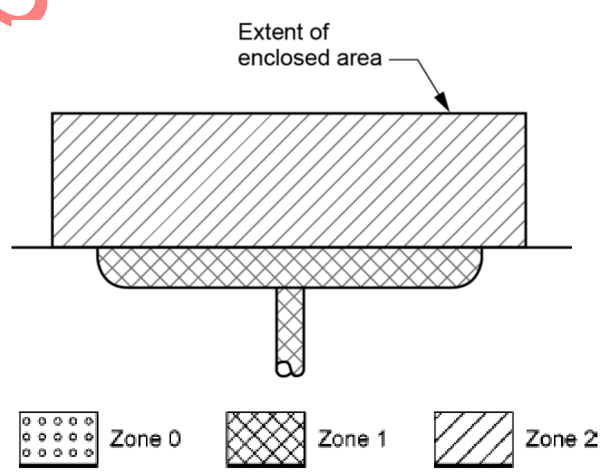


Figure 61—Type 3 Drain System in Enclosed Area (See 10.13.5.4 and 10.13.5.5)

10.13.6 Type 4 Open Drains

10.13.6.1 Type 4 open drains can allow releases (through drain openings) of lighter-than-air flammable gases or vapors at greater than atmospheric pressure.

10.13.6.2 Adequately ventilated, non-enclosed areas:

a) with Type 4 open drains including only open fluid collection systems designed for flammable or non-flammable fluids; and

b) connected to, but not properly isolated from (e.g. with drain traps), closed containment system(s) designed to contain flammable fluids are classified in accordance with Figure 62.

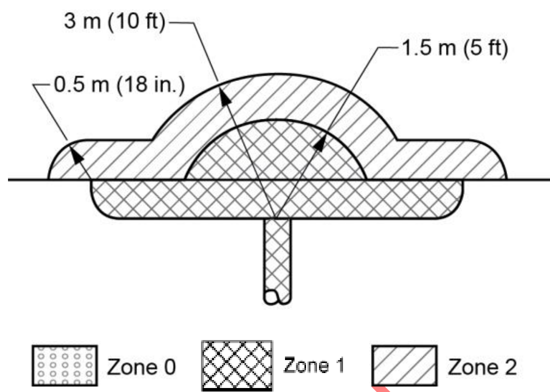


Figure 62—Type 4 Open Drain System in Non-enclosed Area (See 10.13.6.2)

10.13.6.3 Enclosed areass:

a) with Type 4 open drains, including only open fluid collection systems designed for flammable or non-flammable fluids; and

b) connected to, but not properly isolated from (e.g. with liquid traps) closed containment system(s) designed to contain flammable fluids are classified in accordance with Figure 63.

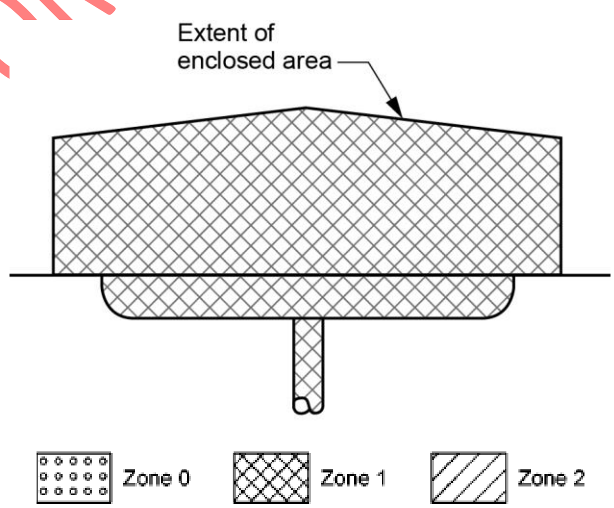


Figure 63—Type 4 Open Drain System in Enclosed Area (See 10.13.6.3)

10.13.7 Closed Drains

10.13.7.1 Closed drain systems should be considered the same as comparable process piping. Piping that contains valves that could open such drains to the atmosphere should be considered the same as process equipment vents (see 8.2.3.1).

10.14 Reserved For Future Use

10.15 Screwed Connections, Flanges, Valves, and Valve Operators

10.15.1 General

This section includes valves with all ports connected to closed piping (or tubing) systems. Vented ports shall be classified at their point of release in accordance with 8.2.3.

10.15.2 Screwed Connections, Flanges, Block Valves, and Check Valves

10.15.2.1 The area around screwed connections, flanges, block valves, and check valves in non-enclosed, adequately ventilated areas is unclassified for low-pressure applications. For medium- and higher-pressure applications, the minimum area is classified Zone 2 within 0.5 m (18 in.) for the connection, flange, or valve. Engineering judgment should be applied to assess the need for extended classification of medium and higher pressure systems. see 10.1.3.

10.15.2.2 The area around screwed connections, flanges, block valves, and check valves in adequately ventilated enclosed areas is Zone 2 to the extent of the enclosed area.

10.15.2.3 The area around screwed connections, flanges, block valves, and check valves in an inadequately ventilated enclosed area is Zone 1 to the extent of the enclosed area.

10.15.3 Process Control Valves including, but not limited to, regulators, back pressure valves, and level control valves (but not level control switches)]

10.15.3.1 The area around process control valves in non-enclosed, adequately ventilated areas is classified Zone 2 within 0.5 m (18 in.) of the stem seal or similar seal.

10.15.3.2 The area around process control valves in adequately ventilated enclosed areas is Zone 2 to the extent of the enclosed area.

10.15.3.3 The area around process control valves in inadequately ventilated enclosed areas is Zone 1 to the extent of the enclosed area.

10.15.4 Sample Valves, Instrument Drain Valves, Gauge Valves, and Similar Devices

10.15.4.1 The area surrounding sample and instrument drain valves, gauge valves, and similar devices is classified the same as screwed connections, flanges, block valves, and check valves in accordance with 10.15.2.

10.15.4.2 The area surrounding the final discharge points of sample and instrument drain valves, gauge valves, and similar devices is classified Zone 2 for 0.5 m (18 in.) as shown by Figure 39 and Figure 40.

10.15.5 Valve Operators

10.15.5.1 The area around valve operators utilizing air or other nonflammable gas or fluid as the power medium is unclassified.

10.15.5.2 The area around valve operators utilizing flammable gas or fluid as the power medium in a non-enclosed, adequately ventilated area is classified Zone 2 within 0.5 m (18 in.) of the operator provided all vents are extended to the outside of the area. If all vents are not extended to the outside of the area, see 8.2.3.2.

10.15.5.3 The area around valve operators utilizing flammable gas or fluid as the power medium in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area provided all vents are extended to the outside of the area. If all vents are not extended to the outside of the area, see 8.2.3.2.

10.15.5.4 The area around control valve operators utilizing flammable gas or flammable hydraulic fluid in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.16 Control Panels Containing Instrumentation Utilizing or Measuring Flammable Liquids or Gases

10.16.1 This section addresses enclosed areas (enclosures) insufficient in size to allow the entry of personnel. See 10.11 for non-enclosed areas and enclosed areas (enclosures) sufficient in size to allow the entry of personnel.

NOTE 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, such as vents.

10.16.2 For the purposes of this section, control panels refer to enclosures (panels) that contain, or have attached to them, instruments with process connections to flammable or combustible fluids for the analysis, measurement, indication, or control of process variables such as flow, pressure, level, and temperature, and also contain the interfaces for the associated electrical wiring.

10.16.3 The interior of a control panel should not be classified less hazardous than the classification of the surrounding area unless additional safety measures such as pressurized enclosures (see 3.1.15), are provided.

10.16.4 The interior of control panels where flammable gas is vented (continuously or intermittently) to the inside of the enclosure is classified Zone 0 to the extent of the enclosure. See Figure 64.

NOTE Typical instruments that may vent flammable gas include current-to-pressure (I/P) transducers, sampling analyzers, pneumatic controllers, and pressure regulators.

10.16.5 The interior of control panels where all flammable gas is vented to the outside of the enclosure is classified as follows:

10.16.5.1 The interior of inadequately ventilated control panels is classified Zone 1 to the extent of the enclosure. See Figure 65.

10.16.5.2 Where instruments are located inside an adequately ventilated enclosure, the interior of the enclosure is classified Zone 2 to the extent of the enclosure. See Figure 66.

10.16.6 Where an instrument is located outside of but attached to an enclosure, its electrical connection is separated from flammable process fluid by more than one barrier, and leakage of the primary seal will be obvious, the interior of the enclosure containing the interconnecting wiring is unclassified.

10.16.7 Where an instrument is located outside of but attached to an enclosure and its electrical connection is separated from flammable process fluid by a single barrier, the interior of the enclosure containing its interconnecting wiring is classified Zone 2 to the extent of the enclosure.

10.16.8 Panels located in enclosed areas sufficient in size to allow the entry of personnel (e.g. buildings) should be classified in accordance with 10.11.

10.16.9 For area classification of instrument vents, see 8.2.3.2.

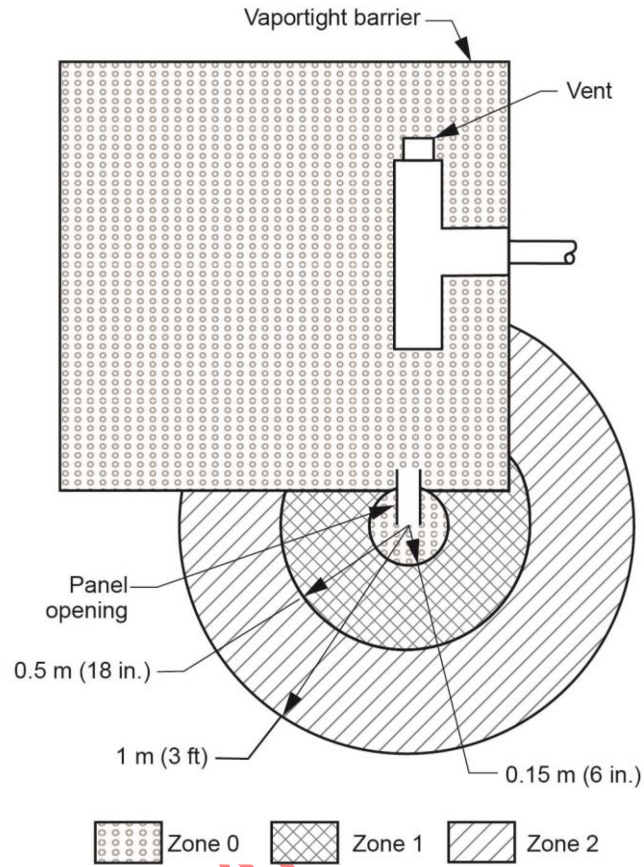


Figure 64—Control Panel with Flammable Gas Vented to the Inside of the Enclosure (See 10.16.4)

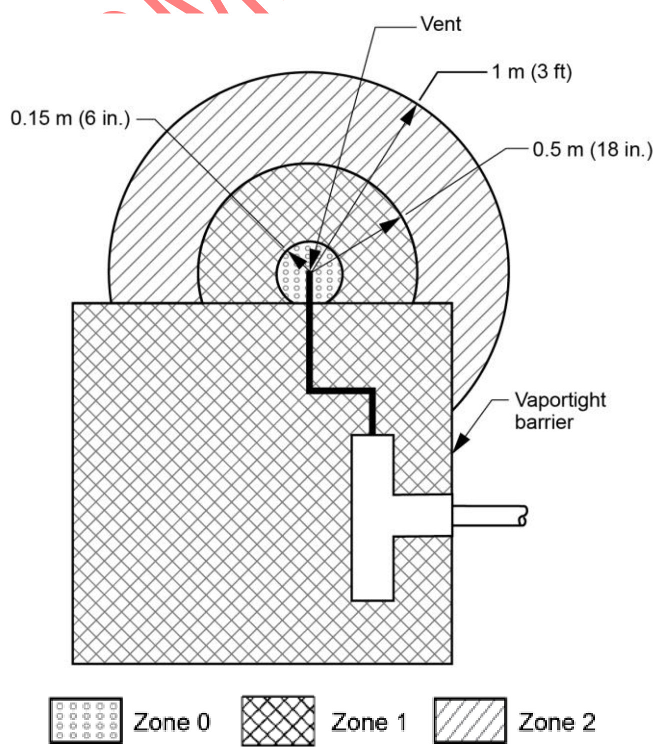


Figure 65—Inadequately Ventilated Control Panel with Instruments Inside

(See 10.16.5.1)

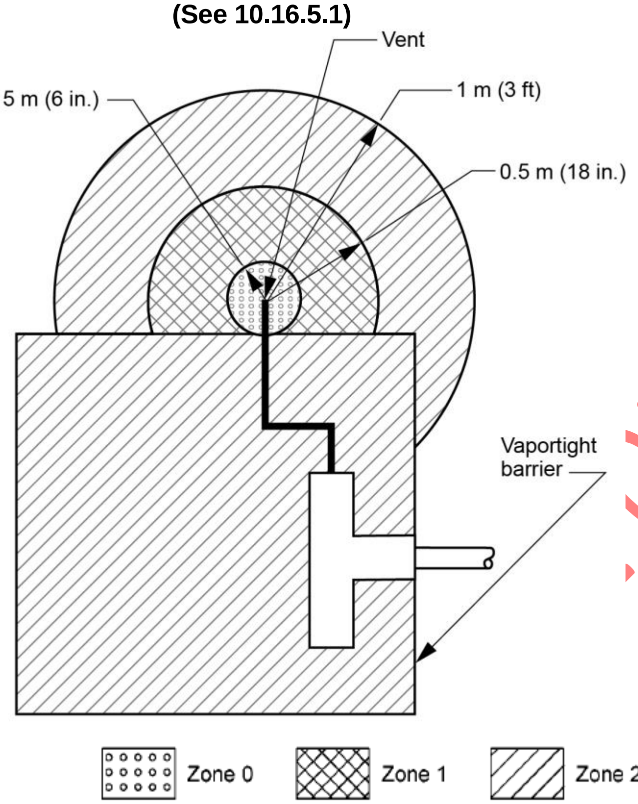


Figure 66—Adequately Ventilated Control Panel with Instruments Inside
(See 10.16.5.2)

10.17 Gas Meters

10.17.1 The area around a natural gas meter (orifice, turbine, etc.) in non-enclosed, adequately ventilated area is classified Zone 2 within 0.5 m (18 in.) of the surface of the gas meter.

10.17.2 The area around a natural gas meter (orifice, turbine, etc.) in adequately ventilated enclosed areas is Zone 2 to the extent of the enclosed area.

10.17.3 The area around a natural gas meter (orifice, turbine, etc.) in an inadequately ventilated enclosed area is Zone 1 to the extent of the enclosed area.

11 Recommendations for Determining Degree and Extent of Classified Locations on Mobile Offshore Drilling Units (MODUs)

11.1 General

11.1.1 This section presents guidelines for classifying locations for electrical installations on mobile offshore drilling units (MODUs) where flammable liquids, gases, or vapors may be present.

11.1.2 This section is not intended to address the classification of locations due to catastrophic failures that result in uncontrolled releases of flammable liquids, gases, or vapors. Catastrophic failures (for example, well blowouts) are extreme conditions that require emergency measures at the time of occurrence.

11.1.3 This section applies to all types of MODUs without production facilities, including, but not limited to, the following types:

a) semi-submersible units (floating column-–stabilized units),

b) submersible units (bottom-sitting column–stabilized units),

c) self-elevating units (bottom-sitting units with movable legs),

d) barge-type units (surface units),

e) drillships (surface units).

11.1.4 Recommendations for determining the degree and extent of classified locations for MODUs containing production facilities are addressed in Section 12.

11.2 Definitions Specific To MODUs

11.2.1 General

The specific definitions below are unique to MODUs. Where definitions of the same or similar terms are given elsewhere within this Recommended Practice, the definitions given elsewhere are superseded by the definitions below.

11.2.2 Locations and Spaces

11.2.2.1 *Locations, Open (Outdoor):* Locations substantially free of structures (or other obstructions) where natural ventilation is not impeded and causes the rapid dispersion (dilution) of gases and vapors, and stagnant areas are not present.

11.2.2.2 *Locations, Semi-enclosed:* Locations where natural conditions of ventilation are notably different from those on open decks due to the presence of structures such as roofs, windbreaks, and bulkheads and that are so arranged that dispersion of gas may not occur. (IMO–I810E)

11.2.2.3 *Spaces, Enclosed:* Spaces delineated by floors, bulkheads, and/or decks, which may have doors or windows. (IMO–I810E)

11.2.3 Tanks

11.2.3.1 *Tanks, Accessible:* Tanks that, under normal operating conditions, are sealed against gas and vapor leakage, but the interior of which may be readily accessed for inspection and maintenance from within the location.

11.2.3.2 *Tanks, Closed Top:* Tanks with limited number of small openings or penetrations, such as shafts, through which gas may occasionally leak within the location.

11.2.3.3 *Tanks, Open:* Tanks that allow the continuous free communication of the tank's internal atmosphere into the surrounding location or space.

11.2.3.4 *Tanks, Sealed:* Tanks that are sealed against gas and vapor leakage and are without provisions for inspection or maintenance from within the location.

11.2.4 Ventilation

11.2.4.1 Throughout this section, the terms "Artificial", "Mechanical", and "Forced" Ventilation should be considered interchangeable.

11.2.4.2 *Ventilation, Adequate:* The degree of ventilation (i.e. the movement and transfer of air) achieved when, under normal operating conditions, the ventilation provided meets the location's required criteria (for example, equal to or greater than a specified minimum number of air changes per hour).

11.2.4.3 *Ventilation, General Artificial:* Movement of air and its replacement with fresh air by artificial means (e.g. fans) and applied to a general area. (ANSI/ISA 60079-10-1)

11.2.4.4 *Ventilation, Inadequate:* The degree of ventilation (i.e. the movement and transfer of air) achieved when, under normal operating conditions, the ventilation provided does not meet the location's required criteria (for example, less than a specified minimum number of air changes per hour).

11.2.4.5 *Ventilation, Local Artificial:* Movement of air and its replacement with fresh air by artificial means (usually extraction) applied to a particular source of release or local area. (ANSI/ISA 60079-10-1)

11.2.4.6 *Ventilation, Natural:* Movement of air and its replacement with fresh air due to the effects of wind or temperature gradients, or both. (ANSI/ISA 60079-10-1)

11.2.4.7 *Ventilation, No:* The lack of ventilation in locations where no arrangements have been made to cause air replacement with fresh air.

11.3 Reserved For Future Use

11.4 Classified Locations on MODUs

11.4.1 General

The following recommendations for determining the degree and extent of classified locations are specific examples of situations commonly encountered during operations and have been developed by experience in the industry. Application of these examples to similar, though not identical, situations should be made with sound engineering judgment employing information presented in this recommended practice and other publications. 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. Also, specific examples listed consider only a MODU as a "stand-alone" unit and do not take into account the possible influence of hazardous (classified) locations on adjacent structures to the classification of locations on the MODU.

11.4.2 Drilling Areas

Drilling areas considered for classification by this section include the following:

a) drill floor and derrick areas,

b) substructure or moonpool areas,

c) mud tanks,

d) mud ditches or troughs,

e) mud pumps,

f) mud-processing equipment,

g) shale shakers,

h) desanders or desilters,

i) degasser or gas buster,

j) vents,

k) diverter line outlets,

l) blowout preventers (BOPs),

m) choke manifold,

n) cement unit.

11.4.3 Well Test Equipment Areas

Well test equipment areas considered for classification include the following:

a) separation equipment,

b) metering equipment,

c) liquid storage equipment,

d) burner booms,

e) gas lift equipment.

11.4.4 Other Areas

Other areas considered for classification by this section include the following:

a) paint lockers,

b) battery rooms,

c) helicopter fuel storage areas.

11.4.5 Drains

11.4.5.1 Drains in MODU service do not constitute a source of release that should be considered for area classification purposes.

11.4.5.2 Drains for well test equipment shall meet the requirements of Section 10 for area classification purposes.

11.5 Basis for Area Classification

11.5.1 General

Areas are classified on each installation to reflect normally anticipated operating conditions. Factors that are taken into account include the following:

a) possible sources of release;

b) whether or not areas are open, enclosed, or semi-enclosed;

c) ventilation; and

d) the nature of the release (mist, gas, or vapor, etc.).

Area classifications recommended in this section are based on spaces being ventilated or pressurized in accordance with 11.5.2, 11.5.3, and 11.5.4.

11.5.2 Ventilation and Pressurization

11.5.2.1 Ventilation is a means of diluting a possible release of flammable gas or vapor in an area.

11.5.2.2 Pressurization is a means to prevent flammable gas–air or vapor–air mixtures from outside a pressurized area from entering the area.

11.5.2.3 Attention should be given to the direction of airflow and the locations of ventilation inlets and outlets to minimize the possibility of cross contamination. 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.

11.5.2.4 Ventilation inlets should be located in unclassified (non-hazardous) locations.

11.5.2.5 Ventilation systems for hazardous (classified) locations should be completely separate from those for unclassified (non-hazardous) locations.

11.5.3 Ventilation and Pressurization of Hazardous (Classified) Locations

11.5.3.1 Enclosed hazardous (classified) locations are to be provided with ventilation as required to maintain them at a pressure lower than adjacent less hazardous locations by a minimum differential of 25 Pa (0.1 in. H_2O). The intent is to minimize the migration of flammable gases and vapors.

11.5.3.2 The arrangement of ventilation inlet and outlet openings in the space is to be such that the entire space is efficiently ventilated—giving special consideration to locations of equipment that may release flammable vapor or gas and to spaces where flammable vapor or gas may accumulate.

11.5.3.3 Enclosed hazardous (classified) spaces containing any open portion of the mud system should be ventilated at a minimum rate of 12 air changes per hour.

11.5.3.4 The outlet air from Zone 0, Zone 1, and Zone 2 spaces should be led in separate ducts to outdoor locations that are the same classification or less hazardous than the ventilated space.

NOTE Zone 1 areas are considered less hazardous than Zone 0 areas. Zone 2 areas are considered less hazardous than Zone 1 areas. Unclassified areas are considered less hazardous than Zone 2 areas.

11.5.3.4.1 Ventilation ducts should be at negative pressure [minimum differential of 25 Pa (0.1 in. H_2O)] in relation to less hazardous locations and at positive pressure [minimum differential of 25 Pa (0.1 in. H_2O)] in relation to more hazardous locations. Such ducts should be rigidly constructed to avoid air leaks.

11.5.3.4.2 The interior of ducts exhausting hazardous (classified) locations should be of the same classification as the area that they exhaust (ventilate).

11.5.4 Ventilation and Pressurization of Unclassified (Non-Hazardous) Locations

11.5.4.1 Ventilation inlets and outlets for unclassified (non-hazardous) locations should be located in unclassified (non-hazardous) locations.

11.5.4.2 Ventilation ducts passing through a hazardous (classified) location should be positive pressure [minimum differential of 25 Pa (0.1 in. H_2O)] in relation to the hazardous (classified) location.

11.6 Classification of Hazardous (Classified) Locations

11.6.1 Zone 0 Hazardous (Classified) Locations

The following hazardous (classified) locations should be considered Zone 0:

a) the internal spaces of tanks and piping systems vented to the atmosphere (i.e. operating at or near atmospheric pressure) intended to contain active drilling mud or produced crude oil or natural gas;

b) other locations in which flammable liquid, gas, or vapor is continuously present or is present for long periods of time.

Exceptions: interiors of pressure vessels not vented to the atmosphere and pressure piping. Zone 0, Zone 1, and Zone 2 hazardous (classified) locations are defined as "...locations where fire or explosive hazards may exist due to flammable gases or vapors." [NEC 505.1]. "Locations shall be classified depending on the properties of the flammable vapors, liquids, or gases—that may be present and the likelihood that a flammable or combustible concentration or quantity is present." [NEC 505.5]. For a mixture to be flammable, air/oxygen is required to be present (in the correct percentages); see Section 4. Air/oxygen normally is not present inside pressure vessels (e.g. oil-water-gas separators and chemical-electric treaters) and pressure piping. Thus, the interior of such vessels and piping normally is not classified. Individuals classifying locations should understand the operation of process equipment and the use of interconnecting piping before making a decision to classify or to not classify all (interior and exterior) locations containing such equipment or piping.

11.6.2 Zone 1 Hazardous (Classified) Locations

The following locations should be considered as Zone 1:

a) an enclosed space containing any part of the mud circulating system between the well and the final degassing discharge that has an opening into the enclosed space;

b) enclosed spaces or semi-enclosed locations that are below the drill floor and contain a possible source of release (such as the top of a bell nipple);

c) enclosed spaces that are on the drill floor and that are not separated by a solid floor from the spaces specified in 11.6.2(b);

d) in outdoor or semi-enclosed locations, the area within 1.5 m (5 ft) from the boundaries of:

- openings to equipment that is part of the mud system as specified in 11.6.2;
- ventilation outlets from Zone 1 spaces; and
- accesses (e.g. doors, windows, or manways) to Zone 1 spaces;

e) pits, ducts, or similar structures in locations that would otherwise be Zone 2, but that are so arranged that dispersion of gas may not occur.

11.6.3 Zone 2 Hazardous (Classified) Locations

11.6.3.1 Enclosed spaces that contain open sections of the mud circulating system between the final degassing discharge to the mud pump suction connection at the mud pit.

11.6.3.2 Outdoor locations within the boundaries of the drilling derrick up to a height of 3 m (10 ft) above the drill floor.

11.6.3.3 Semi-enclosed locations below and contiguous to the drill floor and to the boundaries of the derrick or to the extent of any enclosure that is liable to trap gases.

11.6.3.4 Outdoor locations below the drill floor and within a radius of 3 m (10 ft) from a possible source of release (such as the top of the drilling nipple).

11.6.3.5 Areas within 1.5 m (5 ft) of the Zone 1 areas specified in 11.6.2(d) and areas within 1.5 m (5 ft) of the semi-enclosed locations specified in 11.6.2(b).

11.6.3.6 Outdoor areas within 1.5 m (5 ft) of the ventilation outlets from Zone 2 spaces.

11.6.3.7 Outdoor areas within 1.5 m (5 ft) of the access to Zone 1 spaces.

11.6.3.8 Semi-enclosed derricks to the extent of their enclosure above the drill floor or to a height of 3 m (10 ft) above the drill floor, whichever is greater.

11.6.3.9 Air locks between a Zone 1 space and an unclassified (non-hazardous) space.

11.7 Drill Floor and Derrick Areas

11.7.1 When the derrick is open at the drill floor level, the areas are classified as shown in Figure 67.

11.7.2 When a derrick is of the semi-enclosed open-top type, the areas are classified as shown in Figure 68.

11.7.3 An enclosed derrick is classified as shown in Figure 69.

11.7.4 For units with a movable or skidable drill floor and substructure, the classified area boundary should comply with the requirements of Figure 67, Figure 68, and Figure 69, as applicable, for the particular derrick operating position.

11.8 Substructure or Moonpool Areas

11.8.1 MODUs with open substructures and semi-enclosed derricks are classified as shown in Figure 70.

11.8.2 MODUs with total containment substructures and semi-enclosed derricks are classified as shown in Figure 71.

NOTE MODUs with total containment substructures are designed and constructed to prevent fluid discharges to the surrounding waters.

11.8.3 MODUs with semi-enclosed substructures and semi-enclosed derricks are classified as shown in Figure 72.

11.8.4 MODUs with enclosed moonpool areas are classified as shown in Figure 73.

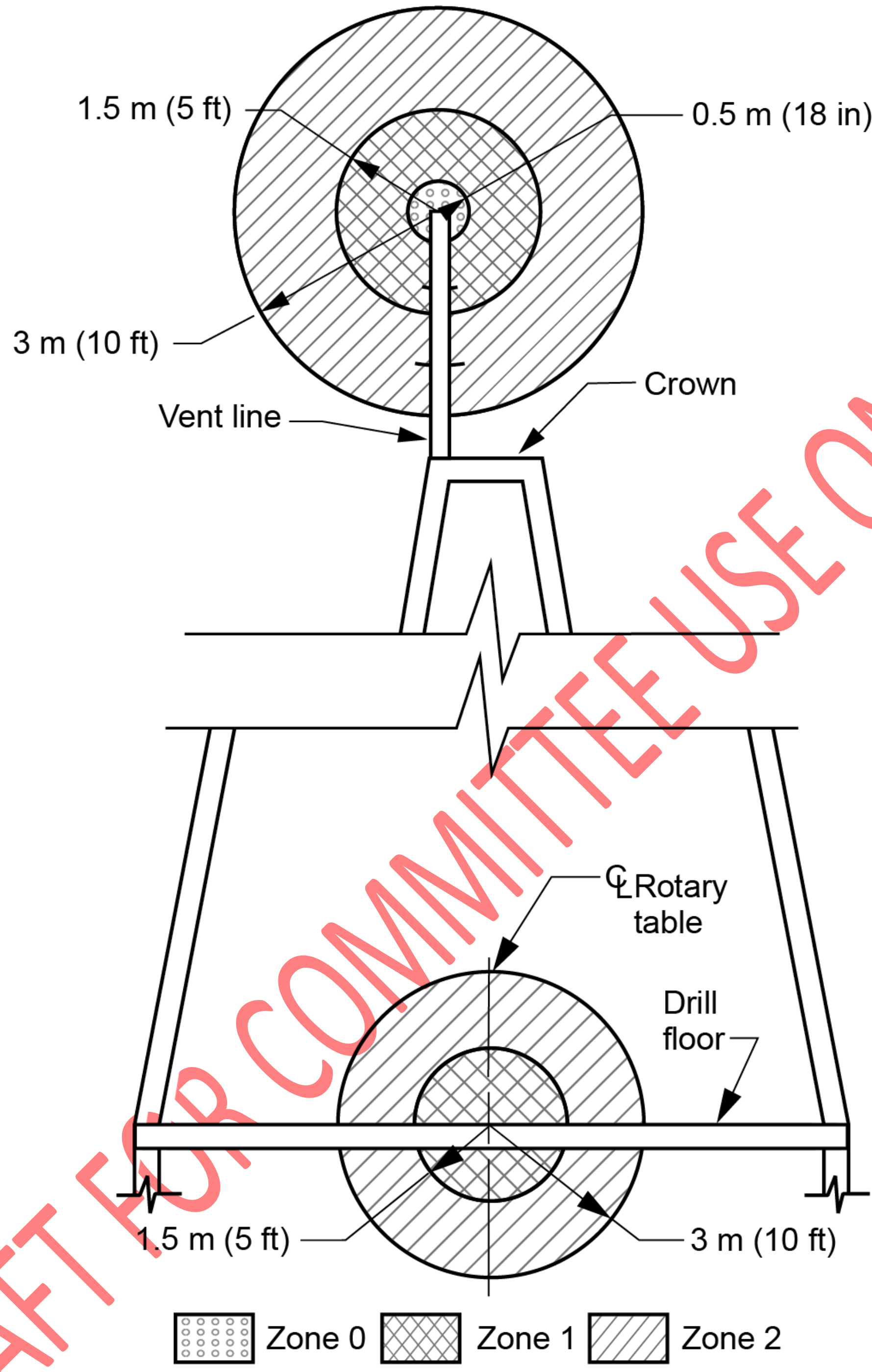


Figure 67—Drilling Rig Open Derrick (See 11.7.1)

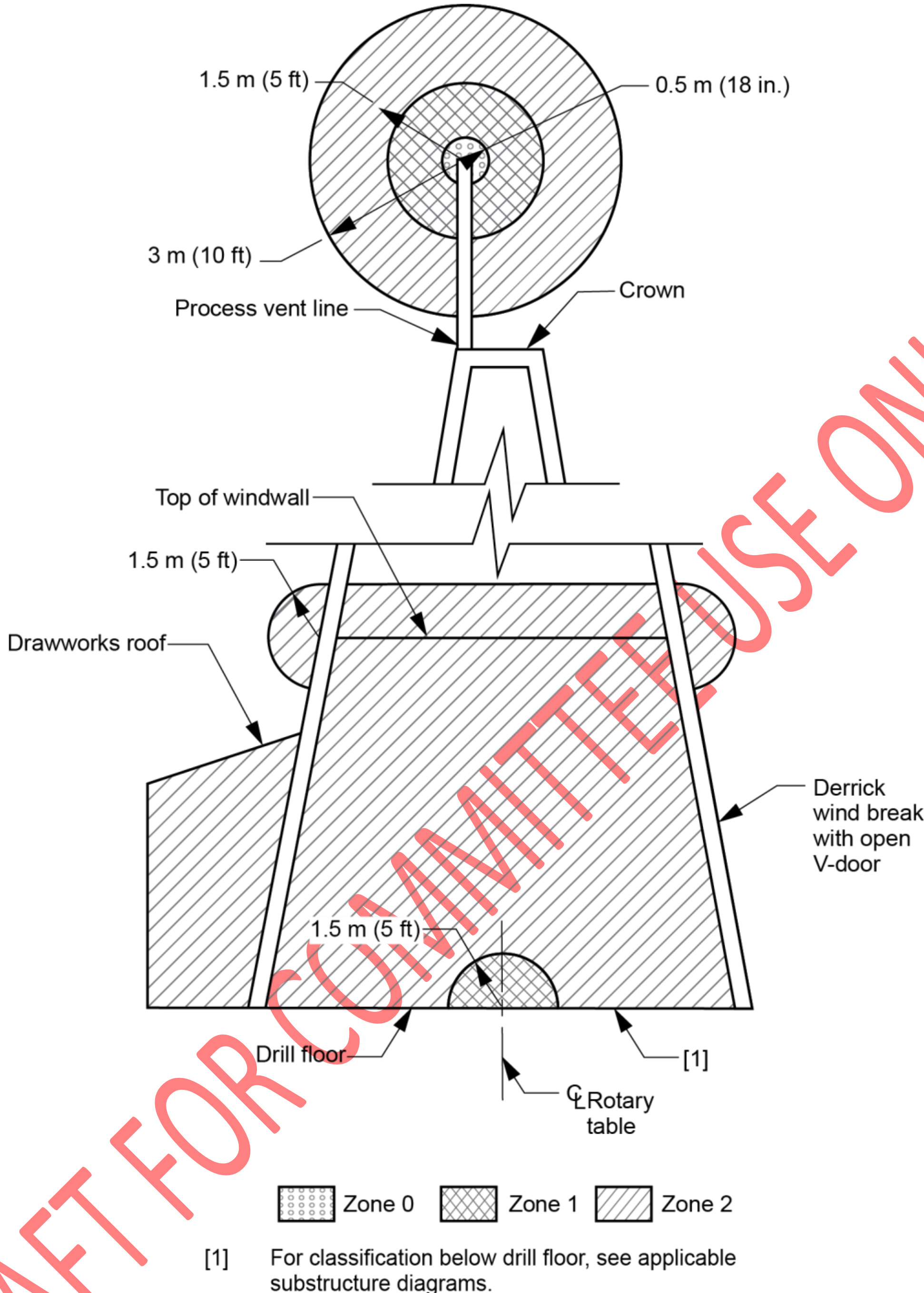
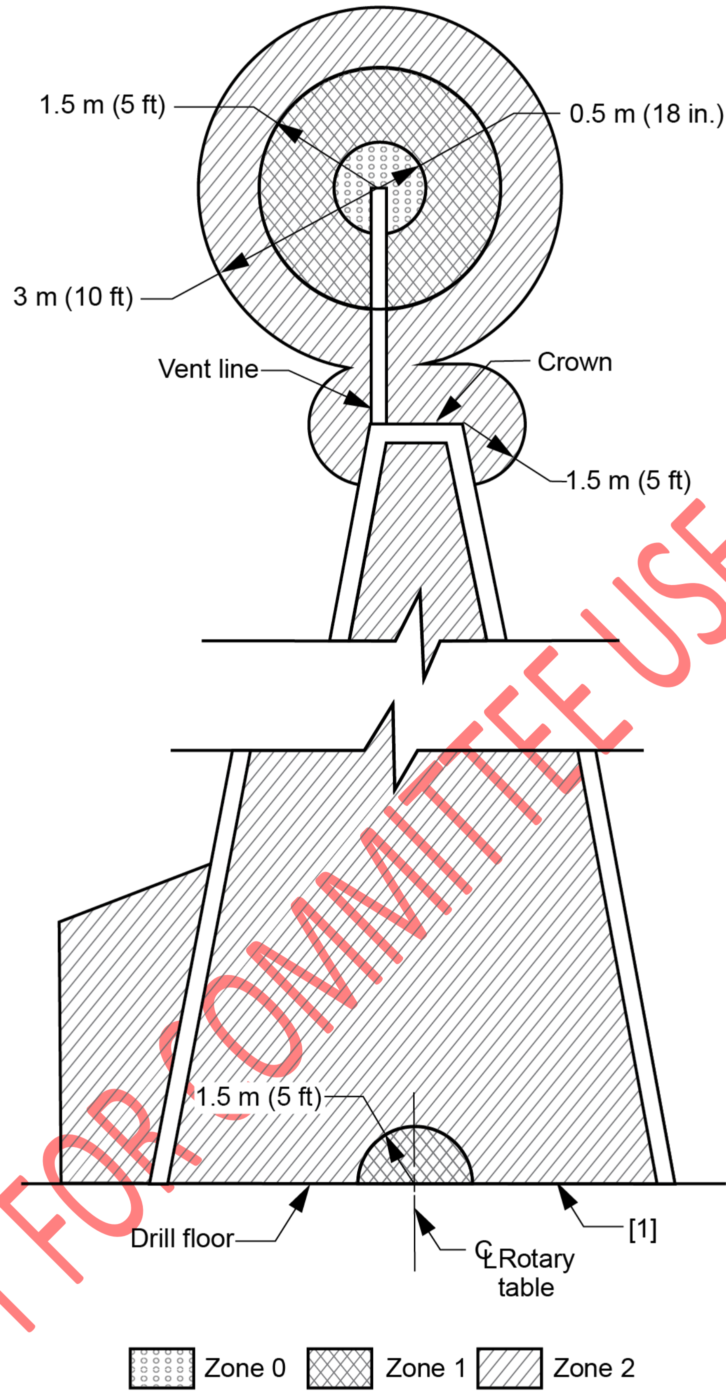


Figure 68—Drilling Rig Semi-enclosed Derrick
(See 11.7.2)



[1] For classification below drill floor, see applicable substructure diagrams.

Figure 69—Drilling Rig Derrick Fully Enclosed (Open Top)
(See 11.7.3)

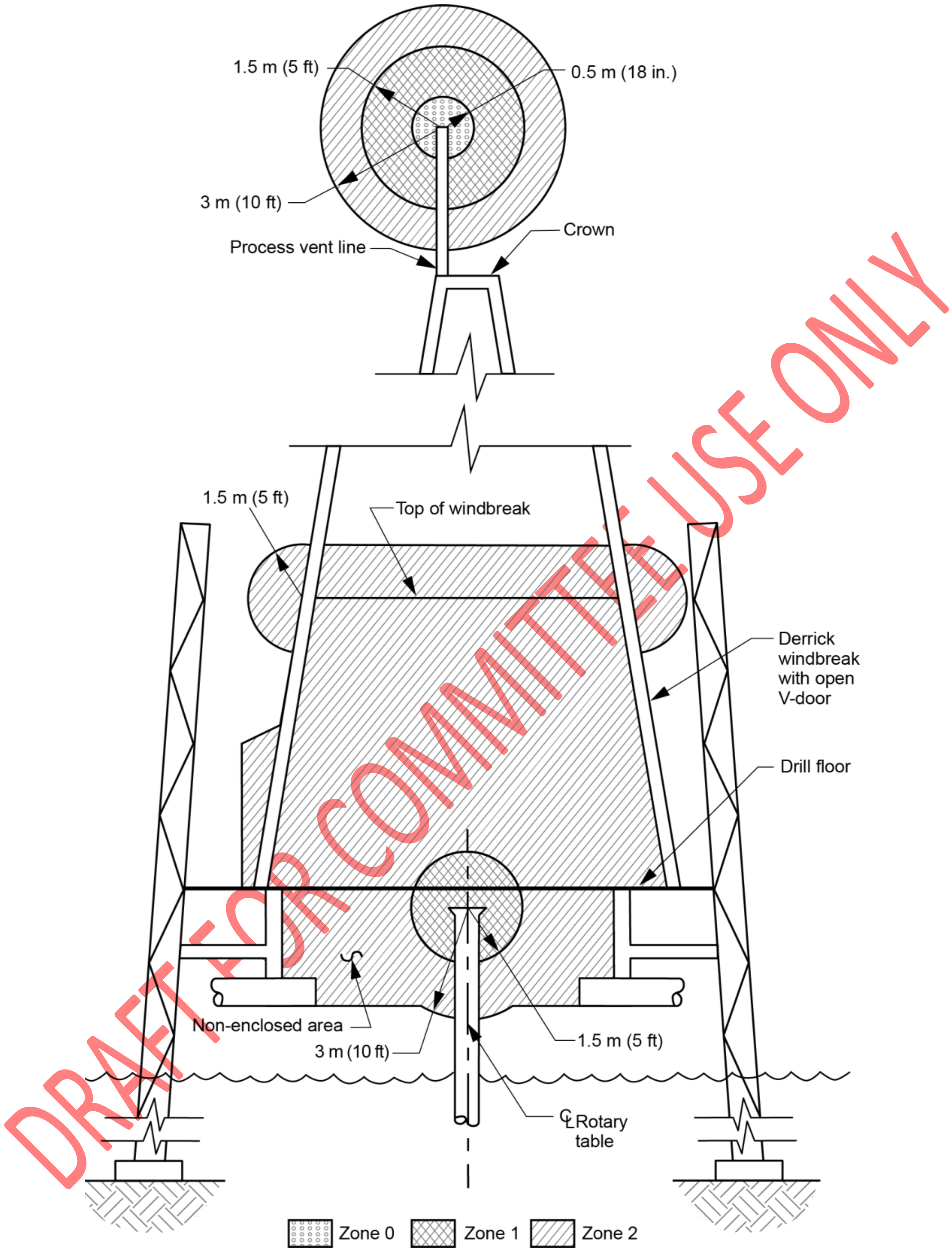


Figure 70—Drilling Rig Open Substructure and Semi-enclosed Derrick (See 11.8.1)

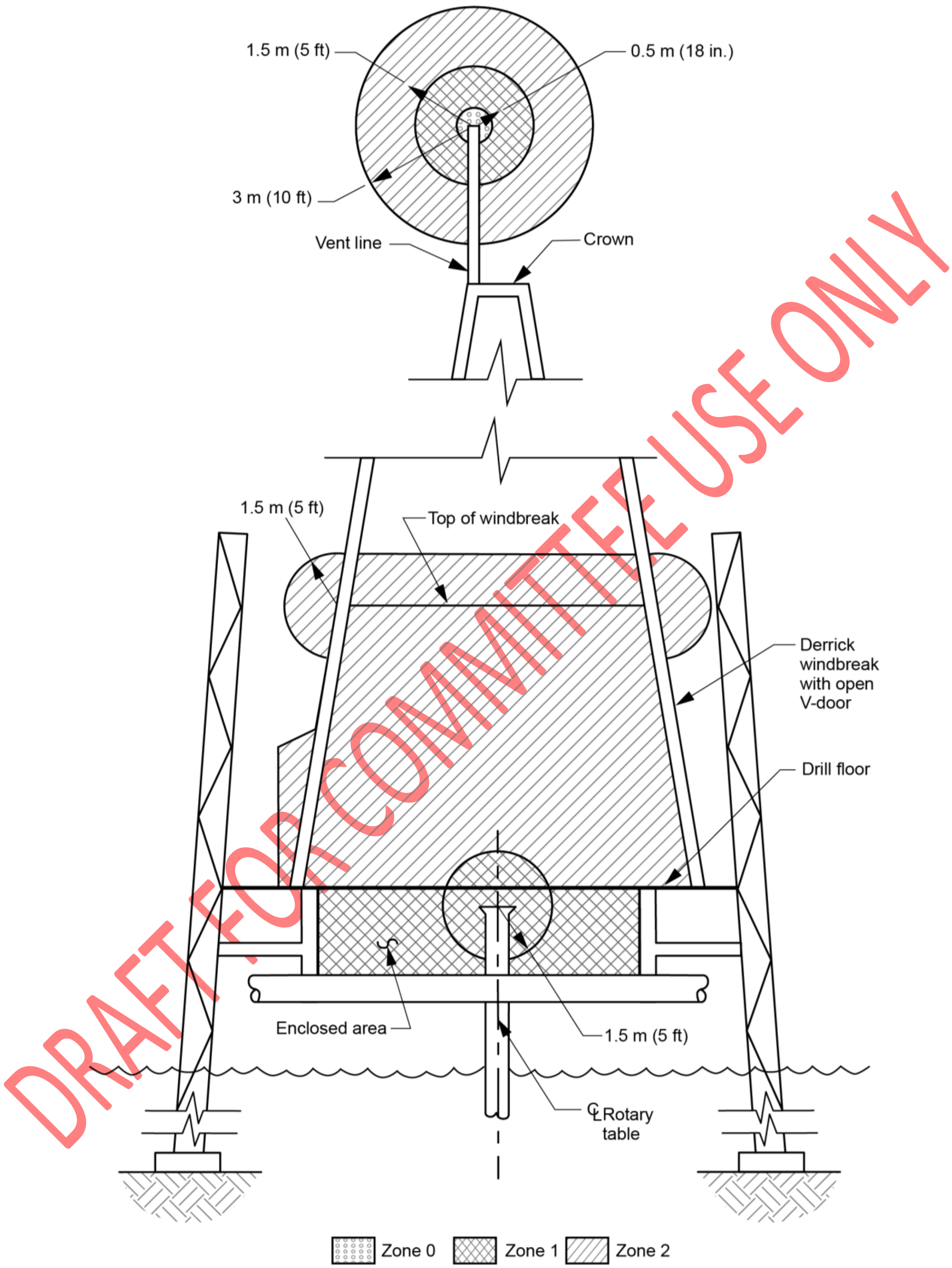


Figure 71—Drilling Rig With Total Containment Substructure and Semi-enclosed Derrick Drilling Rig (See 11.8.2)

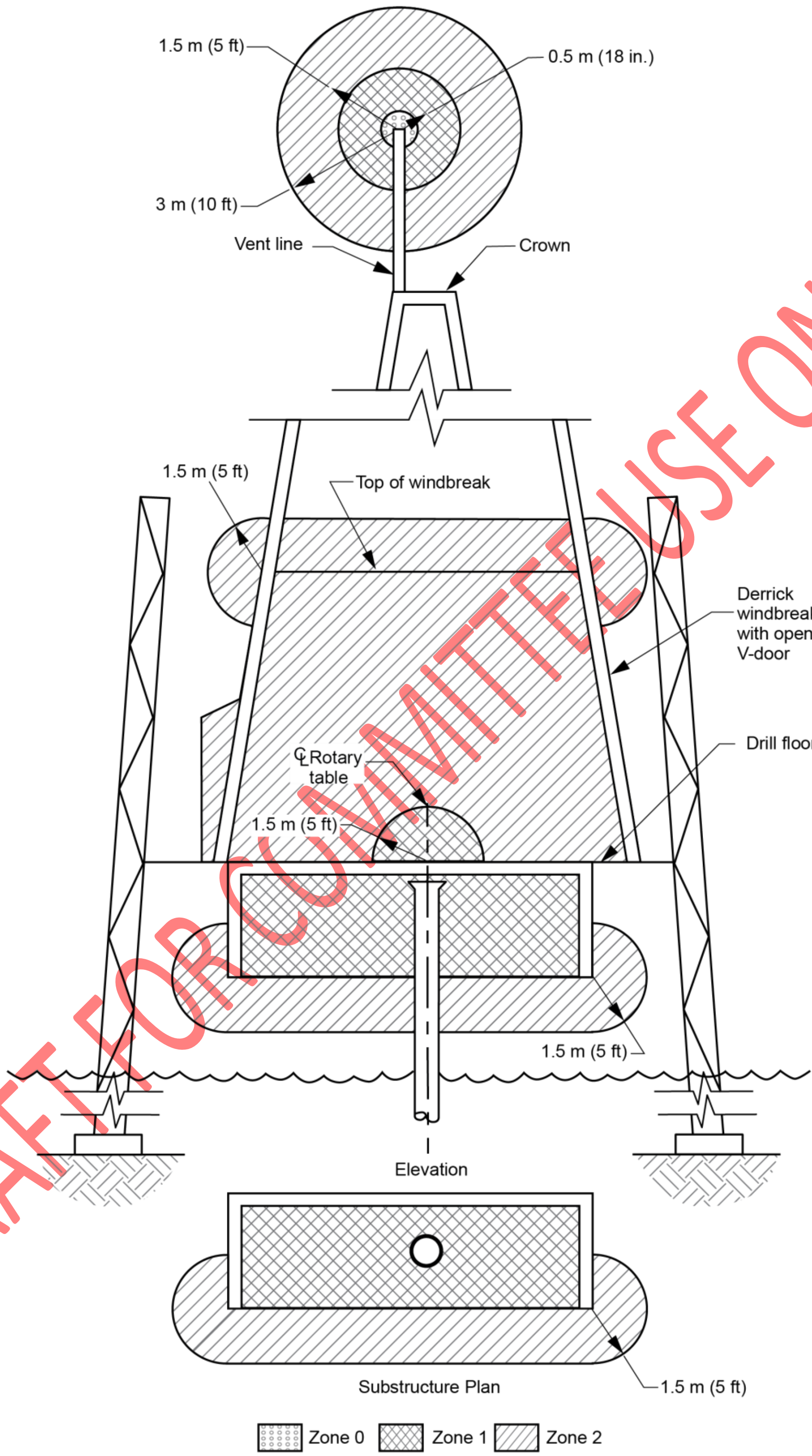


Figure 72—Semi-enclosed Substructure and Semi-enclosed Derrick (See 11.8.3)

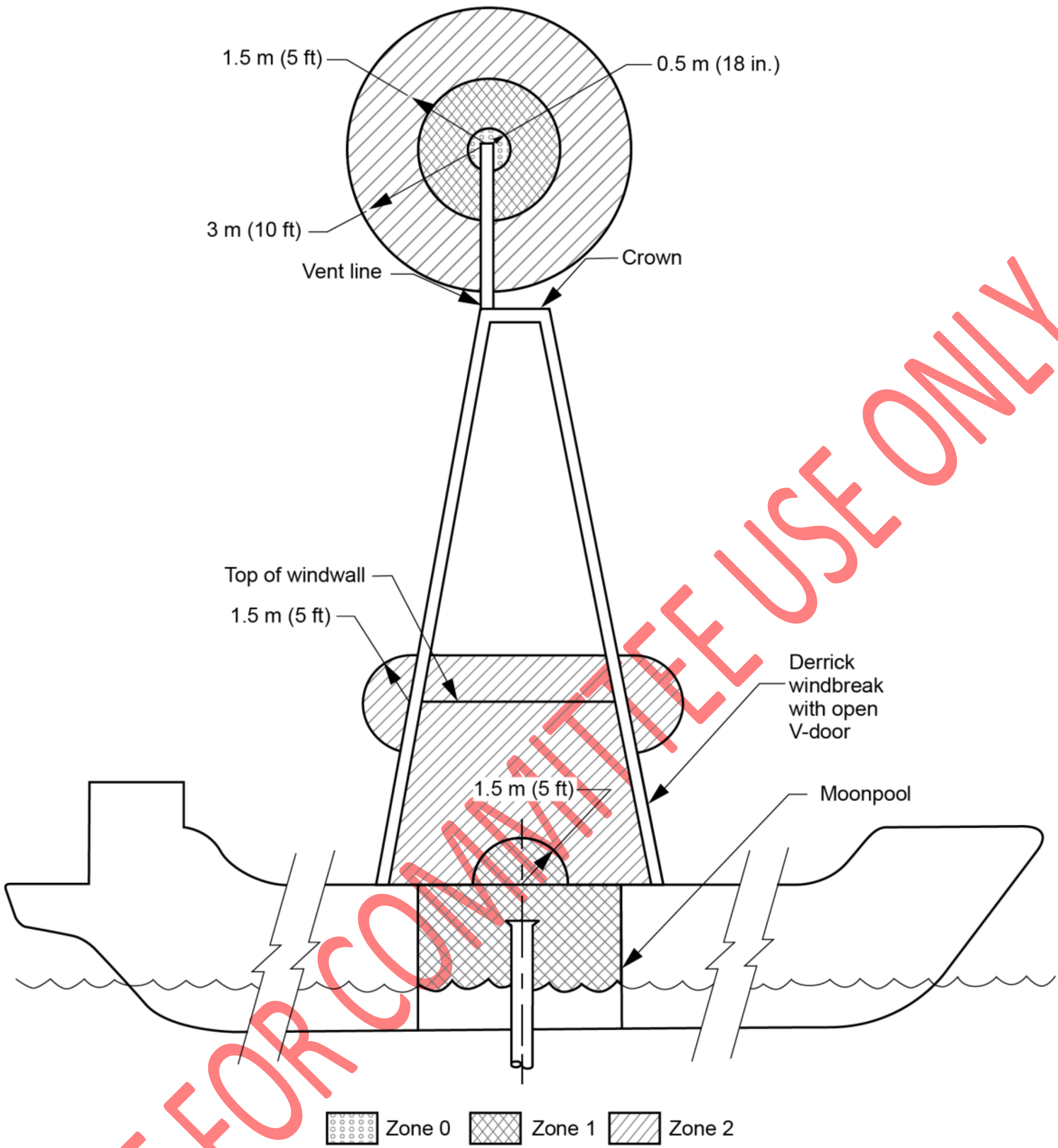


Figure 73—Drilling Rig Enclosed Moonpool and Semi-enclosed Derrick (See 11.8.4)

11.9 Mud System Processing Equipment Overview

11.9.1 Adequately ventilated enclosed spaces containing mud system processing equipment are classified as shown in Figure 74.

11.9.2 Open spaces containing mud system processing equipment are classified as shown in Figure 75.

11.10 Mud Tanks (After Discharge of Final Degasser)

11.10.1 Open areas containing mud tanks are classified as shown in Figure 76.

11.10.2 Adequately ventilated enclosed or adequately ventilated semi-enclosed locations containing open top mud tanks are classified as shown in Figure 77.

11.10.3 Adequately ventilated enclosed or adequately ventilated semi-enclosed locations containing closed top mud tanks are classified as shown in Figure 78.

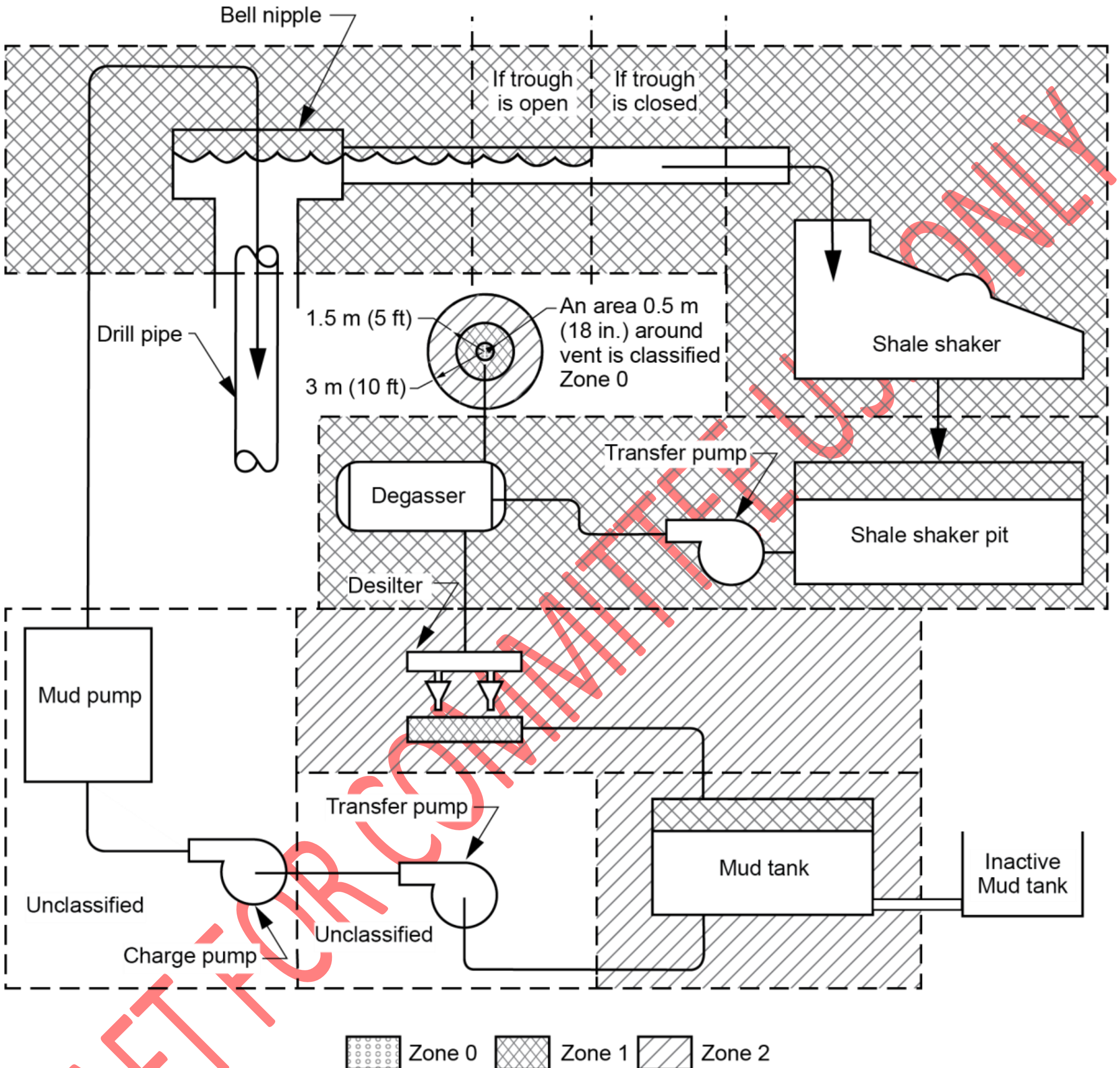


Figure 74—Mud System Processing Equipment in Adequately Ventilated Enclosed Spaces (See 11.9.1)

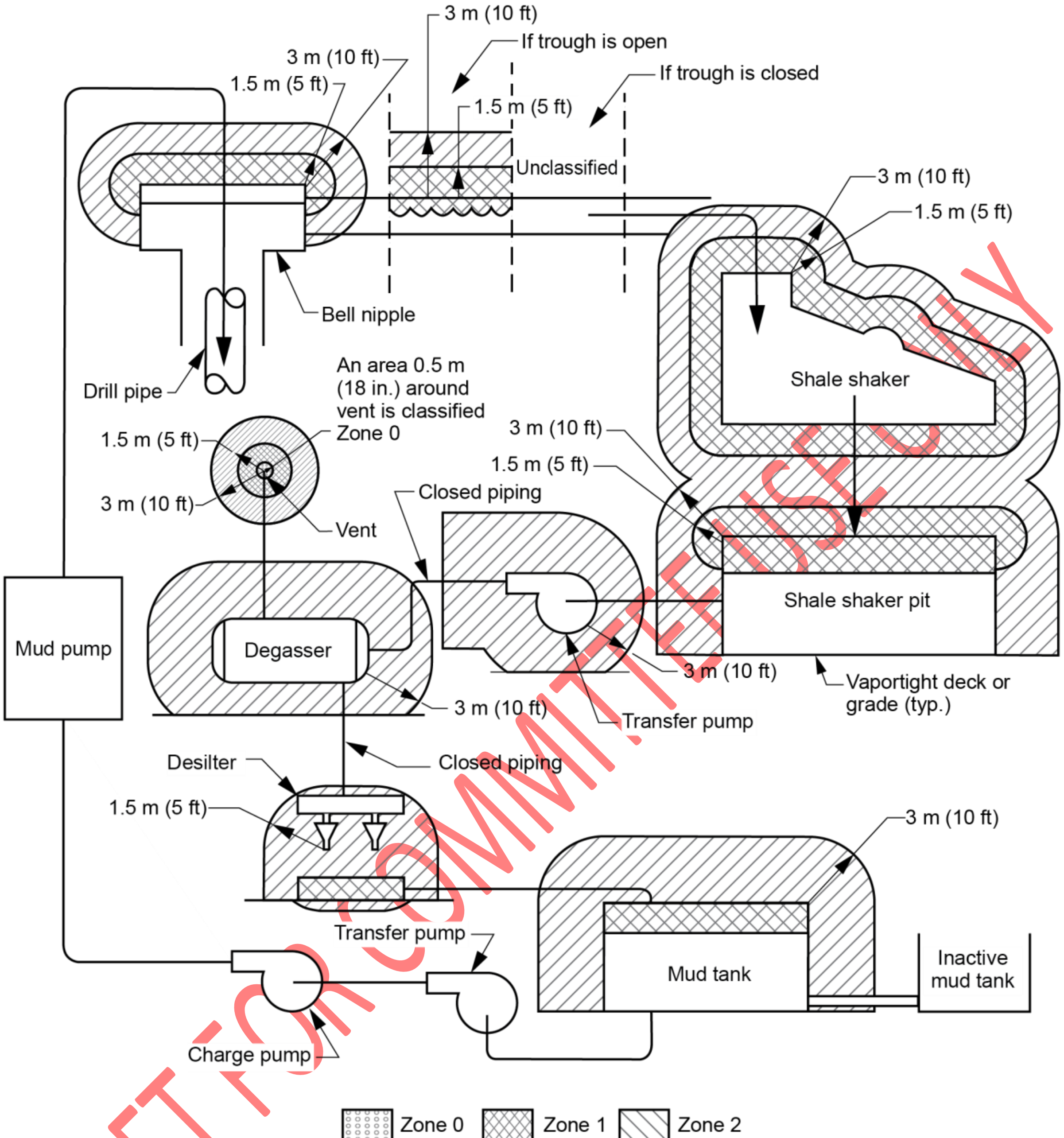


Figure 75—Mud System Processing Equipment in Open Spaces
(See 11.9.2)

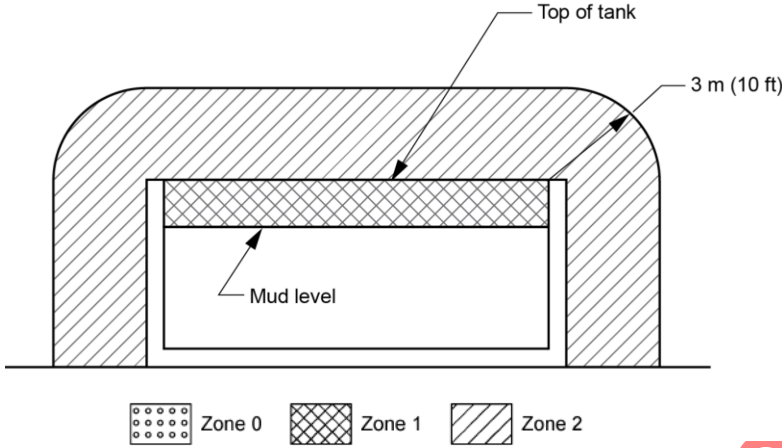


Figure 76—Mud Tanks in Open Areas
(See 11.10.1)

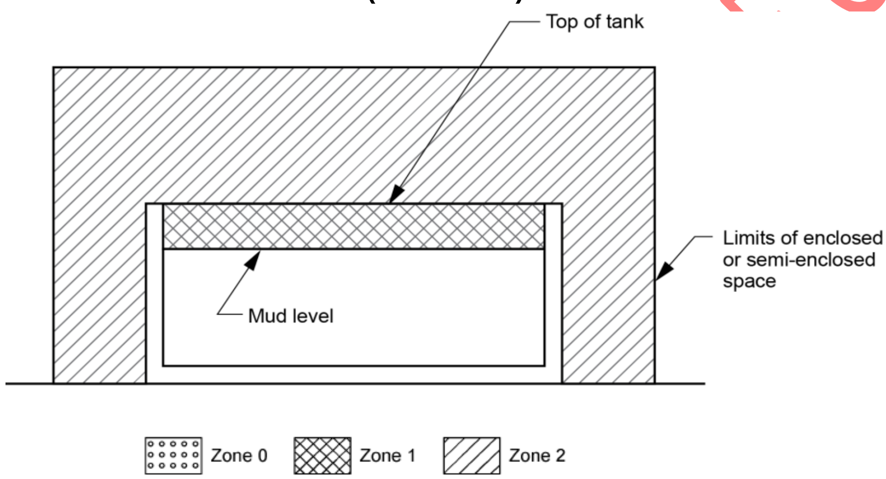
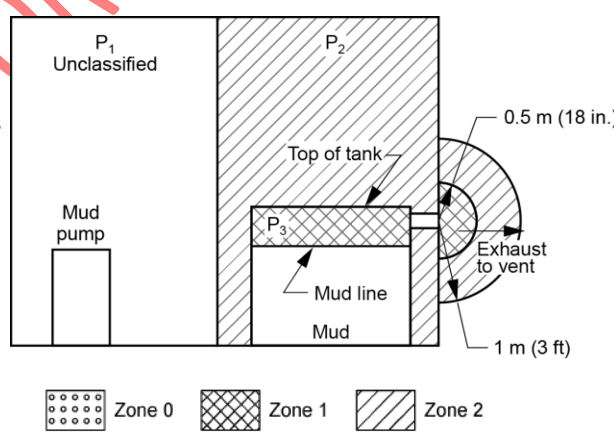


Figure 77—Open Top Mud Tanks in Enclosed or Semi-enclosed Locations with Adequate Ventilation
(See 11.10.2)



[1] P_1 pressure is greater than P_2 pressure.

[2] P_2 pressure is greater than P_3 pressure.

[3] Differential pressure between zones shall be a minimum of 25 Pa (0.1 in. H_20).

Figure 78—Closed Top Mud Tanks in Enclosed or Semi-enclosed Locations With Adequate Ventilation

(See 11.10.3)

11.11 Mud Ditches or Troughs

For classification of locations containing a mud ditch or trough, refer to Figure 79, Figure 80, Figure 81, or Figure 82, as applicable.

11.12 Mud Pumps

Spaces containing mud pumps with totally enclosed piping do not require classification.

NOTE 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.

11.13 Mud Processing Equipment (Between the Bell Nipple and Mud Discharge of Final Degasser)

11.13.1 Adequately ventilated enclosed or adequately ventilated semi-enclosed spaces containing a shale shaker are classified as shown in Figure 83.

11.13.2 Open areas containing a shale shaker are classified as shown in Figure 84.

11.14 Desander or Desilter (Between Mud Discharge of Final Degasser and the Mud Pit)

11.14.1 Adequately ventilated enclosed or adequately ventilated semi-enclosed spaces containing a desander or desilter are classified as shown in Figure 85.

11.14.2 Open areas containing a desander or desilter are classified as shown in Figure 86.

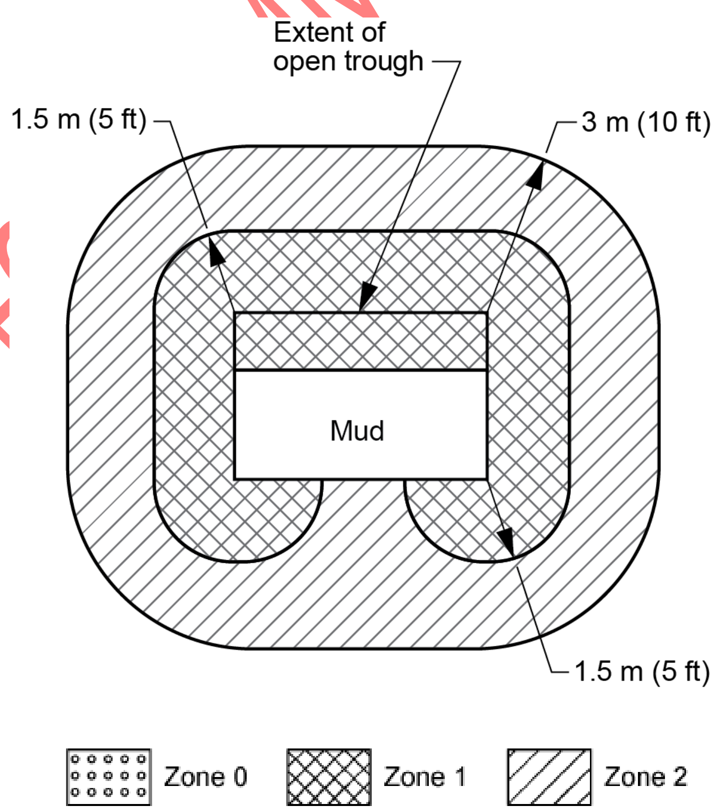


Figure 79—Open Mud Trough in Open Space Before Degasser
(See 11.11)

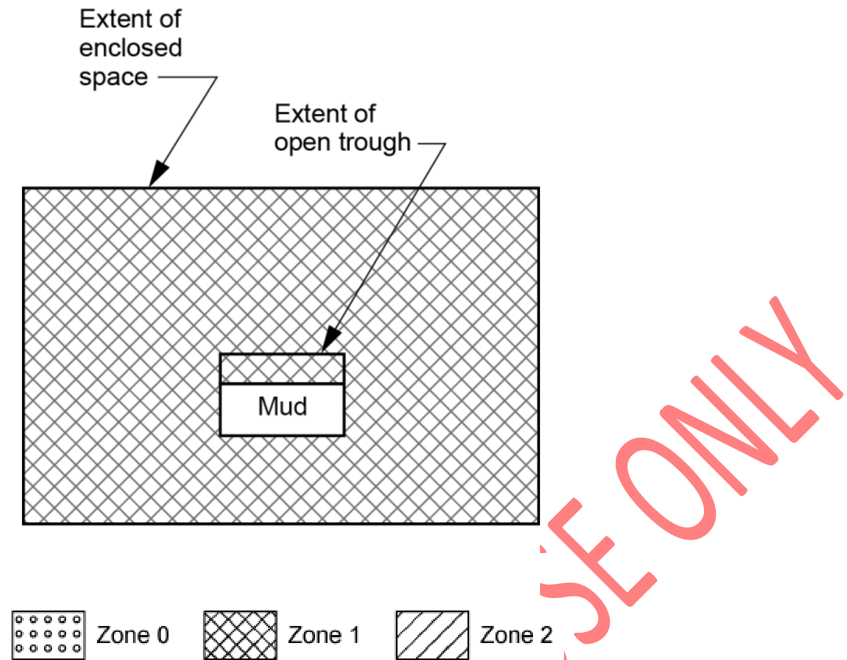


Figure 80—Open Mud Trough in Enclosed Space with Adequate Ventilation Before Degasser
(See 11.11)

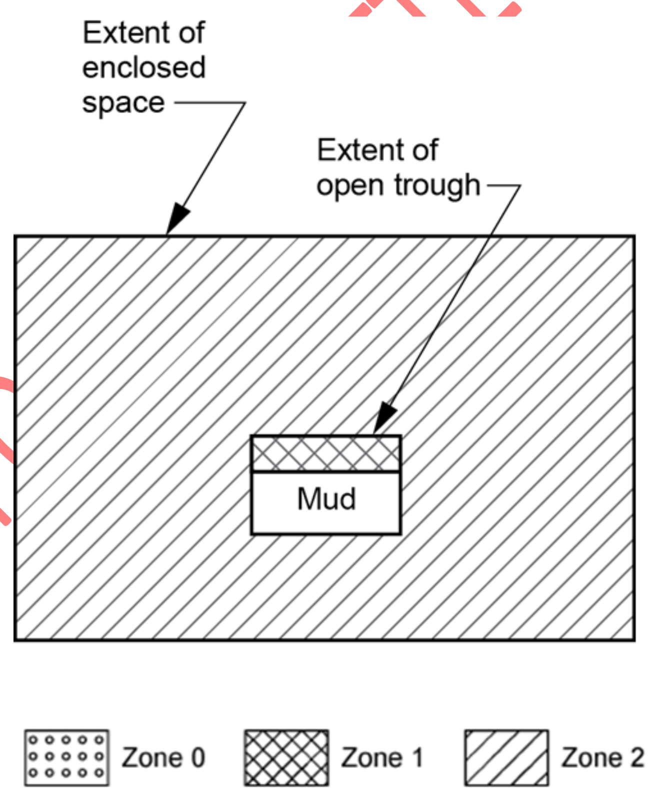


Figure 81—Open Mud Trough in Enclosed Space with Adequate Ventilation
Downstream of Degasser
(See 11.11)

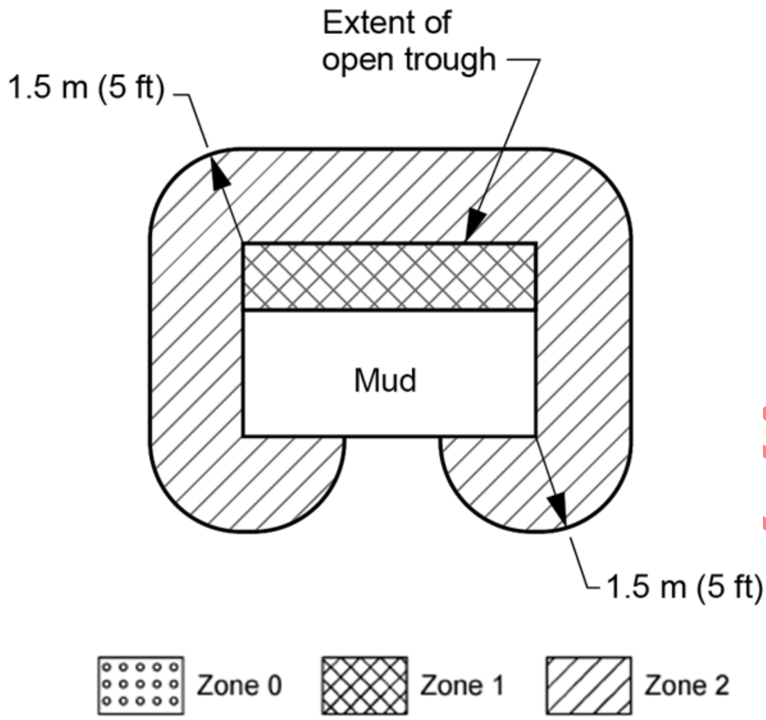


Figure 82—Open Mud Trough in Open Space Downstream of Degasser (See 11.11)

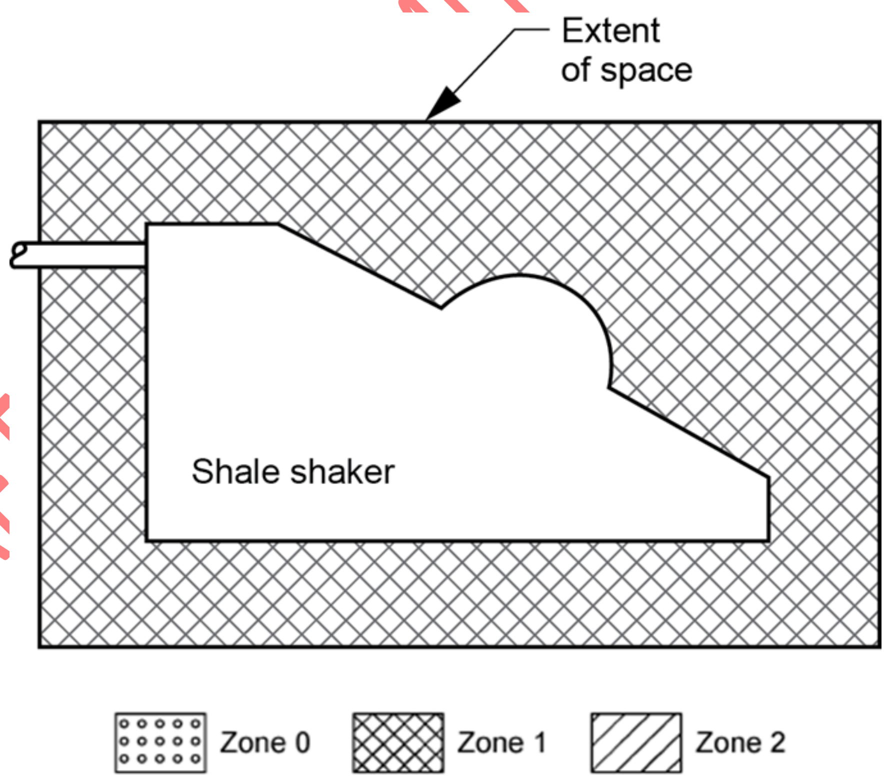


Figure 83—Shale Shaker in Enclosed or Semi-enclosed Space with Adequate Ventilation (See 11.13.1)

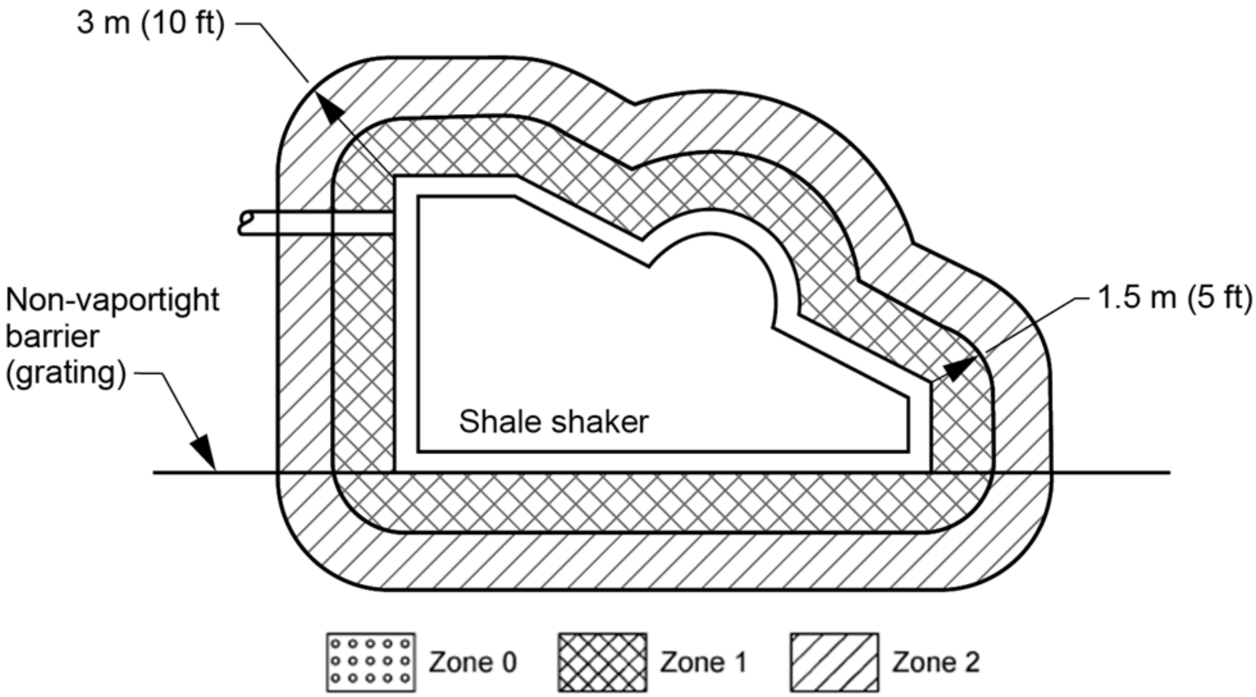


**Figure 84—Shale Shaker in Open Area with Adequate Ventilation
(See 11.13.2)**

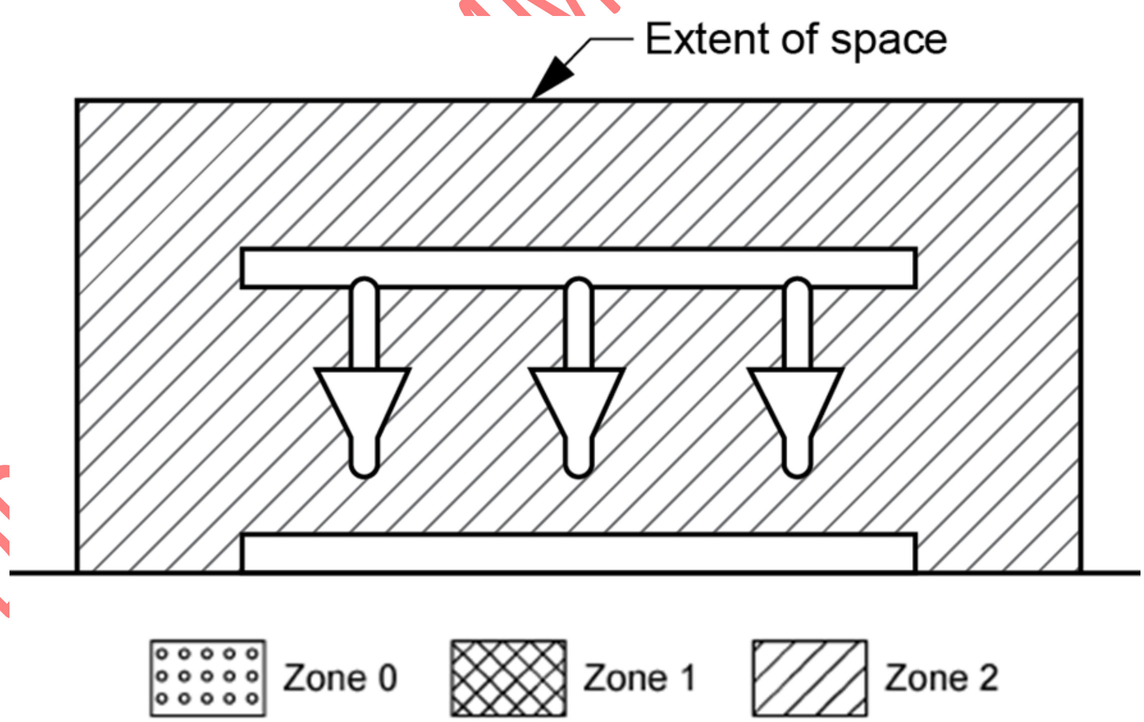


**Figure 85—Desander or Desilter in Enclosed or Semi-enclosed Space with Adequate Ventilation
(See 11.14.1)**

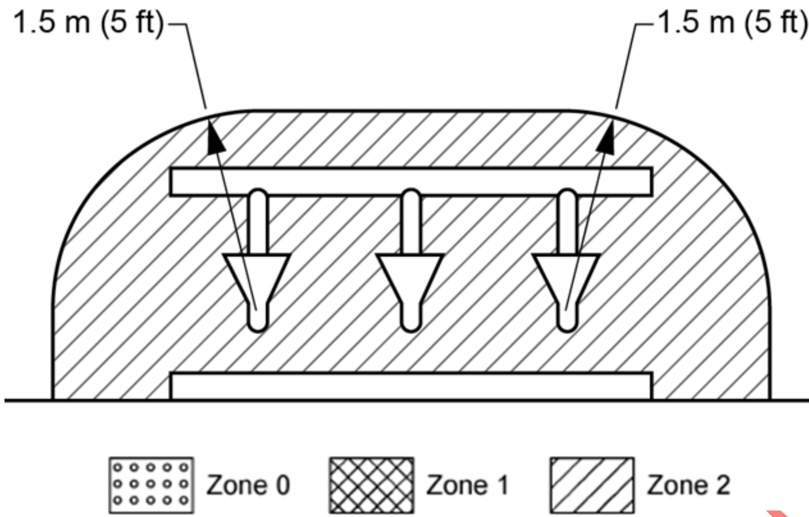


Figure 86—Desander or Desilter in Open Area
(See 11.14.2)

11.15 Choke Manifold

11.15.1 The area surrounding a choke manifold in a non-enclosed, adequately ventilated location is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the choke manifold. The area surrounding a choke manifold in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

11.15.2 The area surrounding a choke manifold in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

11.16 Cement Unit

11.16.1 The area surrounding a mixing/holding tank for a cement unit in a non-enclosed, adequately ventilated location is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the mixing/holding tank.

11.16.2 The area surrounding a mixing/holding tank for a cement unit in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

11.16.3 The area surrounding a mixing/holding tank for a cement unit in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

11.17 Degasser

11.17.1 The area surrounding a degasser located in a non-enclosed, adequately ventilated location is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the degasser or gas buster.

11.17.2 The area surrounding a degasser located in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

11.17.3 The area surrounding a degasser located in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

11.18 Vents

11.18.1 Areas containing discharges of ventilation vents originating in Zone 0 areas should be classified as shown in Figure 14b, Areas containing discharges of ventilation vents originating in Zone 1 areas and equipment vents (such as degasser vents) should be classified as shown in Figure 87.

11.18.2 Areas containing discharges of ventilation vents originating in Zone 2 areas should be classified as shown in Figure 88.

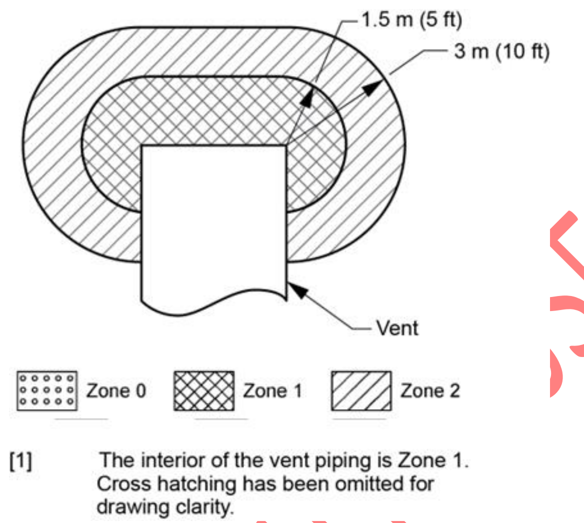


Figure 87—Discharges of Ventilation Vents and Equipment Vents Originating in Zone 1 Areas (See 11.18.1 and 11.18.2)

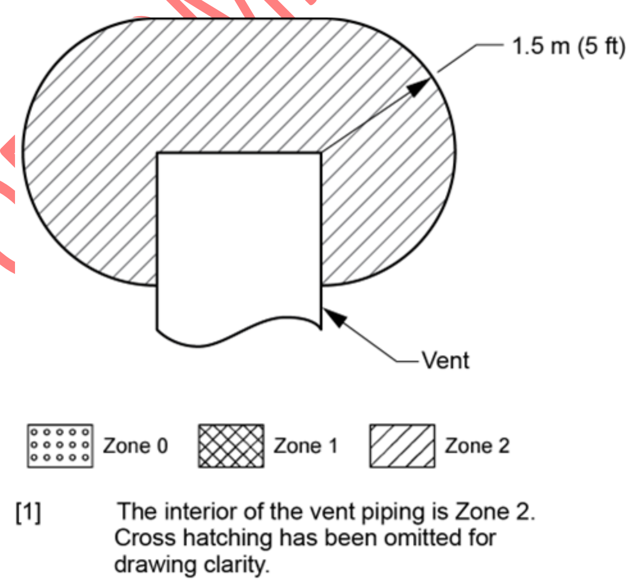


Figure 88—Discharges of Ventilation Vents and Equipment Vents Originating in Zone 2 Areas (See 11.18.3)

11.19 Diverter Line Outlet

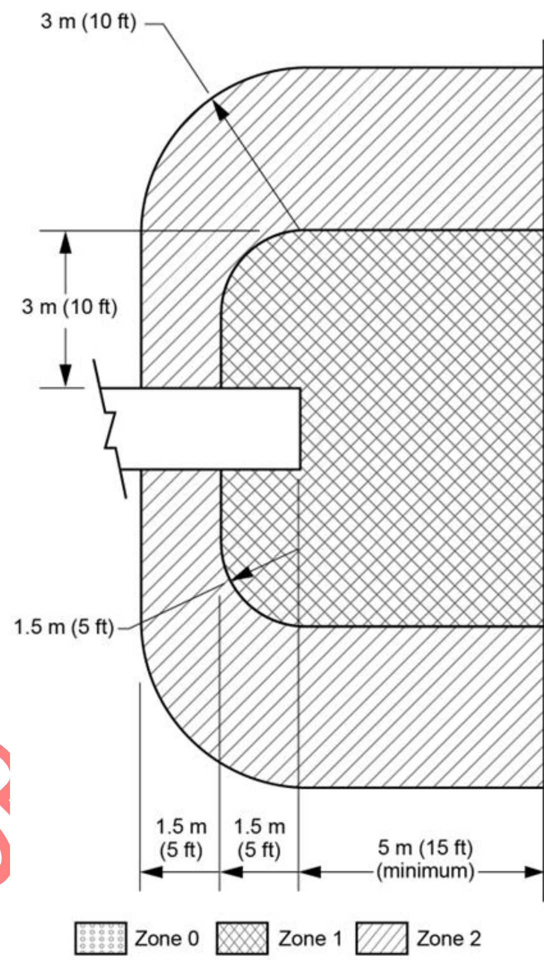
The criteria for the classification of the area surrounding a diverter line outlet are too diverse to specify distances. Individual sound engineering judgment is required for specific cases, but in no case should the classification be less than shown in Figure 89. Refer to API 521.

11.20 Blowout Preventer (BOP)

11.20.1 The area surrounding a BOP in a non-enclosed, adequately ventilated location is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the BOP.

11.20.2 The area surrounding a BOP in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

11.20.3 The area surrounding a BOP in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.



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

Figure 89—Diverter Line Outlet (See 11.19)

11.21 Well Test Equipment Areas

The degree and extent of classified locations for well test equipment on MODUs should be the same as recommended by Section 10 for similar production equipment.

11.22 Rooms Used To Store Paint (Paint Lockers)

The interior of enclosed spaces used for the storage of flammable paint (i.e. paint lockers) should be classified Class I, Zone 1.

11.23 Battery Rooms

Locations containing batteries should be classified in accordance with 8.2.6.

NOTE Authorities having jurisdiction may require special considerations for electrical equipment installed in such locations.

11.24 Helicopter Fuel Storage Areas

Helicopter fuel storage areas should be classified in accordance with 8.2.1.3.1.

11.25 Classification of Adjacent Spaces

11.25.1 Openings, access, and ventilation conditions affect the extent of hazardous (classified) locations.

11.25.2 Where an access door or other opening provides direct access from a hazardous (classified) location (Zone 0, Zone 1, or Zone 2) to an enclosed space, the enclosed space should be classified the same as that classified location, with the following exceptions.

11.25.2.1 An enclosed space with direct access to a Zone 1 location can be considered as Zone 2 provided all the following criteria are met:

a) the access is fitted with an inward opening, self-closing, vaportight door with no hold-back provisions;

b) the ventilation is such that the air flow with the door open is from the Zone 2 space into the Zone 1 space (see 11.5.3.1); and

c) the loss of ventilation is alarmed at a manned station, and corrective action is initiated to restore ventilation.

11.25.2.2 An enclosed space with direct access to a Zone 2 location can be considered unclassified (non-hazardous) provided all the following criteria are met:

a) the access is fitted with an inward opening, self-closing, vaportight door with no holdback provisions;

b) the ventilation is such that the airflow with the door open is from the unclassified space into the Zone 2 location (see 11.5.3.1); and

c) the loss of ventilation is alarmed at a manned station and corrective action is initiated to restore ventilation.

11.25.2.3 An enclosed space with direct access to a Zone 1 location can be considered unclassified provided all the following criteria are met:

a) The access is fitted with two self-closing, vaportight doors with no hold-back provisions, forming an air lock between the two doors. Air locks between a Zone 1 location and an unclassified location should be classified as Zone 2;

b) the ventilation is such that the airflow with the door open is from the unclassified space into the classified space (see 11.5.3.1);

c) the loss of ventilation (overpressure) is alarmed at a manned station and corrective action is initiated to restore ventilation; and

d) air locks between a Zone 1 location and an unclassified location should be classified as Zone 2.

12 Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Floating Production Units

12.1 General

12.1.1 This section presents guidelines for classifying locations for electrical installations at locations surrounding oil and gas drilling and workover rigs and facilities on floating production units where flammable liquids, gases or vapors are produced, processed, stored, transferred, or otherwise handled prior to entering the transportation facilities.

12.1.2 The following recommendations for determining the degree and extent of classified locations are specific examples of situations commonly encountered in producing and drilling operations and have been developed by experience in the industry. Application of these examples to similar, though not identical, situations should be made with sound engineering judgment, employing information presented in this recommended practice and other publications. 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.

12.1.3 High pressures and potentially large releases may justify greater dimensions for classified locations than those shown. See 10.1.3, 10.6.4.2, and 10.15.2.1 for additional guidance for applications at higher pressure.

12.1.4 The classification of locations surrounding oil and gas drilling and workover rigs and production facilities external to the hull should be in accordance with Sections 1 through 8, Section 10, and the annexes of this document are applicable except as noted in this section.

12.1.5 Locations containing batteries should be classified in accordance with 8.2.6.

12.1.6 Storing, handling, or transferring of combustible liquids at or above their flash point will result in hull spaces being classified. Attention should be given to floating installations, which may differ from other oil and gas facilities in that certain spaces may reach higher ambient temperatures than those experienced in other topsides facilities in traditional onshore and offshore facilities. This will affect the design of facilities relative to the flash points of materials stored, handled, or transferred. In addition, the severity of fires and explosions in this type of facility, the difficulty of fighting those fires, and the risk of the loss of the entire facility may necessitate additional caution when classifying areas in the hull spaces of floating facilities.

Variations in seasonal temperatures, the possibility of relocation of the facility to a location with a warmer climate, poorly ventilated sections of large hull spaces, heating from adjacent spaces, heat producing equipment within the space, solar radiation on the skin of the hull, and other conditions that may cause higher than traditionally expected ambient temperatures to exist in the hull should be considered relative to the actual flash point of bulk combustible liquids stored in the hull. Care should be taken to order diesel or fuel oil with a flash point suitable for the ambient temperature of the hull space where it will be stored.

NOTE There are many combustible liquids used on floating production facilities. A common combustible liquid used on floating production facilities is diesel. Various grades of diesel or fuel oils are available for purchase. These grades may meet various specifications such as ASTM D975, *Standard Specifications for Diesel Fuel Oils*, which defines and provides specifications for No 2 diesel whose grades have a range of minimum flash points from 38 °C (100.4 °F) to 52 °C (125.6 °F).

Other common specifications for fuel oils available for purchase include the following:

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

b) ISO 8217, *Quality Standard for Distillate Marine Fuels*

c) NATO F-76, *Fuel Naval Distillate*

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

12.2 Floating Production Storage and Offloading Units (FPSOs)

12.2.1 The area classification of a floating production storage and offloading (FPSO) or similar unit is classified as shown in Figure 90.

12.2.2 Hazardous areas for hydrocarbon product swivels, internal or external turrets, and yokes (Source: *ABS Rules, Single Point Moorings*).

a) Hazardous area classifications include:

1) Zone 0—the internals of tanks, swivels or pipes containing hydrocarbons;

2) Zone 1—an enclosed space where a hydrocarbon product swivel is installed;

3) Zone 2—in a non-enclosed area, the area within 3 m (10 ft) of a hydrocarbon product swivel.

b) The electrical swivel, if installed in a hazardous area, should be certified by an independent laboratory as suitable for installation within such an area.

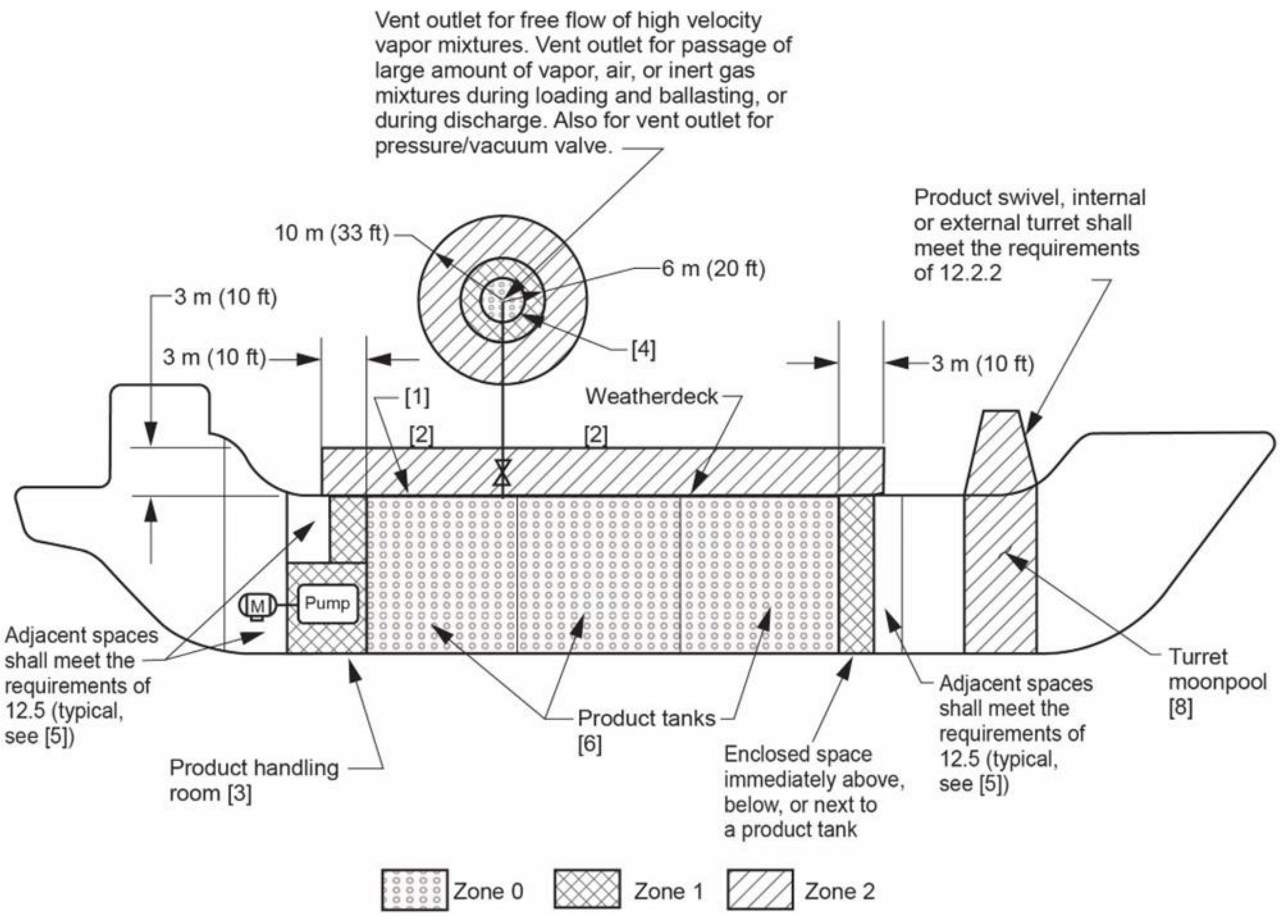
12.3 Tension Leg Platforms (TLPs)

The area classification of a tension leg platform (TLP) or similar unit is classified as shown in Figure 91.

12.4 Spars, Caissons, and Similar Units

12.4.1 The area of the moonpool and other areas of spar, caisson, and similar units whose moonpool contains hydrocarbon production risers, drilling risers, and pipelines containing no flanges, valves, etc. is classified as shown in Figure 92.

12.4.2 The area classification of the moonpool and other areas of spar, caisson, and similar units whose moonpool contains hydrocarbon production risers, drilling risers, and pipelines containing flanges, valves, and similar devices is Zone 1.



[1] This area classified due to proximity to product tanks.

[2] Areas more than 3 m (10 ft) above the weatherdeck are unclassified except as required by this document for production equipment contained therein.

[3] Space containing flammable liquid pump, processing equipment, or natural gas fueled prime movers with all flammable liquid or gas vents extended to the outside of the area are classified Zone 1 if:

a) continuously ventilated at ≥20 air changes per hour, and
b) loss of ventilation is alarmed in a manned space, and
c) combustible gas detection is installed in accordance with 6.8.2.

or, if ventilated at <20 air changes per hour, loss of ventilation is not alarmed, or gas detectors are not installed, then the area is classified a Zone 0.

[4] An area 1 m (3 ft) around vent is classified Zone 0.

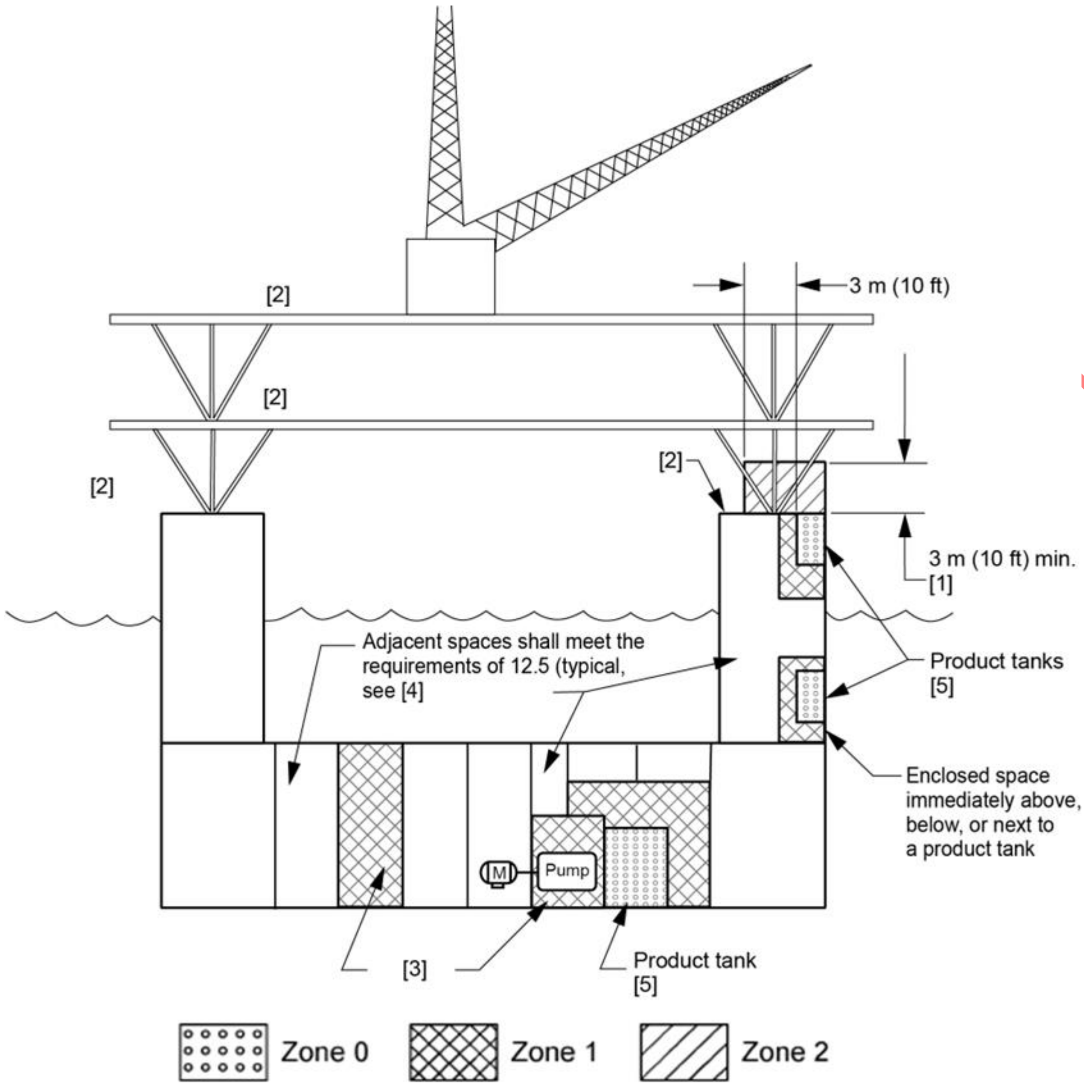
[5] All spaces are subject to the adjacent space requirements of 12.5.

[6] Spaces or areas where flammable gas, vapor, or liquid is stored.

[7] Where combustible liquids are stored at temperatures at or above their flash point, they should be treated as flammable liquids. For combustible liquids stored below their flash point, the recommendations of 8.2.1.4 apply.

[8] Area classification within moonpool is dependent upon swivel or turret specific design type. If designated as Zone 1, adjacent spaces must meet requirements of 12.5.

Figure 90—Typical Floating Production Storage and Offloading Unit (FPSO) (See 12.2.1)



[1] This area classified due to proximity to product tanks.

[2] Areas more than 3 m (10 ft) above the weatherdeck are unclassified except as required by this document for production and drilling equipment contained therein.

[3] Space containing flammable liquid pump, processing equipment or natural gas fueled prime mover with all flammable liquid or gas vents extended to the outside of the area are classified Zone 1 if:

a) continuously ventilated at ≥20 air changes per hour, and
b) loss of ventilation is alarmed in a manned space, and
c) combustible gas detection is installed in accordance with 6.5.2.

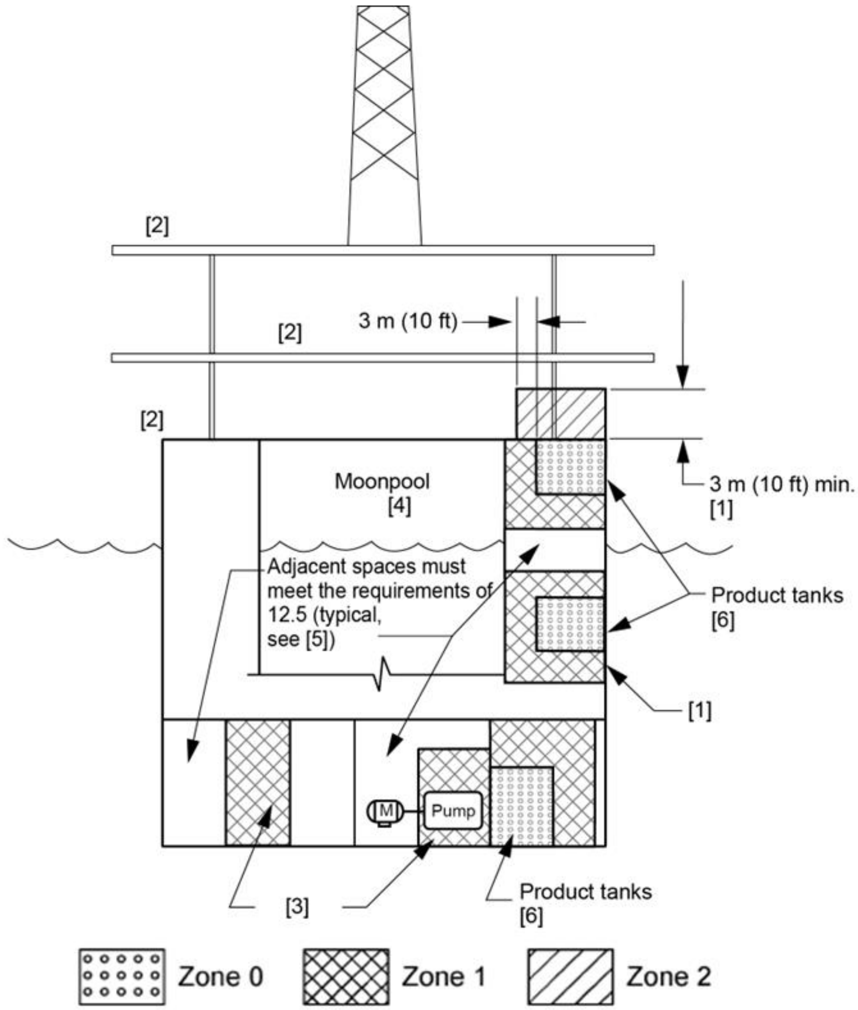
or, if ventilated at <20 air changes per hour, loss of ventilation is not alarmed, or gas detectors are not installed, then the area is classified Zone 0.

[4] All spaces are subject to the adjacent space requirements of 12.5.

[5] Spaces or areas where flammable gas, vapor, or liquid is stored.

[6] Where combustible liquids are stored at temperatures at or above their flash point, they should be treated as flammable liquids. For combustible liquids stored below their flash point, the recommendations of 8.2.1.4 apply.

Figure 91—Typical Tension Leg Platform (TLP)
(See 12.3)



[1] This area classified due to proximity to product tanks.

[2] Areas more than 3 m (10 ft) above the weatherdeck are unclassified except as required by this document for production and drilling equipment contained therein.

[3] Space containing flammable liquid pump, processing equipment or natural gas fueled prime mover with all flammable liquid or gas vents extended to the outside of the area are classified Zone 1 if:

a) continuously ventilated at ≥20 air changes per hour, and
b) loss of ventilation is alarmed in a manned space, and
c) combustible gas detection is installed in accordance with 6.5.2.

or, if ventilated at <20 air changes per hour, loss of ventilation is not alarmed, or gas detectors are not installed, then the area is classified Zone 0.

[4] Moonpool area is unclassified if it contains all welded closed piping and continuous metallic tubing systems without valves flanges or similar devices, and is not within the hazardous area created by adjacent equipment.

[5] All spaces are subject to the adjacent space requirements of 12.5.

[6] Spaces or areas where flammable gas, vapor, or liquid is stored.

[7] Where combustible liquids are stored at temperatures at or above their flash point, they should be treated as flammable liquids. For combustible liquids stored below their flash point, the recommendations of 8.2.1.4 apply.

Figure 92—Typical Spar, Caisson, or Similar Unit (See 12.4.1)

12.5 Classification of Adjacent Spaces

12.5.1 Openings, access provisions, and ventilation conditions affect the extent of hazardous (classified) locations.

12.5.2 Where an access door or other opening provides direct access from a hazardous (classified) location (Zone 1 or Zone 2) to an enclosed space, the enclosed space should be classified the same as that classified location, with the following exceptions.

12.5.2.1 An enclosed space with direct access to a Zone 1 location can be considered as Zone 2 provided the following criteria are met:

a) the access is fitted with an inward opening, self-closing, vaportight door with no hold-back provisions;

b) the ventilation is such that the air flow with the door open is from the Zone 2 space into the Zone 1 space (see 11.5.3.1); and

c) the loss of ventilation is alarmed at a manned station and corrective action is initiated to restore ventilation.

12.5.2.2 An enclosed space with direct access to a Zone 2 location can be considered unclassified (non-hazardous) provided the following criteria are met:

a) the access is fitted with an inward opening, self-closing, vaportight door with no holdback provisions;

b) the ventilation is such that the air flow with the door open is from the unclassified (non-hazardous) space into the Zone 2 location (see 11.5.3.1); and

c) the loss of ventilation is alarmed at a manned station and corrective action is initiated to restore ventilation.

12.5.2.3 An enclosed space with direct access to a Zone 1 location can be considered unclassified provided the following criteria are met:

a) the access is fitted with two self-closing, vaportight doors with no hold-back provisions, forming an air lock between the two doors;

b) the ventilation is such that the air flow with the door open is from the unclassified space into the classified space (see 11.5.3.1); and

c) the loss of ventilation (overpressure) is alarmed at a manned station and corrective action is initiated to restore ventilation.

Air locks between a Zone 1 location and an unclassified location should be classified as Zone 2.

13 Recommendations for Determining Degree and Extent of Classified Locations at Petroleum Pipeline Transportation Facilities

13.1 General

13.1.1 This section presents guidelines for classifying locations for electrical installations at pipeline transportation facilities. The guidelines cover onshore and offshore pipeline facilities handling flammable and combustible liquids and flammable gases and vapors. Pipeline facilities may include pump and compressor stations, storage facilities, manifold areas, and valve sites.

13.1.2 The following recommendations for determining the degree and extent of classified locations are specific examples of situations commonly encountered in pipeline operations and have been developed by experience in the industry. 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. 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.

13.1.3 High pressures, potentially large releases, and the presence of HVLs may justify greater dimensions for classified locations than those shown.

13.1.4 Pipeline facilities are frequently operated by remote control without full time local attendance. This practice was one of the factors considered in developing the classification guidelines. For this reason, some of the guidelines presented are more conservative than other API and NFPA guidelines for similar facilities in other segments of the petroleum industry.

13.2 Use of Figures

13.2.1 The figures show classified locations surrounding typical sources of flammable liquids, vapors, and gases. Some of the illustrations apply to a single source; others apply to an enclosed area or to an operating facility. The intended use of these figures is to develop area classification drawings. Elevations or sections will be required where different classifications apply at different elevations.

13.2.2 A pipeline location may have many interacting sources of flammable liquid, vapor, or gas, including pumps, compressors, manifolds, sampling stations, meters, and operating and control valves. Accordingly, sound engineering judgment is required to set the boundaries for electrical area classification.

13.2.3 Use 14.3 to select the figure or figures that apply to each source or condition. Determine the applicable zones, their extent, and their layout, considering the local environmental conditions. It is recommended that a layout be made of each classified location, based on the interaction of individual sources described in 13.2.2.

13.2.4 It may be found that individual classification of a great number of sources in a location is not feasible. Classification of an entire building or location as a single area should be considered after evaluation of the extent and interaction of various sources and areas within or adjacent to the location.

13.3 Figures

13.3.1 Figure 93, Figure 94, and Figure 95 show classified locations around a pump or compressor handling flammable liquids or highly volatile liquids.

13.3.2 Figure 96, Figure 97, and Figure 98 show classified locations around piping with valves, screwed fittings, flanges, or similar accessories handling flammable liquids or highly volatile liquids. They also cover sampling systems, instrumentation, and instrument-sized pumps.

13.3.3 Figure 99 shows hazardous (classified) locations around an elevated storage tank or pressure vessel.

13.3.4 Figure 100 shows hazardous (classified) locations around a below grade closed sump tank or oil–water separator. For open sump or oil–water separator in a non-enclosed adequately ventilated area, refer to Figure 57.

13.3.5 Figure 101 shows hazardous (classified) locations around a below-grade vault.

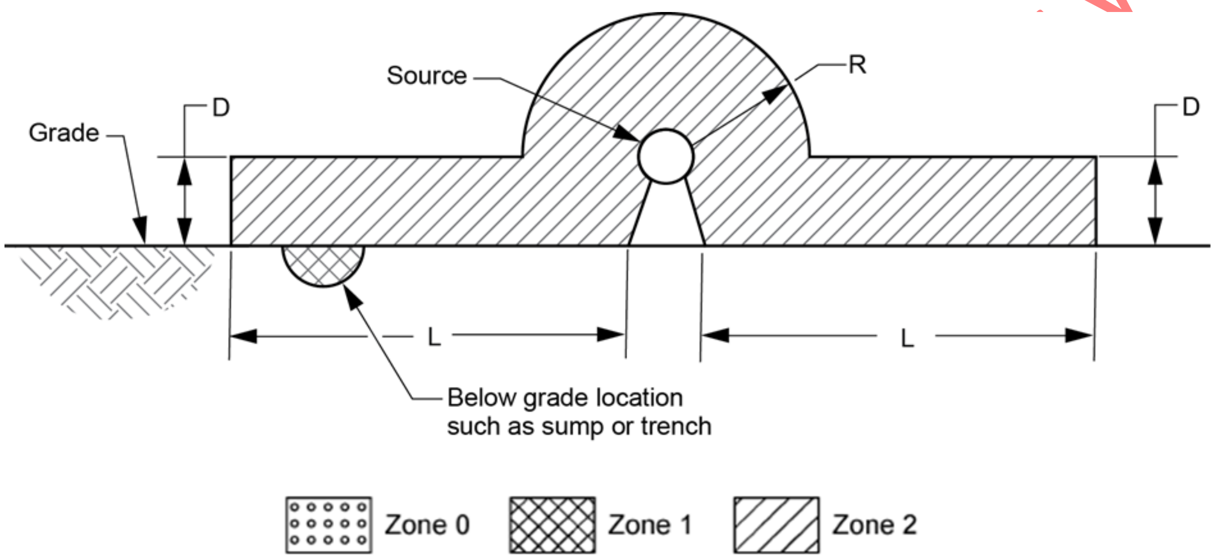
13.3.6 Figure 102 shows hazardous (classified) locations around an above-grade source with closure. This figure is applicable to scraper, launchers and receivers, strainers, and other devices where the flammable liquid or highly volatile liquid may be exposed to the atmosphere.

13.3.7 Figure 103 shows hazardous (classified) locations around a storage cavern.

13.3.8 Figure 104, Figure 105, and Figure 106 show hazardous (classified) locations around a compressor, valves, screwed fittings, flanges, or similar devices handling lighter-than-air flammable gases.

13.3.9 Figure 107 shows hazardous (classified) locations around ball or pig launching or receiving installation handling lighter-than-air flammable gas.

13.3.10 Figure 108 shows hazardous (classified) locations around a storage cavern handling lighter-than-air flammable gases.

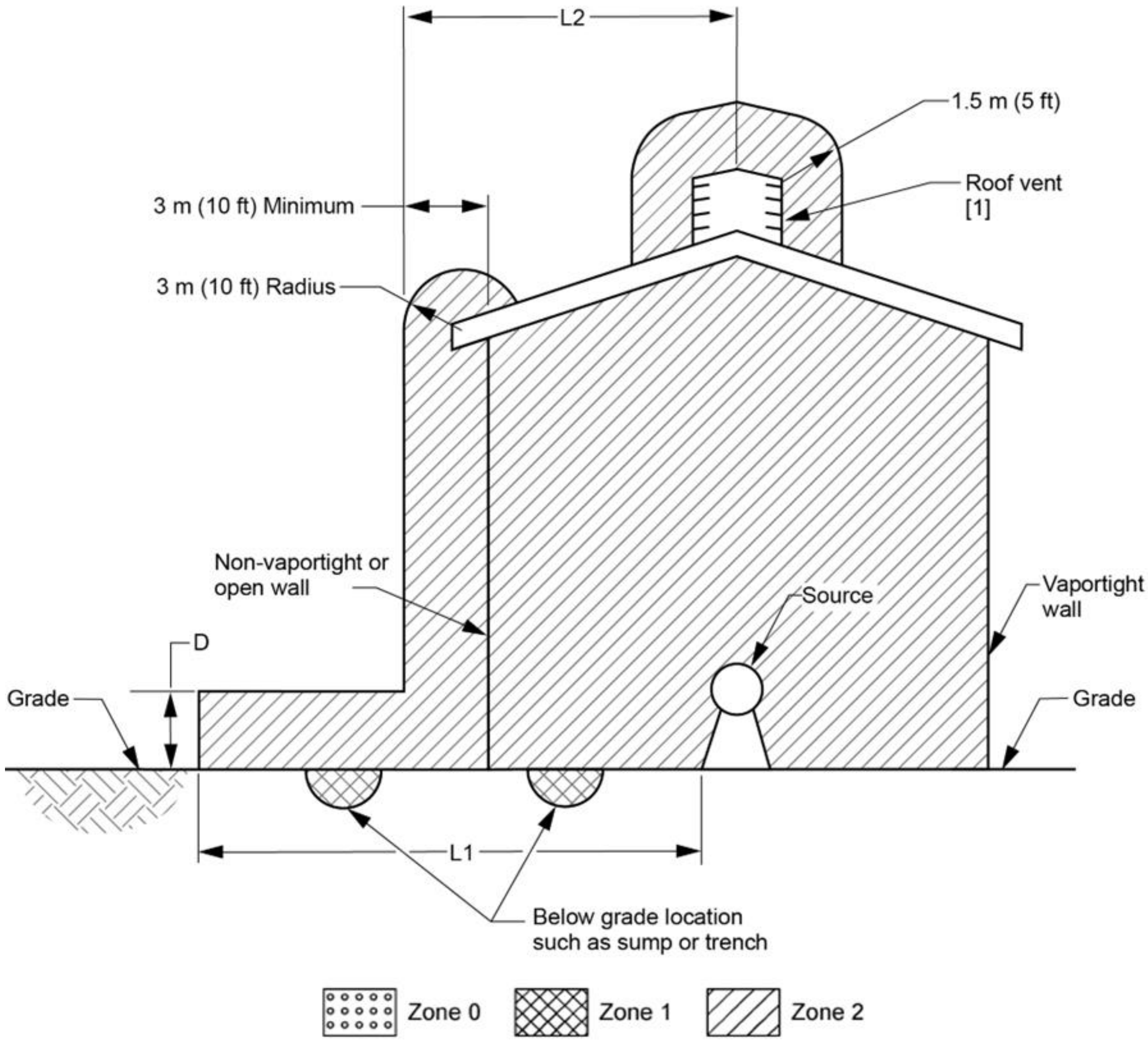


Level	Distance in m (ft) L	R	D
1. Liquid 1900 kPa (275 PSIG) or less	3 (10)	1 (3)	0.6 (2)
2. Liquid above 1900 kPa (275 PSIG) [1]	15 (50)	7.5 (25)	0.6 (2)
3. HVL [2]	30 (100)	7.5 (25)	0.6 (2)

[1] Level 1 dimensions may be used for small pumps operating above 1900 kPa (275 PSIG) where leakage is likely to be small. Pipeline gathering pumps would normally be included in this exception.

[2] Dimension L may be reduced to no less than 15 m (50 ft) where leakage is likely to be small.

Figure 93—Outdoors—Pump Handling Flammable Liquids or Highly Volatile Liquids (See 13.3.1)



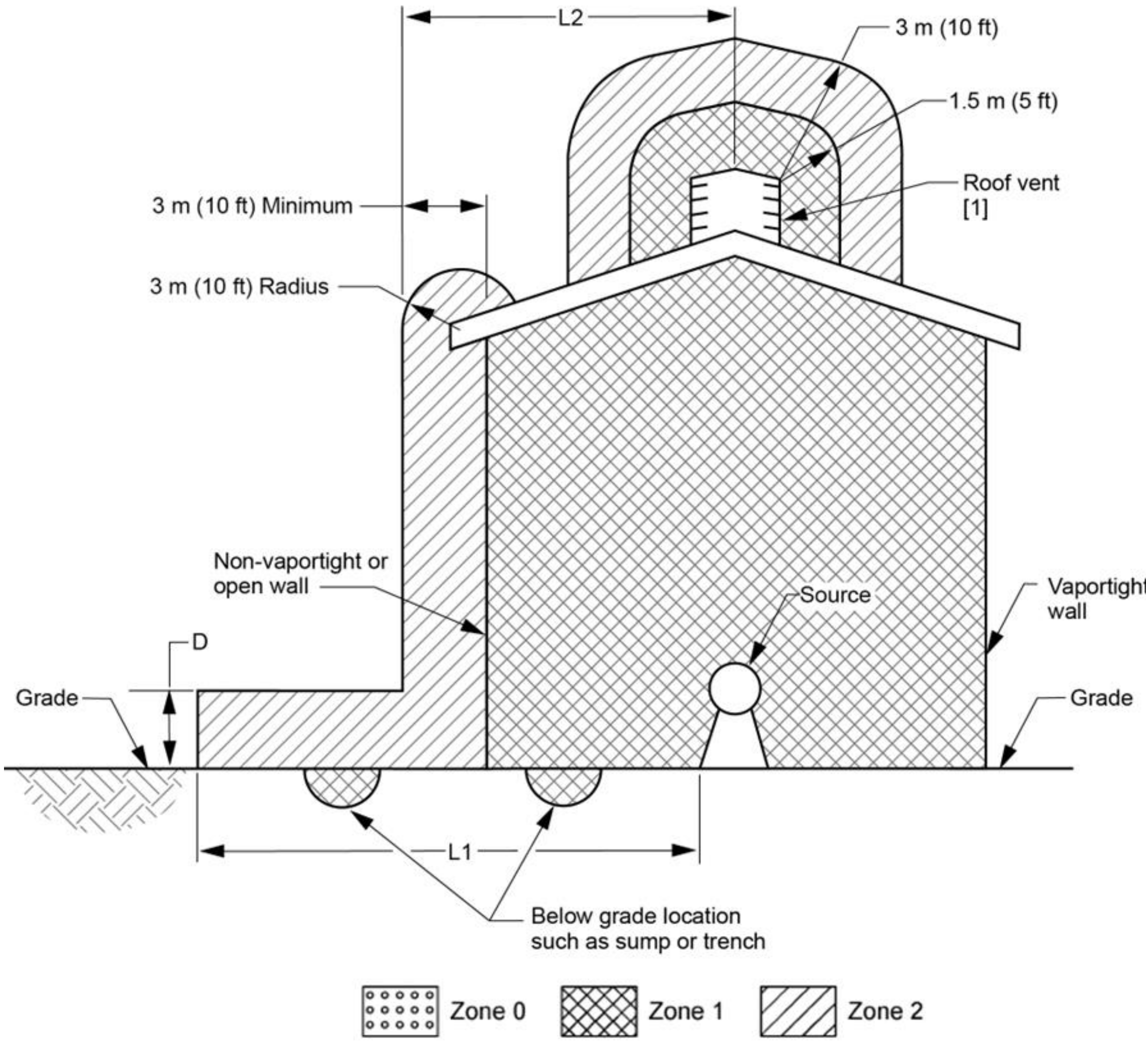
Level	Distance in m (ft) L1	L2	D
1. Liquid 1900 kPa (275 PSIG) or less	3 (10)	3 (10)	0.6 (2)
2. Liquid above 1900 kPa (275 PSIG) [2]	15 (50)	7.5 (25)	0.6 (2)
3. HVL [3]	30 (100)	7.5 (25)	0.6 (2)

[1] The interior of the vent is classified Zone 2. Cross hatching has been omitted for drawing clarity.

[2] Level 1 dimensions may be used for small pumps operating above 1900 kPa (275 PSIG) where leakage is likely to be small. Pipeline gathering pumps would normally be included in this exception.

[3] Dimension L1 may be reduced to no less than 15 m (50 ft) where leakage is likely to be small.

Figure 94—Adequately Ventilated Building—Pump Handling Flammable Liquids or Highly Volatile Liquids
(See 13.3.1)



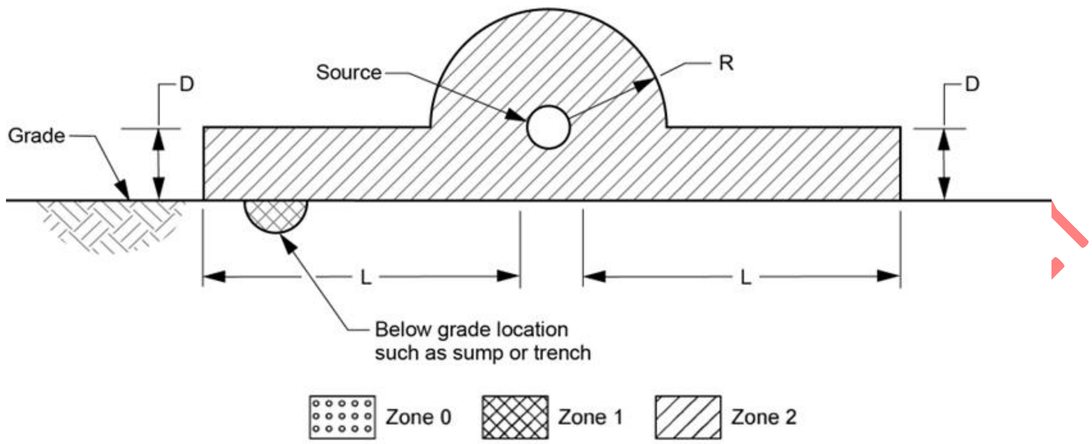
Level	Distance in m (ft) L1	L2	D
1. Liquid 1900 kPa (275 PSIG) or less	3 (10)	3 (10)	0.6 (2)
2. Liquid above 1900 kPa (275 PSIG) [2]	15 (50)	7.5 (25)	0.6 (2)
3. HVL [3]	30 (100)	7.5 (25)	0.6 (2)

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

[2] Level 1 dimensions may be used for small pumps operating above 1900 kPa (275 PSIG) where leakage is likely to be small. Pipeline gathering pumps would normally be included in this exception.

[3] Dimension L1 may be reduced to no less than 15 m (50 ft) where leakage is likely to be small.

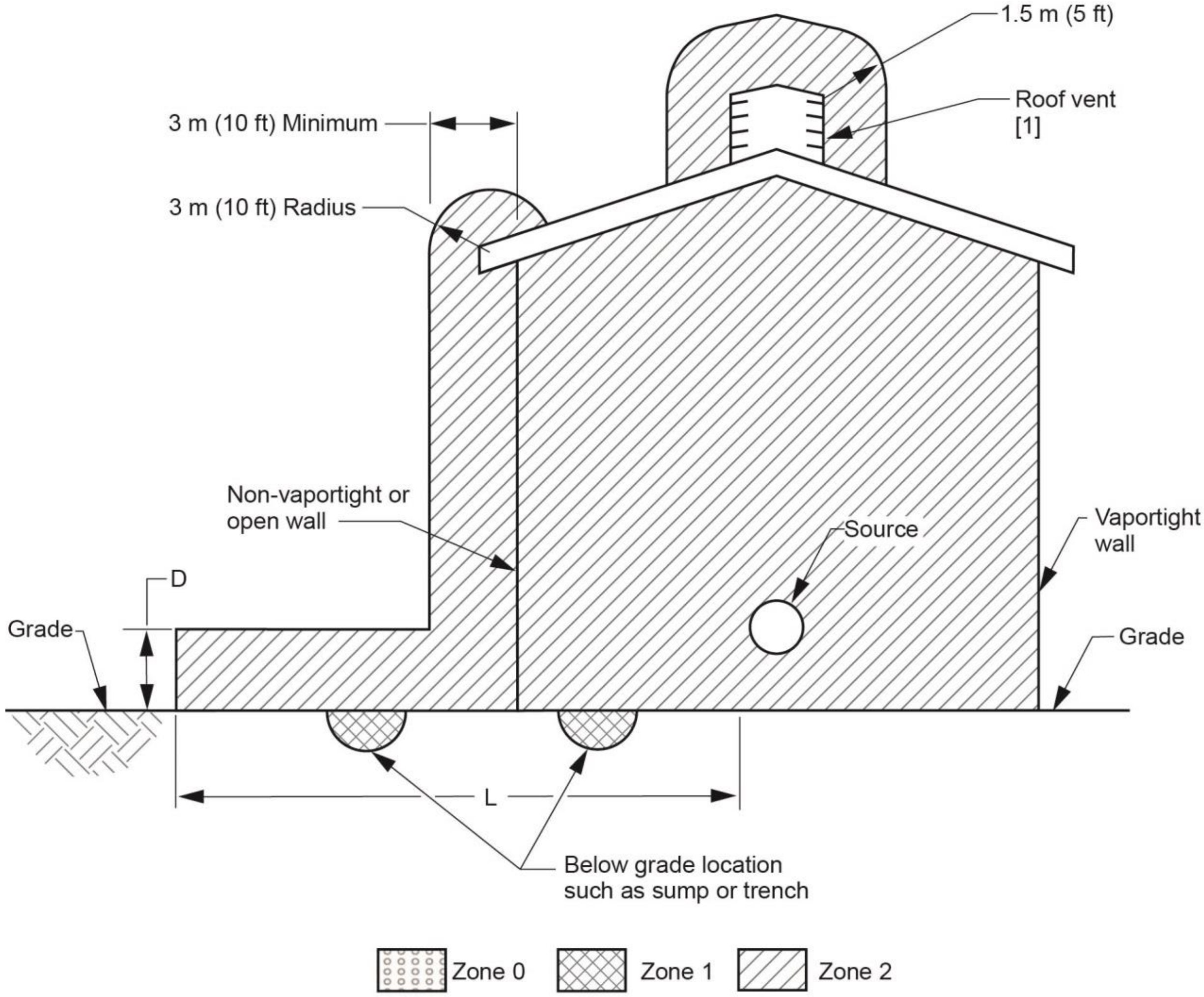
Figure 95—Inadequately Ventilated Building Pump Handling Flammable Liquids or Highly Volatile Liquids
(See 13.3.1)



Level	Distance in m (ft) L	R	D
1. Liquid 1900 kPa (275 PSIG) or less	3 (10)	1 (3)	0.6 (2)
2. Liquid above 1900 kPa (275 PSIG)	3 (10)	1 (3)	0.6 (2)
3. HVL	6 (20)	3 (10)	0.6 (2)

[1] Shown for piping installed above grade. Also applies to buried piping with above grade vents, such as motor operated valve body buried and the motor operator above grade.

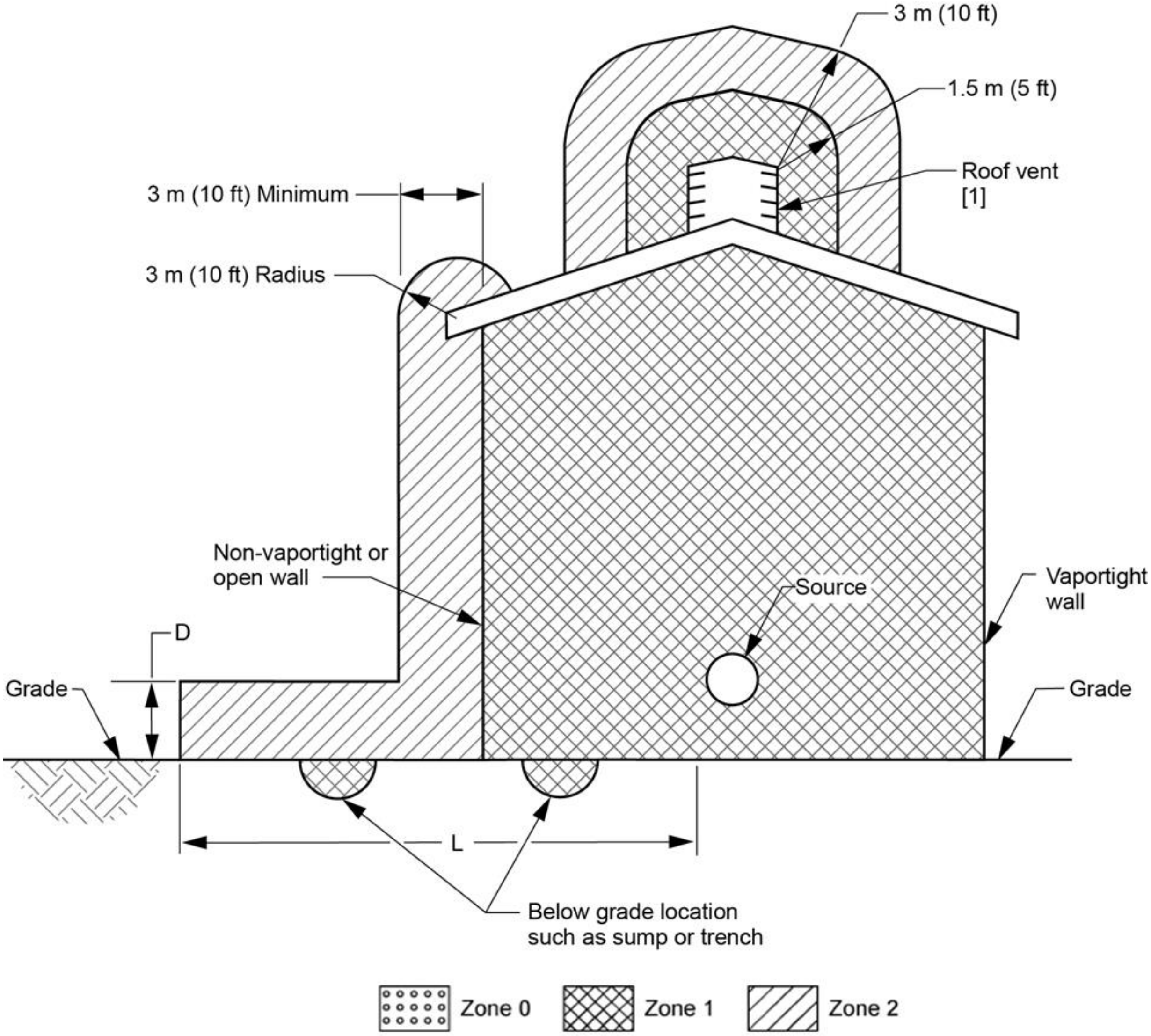
Figure 96—Outdoors—Piping with Valves, Screwed Fittings, Flanges, or Similar Accessories Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation, and Instrument-sized Pumps (See 13.3.2)



Level	Distance in m (ft) L2	D
1. Liquid 1900 kPa (275 PSIG) or less	3 (10)	0.6 (2)
2. Liquid above 1900 kPa (275 PSIG)	3 (10)	0.6 (2)
3. HVL	6 (20)	0.6 (2)

[1] The interior of the vent is classified Zone 2. Cross hatching has been omitted for drawing clarity.

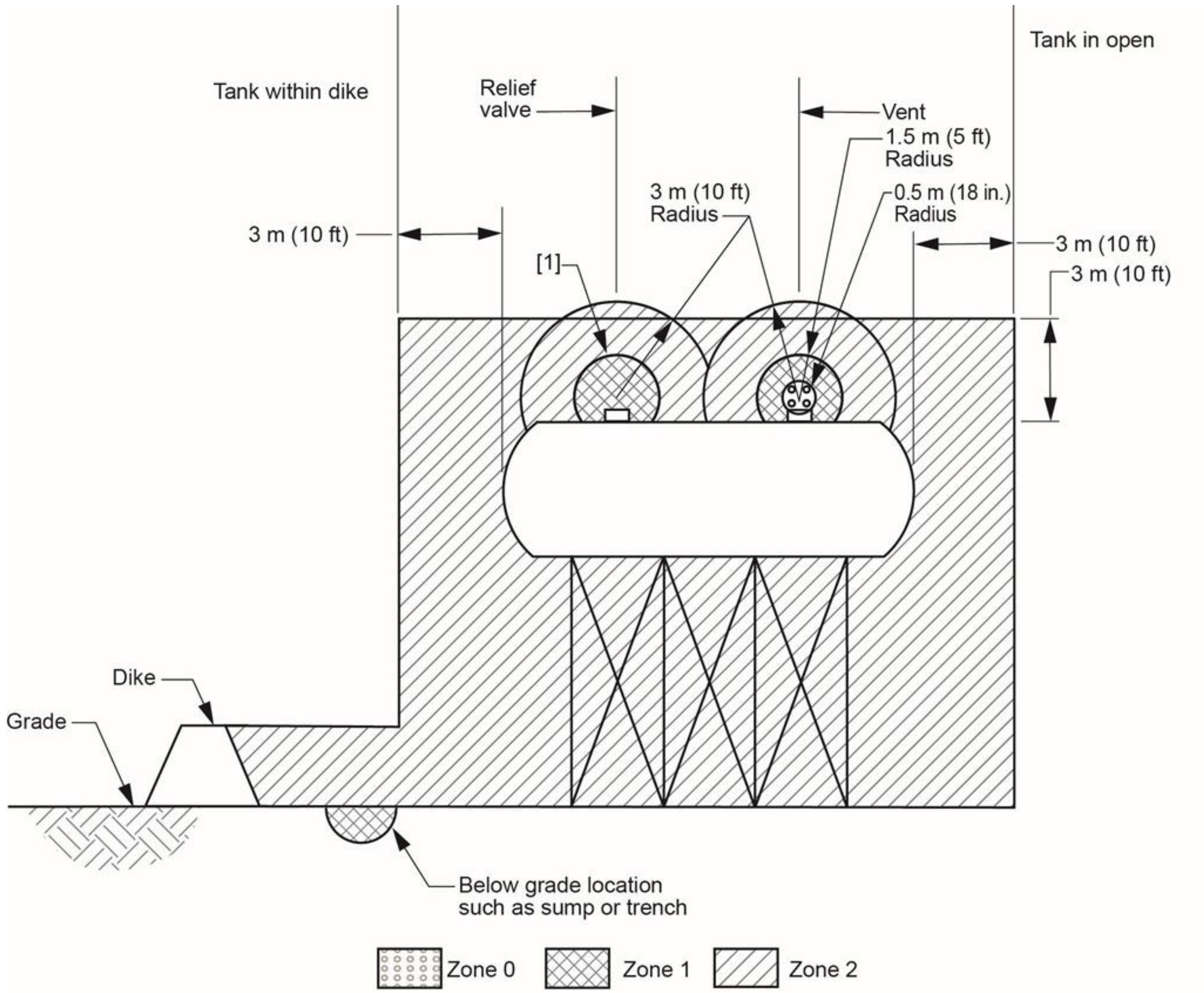
Figure 97—Adequately Ventilated Building—Piping with Valves, Screwed Fittings, Flanges, or Similar Accessories Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation, and Instrument-sized Pumps (See 13.3.2)



Level	Distance in m (ft) L	D
1. Liquid 1900 kPa (275 PSIG) or less	3 (10)	0.6 (2)
2. Liquid above 1900 kPa (275 PSIG)	3 (10)	0.6 (2)
3. HVL	6 (20)	0.6 (2)

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

Figure 98—Inadequately Ventilated Building—Piping with Valves, Screwed Fittings, Flanges, or Similar Accessories Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation, and Instrument-sized Pumps (See 13.3.2)



[1] Refer to 8.2.3.4 for additional guidance on area classification around relief valves.

Figure 99—Elevated Storage Tank or Pressure Vessel (See 13.3.3)

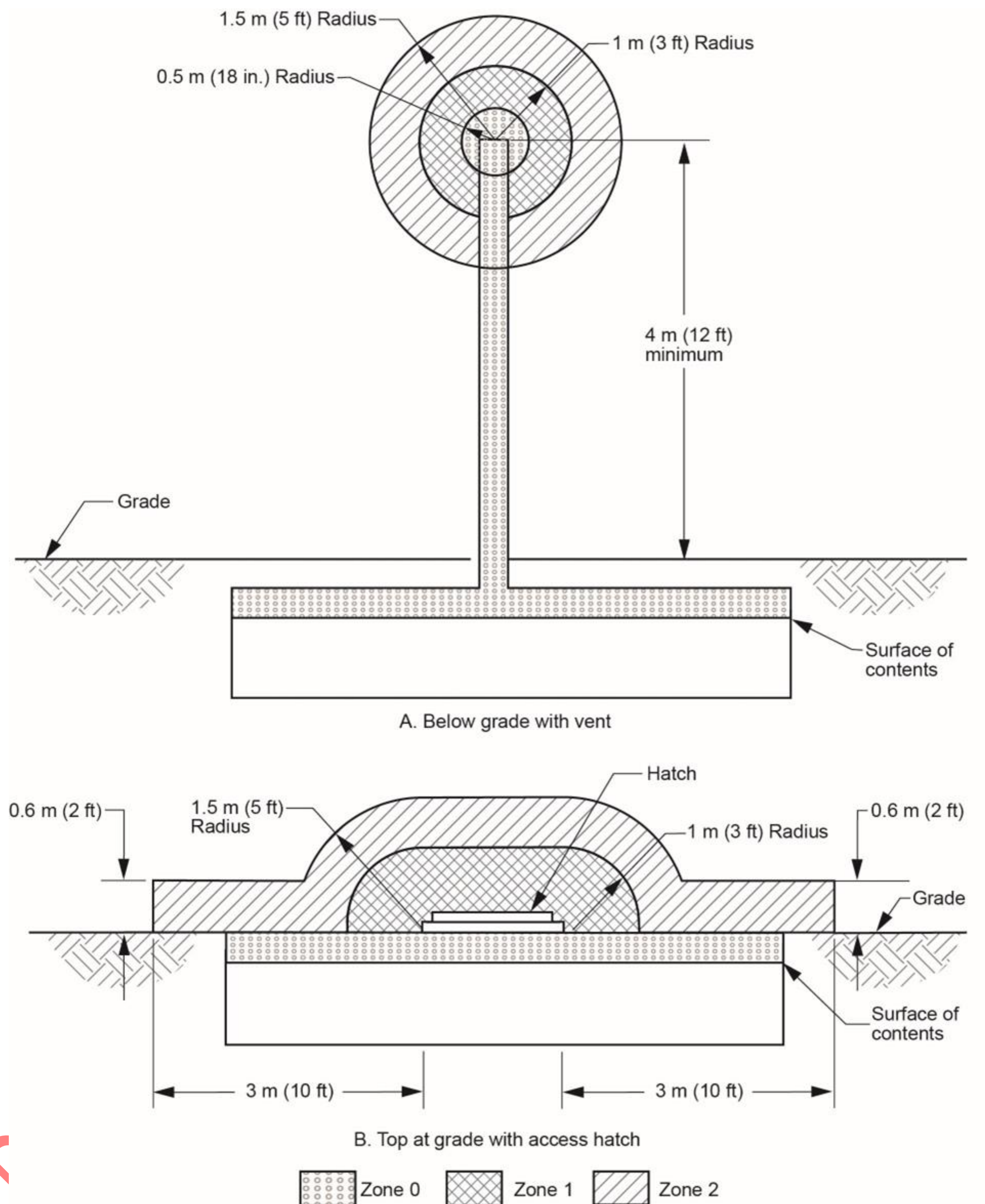
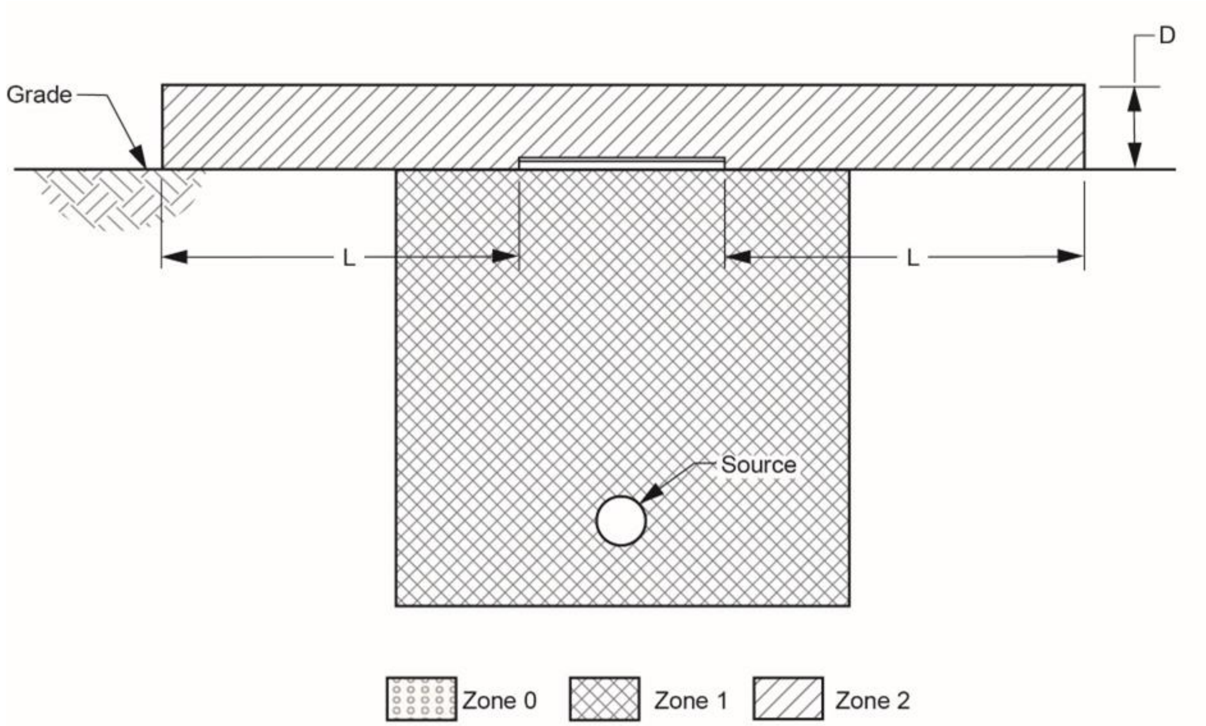
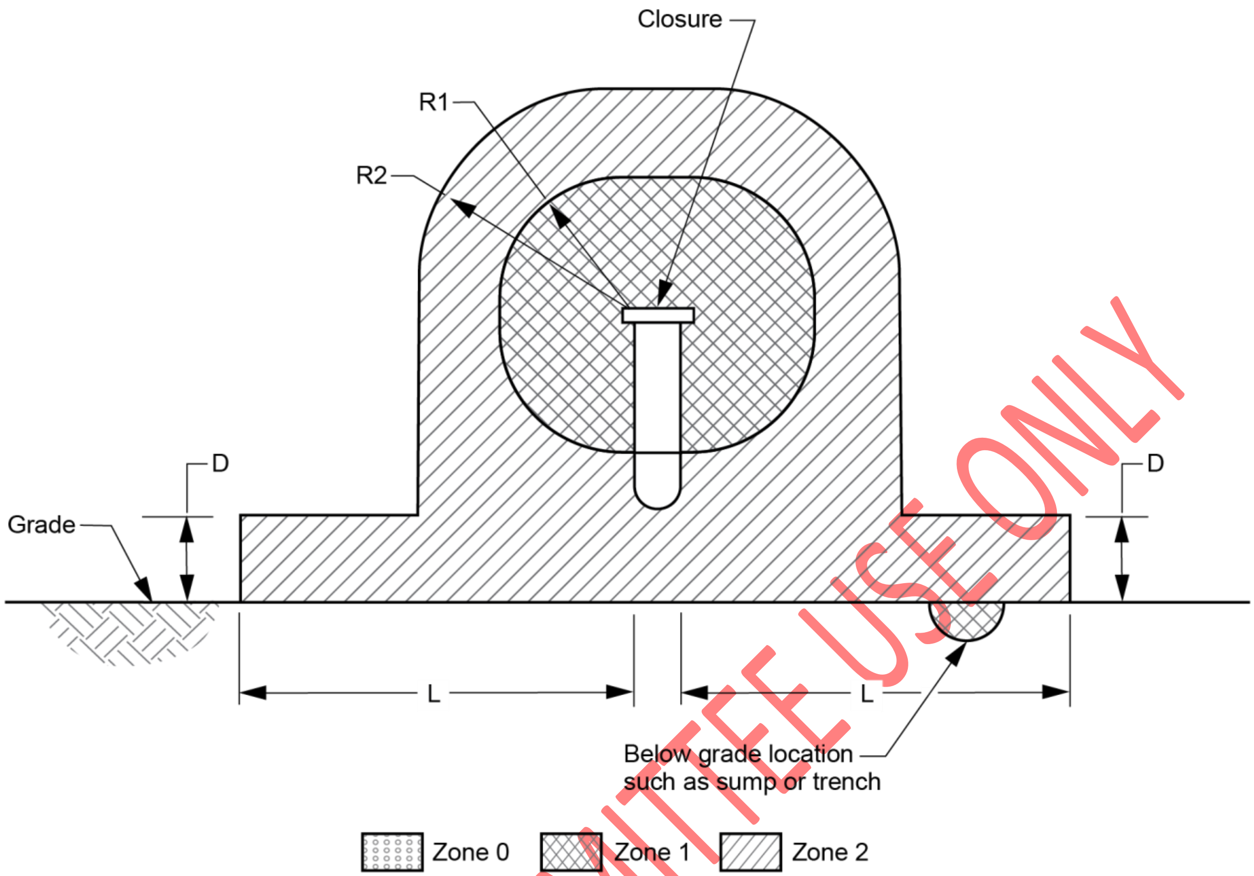


Figure 100—Below-grade Closed Sump Tank and Oil–water Separator (See 13.3.4)



Level	Distance in m (ft) L	Distance in m (ft) D
1. Liquid 1900 kPa (275 PSIG) or less	3 (10)	0.6 (2)
2. Liquid above 1900 kPa (275 PSIG)	3 (10)	0.6 (2)
3. HVL	6 (20)	0.6 (2)

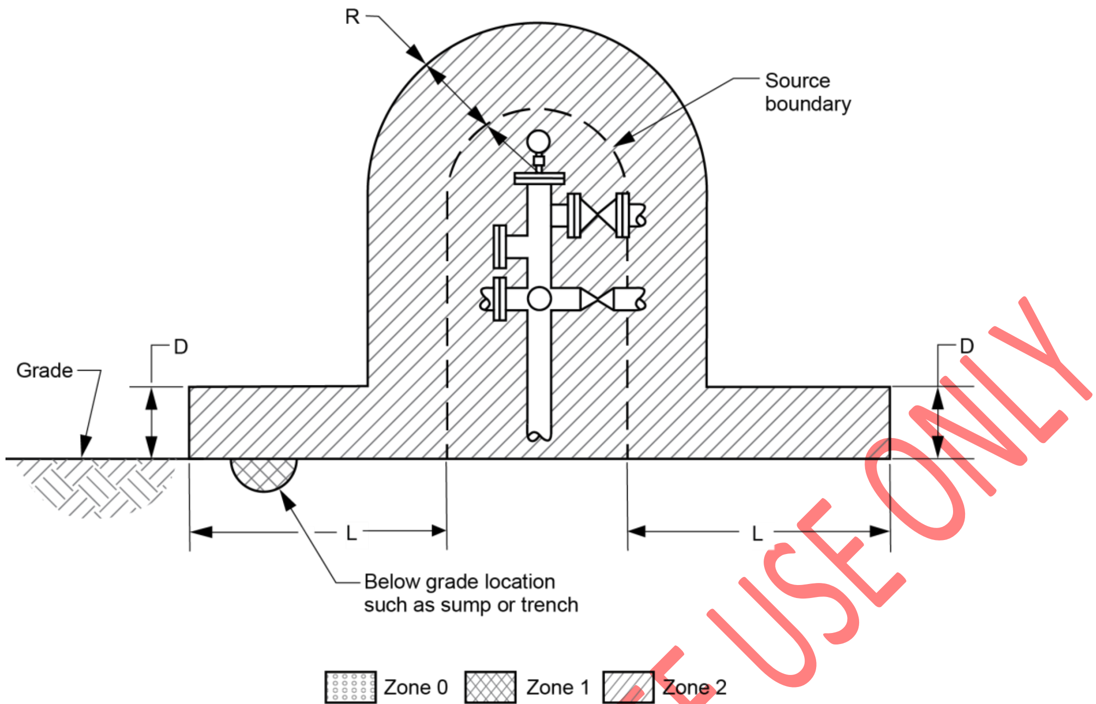
Figure 101—Below-grade Vault—Piping with Valves, Screwed Fittings, Flanges, or Similar Accessories Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation, and Instrument-sized Pumps
(See 13.3.5)



Level	L	R1	R2	D
	Distance in m (ft)			
1. Liquid 1900 kPa (275 PSIG) or less	3 (10)	1 (3)	1.5 (5)	0.6 (2)
2. Liquid above 1900 kPa (275 PSIG)	3 (10)	1 (3)	1.5 (5)	0.6 (2)
3. HVL	6 (20)	1.5 (5)	4.5 (15)	0.6 (2)

[1] Applicable to pig launchers and receivers, strainers, and other devices where flammable liquid or highly volatile liquid may be exposed to the atmosphere.

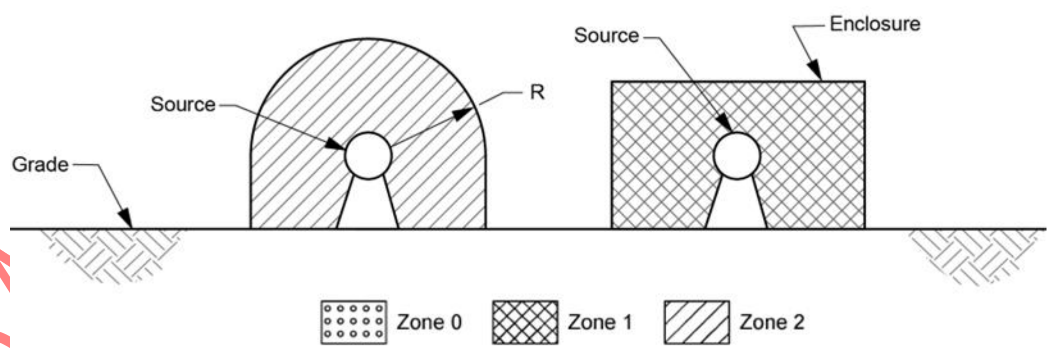
Figure 102—Above-grade Source with Closure Handling Flammable Liquids or Highly Volatile Liquids (See 13.3.6)



Level	Distance L	R	D
1. Liquid 1900 kPa (275 PSIG) or less	6 (20)	3 (10)	0.6 (2)
2. Liquid above 1900 kPa (275 PSIG)	6 (20)	3 (10)	0.6 (2)
3. HVL	15 (50)	7.5 (25)	0.6 (2)

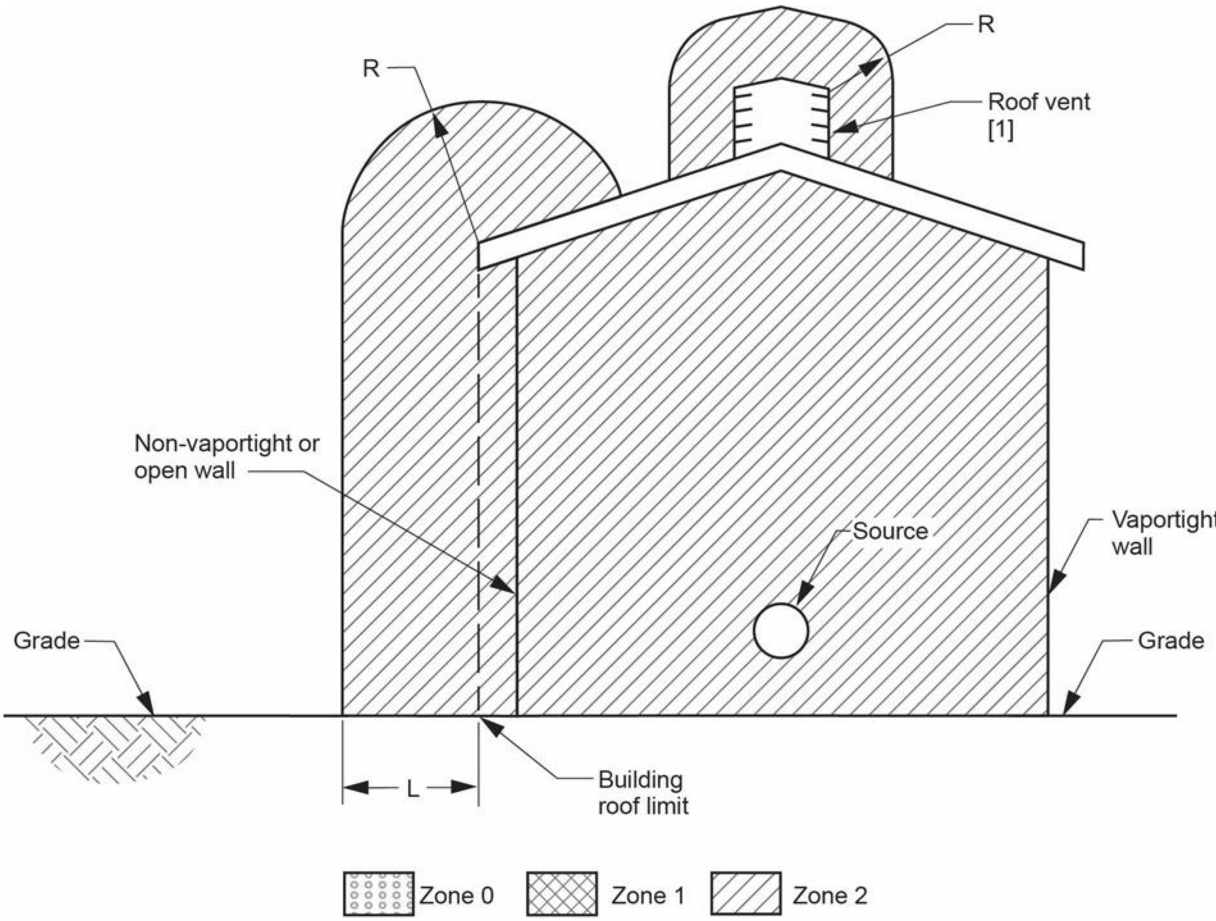
[1] Displacement medium should be treated as flammable liquid because of the entrained ingredients.

Figure 103—Storage Cavern Handling Flammable Liquids or Highly Volatile Liquids (See 13.3.7)



Level	Distance in m (ft) R
1. Gas 1900 kPa (275 PSIG) or less	3 (10)
2. Gas above 1900 kPa (275 PSIG)	7.5 (25)

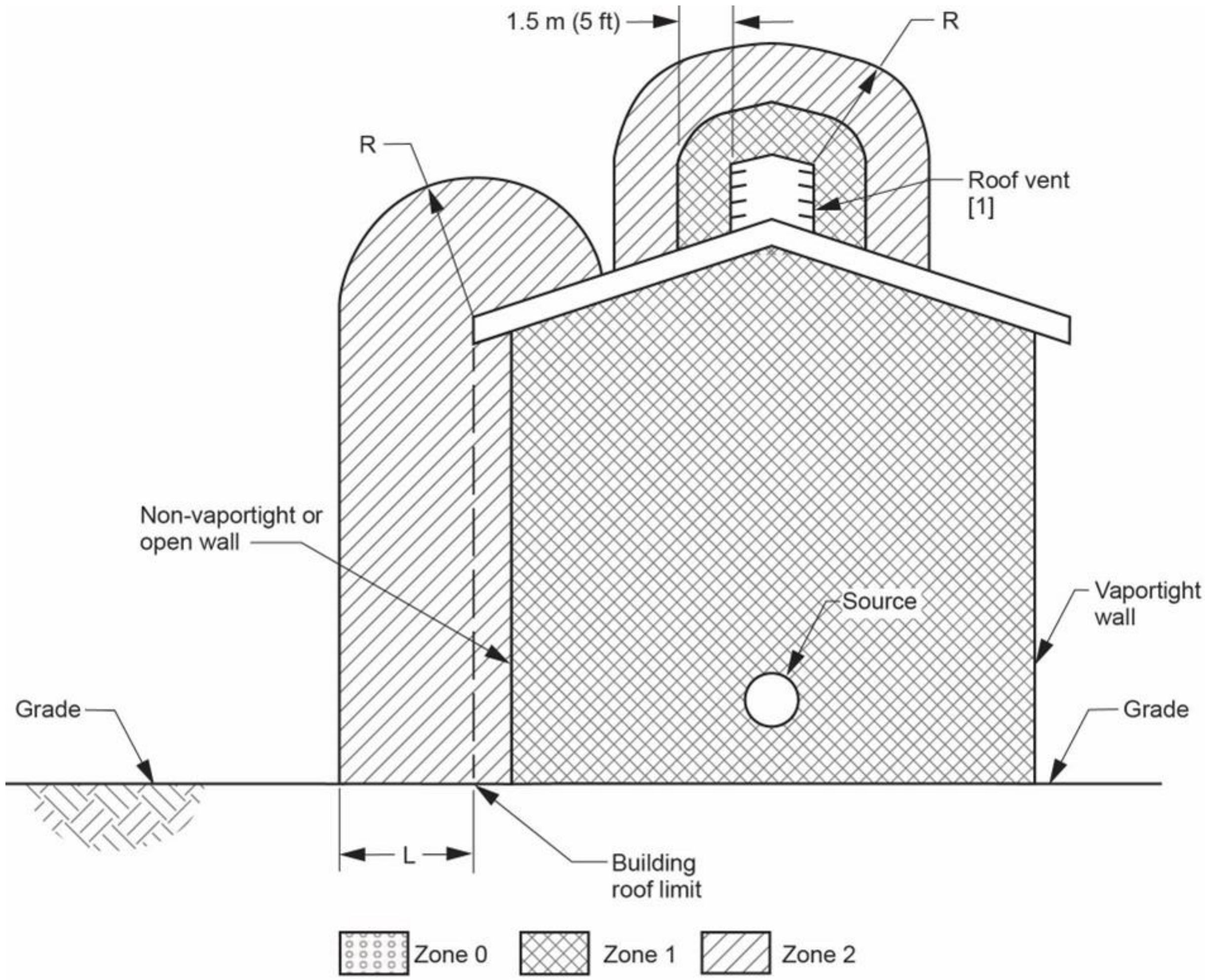
Figure 104—Outdoors—Compressors, Valves, Screwed Fittings, Flanges or Similar Devices Handling Lighter-Than-Air Flammable Gas (See 13.3.8)



Level	Distance in m (ft) L	R
1. Gas 1900 kPa (275 PSIG) or less	3 (10)	3 (10)
2. Gas above 1900 kPa (275 PSIG)	7.5 (25)	7.5 (25)

[1] The interior of the vent is classified Zone 2. Cross hatching has been omitted for drawing clarity.

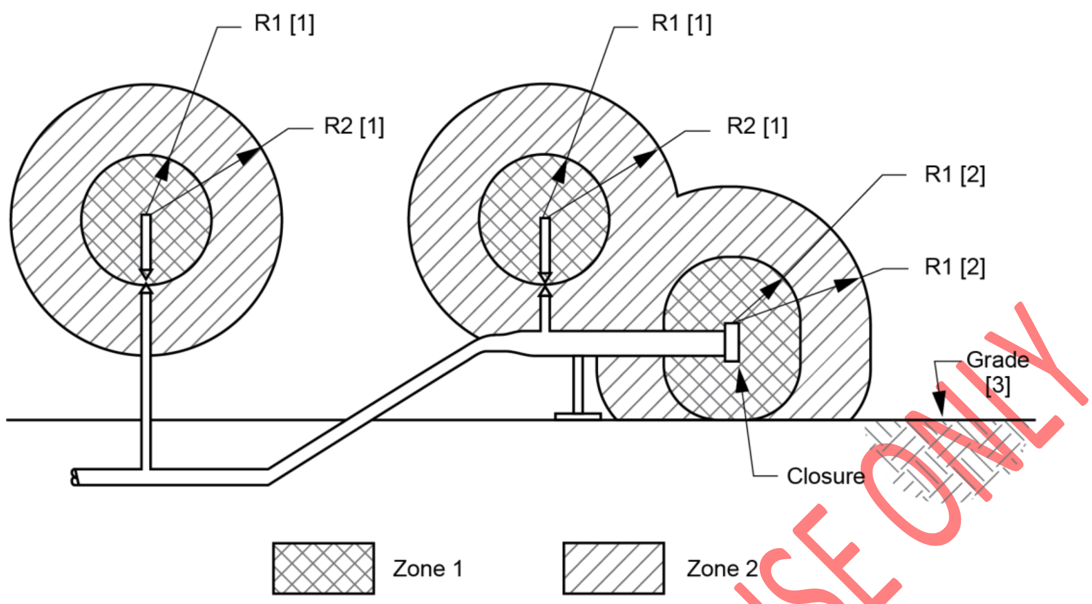
Figure 105—Adequately Ventilated Building—Compressors, Valves, Screwed Fittings, Flanges, or Similar Devices Handling Lighter-than-air Flammable Gas (See 13.3.8)



Level	Distance in m (ft) L	Distance in m (ft) R
1. Gas 1900 kPa (275 PSIG) or less	3 (10)	3 (10)
2. Gas above 1900 kPa (275 PSIG)	7.5 (25)	7.5 (25)

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

Figure 106—Inadequately Ventilated Building—Compressors, Valves, Screwed Fittings, Flanges, or Similar Devices Handling Lighter-than-air Flammable Gas (See 13.3.8)



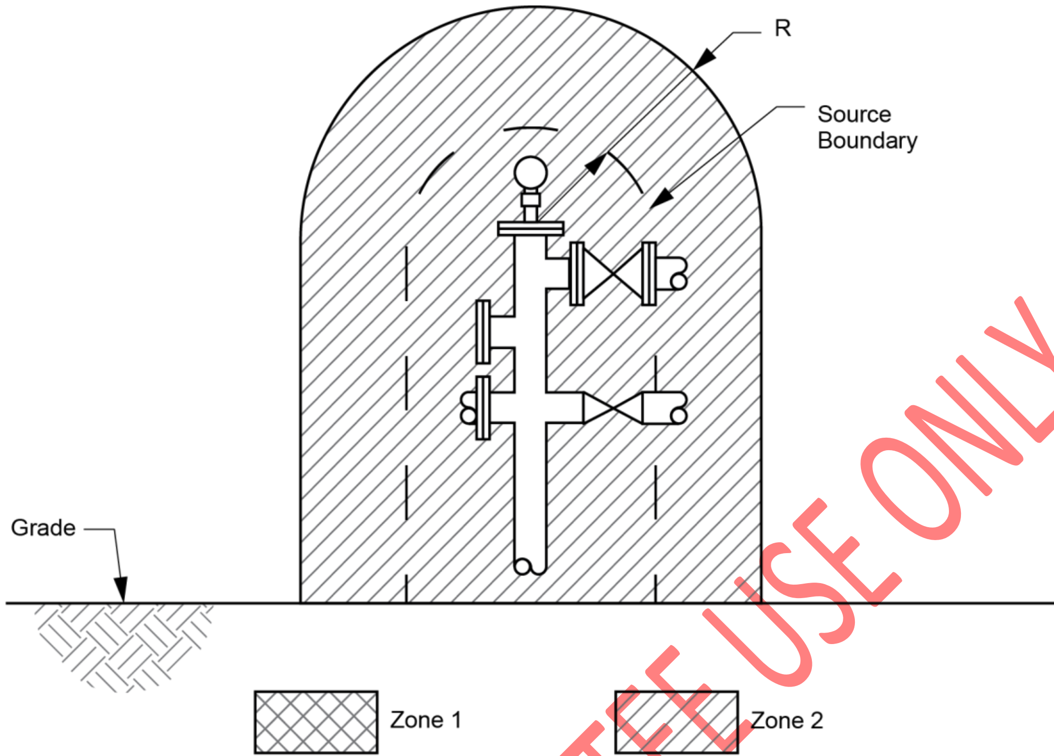
Level	Distance in meters (feet) R1	R2
1. Gas 1900 kPa (275 PSIG) or less	1.5 (5)	3 (10)
2. Gas above 1900 kPa (275 PSIG)	3 (10)	7.5 (25)

[1] Blowdown and drain valve vents should be classified the same as process equipment vents. Refer to Section 8.2.3.1 for additional guidance.

[2] Measured from edge of closure.

[3] Grade is for visual reference only. Physical height of launcher, receiver, and vents will vary with actual design.

Figure 107—Outdoors—Ball or Pig Launching or Receiving Installation Handling Lighter-than-air Flammable Gas (See 13.3.9)



Level	Distance in meters (feet) R
1. Gas 1900 kPa (275 PSIG) or less	3 (10)
2. Gas above 1900 kPa (275 PSIG)	7.5 (25)

Figure 108—Outdoors—Storage Cavern Handling Lighter-than-air Flammable Gas (See 13.3.10)

14 Recommendations for Determining Degree and Extent of Classified Locations at LNG Facilities

14.1 General

14.1.1 LNG is natural gas that has been cooled and condensed into a liquid. LNG contains about 85– 95 % methane and is colorless, odorless, non-corrosive, and non-toxic. Its flammability range is similar to methane, approximately 5-15 % concentration in air. Its autoignition temperature is approximately 540 °C (1004°F). Natural gas liquefies at a temperature below -73 °C (-100°F) at atmospheric pressure. LNG begins to vaporize near its boiling point temperature of -162 °C (-260°F) at atmospheric pressure.

14.1.2 LNG is often confused with liquefied petroleum gas (LPG), which in turn is often incorrectly identified as propane. LPG is a mixture of mainly propane and butane gases that exist in a liquid state at ambient temperatures when maintained under moderate pressure 1.5 MPa (217 psi). LPG's composition and physical properties result in its behavior to be substantially different than LNG.

14.1.3 LNG presents a unique hazard for area classification. At atmospheric pressure, LNG has a relative density of about 1.8, which means that when initially released, the LNG vapors are heavier than air and can remain near the ground and more likely to accumulate in low areas until the vapors warm. However, as the vapors begin to warm, they will rapidly achieve temperatures of approximately -110 °C (-166 °F). At these temperatures, the relative density of the LNG will become less than 1 and the vapors will become buoyant. At ambient temperatures, natural gas has a specific gravity of about 0.6, which results in vapors that are much lighter than air and will rise quickly. The rate of LNG vaporization can be measured in minutes or hours depending upon the quantity of LNG released, ambient weather conditions, and where the LNG is released (e.g., confined or unconfined, low or elevated area, on land or on water)

14.1.4 As LNG vaporizes, the cold vapors will condense the moisture in the air, often causing the formation of a white vapor cloud until the gas warms, dilutes, and disperses. For a relative humidity greater than 50 %, the flammable vapors are normally included in the visible vapor cloud. If the relative humidity is less than 50 %, the flammable vapors can be present outside of the visible cloud, which means that the vapors could be ignited even though the ignition source is distant from the visible vapor cloud.

14.1.5 The LNG manufacturing process requires several steps, including natural gas pretreatment (acid gas removal, dehydration, and mercury removal), liquefaction, refrigeration, and LNG handling (storage, loading, and transportation). The typical flow diagram for a LNG facility is illustrated in Figure 109.

NOTE The manufacturing of LNG includes processes resembling facilities covered in other sections of this recommended practice and facilities covered by other standards. Generally, the area classification of these facilities follow the methodology described below:

a) Pre-treatment facilities—Section 10 (Production).

b) Boil-off gas and liquids removal—Section 9 (Refining).

c) Refrigeration—Section 9 (HVL extension).

d) Liquefaction, storage, and containment—NFPA 59A and Section 14

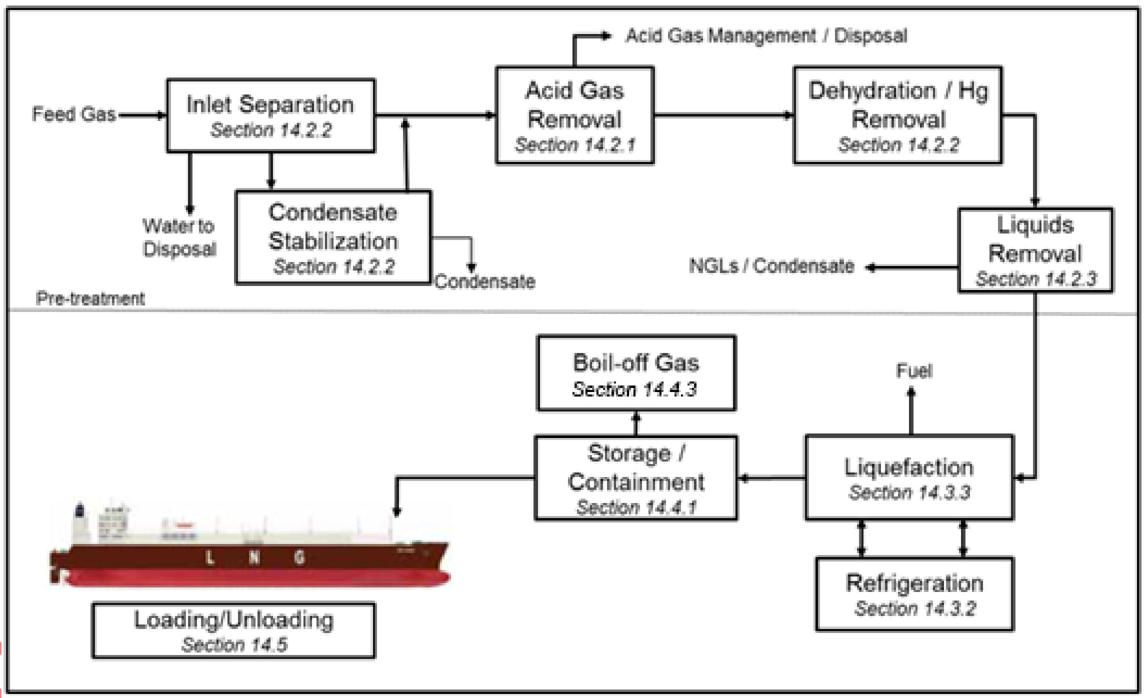


Figure 109—LNG Facility Process Flow Diagram (typical) (see 14.1.5)

14.2 Pretreatment Facilities

14.2.1 When a feed gas stream enters an LNG facility, it is not always suitable for immediate liquefaction. The gas often requires some amount of pretreatment to remove undesirable content, such as acid gas (CO2 and H2S), sulfur, and other contaminants (such as mercaptan or mercury). In some cases, the gas may also require separation and/or dehydration to strip out water and condensate.

14.2.2 Pretreatment processing in an LNG plant is often nearly identical to those processes in a refining or gas production facility. Areas of an LNG facility that are not directly involved in LNG cryogenic process (refrigeration, liquefaction storage, and loading) are classified per Section 10. These areas include inlet separation, acid gas removal, dehydration, and condensate stabilization (refer to 10.1, 10.6, and 10.9–10.17.

14.2.3 When the feed gas entering an LNG facility is considered "wet," hydrocarbon processing is typically required to remove natural gas liquids (NGLs) as illustrated in Figure 109. This liquid, referred to as condensate, is often made up of varying compositions of pentane, butane, ethane, propane, and aromatics like toluene, benzene, and xylene. Pentane, butane, ethane, and propane can be sold as products or used as refrigerants for the liquefaction process. Liquid and condensate handling facilities containing HVLs are classified per Section 9. See Figures 20, 21, and 22.

14.3 Refrigeration and Liquefaction

14.3.1 Liquefaction is the process of condensing natural gas into a liquid and cooling it to approximately -162 °C (-260 °F) for storage at near atmospheric pressure. This is accomplished by circulating the feed gas through multiple refrigeration cycles. Refrigerant gases are compressed, cooled, and circulated through cryogenic heat exchangers to condense the natural gas into a liquid (LNG).

14.3.2 Refrigeration systems can use highly volatile liquids (HVLs) as refrigerants. Section 5.3 provides additional information on the typical behavior of HVLs when released to atmosphere. Recommendations for determining the degree and extent of classified locations for specific examples of refrigeration systems are given in 14.3.2.1 through 14.3.2.5.

14.3.2.1 Locations in and around refrigerant loading facilities in non-enclosed, adequately ventilated areas are classified as shown in Figures 9 and 13. If refrigerants containing HVLs are handled, an extension of an additional 4.5 m (15 ft) as shown in Figures 9 and 13 shall be used.

14.3.2.2 Locations around refrigerant storage tanks in non-enclosed, adequately ventilated areas are classified as shown in Figure 110. If refrigerants containing HVLs are stored without spill containment, an extension of an additional 15 m (50 ft) shall be used, as shown in Figure 110.

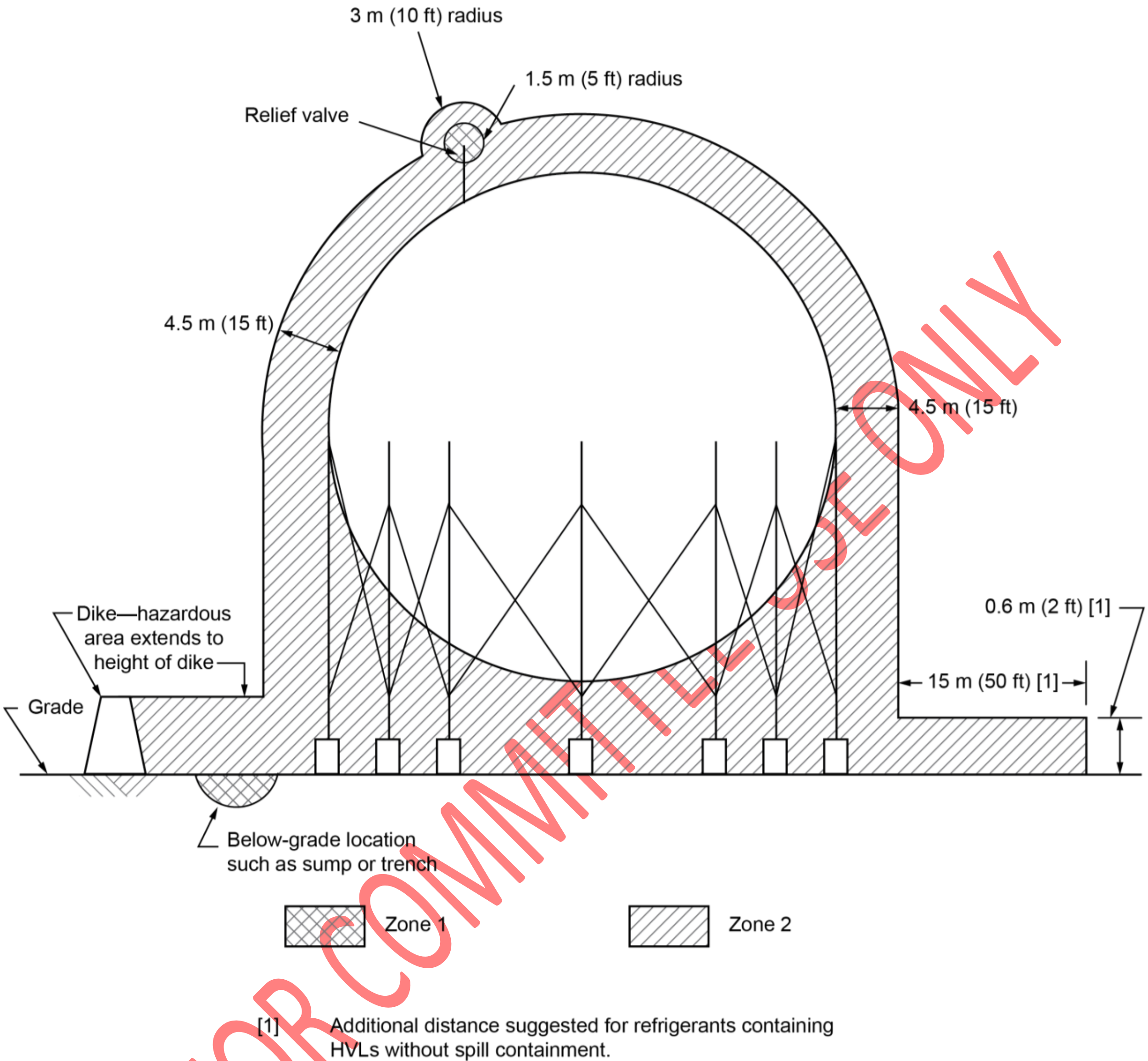


Figure 110—LNG Refrigerant Storage Tank in a Non-enclosed, Adequately Ventilated Area (See 14.3.2.2)

14.3.2.3 Locations around refrigerant compressors and pumps in non-enclosed, adequately ventilated areas are classified as shown in Figures 20 and 21. Locations around refrigerant compressors and pumps in inadequately ventilated areas are classified as shown in Figure 22. If refrigerants contain HVLs, the additional 15 m (50 ft) for HVLs shall be used, as shown in Figures 20, 21, and 22.

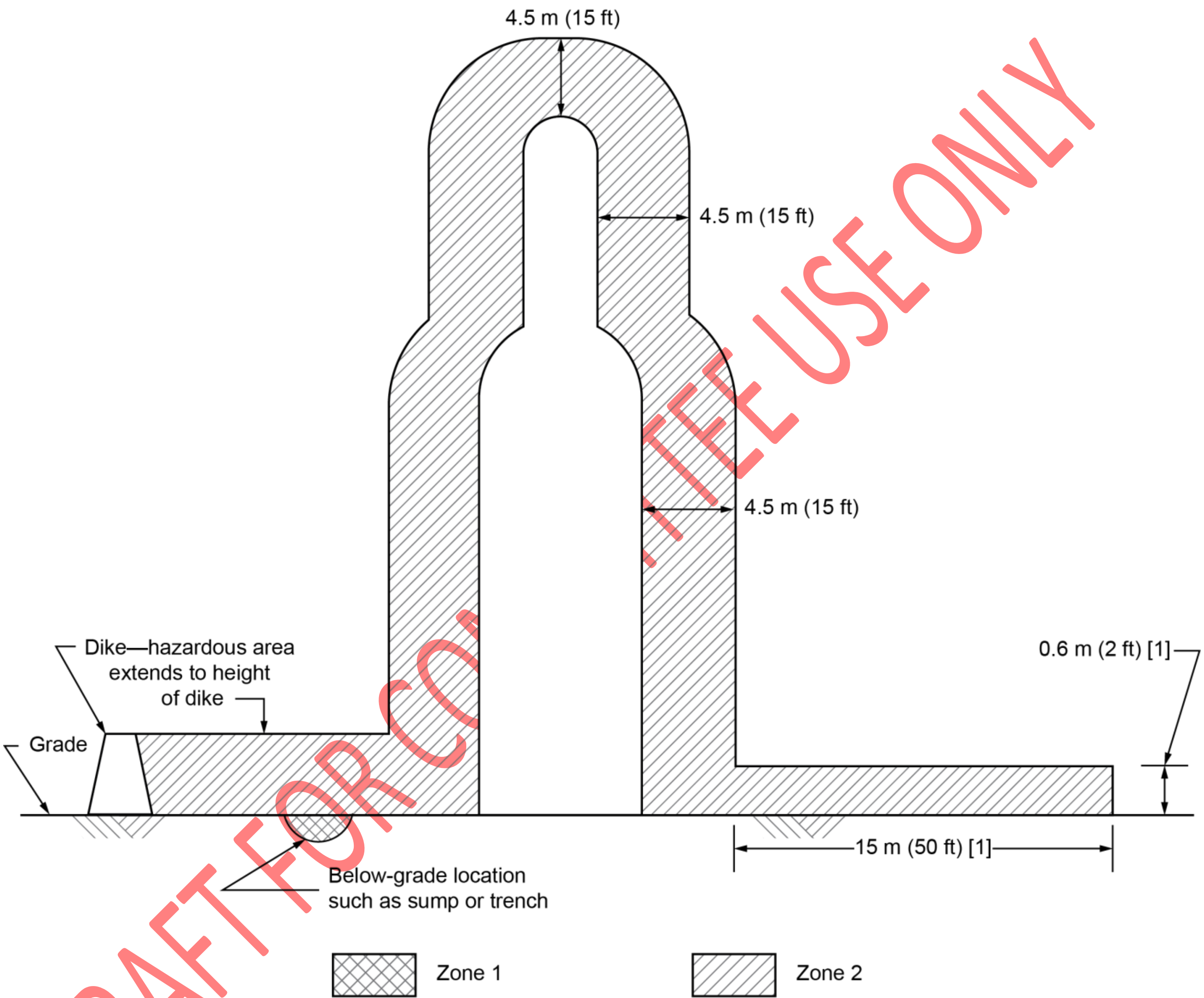
14.3.2.4 Locations around valves with refrigerants with and without HVLs shall be classified in accordance with 9.2.6.

14.3.2.5 The area around a non-enclosed header or manifold handling heavier- or lighter-than-air refrigerants located in an adequately ventilated area is classified Zone 2 for a distance of 3 m (10 ft) from the outside surface of the manifold assembly. If refrigerants contain HVLs, an additional 6 m (20 ft) to a 0.6 m (2 ft) elevation from grade shall be used.

14.3.3 Liquefaction (Cryogenic)

14.3.3.1 Liquefaction facilities can contain natural gas, LNG, and refrigeration process streams. The area classification is dependent on these streams, as well as ventilation and ambient conditions.

14.3.3.2 For cryogenic heat exchangers, natural gas and LNG process streams within the exchangers in non-enclosed, adequately ventilated areas are classified as Zone 2 with a 4.5 m (15 ft) boundary around the exchanger. If refrigerants containing HVLs are handled within an exchanger, the additional 15 m (50 ft) Zone 2 boundary at 0.6 m (2 ft) above grade is required. Distances given should be used with consideration given to single or staged cryogenic heat exchangers. In some instances, greater or lesser distances may be justified. Classification is as shown in Figure 111.



[1] Additional distance suggested where HVLs/LNG are handled within an exchanger.

Figure 111—Adequately Ventilated Cryogenic Heat Exchanger (See 14.3.3.2)

14.3.3.3 The location around a pump handling LNG in a non-enclosed, adequately ventilated area is classified as Zone 2 for a radius of 4.5 m (15 ft). Classification is as shown in Figure 112.

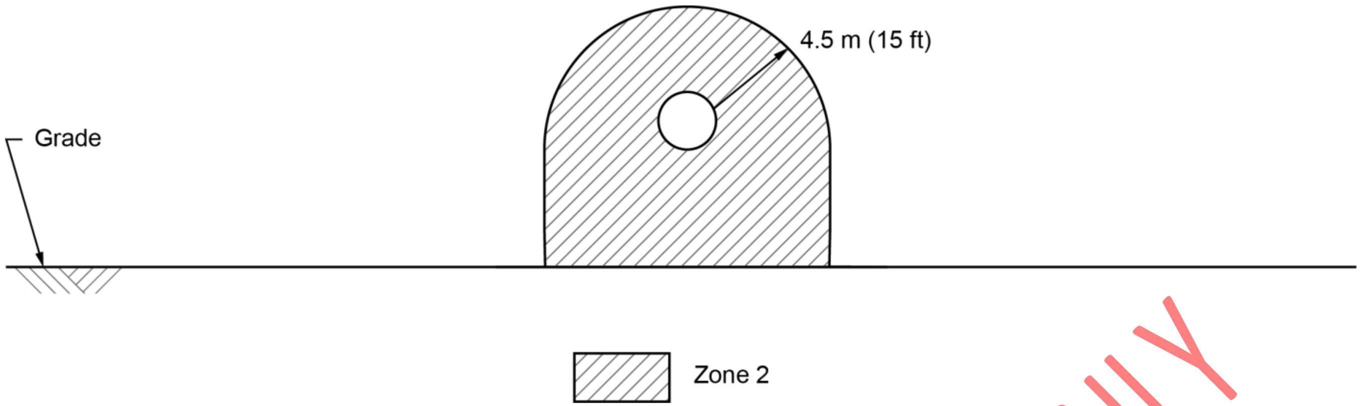


Figure 112—Pumps Handling LNG in Non-enclosed, Adequately Ventilated Areas (See 14.3.3.3

14.3.3.4 Manifolds handling LNG located in a non-enclosed, adequately ventilated area are classified Zone 2 for a distance of 4.5 m (15 ft) from the outside surface of the manifold assembly.

14.3.3.5 Individual valves, flanges, and fittings handling LNG located in a non-enclosed, adequately ventilated area are classified Zone 2 for a distance of 1 m (3 ft) and to grade.

14.3.3.6 Troughs and drip pans located in a non-enclosed, adequately ventilated area providing secondary containment of LNG are classified Zone 2 to the extent of the trough or drip pan. Troughs handling refrigerant containing HVLs in non-enclosed, adequately ventilated areas are classified Zone 2 to the extent of the trough with the additional 0.5 m (18 in.) Zone 2 area extending from the top and from the top of the sides of the trough.

14.3.3.7 Sumps collecting LNG that are located in a non-enclosed, adequately ventilated area are classified Zone 2 4.5 m (15 ft) above and on either side of the sump.

14.3 LNG Storage Equipment and Containment

14.4.1 Single containment LNG storage tanks consist of a cryogenic inner container to hold the LNG, with an outer tank that is not designed to contain LNG in the event of an inner tank leak. Single containment LNG storage tanks typically require secondary containment provided by earthen dikes or concrete walls. See Figure 113 where the height of the dike or wall (H) is less than the distance to the tank (container) (x). See Figure 114 where the height of the dike or wall is greater than the distance to the tank (container).

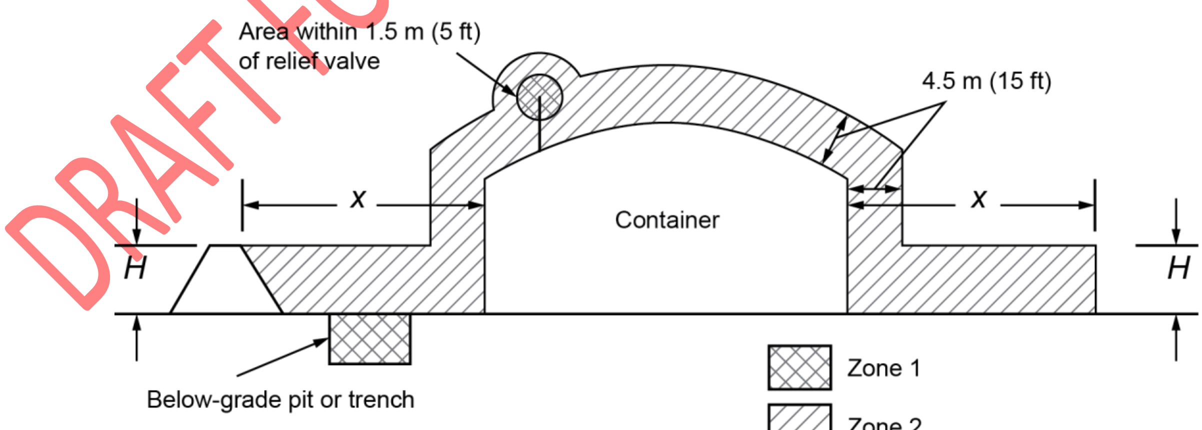


Figure 113—Above-ground, Single Containment LNG Storage Tank with Secondary Containment Provided by Earthen Dike or Concrete Wall (where H < x) (See 14.4.1)

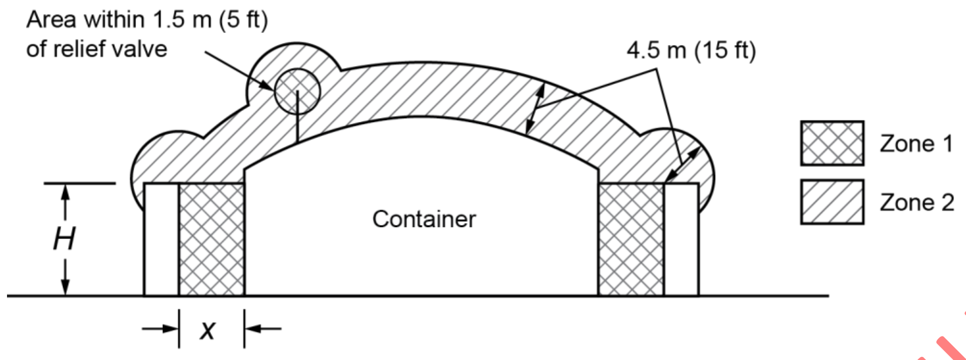


Figure 114—Above-ground, Single Containment LNG Storage Tank with Secondary Containment Provided by Earthen Dike or Concrete Wall (where H > x) (See 14.4.1)

14.4.2 Full containment LNG storage tanks consist of a self-standing cryogenic inner container to hold the LNG, surrounded by a self-standing reinforced concrete outer tank designed to contain cryogenic LNG in the event of an inner tank leak or rupture. The inner tank is also enclosed by a steel or concrete roof designed to contain natural gas vapors caused by a spill or leak. Full containment LNG storage tanks do not require additional earthen dikes or concrete walls for secondary containment (see Figure 115).

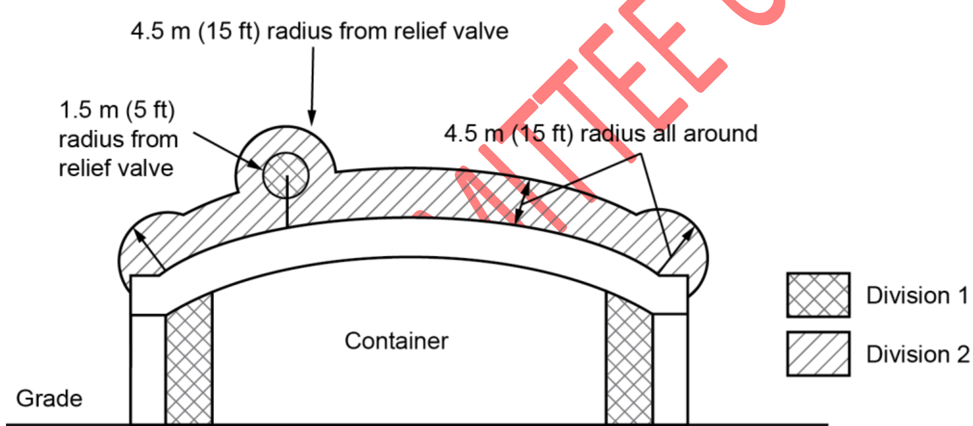


Figure 115—Above-ground, Full Containment LNG Storage Tank (See 14.4.2)

14.3.3 Boil-off Gas Handling

Vaporization of LNG in storage or during loading and unloading operations is known as "boil-off gas." Boil-off gas is typically collected and compressed in boil-off gas compressors and exported as natural gas, used as fuel for generation, or is re-liquefied and returned to storage. For boil-off gas compressor systems within adequately ventilated locations, refer to Figures 23 and 24. For inadequately ventilated location, refer to Figures 25 and 26.

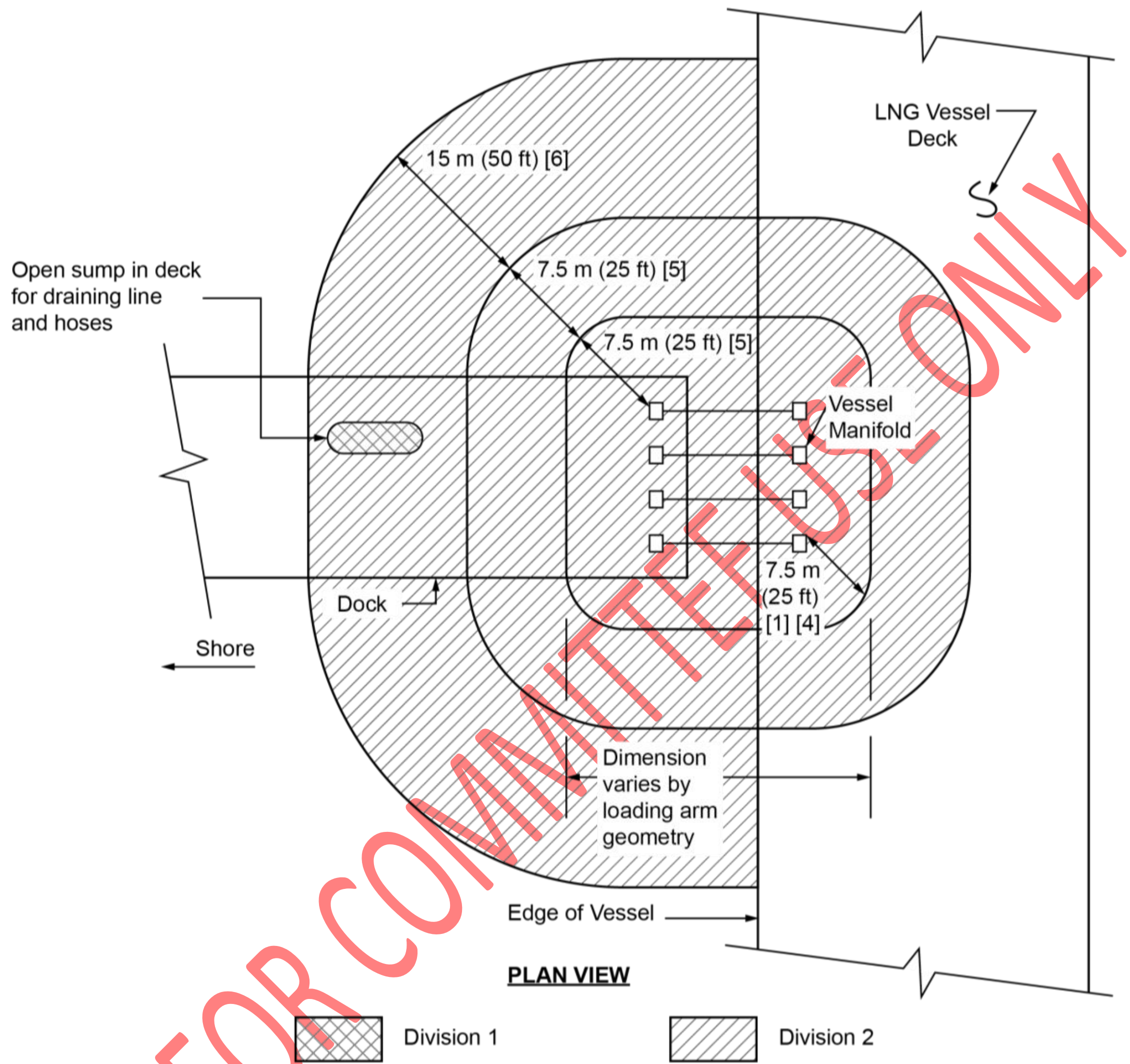
14.4 Loading/Unlaoding Facilities

14.4.1 Marine terminals handling LNG are classified as shown in Figure 19. For a multi-arm installation in a non-enclosed, adequately ventilated area serving the same tank or filling point on the marine vessel, the area between the arms is classified Zone 2. Classification is as shown in Figure 116.

14.4.2 Truck/rail loading: LNG loading facilities in non-enclosed, adequately ventilated areas are classified as shown in Figures 9 and 13.

14.4.3 Custody transfer: For automatic custody transfer (ACT) units where manifolds and valves are utilized, refer to 14.3.3.4 and 14.3.3.5. Areas around meters should be classified the same as valves; see 14.3.3.5. Non-enclosed, adequately ventilated locations around sample containers should be classified Zone 2 for a radius of 3 m (10 ft). Inadequately ventilated, enclosed locations should be classified Zone 1 to the extent of the enclosure.

14.4.4 Boil-off gas handling (recirculation/compression): Refer to 14.4.3.



[1] The operating envelope stored position of the outboard flange connection of the loading arm (or hose should be considered the "source of release".

[2] The berth area adjacent to tanker and barge cargo tanks is to be Division 2 to the following extent:
a. 7.5 meters (25 feet) horizontally in all directions on the pier side from that portion of the hull containing cargo tanks.
b. From the water level to 7.5 meters (25 feet) above the cargo tanks at the highest position.

[3] Additional locations may have to be classified as required by the presence of other sources of flammable liquids on the berth, or by the requirements of the Coast Guard or other authorities having jurisdiction.

[4] To elevation 7.5 m (25 ft) above the highest point of loading arm's operating envelope and down to water line.

[5] To elevation 7.5 m (25 ft) above highest point of loading arm's operating envelope, 7.5 m (25 ft) horizontally from outboard flange connection operating envelope, 7.5 m (25 ft) above dock, and down to water line.

[6] To elevation 0.6 m (2 ft) above dock and down to water line.

Figure 116—Marine Terminal Handling LNG (See 14.5.1 and Figure 19)

Annex A
(informative)

Sample Calculation to Achieve Adequate Ventilation of an Enclosed Area by Natural Means Using Equation 1 and Equation 2

A.1 General

The inside dimensions of a building are given as 6 ft 0 in. wide × 8 ft 0 in. long × 7 ft 6 in. high.

$$V = \text{width} \times \text{length} \times \text{height}$$

$$V = 6 \times 8 \times 7.5 = 360 \text{ ft}^3$$

Assume values of T_i and T_o as follows:

$$T_i = 80\ °\text{F} = 540\ °\text{R}$$

$$T_o = 70\ °\text{F} = 530\ °\text{R}$$

The vertical center-to-center distance (H) between A_1 and A_2 is 6 ft, and $A_1 = A_2$.

Using Equation 2 from Section 6.6:

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

$$h = \frac{6}{1 + 540/530}$$

$$h = 2.97\ ft$$

Using Equation 1 from Section 6.6:

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

$$A = \frac{360}{1200\sqrt{2.97(10)/540}}$$

$$A = 1.28\ ft^2$$

$$A = 1.28\ ft^2 (184.2\ in.^2)$$
for both inlet and outlet

A.2 Number of Louver Panels Required

If each louver panel provides 200 in.^{2} of free area, the number of louver panels required is:

$$\frac{184.2 \text{ in.}^2}{200 \text{ in.}^2/\text{louver panel}} = 0.92 \text{ louver panel required for both inlet and outlet.}$$

A.3 Required Ventilation

Required ventilation can be provided by one louver panel of 200 in.^{2} each for inlet and outlet, for a total of 400 in.^{2} of ventilation area.

Annex B
(informative)

Calculation of Minimum Air Introduction Rate to Achieve Adequate Ventilation Using Fugitive Emissions

B.1 General

An alternative method of providing adequate ventilation for an enclosed area is to make a reasonable estimate of fugitive emissions from hydrocarbon-handling equipment within the enclosed area and provide sufficient diluent ventilation. This method was adopted by NFPA 30 (2003). Application of this method requires certain calculations, and one technique is described below. In calculating the ventilation rate required, the anticipated hydrocarbon leakage rate (under normal operations) should be determined. Sufficient dilution air should then be added to the space in question to ensure that the concentration of flammable vapor or gas is maintained below 25 % of the lower flammable limit (LFL) for all but periods of process upset, abnormal equipment operation, rupture, or breakdown.

Fugitive emission factors for specific hydrocarbon handling equipment can be obtained from emission testing at specific facilities or existing publications. Existing publications include API 4589 *Fugitive Hydrocarbon Emissions from Oil and Gas Operations*, 1993, and API 4615, *Emission Factors for Oil and Gas Production Operations*, 1995. All emission data used should be reviewed to assure emission rates are representative of actual conditions during normal operations.

B.2 Recommended Calculation Technique

In the example below, the required ventilation rate will be determined for an enclosed area (60 ft $W \times$ 120 ft $L \times$ 40 ft H) on an offshore platform containing production equipment. In addition to an offshore oil and gas production platform, four other types of petroleum production facilities could have been considered for this example. These facilities are defined within API 4589 and include onshore light crude production sites, onshore heavy crude production sites, onshore gas production sites, and onshore gas processing plants. This process used to determine the total hydrocarbon emissions in API 4589 is Method One. More sophisticated methods are described in API 4589.

1) Select the appropriate table in Section 3 of API 4589 for the specific facility to determine the total anticipated fugitive emissions.

2) Refer to Executive Summary API 4589 to list the total applicable hydrocarbon-handling components and their anticipated total hydrocarbon fugitive emissions. These components along with their respective hydrocarbon fugitive emissions should be listed in a table.

3) The total number of specific components handling hydrocarbons should be obtained by an actual field count for existing equipment or from the design drawings for proposed equipment. Because all offshore operations (both oil and gas production) were included in one category within API 4589, the components handling gas will not be separated from those handling other hydrocarbons (primarily crude oil or condensate).

4) Determine the total anticipated emission (pounds/day) from the oil and gas streams for each component by multiplying the number of components by the applicable prediction factor. This product is the total emissions from the oil and gas streams anticipated for that specific type component.

5) Add the total anticipated emissions (pounds/day) from the oil and gas stream for all components to obtain the total emission rate.

6) Convert the total hydrocarbon emissions from pounds/day to pounds/hour. For the example chosen, assume that the total anticipated hydrocarbon emissions are 297.26 lb/day. Dividing by 24, the conversion yields 12.39 lb/hour.

7) Calculate the average mole weight of the hydrocarbon emissions. An example follows.

83 %	methane (Molecular Weight = 16)	0.83×16	=	13.28
13 %	ethane (Molecular Weight = 30)	0.13×30	=	3.90
4 %	butane (Molecular Weight = 58)	0.04×58	=	2.32
100 %		Total	=	19.50

To simplify further calculations, the 19.5 is rounded to 20, and 20 is used as the average mole weight of the hydrocarbon emissions mixture.

Calculate the cubic feet/pound-mole at the estimated ambient temperature of the area. This calculation is made utilizing the fact that the volume of one pound-mole of an ideal gas is 359 ft^3 at standard temperature and pressure (32 °F and 14.7 psia).

From the Gas Law ($PV = nRT$) and Charles' Gas Law ($V1\ T2 = V2\ T1$), gas volume at constant pressure varies proportionately to the ratio of temperatures when the temperature is expressed in degrees Rankin (°F + 460).

Assuming an ambient temperature of 88 °F, an example follows.

At 88 °F and 14.7 psia, 359 ft^3 of ideal gas would occupy

(359) (460 + 88) / (460 + 32), or 400 ft^3

8) Determine the total hydrocarbon leak rate in cubic feet per minute (cfm) using the equation:

$$G = (E)(V) / (60)\ (mw) \tag{B.1}$$

where

G is the leak rate in cf;

E is the emission rate in lb/hour;

V is the volume in ft^3/lb-mole;

mw is the average mole weight;

60 is the minutes/hour.

As an example, if E = 12.39 lb/hr and the average mole weight is 20:

G = (12.39 lb/hr) (400 ft^3/lb-mole) / (60 min/hr) (20)

G = 4.13 cfm

9) As per NFPA 69, *Explosion Prevention System*, the hydrocarbon concentration may be expressed by the following equation:

$$C = (G/Q)\,(1\text{-}e\text{-}kn) \tag{B.2}$$

where

C is the concentration of hydrocarbon in air in percent (expressed in decimal format);

G is the leak rate in cfm;

Q is the fresh air introduction rate in cfm;

n is the number of air changes.

It follows that $Q = G/C$ after steady state conditions, as the term ($1\text{-}e\text{-}kn$) approaches one (1).

As an example, if the leakage rate is assumed to be 4.13 cfm, 100 % LFL methane is assumed (0.05 concentration), and it is desired to maintain a 25 % LFL mixture, the required fresh air introduction rate may be determined as follows.

$$Q = 4.13 \text{ cfm} / (0.25 \times 0.05)$$

$$Q = 330 \text{ cfm}$$

10) Using a safety factor of four (4), the required ventilation rate is determined as follows.

$$Q = 330 \text{ cfm} \times 4$$

$$Q = 1320 \text{ cfm, the minimum ventilation rate}$$

Thus, minimum ventilation to achieve adequate ventilation for an enclosed area of the size given, above which contains the fugitive emission sources assumed is 1320 cfm.

NOTE Depending on the size of the enclosed area and the equipment configuration, supplemental internal recirculation may be advisable to avoid inversion layers or stagnant areas.

The above procedure is adapted from *Module Ventilation Rates Quantified, Oil and Gas Journal*, W. E. Gale, December 23, 1985, p. 41.

Annex C
(informative)

Ventilation Criteria Development

This annex provides information on the evolution of the definition of “adequate ventilation”.

Prior to 1990, NFPA 30 defined “adequate ventilation" as that degree of air movement to maintain the vapor-air mixture below 25 % of the LFL of the mixture. The NFPA 30 description required this criterion to be accomplished by ventilating an enclosed area at a rate of at least one cubic foot per minute for each square foot of solid floor area. This ventilation rate imposed severe requirements for many enclosed areas, especially in cold weather.

During its work in the mid-1980s, the API 500B task group originated a definition of limited “ventilation" in the third edition of API 500B. This was meant to bridge the gap between the somewhat rigid requirement for adequate ventilation given in NFPA 30 and inadequate ventilation. The limited-ventilation concept embraced the “fugitive emissions" method of calculation that is referenced in 6.6.2.4.7 and further detailed with example calculations in Annex B of this recommended practice.

In the API 500B task group work, defining the “dividing line" between inadequate ventilation and limited ventilation was difficult. It was agreed that using API-collected data related to fugitive emissions from various production equipment/devices, a typical producing facility could be analyzed for total fugitive emissions anticipated during normal operations. The amount of air needed to prevent gas accumulations from exceeding 25 % LFL, after steady state conditions were reached, could then be determined. It was decided that if a safety factor of four was applied, the minimum air change rate calculated could be used to satisfy “limited ventilation,”, and the term “limited ventilation” was deleted.

During the technical committee review of proposed changes for the 1990 edition of NFPA 30, a proposal was made to make the requirements for ventilation more quantitative. The approved requirements in the 1990 edition of NFPA 30 permitted two methods for assuring adequate ventilation: (1) calculations by the fugitive emissions method, and (2) sampling the actual vapor concentration under normal operating conditions. An acceptable alternative was to provide ventilation at a rate of not less than one cubic foot per minute for each square foot of solid floor area. In the current edition of NFPA 30 (2024), the definition of ventilation is: "As specified in this code, movement of air that is provided for the prevention of fire and explosion." According to NFPA 30-2024, Section 17.11.2 and 17.11.3:

Ventilation requirements shall be confirmed by one of the following procedures:

1) Calculations based on the anticipated fugitive emissions (see Annex H of NFPA 30 for calculation methods).

2) Sampling of the actual vapor concentration under normal operating conditions.

   — The sampling shall be conducted at a distance of 1.5 m (5 ft) radius from each potential vapor source extending to or toward the bottom and the top of the enclosed processing area. The vapor concentration used to determine the required ventilation rate shall be the highest measured concentration during the sampling procedure.

3) Ventilation at a rate of not less than 0.3 m^3/min of exhaust air for each m^2 of solid floor area (1 cfm/ft^2).

The method in Annex B results in a safety factor of 16 that includes the inherent safety factor of 4 (since the maximum vapor-air concentration permitted is 25% of the LFL}. In many cases, this permits an area to be classified Zone 2 instead of Zone 1. However, an enclosed area cannot be designated unclassified if it contains process, storage, transfer, or similar equipment handling flammable gases or vapors. These areas carry at least a Zone 2 classification, except as identified in 6.3.1.2.

ANSI/ISA 60079-10-1 uses a different approach to area classification and assumptions on various criteria including ventilation. Utilizing the ANSI/ISA 60079-10-1 method should be applied in its entirety and should not be mixed with this RP.

API RP 505 establishes ventilation criteria based on “adequate” and “inadequate” as defined in this document. This simplified approach continues to be an effective area classification methodology.

Annex D
(informative)

An Alternate Method for Area Classification

D.1 Introduction

This section presents an alternate method for classifying non-enclosed adequately ventilated locations in petroleum facilities.

D.2 Explanation of "Point Source" Concept

D.2.1 Developing area classification boundaries using the "Point Source" concept involves creating the classified area boundaries for all individual potential sources and then superimposing all of the boundaries created by the individual point sources to develop a composite classified area boundary for all sources combined. Usually the composite boundary is simplified and extended beyond that defined by each individual point.

D.2.2 The recommendations presented below provide a means to evaluate the extent of classified areas in non-enclosed, adequately ventilated locations based on the nature of potential flammable releases. These means recognize that as the quantity of potential sources is reduced, the extent of classified areas tends to be reduced. Also, other factors such as the volatility of the released materials, the quantity of the release, weather, nature of the release, and the velocity of the material released can have an influence on the boundaries of classified areas. This alternative method presents area classification schemes that consider volatility and release rates.

D.2.3 The concept of "Hazard Radius" is introduced. The concept of hazard radius is a function of two parameters: the volatility of the material being released and the rate of release of the material. For less volatile materials with low release rates, the hazard radius is quite small. For more volatile materials with a low release rate, or for less volatile materials with a high release rate, the hazard radius is "midrange". For a highly volatile material released at a high rate, the hazard radius is large. The velocity of the release has a significant influence on the hazard radius. High velocity releases, normally considered as releases over 15.2 m/sec (50 ft/sec), often result in misting of the material. Misting, coupled with moderate winds, can result in relatively large hazard radii. In a similar manner, low velocity releases, normally considered as releases less than 3.0 m/sec (10 ft/sec), are not normally influenced by weather conditions, and the hazard radius may be relatively small. As an example, gasoline released through a fine nozzle at a rate of 18.9 liters (5 gallons) per minute in a 4.8 km/hr (3 mph) wind results in rather large vapor cloud. However, gasoline poured slowly from a container at a rate of 18.9 liters (5 gallons) per minute has a very limited vapor cloud, somewhat independent of the wind velocity. Misting, vapor release rates, velocities of, vapor releases, and volatility are all important factors to consider when developing area classification boundaries.

D.3 Determination of Volatility Category

D.3.1 The flammability of various liquids, vapors, and gases is well documented (e.g. NFPA 30, *Flammable and Combustible Liquids Code*). The volatility of a material can have a significant impact on area classification. Figure D.1 is a chart used to determine the relative volatility of a material based on fluid process temperature and fluid vapor pressure. The basic concept for this approach is derived from the Institute of Petroleum publication IP-15 (first edition), *Area Classification Code for Petroleum Installations*, Appendix B. The data relating to the flammability of specific materials is based primarily on various NFPA documents.

D.3.2 This process groups all flammable liquids, vapors, and gases into one of five "Volatility Categories".

a) Category G materials include flammable fluids handled or processed as gases or vapors.

b) Category 1 materials include LPGs and light hydrocarbons (butane and lighter) and heavier flammable and combustible liquids with a vapor pressure above 482.6 kPa (70 psia) at operating temperature. These materials, when released, almost completely vaporize in a very short period of time. Category 1 materials almost immediately flash to a vapor, even when they are processed in a liquid form. For example, when liquid propane is released, it immediately flashes to a vapor. At 32.2 °C (90°F) and 1034.2 kPa (150 psi), $^1/_3$ of propane flashes immediately and cools the liquid to -42.2 °C (-44 °F), the liquid continues to boil and vaporize as it absorbs heat from the ground. A second example is hot kerosene. Normally, kerosene at room temperature and low pressures is considered an unclassified material. However, when kerosene is operated at 260 °C (500 °F), the vapor pressure is over 482.6 kPa (70 psia), and this hot material is considered a Category 1 material. When it is released to the atmosphere, about 45 % flashes to a vapor, cooling the liquid to about 210 °C (410 °F). The remaining liquid "pools" and continues to evaporate at a reduced rate until it cools to ambient. Even an asphaltic type material, when processed at very high temperatures, exhibits similar characteristics when initially released.

c) Category 2 materials are all Class IA Flammable Liquids operated at temperatures producing a vapor pressure of 482.6 kPa (70 psia) or less and all other flammable and combustible liquids with a vapor pressure between 101.3 kPa (14.7 psia) and 482.6 kPa (70 psia) at operating temperature. Pentane is an example of a Class IA Flammable Liquid. It is considered a Category 2 material for all operating temperatures in which the vapor pressure is less than 482.6 kPa (70 psia) (i.e. 90.6 °C [195°F] and lower). If Category 2 pentane at 60 °C (140 °F) should be released to the atmosphere, approximately $^1/_6$ immediately vaporizes, the liquid pools, and eventually all the pentane evaporates. Isopropyl alcohol is a Category 3 material at room temperature, but is a Category 2 material when operated above its boiling point of 82.2 °C (180 °F). It is a Category 1 material when operated above 129 °C (265 °F). As a Category 2 material at 127 °C (260 °F), when released to the atmosphere, isopropyl alcohol acts similar to the pentane example above—i.e. about $^1/_4$ initially flashes and the remainder has a high evaporation rate.

d) Category 3 materials are all Class IB Flammable Liquids operated at temperatures producing a vapor pressure less than 101.3 kPa (14.7 psia), and all other flammable and combustible liquids operated at temperatures producing a vapor pressure less than 101.3 kPa (14.7 psia) when the process or storage temperature is above the flash point of the material. An example is kerosene at 65.6 °C (150 °F). A leak of this material flashes very little vapor, and the resulting pool has a moderate evaporation rate.

e) Category 4 materials are all Class II and heavier materials operated below their flash points. Examples of Category 4 materials include kerosene, lubrication oil, asphalt, and diesel fuel handled at room temperature. These materials do not produce a flammable fuel–air mixture when released at operating conditions. When operated at elevated temperatures, most of these materials are in a higher hazard category.

The following standards provide additional information on the properties of flammable and combustible liquids, gases, and volatile solids.

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 497, *Recommended Practice for Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.* The notes in D.8 provide additional information concerning volatility of sources, as extracted from Standard 60079-10.

To use Figure D.1, the following information is required:

a) material name or class;

b) material operating temperature;

c) if the material curve is not shown in Figure D.1, the material vapor pressure at operating temperature may also be required.

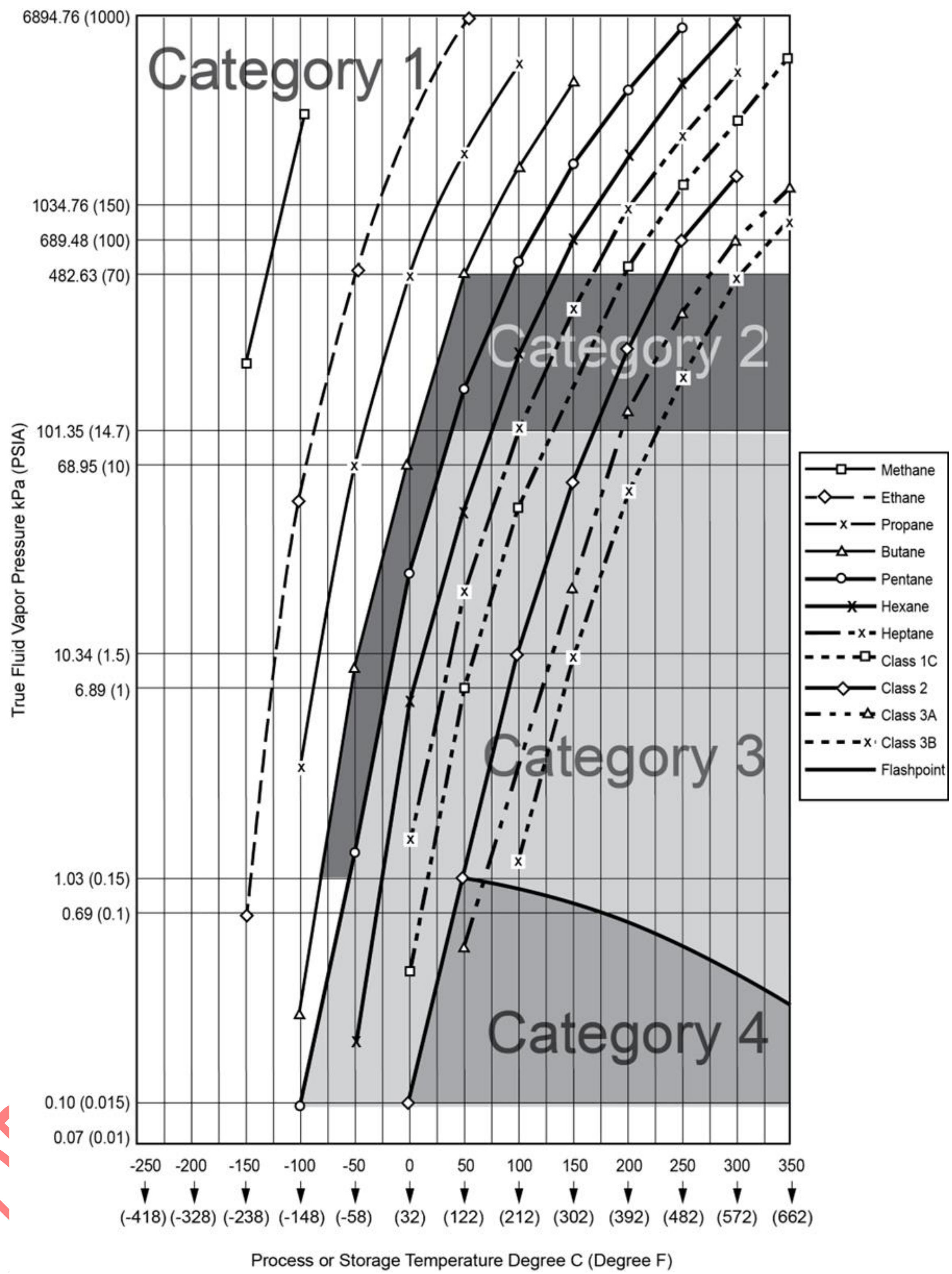


Figure D.1—Vapor Pressure–temperature Volatility Chart

EXAMPLE 1 To determine the volatility classification of pentane operating at 100 °C (212 °F), locate the operating temperature on the horizontal axis of Figure D.1 and move vertically until intersecting the pentane curve. In this example, pentane operating at 100 °C (212 °F) is a Category 1 material.

EXAMPLE 2 A kerosene curve is not shown in Figure D.1. Per NFPA 497, kerosene is a Class 2 combustible liquid. To determine the volatility classification of kerosene operating at 200 °C (392 °F), locate the operating temperature on the horizontal axis of Figure D.1 and move vertically until intersecting the Class 2 curve. In this example, kerosene operating at 200 °C (392 °F) is a Category 2 material.

EXAMPLE 3 To determine the volatility classification of a material whose curve is not shown, it may be necessary to determine the vapor pressure at the operating temperature of the material and to plot this point on Figure D.1. Vapor pressure–temperature curves are available in chemical reference books. Vapor pressure–temperature calculators are available on the Internet and through commercially available software. To determine the volatility classification of toluene operating at 50 °C (122 °F), determine the vapor pressure at the operating temperature and plot this point on Figure D.1. Using an Internet-based vapor pressure calculator, the vapor pressure of toluene at 50 °C (122 °F) is 92.12 mmHg (1.8 psia). Plotting this point on Figure D.1, toluene operating at 50 °C (122 °F) is a Category 3 material.

D.4 Determination of the Hazard Radius for Area Classification Purposes

After determining the material volatility category using D.3, the hazard radius and extent of the classified area can be determined. The hazard radius is a function of the material volatility, release rate and the dispersion rate of the gases and vapors. Section D.5 addresses heavier-than-air sources located in non-enclosed, adequately ventilated locations. Section D.6 addresses lighter-than-air sources located in non-enclosed, adequately ventilated locations.

D.5 Application to Non-enclosed, Adequately Ventilated Locations Containing a Heavier-than-air Gas or Vapor Source

D.5.1 Point Source Located Near or Above Grade

The matrix in Figure D.2 provides a means for determining a hazard radius as a function of the volatility category and the mass release rate of the material. Using the matrix, a Category 3 fluid with a release rate of less than 0.04 m^3/min (10 gpm) results in a hazard radius of 1m (3 ft). A Category 1 fluid with a release rate of between 0.19 m^3/min (50 gpm) and 0.38 m^3/min (100 gpm) results in a hazard radius of 15.2 m (50 ft) to 30.5 m (100 ft). Determining the mass release rate requires detailed knowledge of the source point design. For pumps, the required design information includes seal design, pump suction and discharge pressures, seal clearances to the shaft, and likely failure scenarios. It should be recognized that both the volatility categories and the product release rates are actually a continuum rather than absolute, and sound engineering judgment should be used in determining the hazard radius. This method should not be used for classifying locations when the anticipated release rate from a source exceeds 0.38 m^3/min (100 gpm). The hazard radii presented are based on sources with some misting or impingement. As the level of misting increases, it should be expected that the hazard radius also increases. Conversely, sources with extremely low release velocities could have appreciably smaller hazard radii. The nature or configuration of the source of the release can have a significant impact on the hazard radius.

After the hazard radius is determined from Figure D.2, refer to D.5.8 to determine the extent of the classified areas.

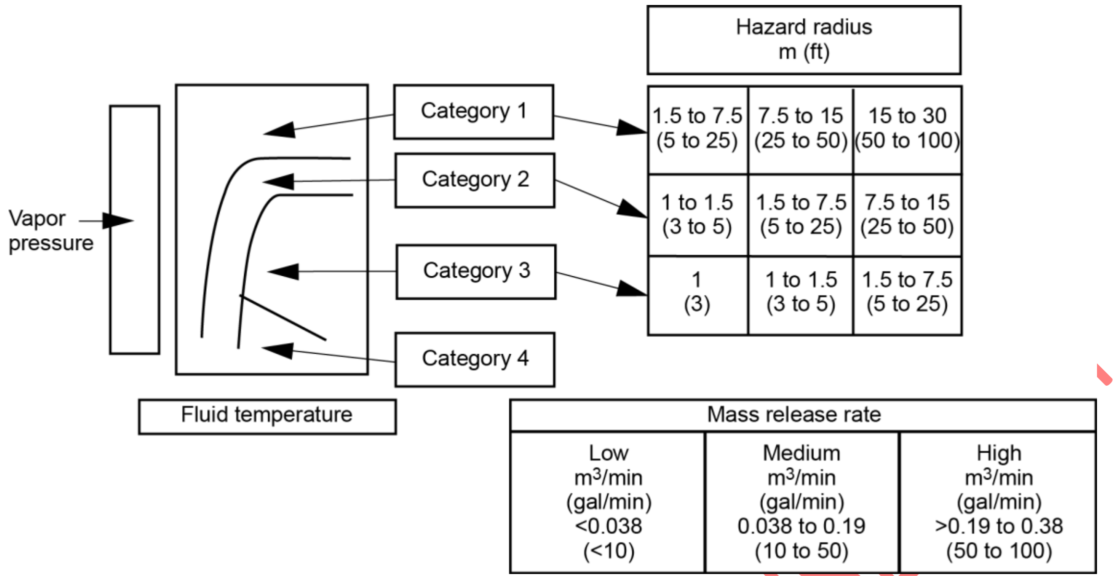


Figure D.2—Volatility—Release Rate Matrix for Determining Hazard Radius

D.5.2 Pumps—Located Near or Above Grade

The release rate from process pumps is typically a function of the type of pump, the type of shaft sealing, the physical size of the pump, and the pump seal chamber pressure (the pressure in the cavity internal to the pump shaft seal, also referred to as the stuffing box pressure). Most horizontal shaft pumps have a seal chamber pressure near the pump suction pressure, whereas most vertical pumps have seal chamber pressures near pump discharge pressure. Although pump seal chamber pressure tends to be the driving force behind a release, the pump seal technology often creates the restriction that determines the release rate. For some pumps typically used around very hazardous materials, the seals may be designed with dual sealing chambers, buffer gases, and other detection and alarm technology such that even under abnormal circumstances, the seal would not be considered a source of release. Table D.1 provides guidance in determining the hazard radius for various types of pumps. In order to be considered a "high technology seal", the seal should be "Arrangement 2", with a liquid or gas buffer system, or "Arrangement 3" in accordance with ANSI/API 682, *Pumps-shaft Sealing Systems for Centrifugal and Rotary Pumps*. An API Plan 52 seal is an example of a "high technology seal". After the hazard radius is determined from Table D.1, refer to D.5.8 to determine the extent of the classified areas.

Table D.1(a)—Pumps Handling Heavier-than-air Gases or Vapors Located in Non-enclosed, Adequately Ventilated Process Areas

Pumps	Category	Low Flow < 100 gpm			Medium Flow 100 to 500 gpm			High Flow >500 gpm			Pump Flow Rate
Low = <100 psig Medium = 100 to 500 psig High = >500 psig		Low Pressure	Medium Pressure	High Pressure	Low Pressure	Medium Pressure	High Pressure	Low Pressure	Medium Pressure	High Pressure	Seal Chamber Pressure
Standard Pump	1	15	25	50	25	50	100	25	50	100	Hazard Radius (ft)
	2	10	15	25	10	25	50	15	25	50	
	3	3	10	15	5	10	25	15	15	25	
High Technology Low Seal Emissions Pump	1	5	10	15	5	10	25	10	10	25	Hazard Radius (ft)
	2	3	5	10	3	5	10	5	10	10	
	3	3	3	5	3	3	5	5	5	10	

Table D.1(b)—Pumps Handling Heavier-than-air Gases or Vapors Located in Non-enclosed, Adequately Ventilated Process Areas (Metric)

Pumps	Category	Low Flow <0.38 m^3/min			Medium Flow 0.38 to 1.89 m^3/min			High Flow >1.89 m^3/min			Pump Flow Rate
Low = <689.5 kPa Medium = 689.5 to 3447.5 kPa High = >3447.5 kPa		Low Pressure	Medium Pressure	High Pressure	Low Pressure	Medium Pressure	High Pressure	Low Pressure	Medium Pressure	High Pressure	Seal Chamber Pressure
Standard Pump	1	4.6	7.6	15.2	7.6	15.2	30.5	7.6	15.2	30.5	Hazard Radius (m)
	2	3.0	4.6	7.6	3.0	7.6	15.2	4.6	7.6	15.2	
	3	0.9	3.0	4.6	1.5	10	7.6	4.6	4.6	7.6	
High Technology Low Seal Emissions Pump	1	1.5	3.0	4.6	1.5	3.0	7.6	3.0	3.0	7.6	Hazard Radius (m)
	2	0.9	1.5	3.0	0.9	1.5	3.0	1.5	3.0	3.0	
	3	0.9	0.9	1.5	0.9	0.9	1.5	1.5	1.5	3.0	

D.5.3 Mixtures

Determining the hazard radius for streams containing a mixture of different components of which some are volatile hydrocarbons is often quite difficult. The reason for this is twofold. First, during a release, knowing the extent of dispersion for a hydrocarbon mixture is sometimes difficult to know. Second, the majority of technical data pertaining to area classification groups only addresses pure components and does not address mixtures. (See 5.5.4, which addresses hydrogen sulfide and methane mixtures.) The first concern can be addressed to some extent using commercially available dispersion modeling programs. Using these programs, one can predict the extent of the lower flammable limit (LFL) and 50 % LFL for gas mixtures from the source. Unfortunately, dispersion modeling often requires highly sophisticated modeling programs and special skills and knowledge for one to apply the techniques. The hazard radius matrix shown in Figure D.2 can be applied to mixtures to determine the extent of the classified location. In the case of mixtures, one would first determine the mass release rate for the volatile portion of the mixture. Assuming that all of the volatile hydrocarbons are freely dissipated from the mixture during the release, one can then determine both the category and rate of release for that portion and determine a hazard radius. This method will result in a conservative hazard radius.

D.5.4 Equipment Containing Medium- and Low-pressure Restrictions (Orifices, Drains, etc.)

Table D.2 applies to any type of potential source in a medium- or low-pressure system that has a restriction orifice or similar restriction to reduce the rate of release of the source.

After the hazard radius is determined from Table D.2, refer to D.5.8 to determine the extent of the classified areas.

Table D.2—Determining Hazard Radius for Sources with Restrictions for Heavier-than-air Gases or Vapors

Hazard Radius for Restrictions, m (ft)				
Category	**Restriction Diameter, cm (in.)**			
	0.3 cm (0.125 in.)	0.6 cm (0.25 in.)	1.3 cm (0.5 in.)	2.5 cm (1 in.)
1	7.6 m (25 ft)	15.2 m (50 ft)	30.5 m (100 ft)	—
2 or G	3.0 m (10 ft)	7.6 m (25 ft)	15.2 m (50 ft)	30.5 m (100 ft)
3	0.9 m (3 ft)	1.5 m (5 ft)	1.5 m (5 ft)	3.0 m (10 ft)

D.5.5 Compressors

For reciprocating, centrifugal, and axial flow compressors handling heavier-than-air gases or vapors, the recommended hazard radius is 15.2 m (50 ft), with the following exceptions.

a) The radius may be reduced to 7.6 m (25 ft) for pressures below 20 bar (abs) (291 psia) and shaft diameters of 5.1 cm (2 in.) or less.

b) For diaphragm compressors, the hazard radius may be reduced to 3 m (10 ft). Note, however, any vents or drains at the location shall be considered separately.

c) Advanced seal technology may allow a reduced hazard radius if so determined by sound engineering judgment.

After the radius is determined by the guidance provided in this section, refer to D.5.8 to determine the extent of the classified areas.

D.5.6 Instrument and Process Vents and Drains to Atmosphere

Table D.3 applies to atmospheric process vents discharging a heavier-than-air gas or vapor at a velocity of 152 m/sec (500 ft/sec) or less.

After the hazard radius is determined from Table D.3, refer to D.5.8 to determine the extent of the classified areas.

Table D.3—Atmospheric Vents and Drains Handling Heavier-than-air Gases or Vapors

Ventilation Rate at Ambient Conditions m^3/hr (ft^3/hr)	**Hazardous Radius** m (ft)
Less than 8.5 (300)	3.0 (10)
8.5 to 85 (300 to 3000)	7.6 (25)
Greater than 85 to 170 (3000 to 6000)	15.2 (50)

D.5.7 Flanges and Valves

D.5.7.1 Flanges

Flanged joints are rarely broken except during major maintenance work, and then typically at intervals of two or more years. If there is any leakage from these joints, it is likely to be small. Depending upon the nature of the facility, the level of maintenance, and past experience, a nominal hazard radius of 0 to 1 m (3 ft) from the periphery of the flange may be assumed for such joints on well-maintained systems, provided there are no factors that could increase leakage (for example, pressure or thermal shocks, including thermal shocks caused by rain, or excessive piping loads on the flanged joints). For certain flanges that offer a higher probability of leakage, such as those around filter manways, vessel manways, and heat exchanger heads that require bundle pulling, one should consider increasing the hazard radius as shown in Table D.4.

Table D.4—Flanges Containing Heavier-than-air Gases or Vapors with a Higher Probability of Leakage

Category	**Hazard Radius** m (ft)
1	3.0 (10)
2 or G	3.0 (10)
3	1.5 (5)

After the hazard radius is determined from Table D.4, refer to D.5.8 to determine the extent of the classified areas.

D.5.7.2 Valves

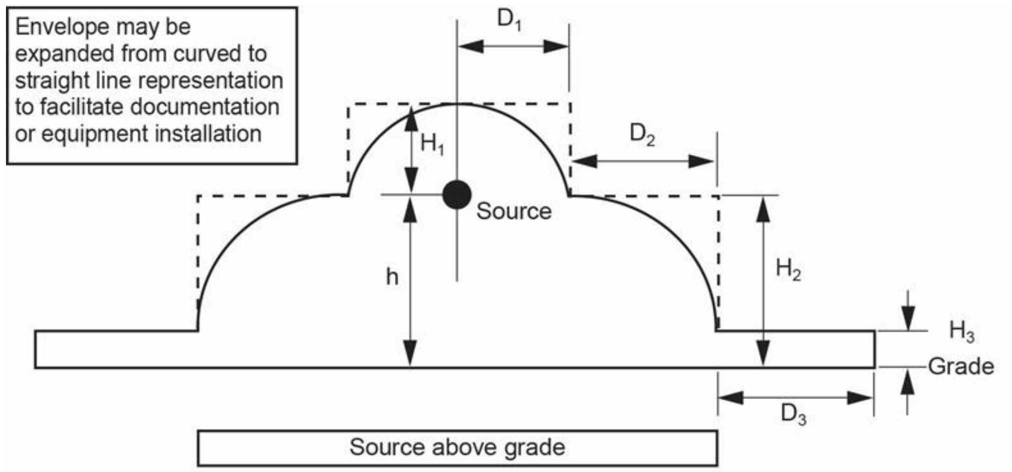
The requirements of Sections 9 through 14 (as applicable) should be utilized for classifying the locations for process control and block valves.

D.5.8 Determining the Extent of the Zone 2 Location

After the hazard radius is determined by the methods given in D.5.1 through D.5.7, Figure D.3 is used to determine the extent of the Zone 2 boundaries.

a) Extent of Zone 0: Areas that should be classified as Zone 0 are typically limited to inside process vessels, pipes, tanks, and other equipment where ignitable concentrations of flammable liquids and vapors are present continuously or for long periods of time. Figure D.3 is not applicable to Zone 0 areas.

b) Extent of Zone 1: Areas that should be classified as Zone 1 are negligible for above-grade locations. Most Zone 1 locations are limited to below-grade locations such as pits, sumps, and trenches. Such below-grade locations may collect flammable liquids or gases, which can then be transported to other locations by buried conduits unless prevented by proper sealing, purging water traps, or similar measures. Figure D.3 is not applicable to Zone 1 areas.



Hazard Radius m (ft)	D_1 m (ft)	H_1 m (ft)	D_2 m (ft)	H_2 m (ft)	D_3 m (ft)	H_3 m (ft)
1 (3)	1 (3)	1 (3)	0 (0)	NA	2 (7)	0.5 (1.5)
1.5 (5)	1.5 (5)	1.5 (5)	0 (0)	NA	3 (10)	0.5 (1.5)
3 (10)	3 (10)	3 (10)	0 (0)	NA	3 (10)	0.6 (2)
5 (15)	5 (15)	5 (15)	0 (0)	NA	3 (10)	0.6 (2)
7.5 (25)	6 (20)	6 (20)	1.5 (5)	3 (10)	6 (20)	0.6 (2)
15 (50)	7.5 (25)	7.5 (25)	7.5 (25)	7.5 (25)	7.5 (25)	0.6 (2)
30 (100)	7.5 (25)	7.5 (25)	7.5 (25)	7.5 (25)	7.5 (25)	0.6 (2)

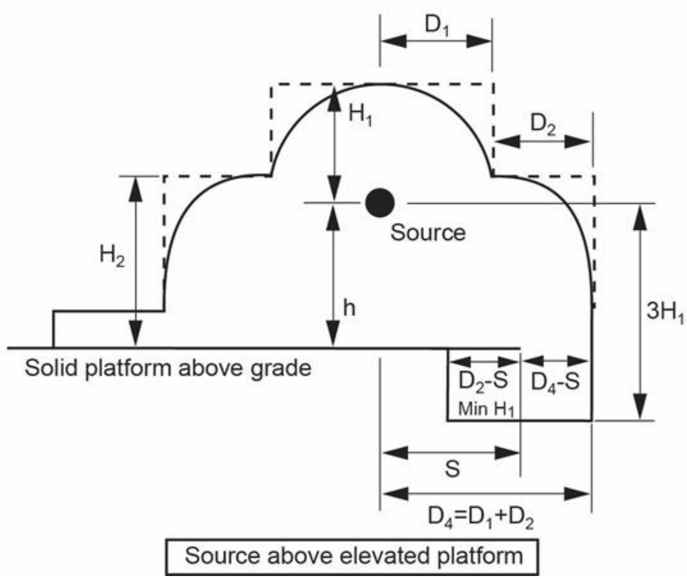


Figure D.3—Adequately Ventilated Process Area with Heavier-than-air Gas or Vapor Source Located Near or Above Grade

D.6 Determining the Hazard Radius for Sources Handling Lighter-than-air Gases and Vapors

The requirements of Section 9 through Section 14 should be utilized for classifying sources handling lighter-than-air gases and vapors.

D.7 Application to Inadequately Ventilated Areas

For sources located in inadequately ventilated areas, the extent of the classified location not only is a factor of the volatility of the gas or vapor released, the velocity of the release, and the rate of the release, but it also is (perhaps even more important) a function of the degree of ventilation, the ability to detect hydrocarbon releases, and the ability to respond to hydrocarbon releases. The methodology presented in Annex D is NOT recommended for applications in enclosed or inadequately ventilated areas.

Annex E
(informative)

Procedure for Classifying Locations

E.1 General

Annex E is intended to provide an outline of the basic procedures required to classify a location. It is not all inclusive, but combined with sound engineering judgment, should offer guidance to individuals classifying locations.

Once an area has been classified and all necessary documentation completed, it is important that no modifications to equipment or operating procedures are made without first reviewing the proposed modifications through a change management process including those responsible for the area classification. Unauthorized changes may invalidate the area classification.

E.2 Introduction

The following procedure requires answering a series of questions. An affirmative answer to either question in E.3 verifies the likely existence of a hazardous (classified) location. Boundaries of locations may be determined by applying the recommendations of the preceding sections and referring to appropriate figures in Section 8 through Section 14, as applicable. Each room, section, or area should be considered individually in determining its classification. Initial planning should focus on grouping of sources to allow unclassified locations for electrical equipment installations.

Final determinations of classification should involve coordinated efforts between process engineers, facility design engineers, fire and safety specialists, instrumentation engineers, and electrical engineers.

E.3 Step 1—Need for Classification

The need for classification of a location is indicated by an affirmative answer to either of the following two questions.

a) Are flammable liquids, gases, or vapors handled, processed, or stored in or adjacent to the area?

b) Are combustible liquids at temperatures above their flash points likely to be handled, processed, or stored in or adjacent to the area?

NOTE For exceptions, see 6.5.9.

E.4 Step 2—Assignment of Classification

E.4.1 Assuming an affirmative answer from Step 1, the questions in E.4.2 and E.4.3 should be answered to determine the degree of classification (Zone 0, Zone 1, or Zone 2).

E.4.2 Zone 0 locations normally are dictated by an affirmative answer to any one of the questions that follow.

a) Is an ignitable atmospheric concentration of gas or vapor likely to exist continuously in the location?

b) Is an ignitable atmospheric concentration of gas or vapor likely to occur in the location frequently (greater than approximately 10 % of the time) because of maintenance, repairs, or leakage?

NOTE Specific piping and tubing systems described in 6.5.9.1.1 are excluded from this consideration.

E.4.3 After Zone 0 locations have been determined, Zone 1 locations usually may be distinguished by an affirmative answer to any one of the following questions.

a) Is an ignitable atmospheric concentration of gas or vapor likely to exist in the location under normal operating conditions? (See E.4.2 if ignitable concentrations are likely to exist continuously.)

b) Is an ignitable atmospheric concentration of gas or vapor likely to occur in the location frequently because of maintenance, repairs, or leakage? (See E.4.2 if ignitable concentrations are likely to exist greater than approximately 10 % of the time.)

c) Would a failure of process, storage, transfer or similar equipment likely cause an electrical system failure that would create an ignition source (e.g. electrical arcing) simultaneously with the release of ignitable concentrations of gas or vapor?

d) Is flammable liquid or gas handled, processed, or stored in an inadequately ventilated location?

NOTE Specific piping and tubing systems and storage containers described in 6.5.9.1.1 are excluded from this consideration.

e) For flammable liquids with heavier-than-air vapors, is ventilation inadequate to ventilate all areas (particularly floor areas) where flammable vapors might collect?

f) For lighter-than-air gases, are roof or wall openings inadequately arranged to ventilate all areas (particularly ceiling areas) where gases might collect?

E.4.4 After Zone 0 and Zone 1 locations have been determined, Zone 2 locations usually may be distinguished by an affirmative answer to any one of the following questions.

a) In a system containing flammable liquids or gases in an adequately ventilated location, can the liquid or gas escape from potential sources (such as atmospheric relief valves, or pump seals) as a result of an abnormal condition?

NOTE Specific piping and tubing systems described in 6.5.9.1.1 are excluded from this consideration.

b) Is the location adjacent to a Zone 1 location without separation by vaportight walls or barriers?

NOTE In some cases, communications of flammable gases or vapors between adjacent locations can be prevented by adequate positive-pressure ventilation from a source of clean air. Reference 6.7.4.

c) If positive mechanical ventilation is provided, could failure or abnormal operation of the ventilating equipment permit ignitable concentrations of gas or vapor to enter or accumulate in the location?

E.5 Step 3—Extent of Classified Locations

Reference 6.7, 7.1, 7.2, and 7.3. Reference also Section 8 through Section 14, as applicable.

E.6 Step 4—Determination of Group

Reference 5.5 to determine the proper group.

E.7 Documentation

E.7.1 All areas designated as hazardous (classified) locations should be properly documented. This documentation should be available to those authorized to design, install, inspect, maintain, or operate electrical equipment at the location.

Information for each potential source of flammable gas or vapor may also include the following:

— equipment description and/or number,

— flammable or combustible material,

— operating temperature,

— operating pressure,

— operating flow rate,

— material flash point,

— material autoignition temperature,

— material lower and upper flammable limits,

— material vapor pressure at operating temperature,

— material vapor density (where air = 1.0).

E.7.2 The customary means of documenting this information is with an area classification drawing, a plan view drawing of the location depicting:

a) the major process or other equipment and components that may be the release source of flammable gases or vapors, or flammable liquids to the atmosphere;

b) the boundaries of the various area classifications;

c) other information (i.e. information on ventilation) necessary to properly classify a location. Elevations or sections are desirable where different classifications apply at different elevations. The documentation should include references, worksheets, drawings, and special considerations or calculations used in determining the classification. This documentation will serve as a record of the original classifications and will serve as a guide when future additions or revisions to the facility are considered; and

d) other information (i.e. information on application of gas detection) necessary to properly identify the electrical equipment suitable for installation in the classified location.

Annex F
(informative)

Symbols for Denoting Zone 0, Zone 1, and Zone 2 Hazardous (Classified) Locations

Zone 0 Zone 1 Zone 2

Figure F.1—Preferred Symbols for Denoting Hazardous (Classified) Locations

Annex G
(normative)

Use of Combustible Gas Detection Equipment

G.1 Combustible gas detection shall not be used as the basis for determining the classification of an area.

G.2 Combustible gas detection equipment may be used as an electrical equipment protection technique for a) and b) below, provided the conditions of G.3 are met.

a) An inadequately ventilated area containing equipment that could release flammable gas or vapor can be designated as suitable for installation of 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 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.

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 shall not introduce outside air from a hazardous (classified) area 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.

G.3 The criteria for use of combustible gas detection equipment to be utilized as a method of protection as detailed in this section shall meet the following requirements:

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 and explosive mixtures of representative gases with air. Combustible Gas Detector equipment shall 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 G.3 b), 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 classified hazardous atmospheres; and

— classified gas or vapor detection equipment—combustible gas detectors in this category have only been evaluated for explosions in classified 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) shall 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 may require power disconnection depending on the application.

e) Sensing a gas concentration of 40 % LFL has different requirements for applications of G.2.a) or G.2.b) as follows:

   1) For applications of G.2 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 shall activate an alarm (audible or visual, or both, as most appropriate for the area)

   2) For applications of G.2 b), sensing a gas concentration of 40 % LFL (maximum) or a gas detector system malfunction shall 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 Zone2. The power disconnecting device(s) shall be suitable for 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 equipment suitability requirements should not be used.

   3) When 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 could release flammable gas or vapor into the area. The status of 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 enclosures) that may operate at a temperature equal to or above 80 % of the autoignition temperature (expressed in degrees Celsius) 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 ignition temperature for some time after de-energization.

G.4 Gas detectors should be installed, operated, and maintained in accordance with ANSI/ISA-60079-29-2 and manufacturer instructions.

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