

Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1, and Division 2

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Contents

	Page
1	Scope..... 1
1.1	Purpose..... 1
1.2	Application 1
2	Normative References..... 2
2.1	General..... 2
3	Terms, Definitions, and Acronyms 3
3.1	Terms and Definitions 3
3.2	Acronyms 10
4	Basic Conditions for a Fire or Explosion..... 11
5	Flammable and Combustible Liquids, Gases and Vapors 11
5.1	General 11
5.2	Flammable and Combustible Liquids..... 11
5.3	Flammable Highly Volatile Liquids 12
5.4	Flammable Lighter-than-air Gases 13
5.5	<i>National Electrical Code</i> Grouping of Atmospheric Mixtures 13
6	Classification Criteria..... 14
6.1	General 14
6.2	Classification Criteria and Considerations 15
6.3	Ventilation 18
6.4	Adjacent Areas 22
6.5	Use of Combustible Gas Detection Equipment 23
7	Extent of a Classified Location 24
7.1	General..... 24
7.2	Outdoor Locations 24
7.3	Enclosed Locations Containing Sources of Release..... 25
8	Recommendations for Determining Degree and Extent of Classified Locations— Common Applications 25
8.1	General 25
8.2	Recommendations for Areas Surrounding Specific Equipment 25
9	Recommendations for Determining Degree and Extent of Classified Locations in Petroleum Refineries 43
9.1	Introduction..... 43
9.2	Recommendations..... 44
10	Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Land and on Marine Platforms..... 51
10.1	General 51
10.2	Drilling Areas 53
10.3	Production Facilities 53
10.4	Drilling Wells..... 54
10.5	Producing Oil and Gas Wells 63
10.6	Oil and Gas Processing and Storage Equipment 70

Contents

	Page
10.7 Automatic Custody Transfer (ACT) Units.....	73
10.8 Produced, Processed, or Injection Water Handling Equipment.....	73
10.9 Compressor or Pump Handling Flammable Liquids, Gases, or Vapors	76
10.10 Drip Pans	77
10.11 Instruments	78
10.12 Sumps	80
10.13 Drains.....	82
10.14 Reserved For Future Use.....	86
10.15 Screwed Connections, Flanges, Valves, and Valve Operators	86
10.16 Control Panels Containing Instrumentation Utilizing or Measuring Flammable Liquids or Gases.....	87
10.17 Gas Meters	89
11 Recommendations for Determining Degree and Extent of Classified Locations on Mobile Offshore Drilling Units (MODUs)	90
11.1 General.....	90
11.2 Definitions Specific to MODUs	91
11.3 Reserved for Future Use.....	92
11.4 Classified Locations on Mobile Offshore Drilling Units (MODUs).....	92
11.5 Basis for Area Classification.....	94
11.6 Classification of Hazardous (Classified) Locations	95
11.7 Drill Floor and Derrick Areas	97
11.8 Substructure or Moonpool Areas	97
11.9 Mud System Processing Equipment Overview	99
11.10 Mud Tanks (After Discharge of Final Degasser)	99
11.11 Mud Ditches or Troughs	103
11.12 Mud Pumps.....	106
11.13 Mud Processing Equipment (Between the Bell Nipple and Mud Discharge of Final Degasser)	106
11.14 Desander or Desilter (Between Mud Discharge of Final Degasser and the Mud Pit).....	106
11.15 Choke Manifold	109
11.16 Cement Unit	110
11.17 Degasser.....	110
11.18 Vents	111
11.19 Diverter Line Outlet.....	111
11.20 Blowout Preventer (BOP)	112
11.21 Well Test Equipment Areas.....	112
11.22 Rooms Used to Store Paint (Paint Lockers)	113
11.23 Battery Rooms.....	113
11.24 Helicopter Fuel Storage Areas	113
11.25 Classification of Adjacent Spaces	113
12 Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Floating Production Units.....	114
12.1 General	114
12.2 Floating Production Storage and Offloading Units (FPSOs)	115
12.3 Tension Leg Platforms (TLPs).....	115
12.4 Spars, Caissons, and Similar Units	115
12.5 Classification of Adjacent Spaces	115
13 Recommendations for Determining Degree and Extent of Classified Locations at Petroleum and Gas Pipeline Transportation Facilities.....	120

Contents

	Page
13.1 General	120
13.2 Use of Figures	120
13.3 Figures	120
14 Recommendations for Determining Degree and Extent of Classified Locations at LNG Facilities	136
14.1 General	136
14.2 Pretreatment Facilities	138
14.3 Refrigeration and Liquefaction	138
14.4 LNG Storage Equipment and Containment	142
14.5 Loading/unloading Facilities	144
Annex A (informative) Sample Calculation to Achieve Adequate Ventilation of an Enclosed Area by Natural Means Using Equation (1) and Equation (2)	146
Annex B (informative) Calculation of Minimum Air Introduction Rate to Achieve Adequate Ventilation Using Fugitive Emissions	148
Annex C (informative) Development of Ventilation Criteria	151
Annex D (informative) An Alternate Method for Area Classification	153
Annex E (informative) Procedure for Classifying Locations	163
Annex F (informative) Preferred Symbols for Denoting Class I, Division 1, and Division 2 Hazardous (Classified) Locations	166
Annex G (normative) Use of Combustible Gas Detection Equipment	167
Bibliography	169
Figures	
1 Increase in Flow Caused by Excess of One Opening Over Another	21
2 Non-enclosed or Adequately Ventilated Enclosed Area Adjacent to a Classified Area	23
3 Enclosed Area Adjacent to a Classified Area	23
4 Inadequately Ventilated, Enclosed Area Adjacent to a Classified Area	23
5 Inadequately Ventilated, Enclosed Area Adjacent to a Classified Area	23
6 Fixed-roof Flammable Liquid Storage Tank in a Non-enclosed, Adequately Ventilated Area	27
7 Open-top Floating Roof Flammable Liquid Storage Tank in a Non-enclosed, Adequately Ventilated Area	28
8 Combustible Liquid Storage Tank in a Non-enclosed, Adequately Ventilated Area	29
9 Tank Car or Tank Truck Loading and Unloading Via Closed System Product Transfer Through Dome Only	30
10 Tank Car or Tank Truck Loading and Unloading via Closed System Product Transfer Through Dome Only	31
11 Tank Car or Tank Truck Loading and Unloading via Closed System Product Transfer Through Bottom Only	31
12 Tank Car or Tank Truck Loading and Unloading via Closed System Product Transfer Through Top or Bottom	32
13 Tank Car or Tank Truck Loading and Unloading via Closed System Product Transfer Through Bottom Only	33
14 Process Equipment Vent in a Non-enclosed, Adequately Ventilated Area	34
15 Instrument or Control Device Vent in a Non-enclosed, Adequately Ventilated Area	34

Contents

	Page
16 Atmospheric Vent from a Division 1 Area	35
17 Atmospheric Vent from a Division 2 Area	35
18 Relief Valve in a Non-enclosed, Adequately Ventilated Area	35
19 Marine Terminal Handling Flammable Liquids	37
20 Adequately Ventilated Process Location With Heavier-than-air Gas or Vapor Source Located Near Grade	44
21 Adequately Ventilated Process Location With Heavier-than-air Gas or Vapor Source Located Above Grade	45
22 Inadequately Ventilated Process Location With Heavier-than-air Gas or Vapor Source	46
23 Adequately Ventilated Compressor Shelter With Lighter-than-air Gas or Vapor Source	47
24 Adequately Ventilated Process Location With Lighter-than-air Gas or Vapor Source	47
25 Inadequately Ventilated Compressor Shelter With Lighter-than-air Gas or Vapor Source ..	48
26 Inadequately Ventilated Process Location With Lighter-than-air Gas or Vapor Source	49
27 Separators, Dissolved Air Flotation (DAF) Units, and Biological Oxidation (BIOX) Units	50
28 Mechanical Draft Cooling Tower Handling Process Cooling Water	51
29 Drilling Rig, Adequate Ventilation in Substructure, and Derrick is Not Enclosed, But is Equipped With a Windbreak, Open Top, and Open V-Door	55
30 Drilling Rig, Adequate Ventilation in Enclosed Derrick (Open Top), and Inadequately Ventilated Substructure	56
31 Platform Drilling Rig, Adequately Ventilated in Substructure and Inside Derrick, Several Producing Wells Beneath in an Adequately Ventilated Area	58
32 Platform Drilling Rig, Adequate Ventilation in Substructure and Inside Derrick, Several Producing Wells Beneath in an Inadequately Ventilated Location	59
33 Mud Tank in a Non-enclosed, Adequately Ventilated Area	60
34 Mud Tank in an Inadequately Ventilated Area	60
35 Shale Shaker in a Non-enclosed, Adequately Ventilated Area	61
36 Desander or Desilter in a Non-enclosed, Adequately Ventilated Area	61
37 Desander or Desilter in an Adequately Ventilated Enclosed Area	61
38 Degasser Vent in Non-enclosed, Adequately Ventilated Area	62
39 Flowing Well in a Non-enclosed, Adequately Ventilated Area and Without a Cellar or Below-grade Sump	64
40 Flowing Well in a Non-enclosed, Adequately Ventilated Area With an Inadequately Ventilated Cellar or Below-grade Sump	64
41 Flowing Well in an Inadequately Ventilated, Enclosed Area	65
42 Non-enclosed Beam Pumping Well in an Adequately Ventilated Area Without a Cellar	65
43 Non-enclosed Beam Pumping Well in an Adequately Ventilated Area With an Inadequately Ventilated Cellar	66
44 Electric Submersible Pumping Well in a Non-enclosed, Adequately Ventilated Area Without a Cellar	67
45 Electric Submersible Pumping Well in a Non-enclosed, Adequately Ventilated Area With an Inadequately Ventilated Cellar	67
46 Junction Box in a Non-enclosed, Adequately Ventilated Area Connected to an Electric Submersible Pump	68
47 Non-enclosed, Adequately Ventilated Well on Which Wireline Work is Being Performed ...	70
48 Hydrocarbon Pressure Vessel or Protected Fired Vessel in a Non-enclosed Adequately Ventilated Area	71
49 Ball or Pig Launching or Receiving Installation in a Non-enclosed Adequately Ventilated Area	73
50 Flammable Gas-blanketed and Produced/Processed/Injected Water-handling Equipment [Tank (in lower figure) and Flotation Cell (in upper figure)] in a Non-enclosed, Adequately Ventilated Area	75

Contents

	Page
51 Compressor or Pump in an Adequately Ventilated, Non-enclosed Area	76
52 Compressor or Pump in an Adequately Ventilated, Non-enclosed Area	76
53 Compressor or Pump in an Adequately Ventilated Enclosed Area	77
54a Compressor or Pump in an Inadequately Ventilated, Enclosed Area	78
54b Turbine-driven Compressor or Pump in an Adequately Ventilated, Non-enclosed Area	79
55 Flammable Gas-operated Instruments in an Adequately Ventilated, Enclosed Area with all Devices Vented to the Outside	80
56 Flammable Gas-operated Instruments in an Inadequately Ventilated, Enclosed Area	81
57 Open Sump in Non-enclosed, Adequately Ventilated Area	82
58 Type 1 Open Drain System	83
59 Type 2 Open Drain System	83
60 Type 3 Open Drain System in Non-enclosed Area	84
61 Type 3 Drain System In Enclosed Area	85
62 Type 4 Open Drain System in Non-enclosed Area	85
63 Type 4 Open Drain System in Enclosed Area	86
64 Control Panel With Flammable Gas Vented to the Inside of the Enclosure	88
65 Inadequately Ventilated Control Panel with Instruments Inside	89
66 Adequately Ventilated Control Panel with Instruments Inside	90
67 Drilling Rig Open Derrick	97
68 Drilling Rig Semi-enclosed Derrick	98
69 Drilling Rig Derrick Fully Enclosed (Open Top)	99
70 Drilling Rig Open Substructure and Semi-Enclosed Derrick	100
71 Drilling Rig with Total Containment Substructure and Semi-enclosed Derrick	101
72 Drilling Rig Semi-enclosed Substructure and Semi-Enclosed Derrick	102
73 Drilling Rig Enclosed Moonpool and Semi-enclosed Derrick	103
74 Mud System Processing Equipment in Adequately Ventilated, Enclosed Spaces	104
75 Mud System Processing Equipment in Open Spaces	105
76 Mud Tanks in Open Areas	106
77 Open-top Mud Tanks in Enclosed or Semi-Enclosed Locations With Adequate Ventilation	106
78 Closed-top Mud Tanks In Enclosed or Semi-enclosed Locations With Adequate Ventilation	107
79 Open Mud Trough in Open Space Before Degasser	107
80 Open Mud Trough in Enclosed Space With Adequate Ventilation Before Degasser	108
81 Open Mud Trough In Enclosed Space With Adequate Ventilation Downstream of Degasser	108
82 Open Mud Trough in Open Space Downstream of Degasser	108
83 Shale Shaker in Enclosed or Semi-enclosed Space with Adequate Ventilation	109
84 Shale Shaker in Open Area With Adequate Ventilation	109
85 Desander or Desilter in Enclosed or Semi-enclosed Space With Adequate Ventilation	110
86 Desander or Desilter in Open Area	110
87 Discharges of Ventilation Vents and Equipment Vents Originating In Division 1 Areas	111
88 Ventilation Vents Originating in Division 2 Areas	111
89 Diverter Line Outlet	112
90 Typical Floating Production Storage and Offloading Unit (FPSO and FSO)	117
91 Typical Tension Leg Platform (TLP)	118
92 Typical Spar, Caisson, or Similar Unit	119
93 Outdoors—Pump Handling Flammable Liquids or Highly Volatile Liquids	122
94 Adequately Ventilated Building—Pump Handling Flammable Liquids or Highly Volatile Liquids	123
95 Inadequately Ventilated Building—Pump Handling Flammable Liquids or Highly Volatile Liquids	124

Contents

	Page
96 Outdoors—Valves, Screwed Fittings, Flanges, or Similar Devices Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation, and Instrument-sized Pumps	125
97 Adequately Ventilated Building—Valves, Screwed Fittings, Flanges, or Similar Devices Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation, and Instrument-sized Pumps	126
98 Inadequately Ventilated Building—Valves, Screwed Fittings, Flanges, or Similar Devices Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation, and Instrument-sized Pumps	127
99 Elevated Storage Tank or Pressure Vessel	128
100 Below-grade Sump Tank and Oil-water Separator	129
101 Below-grade Vault—Valves, Screwed Fittings, Flanges, or Similar Accessories Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation, and Instrument-sized Pumps	130
102 Above-grade Source With Closure Handling Flammable Liquid or Highly Volatile Liquids	131
103 Storage Cavern Handling Flammable Liquids and Highly Volatile Liquids	132
104 Outdoors—Compressors, Valves, Screwed Fittings, Flanges, or Similar Devices Handling Lighter-than-air Flammable Gas	132
105 Adequately Ventilated Building—Compressors, Valves, Screwed Fittings, Flanges, or Similar Devices Handling Lighter-than-air Flammable Gas	133
106 Inadequately Ventilated Building—Compressors, Valves, Screwed Fittings, Flanges, or Similar Devices Handling Lighter-than-air Flammable Gas	134
107 Outdoors—Ball or Pig Launching or Receiving Installation Handling Lighter-than-air Flammable Gas	135
108 Outdoors—Storage Cavern Handling Lighter-than-air Flammable Gas	136
109 LNG Facility Process Flow Diagram (typical)	137
110 Refrigerant Storage Tank in a Non-enclosed, Adequately Ventilated Area	139
111 Adequately Ventilated Cryogenic Heat Exchanger	141
112 Pumps Handling LNG in Non-enclosed, Adequately Ventilated Areas.....	142
113 Above-ground, Single Containment LNG Storage Tank with Secondary Containment Provided by Earthen Dike or Concrete Wall (where $H < x$).....	143
114 Above-ground, Single Containment LNG Storage Tank with Secondary Containment Provided by Earthen Dike or Concrete Wall (where $H > x$).....	143
115 Above-ground, Full Containment LNG Storage Tank	143
116 Marine Terminal Handling LNG	145
D.1 Vapor Pressure-Temperature Volatility Chart	156
D.2 Volatility Release Rate Matrix for Determining Hazard Radius.....	158
D.3 Adequately Ventilated Process Area With Heavier-than-air Gas or Vapor Source Located Near or Above Grade	161
F.1 Preferred Symbols for Denoting Class I, Hazardous (Classified) Locations	165

Tables

1 Pressure Adjustment Factor	52
D.1(a) Pumps Handling Liquids with Heavier-than-air Gases or Vapors Located in Non-enclosed, Adequately Ventilated Process Areas	159
D.1(b) Pumps Handling Liquids with Heavier-than-air Gases or Vapors Located in Non-enclosed, Adequately Ventilated Process Areas (Metric)	160
D.2 Determining Hazard Radius for Sources With Restrictions for Heavier-than-air Gases or Vapors	160
D.3 Atmospheric Vents and Drains Handling Heavier-than-air Gases or Vapors	160
D.4 Flanges Containing Heavier-than-air Gases or Vapors with a Higher Probability of Leakage	161

Introduction

This recommended practice (RP) is under the jurisdiction of the Committee on Refinery Equipment (CRE). It is based upon a level of knowledge gained through experience and through the successful application of this practice in the refining, drilling and producing, and pipeline segments of the petroleum industry. The first edition of this recommended practice was issued June 1, 1991, under the joint jurisdiction of the API Production, Refining, and Transportation departments. The second edition was issued in November 1997 and reaffirmed in November 2002. The third edition was issued in December 2012.

The first edition of Recommended Practice 500A was published in February 1955 as API 500, *Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries*. The second edition was published in January 1957. The third edition was published as API 500A in April 1966. The third edition was reaffirmed in 1973. The fourth edition was published in January 1982 as API 500A, with a new title, *Classification of Locations for Electrical Installations in Petroleum Refineries*. The fourth edition was reaffirmed in December 1987.

API 500B was originally issued in January 1961 as API 11J, *Recommended Practice for Placement of Electrical Equipment on Production Leases*. The first edition of API 500B was issued in January 1966 with the title *Recommended Practice for Classification in Areas for Electrical Installations at Production Facilities*. The title was changed in the second edition, July 1973, to *Recommended Practice for Classification of Areas for Electrical Installations at Drilling Rigs and Production Facilities on Land and on Marine Fixed and Mobile Platforms*. The third edition of API 500B, *Recommended Practice for Classification of Locations for Electrical Installations at Drilling Rigs and Production Facilities on Land and on Marine Fixed and Mobile Platforms*, was issued October 1, 1987.

The first edition of API 500C was published in September 1966, under the title *Recommended Practice for Classification of Areas for Electrical Installations at Petroleum and Gas Pipeline Transportation Facilities*. The first edition was reaffirmed in 1974. The title was changed in the second edition (July 1984) to *Classification of Locations for Electrical Installations at Pipeline Transportation Facilities*. The second edition was reaffirmed in March 1990.

Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2

1 Scope

1.1 Purpose

1.1.1 The purpose of this recommended practice is to provide guidelines for classifying locations Class I, Division 1 and Class I, Division 2 at petroleum facilities for the selection and installation of electrical equipment. Basic definitions given in the 2023 edition of NFPA 70, *National Electrical Code (NEC)*, have been followed in developing this recommended practice. This publication is only a guide and requires the application of sound engineering judgment.

NOTE Recommendations for determining the degree and extent of locations classified Class I, Zone 0, Zone 1, and Zone 2 are addressed in API 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*.

1.1.2 Electrical installations in areas where flammable liquids, flammable gases or vapors, or combustible liquids 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 should be determined from applicable publications. Applicable publications may include NFPA 70 (NEC), CSA C22.1 (Canadian Electrical Code), or API 14F.

NOTE Recommendations for electrical installations for locations classified Class I, Zone 0, Zone 1, and Zone 2 are addressed in API 14FZ, *Recommended Practice for Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Zone 0, Zone 1, and Zone 2 Locations*.

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 RP:

- 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) suitability of locations for the placement of non-electrical incendiary equipment;
- d) classification of 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 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 off-loading (FPSOs), single anchor leg mooring buoys (SALMs), caisson structures, spars, and other floating structures where flammable petroleum gas and volatile liquids are produced, processed (e.g. compressed), stored, transferred (e.g. pumped), or otherwise handled prior to entering the transportation facilities.

1.2.8 Section 13 is 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.

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

ASHRAE ¹, *ASHRAE Fundamentals Handbook*

ASTM D323 ², *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*

IMO, I810E ³, *Code for the Construction and Equipment of Mobile Offshore Drilling Units*

ANSI/ISA 60079-29-1 (12.13.01) ⁴, *Explosive Atmospheres – Part 29-1: Gas Detectors – Performance Requirements of Detectors for Flammable Gas*

ANSI/ISA 60079-29-2 (12.13.02), *Explosive Atmospheres – Part 29-1: Gas Detectors – Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen*

NFPA 30 ⁵, *Flammable and Combustible Liquids Code*

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

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

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

NFPA 69, *Standard on Explosion Prevention Systems*

NFPA 70, *National Electrical Code*

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment in Hazardous (Classified) Locations*

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, and 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 RP, the following abbreviated definitions apply.

3.1.1

approved

Acceptable to the authority having jurisdiction.

3.1.2

area

See “location”.

¹ American Society of Heating, Refrigerating, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, Georgia 30329, www.ashrae.org.

² ASTM, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

³ International Maritime Organization, 4 Albert Embankment, London, United Kingdom, www.imo.org.

⁴ International Society of Automation, 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, North Carolina 22709, www.isa.org.

⁵ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

3.1.3

autoignition temperature

AIT

The minimum temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gas independently of the heating or heated element (NFPA 497).

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).

NOTE "Barrier, non-vaportight" applies to any wall or other obstruction that will not meet the criteria for "barrier, vaportight".

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).

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

Class I location

Class I locations are those in which flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

3.1.7.2

Class I, Division 1

A location:

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

3.1.7.3

Class I, Division 2 location

A location:

- 1) in which volatile flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of

accidental rupture or breakdown of such containers or systems or in a case of abnormal operation of equipment; or

- 2) in which ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are normally prevented by positive ventilation and which might become hazardous through failure or abnormal operation of the ventilating equipment; or
- 3) that is adjacent to a Class I, Division 1 location, and to which ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors above their flash points might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

3.1.7.4

Class I material groups

For the purpose of testing, approval, and area classification, various air mixtures (not oxygen enriched) are subdivided into Groups A, B, C, or D for Class I, Division 1 and Class I, Division 2 locations.

3.1.7.4.1

Group A

Atmospheres containing acetylene. Refer to 5.5.

3.1.7.4.2

Group B

A typical Class I, Group B material is hydrogen. Refer to 5.5.

3.1.7.4.3

Group C

A typical Class I, Group C material is ethylene. Refer to 5.5.

3.1.7.4.4

Group D

Atmospheres containing butane, gasoline, hexane, methane, natural gas, propane, and many other hydrocarbon gases and vapors encountered in oil and gas production, refining, and pipeline operations. Refer to 5.5.

3.1.7.5

hazardous (classified) location

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

3.1.7.6

unclassified locations (non-hazardous location)

Locations determined to be neither Class I, Division 1 nor Class I, Division 2; or any combination thereof.

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**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.

3.1.10**enclosed area (room, building, or space)**

A three-dimensional space enclosed by more than two-thirds 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 of the walls, ceiling, and floor be present.

3.1.11**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.

3.1.12**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.

3.1.13**enclosure, purged**

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

3.1.14**flammable**

Capable of igniting easily, burning intensely, or spreading flame rapidly.

3.1.15**flammable, highly volatile liquid**

See “highly volatile liquid”.

3.1.16**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; 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.

3.1.17

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. See 5.2. Flammable (Class I) liquids are subdivided into Classes IA, IB, and IC (NFPA 30).

3.1.18

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.

3.1.19

floor area

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

3.1.20

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.

3.1.21

gases, heavier-than-air

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

3.1.22

gases, lighter-than-air

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

3.1.23

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.

3.1.24

highly volatile liquid HVL

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

3.1.25

ignitable (flammable) mixture

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

3.1.26

ignition (autoignition) temperature

See “autoignition temperature”.

3.1.27**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.

3.1.28**location**

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

3.1.29**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.

3.1.30**minimum ignition 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).

3.1.31**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).

3.1.32**mist, flammable**

Droplets of flammable liquid dispersed in air so as to form a flammable gas atmosphere.

3.1.33**non-hazardous location**

See "unclassified location".

3.1.34**normal operation**

A state in which the equipment is operating within its design parameters.

3.1.35**petroleum refinery**

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

3.1.36**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.

3.1.37**production areas**

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 transportation facilities.

3.1.38**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 air intake, high surface temperatures, and exhaust as sources of ignition.

3.1.39**purged and pressurized**

The result of 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.

3.1.40**source of release**

A point or location from which a flammable gas, vapor, mist, or liquid may be released into the atmosphere such that a flammable gas atmosphere could be formed.

3.1.41**space**

See "location".

3.1.42**unclassified location**

See "classification".

3.1.43**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)*.

3.1.44**vaportight barrier**

See "barrier, vaportight".

3.1.45**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).

3.1.46**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 6.3.2.

3.1.47**ventilation, inadequate**

Ventilation that is less than adequate. See 6.3.3.

3.1.48**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.

3.1.49**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
DOI	Department of Interior
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 in order 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 division classification. The decision is based principally on whether the flammable mixture may be present under normal conditions or 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 group(s) (A, B, C, or D) 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 3.1.17. 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 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 points, 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 (20 °F) to 32.2 °C (90 °F).

5.3 Flammable Highly Volatile Liquids

5.3.1 Highly volatile liquids (HVLs) include liquids such as butane, ethane, ethylene, propane, propylene, natural gas liquids, and similar mixtures. Vapor pressures of these liquids exceed 276 kPa (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 LFL concentrations are present is less.

5.3.3 A spill resulting from a loss of containment of LNG will initially behave as a HVL but will transform into a flammable lighter-than-air gas, time-dependent on ambient and other atmospheric conditions. For specific properties related to the flammable hazards associated with a LNG release and the recommendations for area classification of LNG facilities, see Section 14.

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 is 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.

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 of specific materials, refer to NFPA 497.

- Group A: Atmospheres containing acetylene (NEC Article 500.6(A)(1)).
- Group B: Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value less than or equal to 0.45 mm or a minimum igniting current ratio (MIC ratio) less than or equal to 0.40 (NEC Article 500.6(A)(2)).
- Group C: Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value greater than 0.45 mm and less than or equal to 0.75 mm, or a minimum igniting current ratio (MIC ratio) greater than 0.40 and less than or equal to 0.80 (NEC Article 500.6(A)(3)).
- Group D: Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either a MESG value greater than 0.75 mm or a MIC ratio greater than 0.80 (NEC Article 500.6(A)(4)).
- The flammable characteristics of mixtures of gases or vapors and air vary with the specific material(s) involved. For Class I locations (Groups A, B, C, and D), 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 MESG or MIC ratio to standard reference test materials for each group. NFPA 497 gives the pertinent data.

5.5.2 Most petroleum products are placed in Group D. However, ethylene production, catalytic reforming, ammonia synthesis, and other processes may involve other groups, particularly Groups B and C.

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

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

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

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 A, B, C, or D, the next step is to designate the location as either Division 1 or Division 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:

- the extent of the areas that are classified;
- the Class;
- the Division;
- the gas or gas group(s); and
- the maximum permissible surface temperature for the electrical equipment in the area.

The identification of Division 1 and Division 2 locations should utilize the symbols in Annex F, except for additions and modifications to existing documentation, which may use the symbols of the existing documentation. See E.7 for additional documentation considerations.

6.1.3 Mists may form or be present at the same time as flammable vapors. This may affect the way flammable material disperses and the extent of any hazardous areas. The strict application of area classification for gases and vapors may not be appropriate because the flammability characteristics of mists are not always predictable. Although it can be difficult to decide upon the type and extent of divisions, 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.

6.2 Classification Criteria and Considerations

6.2.1 NEC Classifications

6.2.1.1 General

The following basic definitions concerning the classifications of areas are the same as those contained in Article 500 of NFPA 70, the *National Electrical Code*, except for a few editorial changes for clarity and the deletion of some subject matter not relevant to petroleum operations.

6.2.1.2 Class I Locations

6.2.1.2.1 Class I locations are those in which flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are, or may be, present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations include the following:

6.2.1.2.2 Class I, Division 1 locations are those in which:

- 1) ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors exist under normal operating conditions;
- 2) ignitable concentrations of such flammable gases, flammable liquid-produced vapors, or combustible liquids above their flash points may exist frequently because of repair or maintenance operations or because of leakage; or
- 3) breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors, and might also cause simultaneous failure of electrical equipment that could become a source of ignition.

This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interior areas where volatile flammable solvents are used; locations containing open tanks of volatile flammable liquid; inadequately ventilated locations where flammable gases accumulate or volatile flammable liquids stand or collect; the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers; and all other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

6.2.1.2.3 Class I, Division 2 locations are those in which:

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

This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but that would become ignitable only in case of a malfunction or some unusual operating condition. The quantity of ignitable material that might escape in case of accident, the adequacy of ventilation (natural or artificial), the total area involved, and the record of the industry with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

NOTE In 6.2.1.2.3, item 2), the word “mechanical” has been removed (between “positive” and “ventilation”) from the *NEC* definition to allow both natural and mechanical means to provide for adequate ventilation.

6.2.2 Class I, Division 1 Considerations

6.2.2.1 Division 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 a tank vent is normal and requires a Division 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 Division 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.

6.2.2.2 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 Division 1. However, if the maintenance and repairs are required infrequently, the work is to be considered abnormal.

6.2.3 Class I, Division 2 Considerations

6.2.3.1 Division 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 shaft seal that releases flammable gases or vapors only under abnormal conditions. In this case, there is no Division 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 Division 2. In facilities where a gas release within a building (or similar enclosed area) may go undetected for an extended period of time, consideration should be given to classify such locations as Division 1. Remote monitoring and notification is one method to reduce the period of time a gas release goes undetected.

6.2.3.2 Petroleum handling equipment does not fail frequently. Furthermore, the *NEC* requirements for electrical installations in Division 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 Division 2 (vs. Division 1) classification.

NOTE For example, assume that the electrical and petroleum handling equipment each fail at the rate of once every 8000 hours (about once per year). The probability that both types of equipment will fail during the same hour is only one in 64 million. These assumed failure rates are deliberately high and the failures usually would occur during a time interval shorter than one hour.

6.2.3.3 The Division 2 classification also applies to the “transition zone” that normally exists between a Division 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 6.2.1.2.3, item 2), 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.

6.2.3.4 When a building (or similar enclosed area) is classified Division 1 “to the extent of the building” due to specific oil or gas handling equipment enclosed by the building, a Division 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 Division 2 area should extend as follows:

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

6.2.3.5 When a building (or similar enclosed area) is classified Division 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 Division 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 non-explosion proof arcing or high-temperature electrical equipment not be installed immediately adjacent to such openings.

6.2.4 Vent Openings

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

6.2.4.2 Consider the case of a non-enclosed source that releases flammable gas or vapor during normal operations. The classified area around the source would appear as a Division 1 concentric circle around the source. This would be surrounded by a concentric Division 2 circle. The Division 2 area is the “transition zone.”

6.2.5 Unclassified Locations

6.2.5.1 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.

6.2.5.1.1 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.

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

6.2.5.2 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 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.

6.2.5.3 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 500. 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 criterion 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.

6.2.5.4 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.

6.3 Ventilation

6.3.1 General

6.3.1.1 The decision to classify a location as Division 1, Division 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 reduce the duration of a flammable gas atmosphere, thus influencing the classification of the area. Annex C provides background on the development of adequate ventilation criteria.

6.3.1.2 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:

6.3.1.2.1 Equipment as described by 6.2.5.1.

6.3.1.2.2 Hydrocarbon-fueled prime movers with fuel gas pressure at 125 psig or less as provided for in 8.2.5.

6.3.1.2.3 Laboratory and analyzer applications as provided for in 8.2.8.

6.3.1.3 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.

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.

6.3.2 Adequate Ventilation

6.3.2.1 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 LFL.

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

6.3.2.3 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. Obstacles that impede the ventilation can impact the extent of the classified location.

6.3.2.4 Adequate ventilation is addressed in 6.3.2.4.1.

6.3.2.4.1 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 items a) and b), 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.

6.3.2.4.2 Enclosed areas (rooms, buildings, or spaces) that are provided with at least six 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.

6.3.2.4.3 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 6.3.2.4.2) 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.

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

6.3.2.4.5 Provisions need to be made for the introduction of air in a manner to properly distribute ventilation; that is, air should not 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 in 6.3.2.4.4. 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 10 minutes. As T_i approaches T_o , the stack effect is reduced.

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

where

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

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

h see Equation (2);

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

T_o is the temperature of outdoor air, in degrees Rankine.

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

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

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 in Chapter 22, of the ASHRAE *Handbook of Fundamentals* (1985), 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.

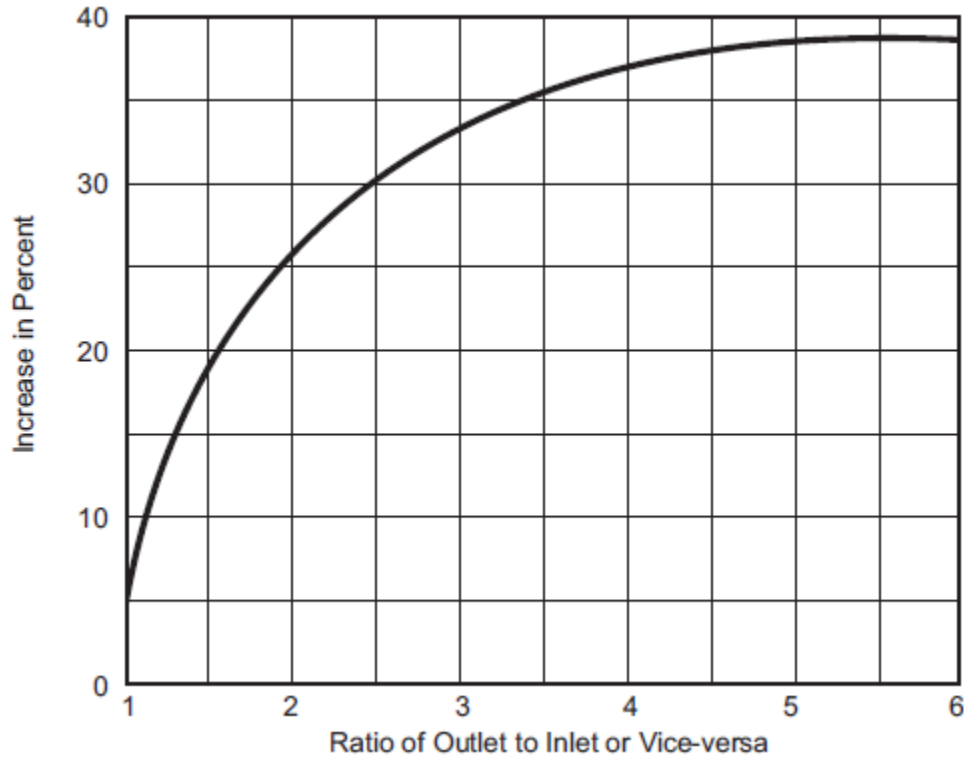


Figure 1—Increase in Flow Caused by Excess of One Opening Over Another (See 6.3.2.4.5)

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

where

h is the height from the center of the lower 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;

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

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

A_2 is the free area of upper opening, in square feet.

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

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

6.3.2.4.6 Buildings or other enclosed or partially enclosed areas are considered adequately ventilated because of their construction characteristics if they conform with both 6.3.2.4.1 and one of the following:

- a building or area having a roof or ceiling with walls comprising 50 % or less vertical wall area than the total wall area possible is considered to be adequately ventilated (regardless of the type of floor);
- a building or area is considered to be adequately ventilated provided it has neither a floor (e.g., 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.

6.3.2.4.7 Enclosed areas can be considered to be 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 in accordance with the requirements of Annex G 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 6.3.2.4.3.

6.3.3 Inadequately Ventilated Areas

6.3.3.1 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 6.3.2.

6.3.3.2 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.

6.4 Adjacent Areas

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

6.4.2 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.

6.4.3 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.

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

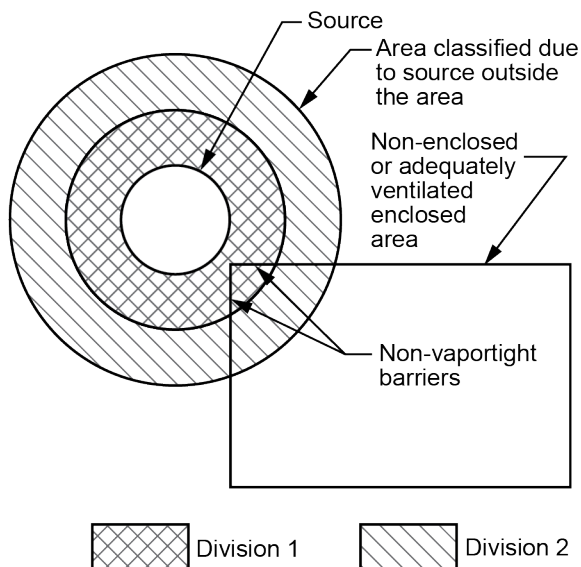


Figure 2—Non-enclosed or Adequately Ventilated Enclosed Area Adjacent to a Classified Area (Section 6.4.1)

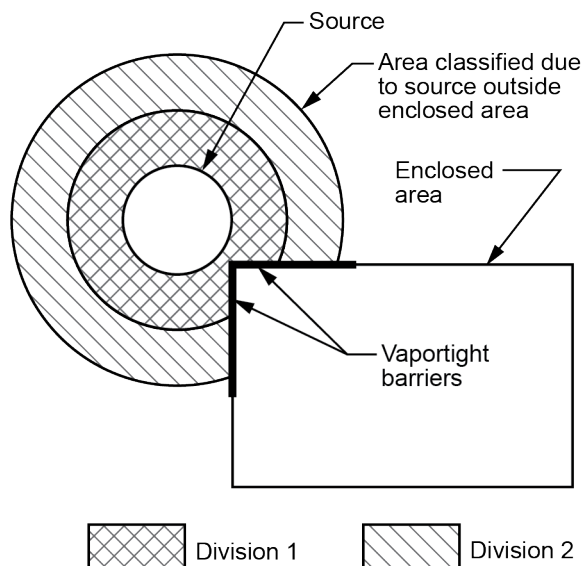


Figure 3—Enclosed Area Adjacent to a Classified Area (Section 6.4.2)

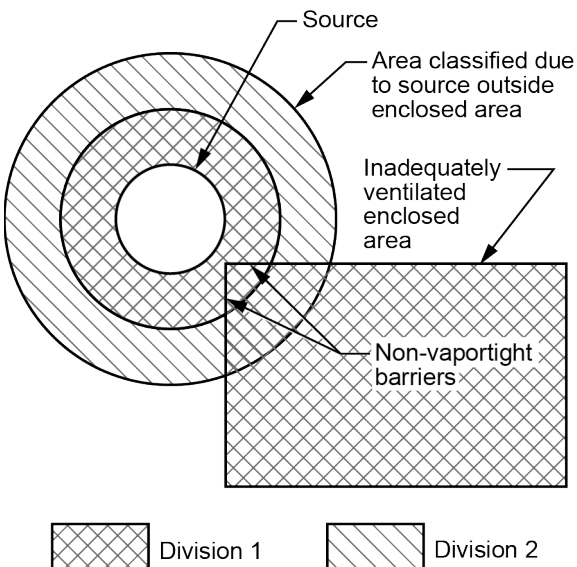


Figure 4—Inadequately Ventilated, Enclosed Area Adjacent to a Classified Area (Section 6.4.3)

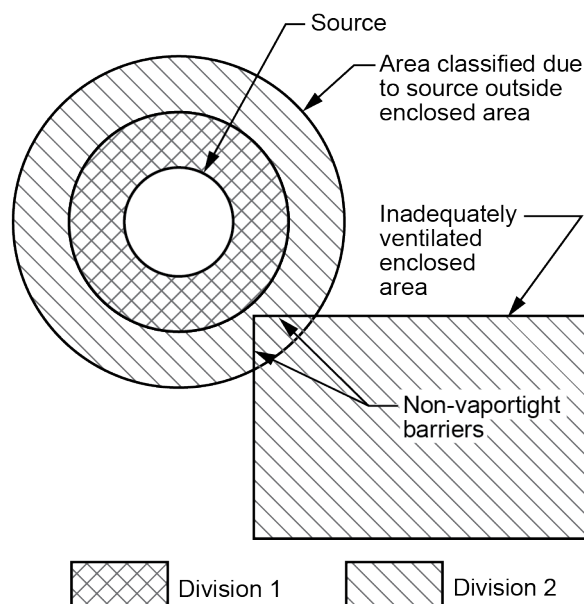


Figure 5—Inadequately Ventilated, Enclosed Area Adjacent to a Classified Area (Section 6.4.3)

6.5 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 Division 1 or Division 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 Division 2 or unclassified. However, where ventilation is inadequate, vapor-air and gas-air mixtures are more likely to reach flammable limits, and the situation can 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 classified Division 1 to the extent of the enclosure. The addition of adequate ventilation through mechanical or natural means may justify the reduction of the area classified as Division 1 to Division 2. For sources of release under normal operating conditions, the area immediately surrounding the source of release still requires a Division 1 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, transportation, and LNG 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 fixed roof flammable liquid storage tanks in Non-enclosed, Adequately Ventilated areas are classified as shown in Figure 6. See 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 Division 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 Division 1 both inside the tank (as shown in Figure 6) and outside the tank to the extent of 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. See 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 enclosed adequately ventilated areas are classified as shown in Figure 7, but with the remainder of the enclosed area designated as Division 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.

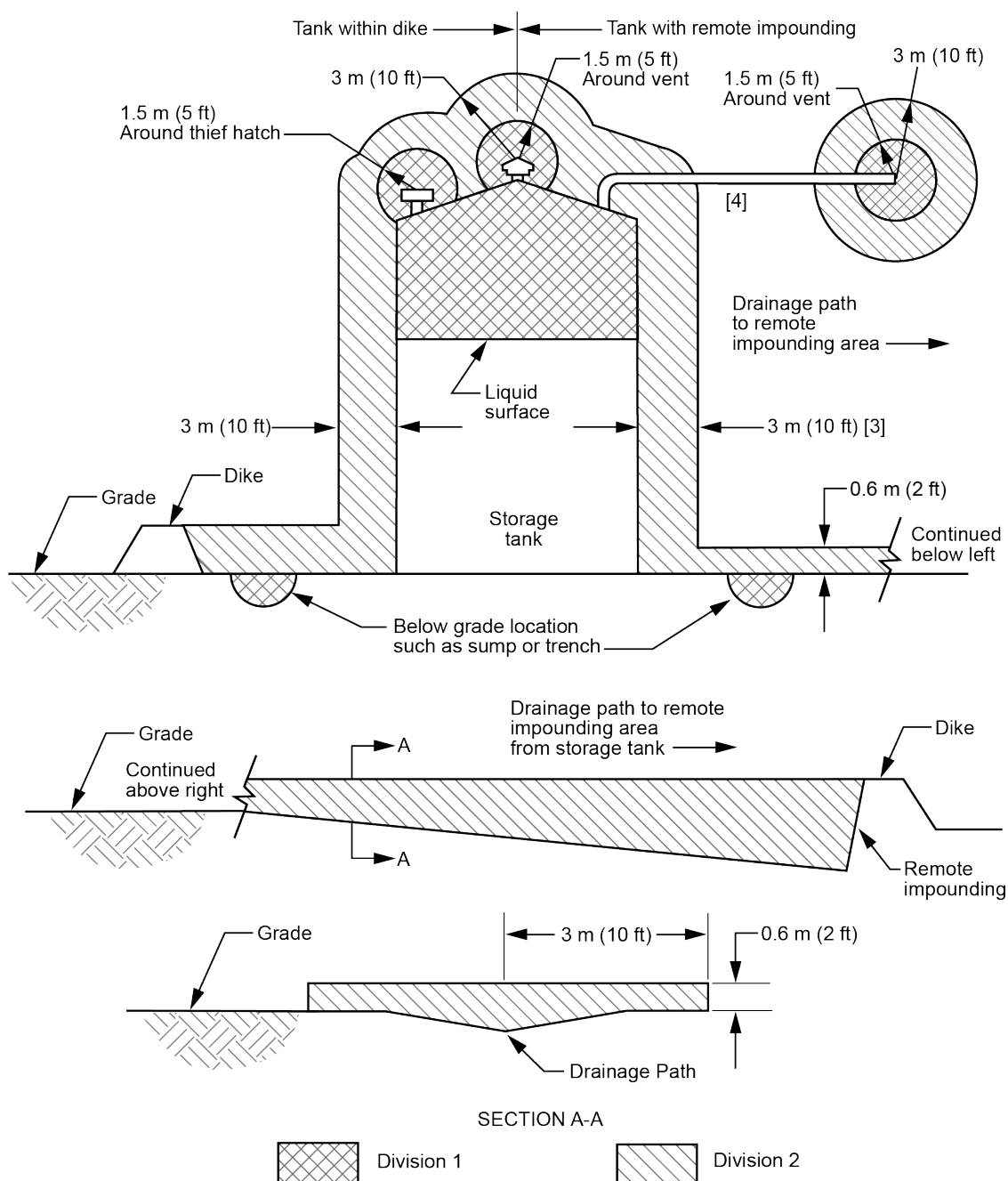
8.2.1.3.3 Areas in and around open-top floating roof flammable liquid storage tanks in Inadequately Ventilated, Enclosed areas are classified Division 1 inside the tank (as shown in Figure 7) and outside the tank to the extent of the enclosed area.

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. See 5.2 for a discussion of combustible liquids.

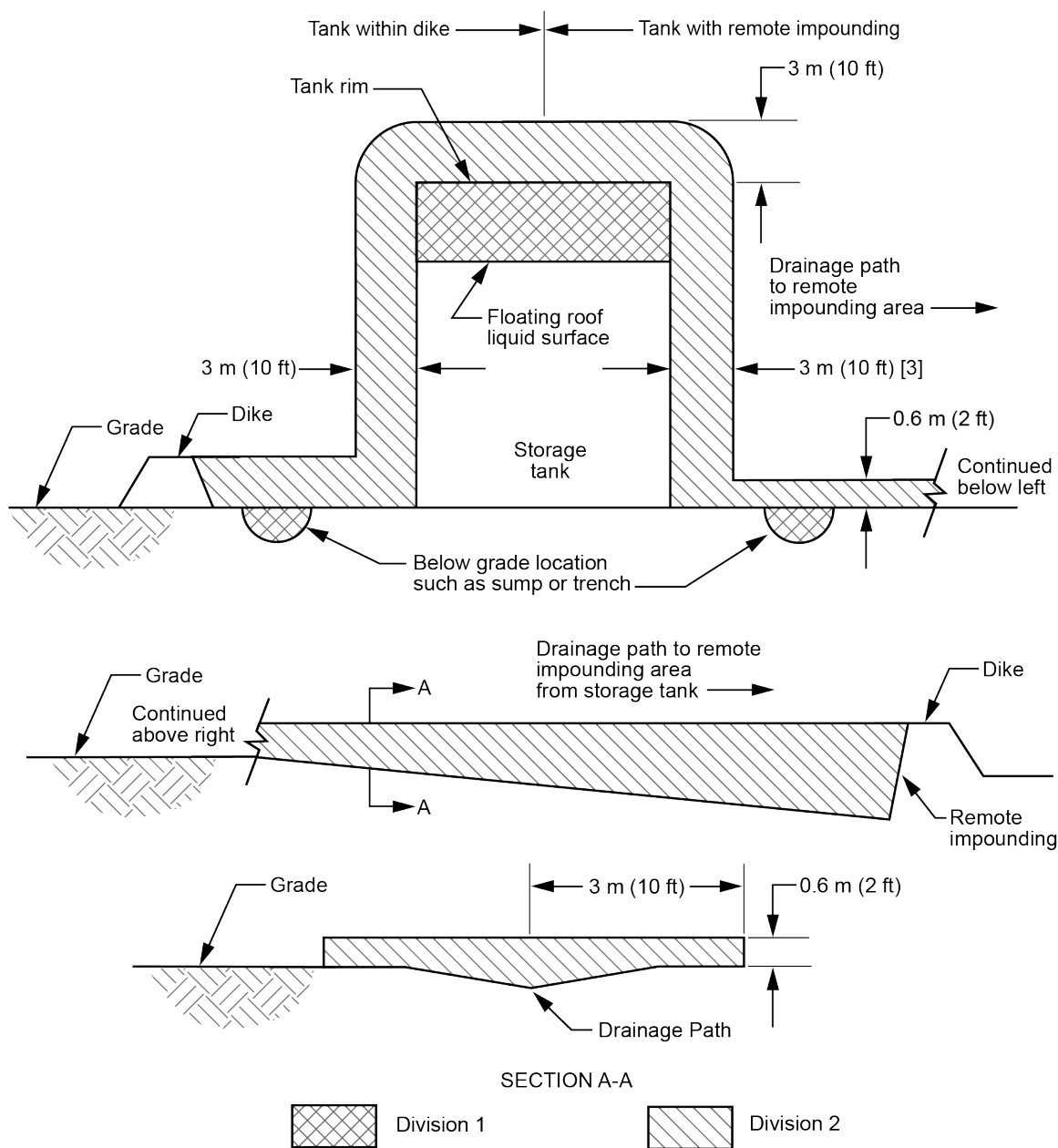
8.2.1.4.2 Enclosed areas containing unheated storage tanks for combustible liquids are unclassified provided all vents are extended to the outside of the enclosed area.

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.



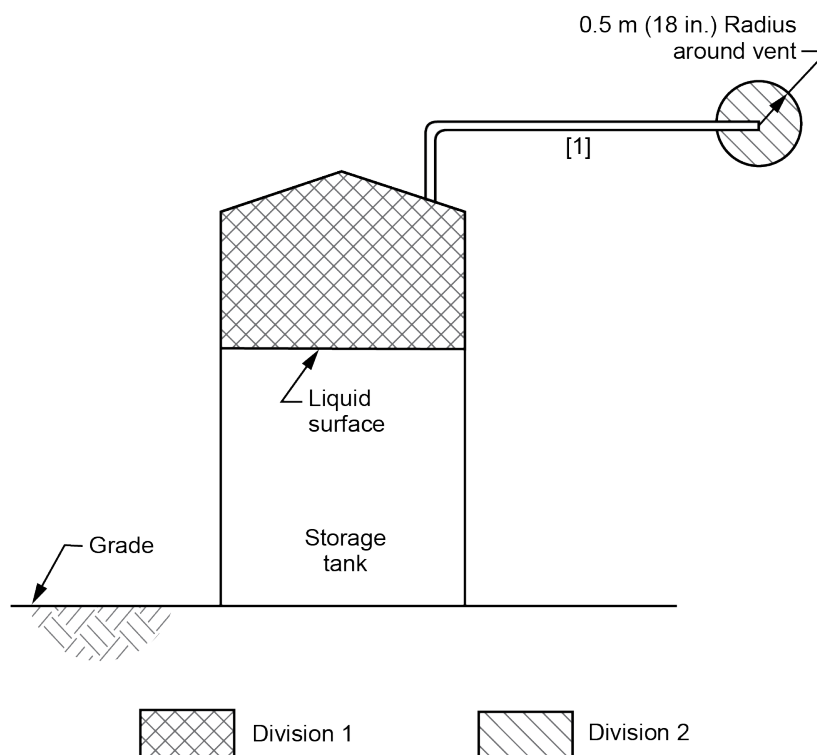
- [1] High filling rates or blending operations involving Class I flammable liquids may require extending the boundaries of classified areas.
- [2] Distances given are for typical petroleum facilities; they shall be used with judgment, with consideration given to all factors discussed in the text.
-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

Figure 6—Fixed-roof Flammable Liquid Storage Tank in a Non-enclosed, Adequately Ventilated Area (See 8.2.1.2.1)



- [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 dyke or no remote impounding, the Division 2 area only extends 3 meters (10 feet) 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 Division 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.

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.) Division 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.

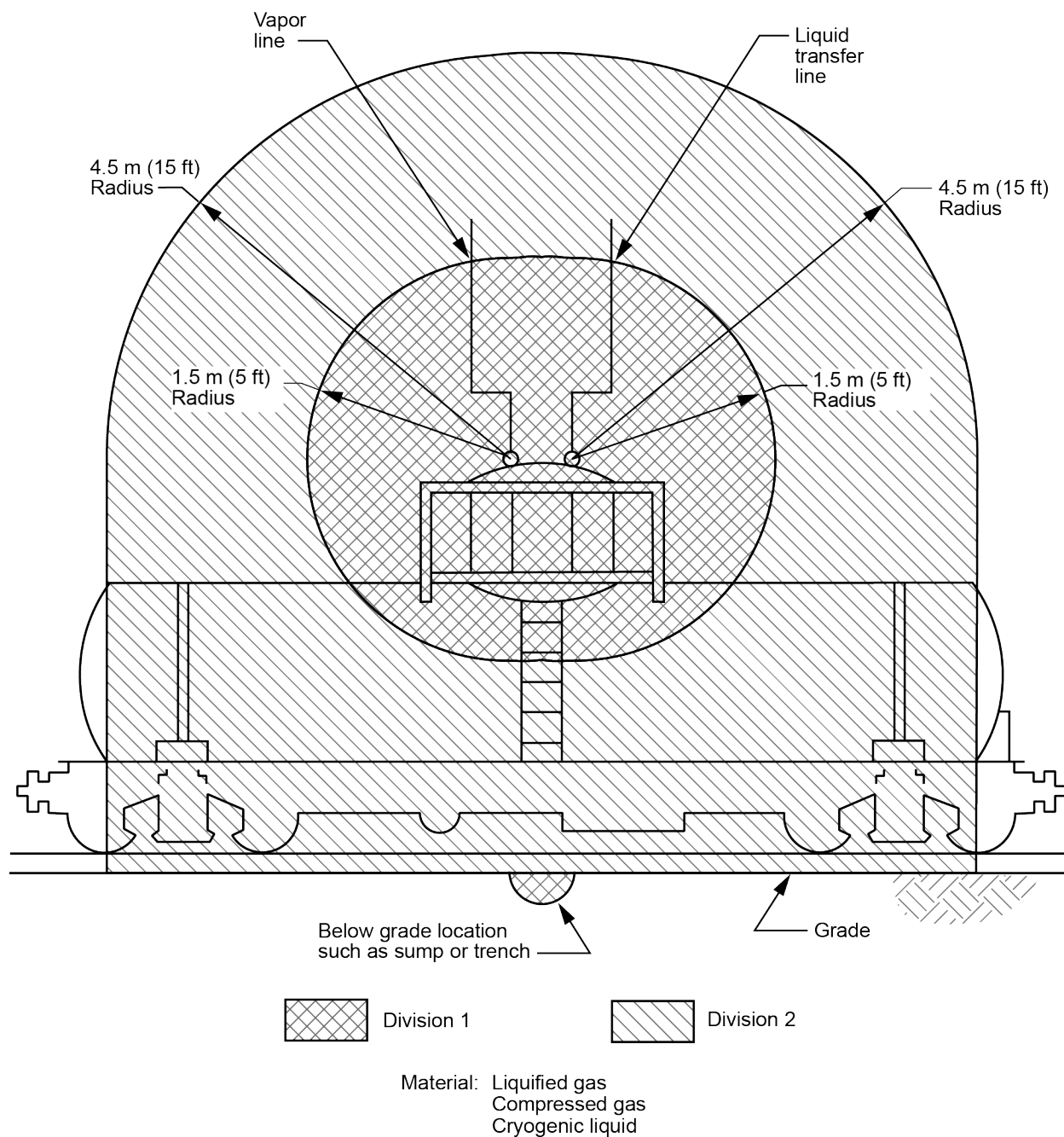


Figure 9—Tank Car or Tank Truck Loading and Unloading Via Closed System Product Transfer Through Dome Only (See 8.2.2.1)

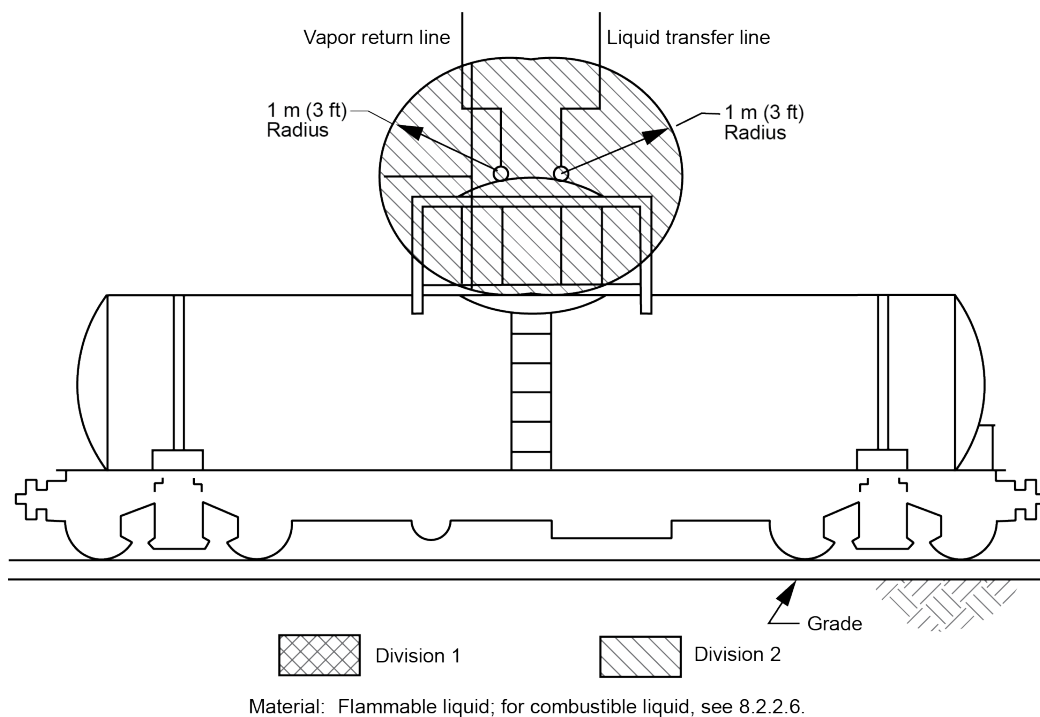


Figure 10—Tank Car or Tank Truck Loading and Unloading via Closed System Product Transfer Through Dome Only (See 8.2.2.2)

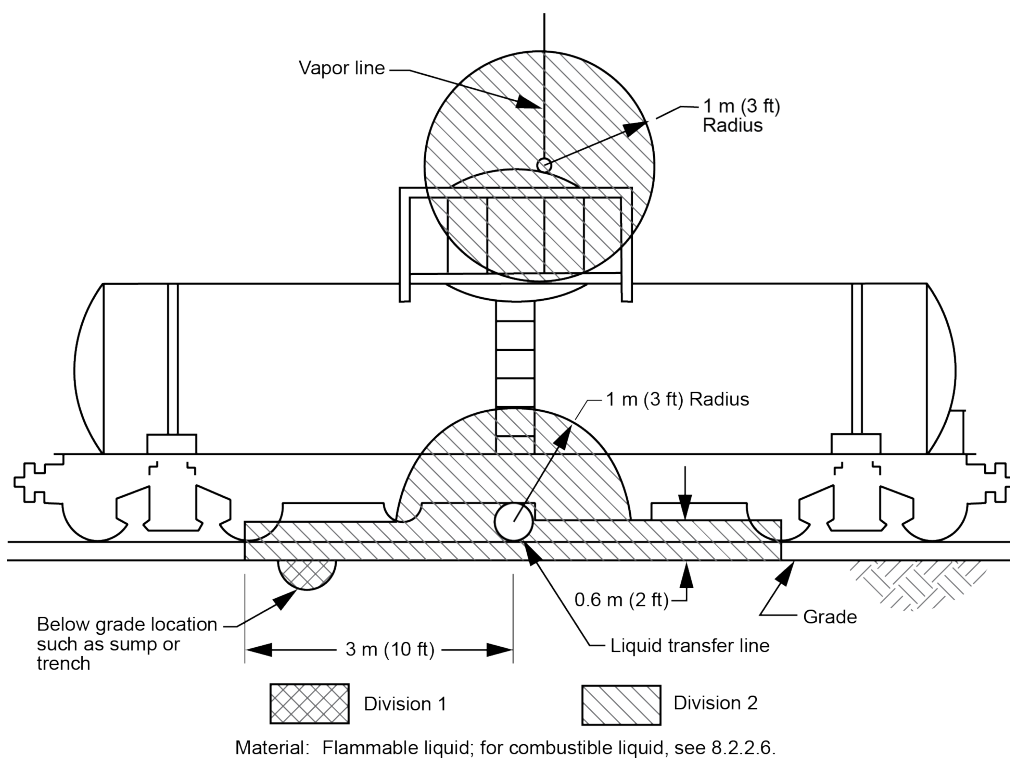


Figure 11—Tank Car or Tank Truck Loading and Unloading via Closed System Product Transfer Through Bottom Only (See 8.2.2.3)

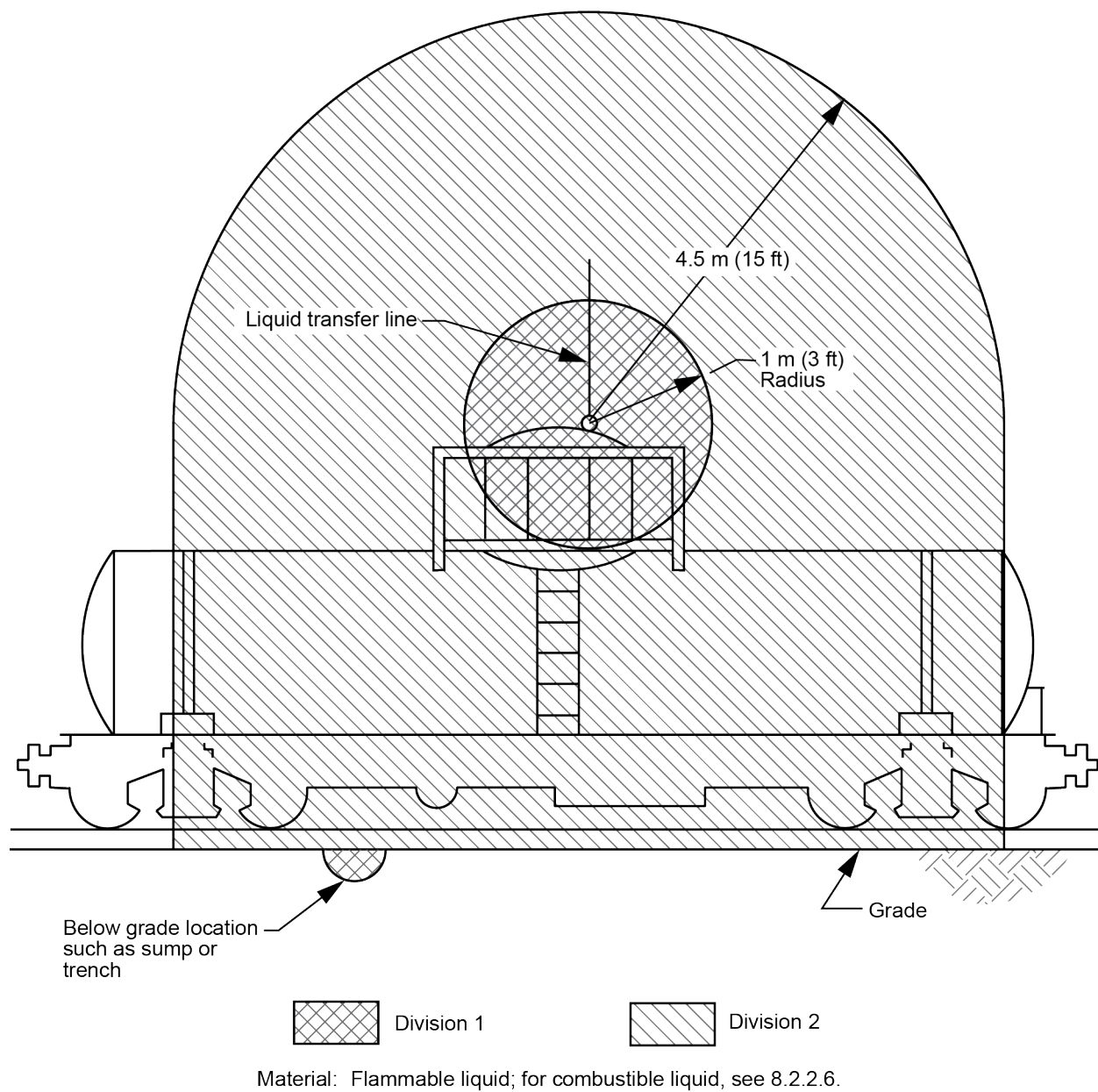


Figure 12—Tank Car or Tank Truck Loading and Unloading via Open System Product Transfer Through Top or Bottom (See 8.2.2.4)

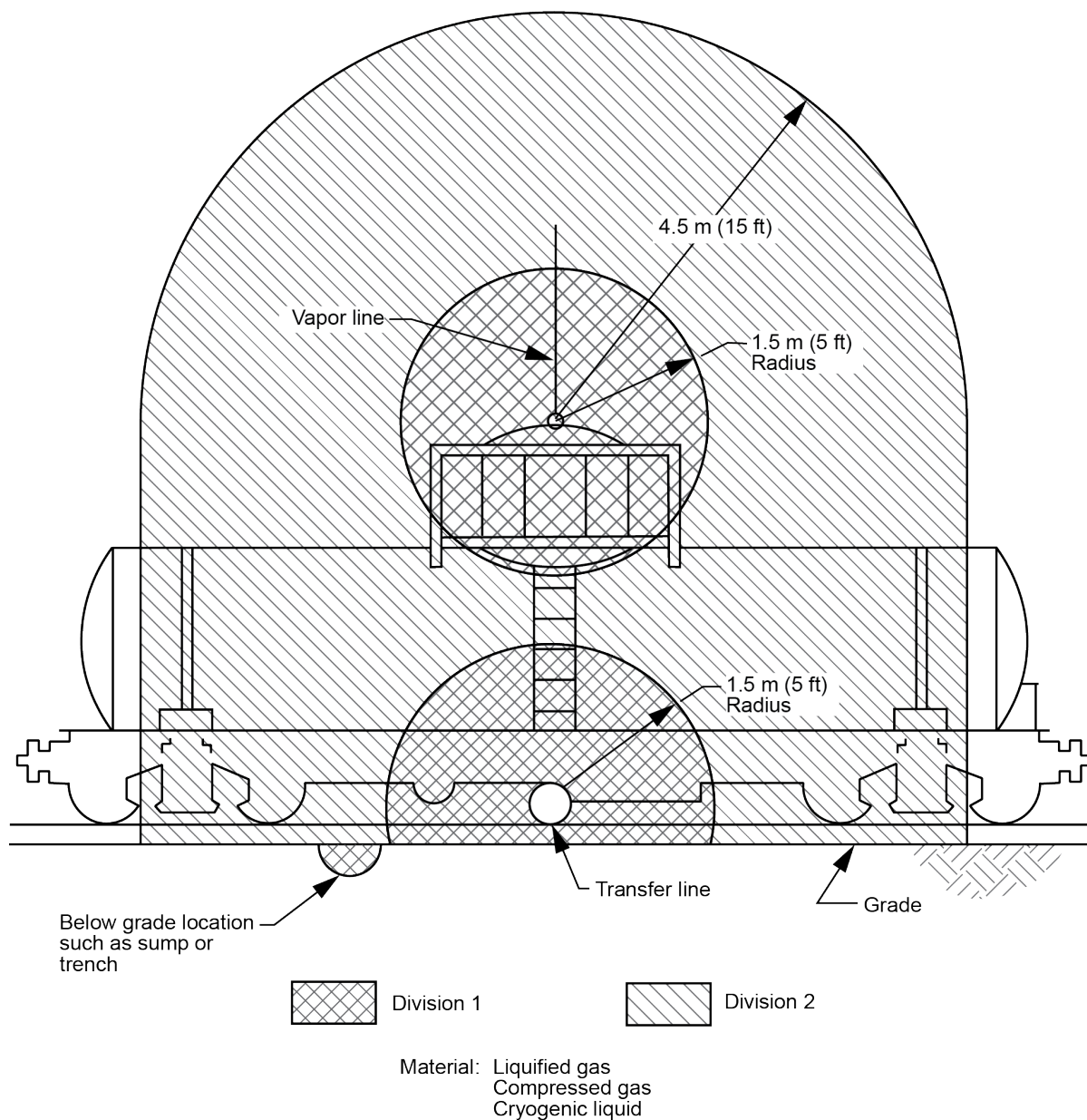


Figure 13—Tank Car or Tank Truck Loading and Unloading via Closed System Product Transfer Through Bottom Only (See 8.2.2.5)

8.2.3 Vents, Relief Valves, and Rupture Disks

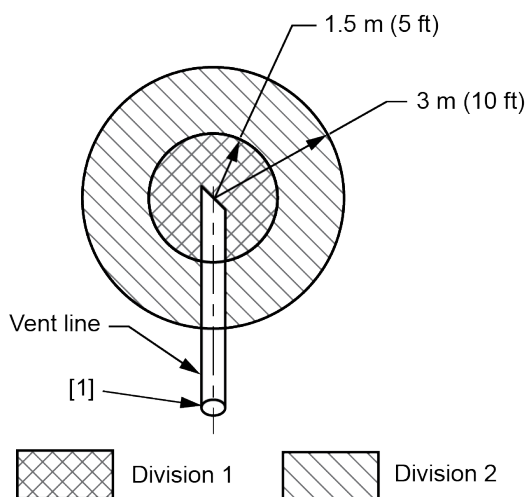
8.2.3.1 Process Equipment Vents

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 Division 1 to the extent of the enclosed area.

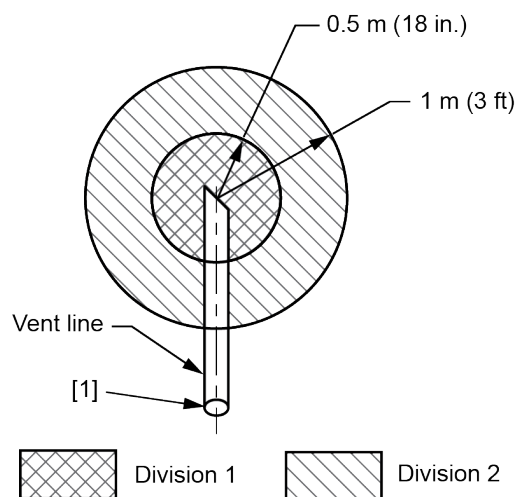
8.2.3.2 Instrument and Control Device Vents

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.



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

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



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

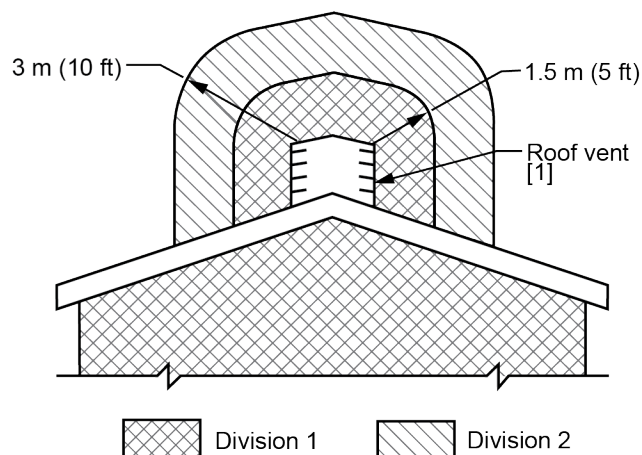
Figure 15—Instrument or Control Device Vent in a Non-enclosed, Adequately Ventilated Area (Section 8.2.3.2)

8.2.3.2.2 Enclosed areas containing vents from instruments and control devices utilizing flammable gas for control are classified Division 1 to the extent of the enclosed area.

8.2.3.3 Atmospheric Vents

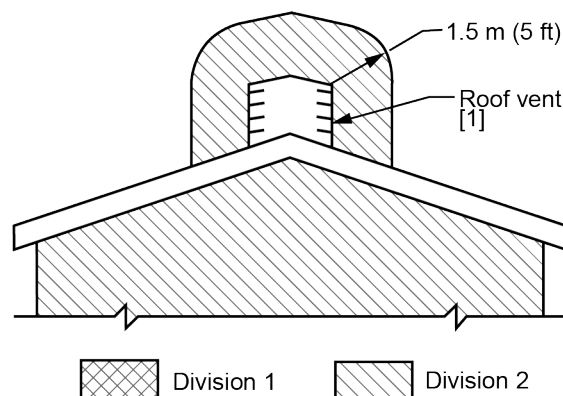
8.2.3.3.1 Atmospheric vents (e.g., building ridge vents, building roof vents, and atmospheric tank vents) are classified as shown in Figure 16 when they vent from a Division 1 area.

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



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

Figure 16—Atmospheric Vent from a Division 1 Area (Section 8.2.3.3.1)

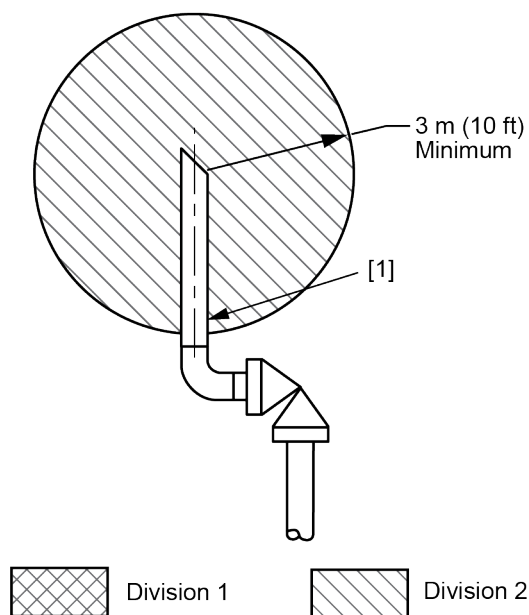


[1] The interior of the roof vent is Division 2.
Cross hatching has been omitted for drawing clarity.

Figure 17—Atmospheric Vent from a Division 2 Area (Section 8.2.3.3.2)

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, Adequately Ventilated 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.



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

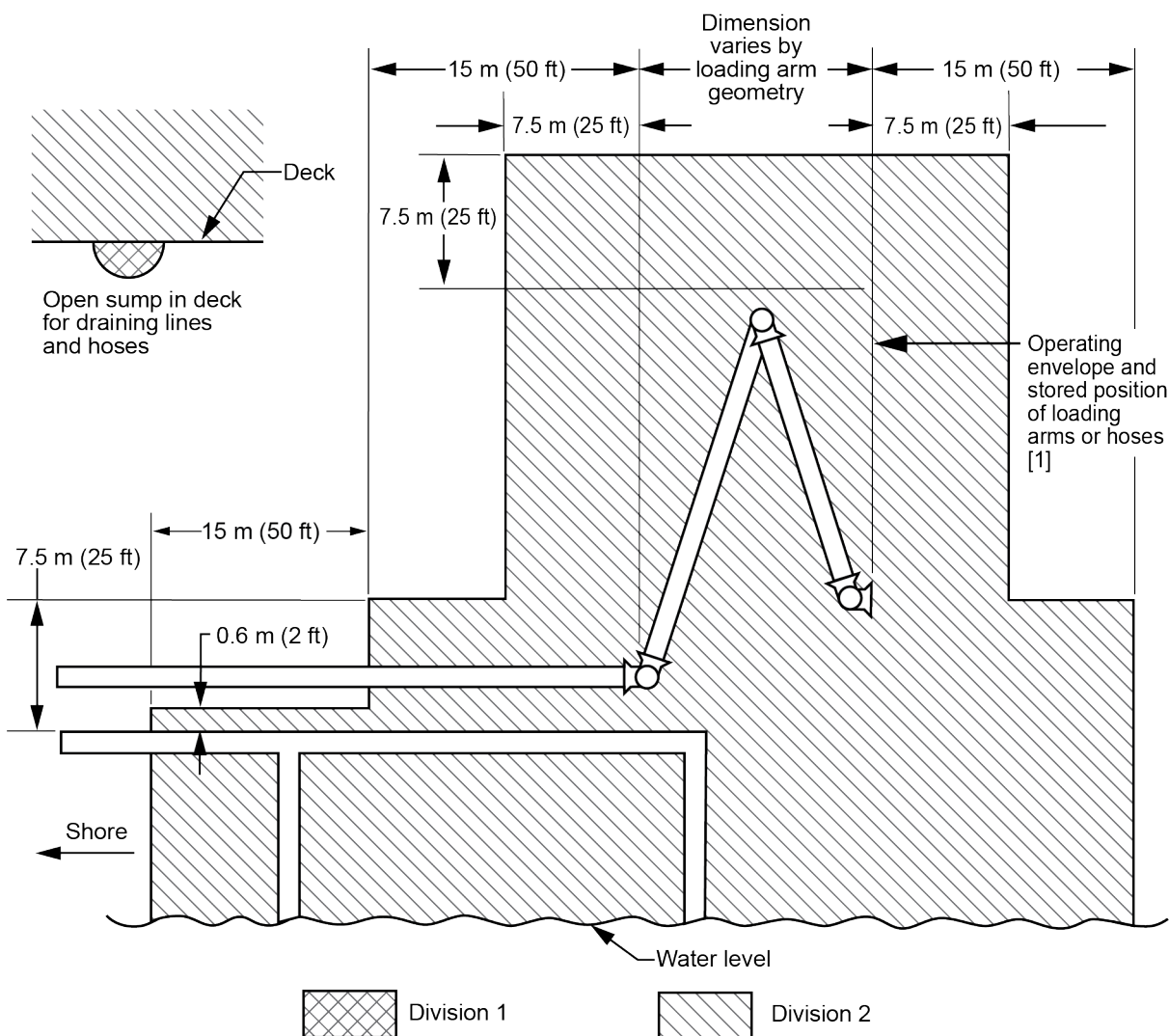
Figure 18—Relief Valve in a Non-enclosed, Adequately Ventilated Area (See 8.2.3.4.1)

8.2.3.4.2 Enclosed areas containing relief valve vents are classified Division 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 Terminal 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 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 Division 1.



- [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 Division 2 to the following extent:
- 7.5 meters (25 feet) horizontally in all directions on the pier side from that portion of the hull containing cargo tanks.
 - 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.

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

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 Division 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-fueled prime movers is based on NFPA 37, is specific to this application, and is not applicable for other systems.

NOTE 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.

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 B 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; are of the nickel-cadmium or nickel-hydride type; have a total volume less than one-hundredth of the free volume of the enclosed area; and have a capacity not exceeding 1.5 ampere-hours at a one-hour discharge rate do not require area classification solely due to the presence of the batteries.

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, and either have a total volume less than one-hundredth of the free volume of the enclosed area or have a charging system that has a rated output of 200 watts or less and that is designed to prevent inadvertent overcharging, do not require area classification solely due to the presence of the batteries.

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 degrees 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 6.3.2. The method of ventilation should be 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 Division 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 degrees 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 8.2.6.6.2 a), 8.2.6.6.2 b), or 8.2.6.6.2 c) would be classified Division 1 and therefore unsuitable for battery installations.

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 1.27×10^{-7} cubic meters per second (0.000269 ft³ per minute) 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 Division 2 provided:

- a) ventilation is at least 25 % of that required for adequate ventilation; and
- b) the battery charging system is designed to prevent inadvertent overcharging.

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

8.2.7 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*. 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 sub-section 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 sub-section 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, see 8.2.7.3.

8.2.7.2.3 Non-enclosed, 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