NFPA 385

Standard for

Tank Vehicles for Flammable and Combustible Liquids

2007 Edition

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This edition of NFPA 385, *Standard for Tank Vehicles for Flammable and Combustible Liquids*, was prepared by the Technical Committee on Transportation of Flammable Liquids. It was issued by the Standards Council on December 1, 2006, with an effective date of December 20, 2006, and supersedes all previous editions.

This edition of NFPA 385 was approved as an American National Standard on December 20, 2006.

Origin and Development of NFPA 385

This standards project was initiated in 1926, and the first edition of NFPA 385 was officially adopted in 1929. NFPA 385 was revised in 1933, 1948, 1953, 1954, 1955, 1957, 1958, 1959, 1960, 1963, 1964, 1966, 1971, 1974, 1979, 1985, 1990, 2000, and 2006. Editions prior to 1948 had different titles.

The 2000 edition incorporated the following amendments:

(1) Revised requirements for warning signs, in 3.4.5

(2) Revised requirements for fire extinguishers for tank vehicles, in 6.3.1

The 2007 edition incorporates the following amendments:

(1) Revised definitions to correlate with NFPA 30, *Flammable and Combustible Liquids Code*

(2) Correction of an error in 6.3.1 (now 9.3.1) related to fire extinguisher rating

(3) Complete editorial revision to comply with the *Manual of Style for NFPA Technical Committee Documents*

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This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

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

Committee Scope: This Committee shall have primary responsibility for documents on safeguarding against the fire and explosion hazards associated with over-the-road transportation of flammable and combustible liquids in tank vehicles and in portable tanks and containers.

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

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

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

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Chapter 1 Administration

1.1 Scope.

1.1.1* This standard shall apply to tank vehicles used for the transportation of asphalt or normally stable flammable and combustible liquids with flash points below 200°F (93°C).

1.1.2 This standard shall also provide minimum requirements for the design and construction of cargo tanks and their appurtenances and shall set forth certain matters pertaining to tank vehicles.

1.1.3 The provisions of this standard shall not preclude the use of additional safeguards for tank vehicles used for the transportation of flammable and combustible liquids having characteristics that introduce additional factors such as high rates of expansion, instability, corrosiveness, and toxicity.

1.1.4 The provisions of this standard shall also apply to cutback asphalts that have flash points below 100°F (37.8°C) and to liquids transported at temperatures elevated above their flash points.

1.1.5 The requirements for aircraft fuel servicing tank vehicles shall be in accordance with NFPA 407, *Standard for Aircraft Fuel Servicing*.

1.1.6 A tank vehicle transporting a flammable or combustible liquid in interstate service shall be considered to be in compliance with this standard while it is in interstate service if it meets the requirements of the U.S. Department of Transportation 49 CFR 171–179, "Hazardous Materials Regulations."

1.2 Purpose.

The purpose of this standard shall be to provide for safe transportation of flammable and combustible liquids in tank vehicles.

Chapter 2 Referenced Publications

2.1 General.

The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications.

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

NFPA 10, *Standard for Portable Fire Extinguishers,* 2007 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2004 edition.

NFPA 70, *National Electrical Code®,* 2005 edition.

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NFPA 407, *Standard for Aircraft Fuel Servicing,* 2007 edition.

2.3 Other Publications.

2.3.1 ANSI Publications.

American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI Z535.1, *Safety Color Code*, 1998.

2.3.2 ASME Publications.

American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

Boiler and Pressure Vessel Code, 2004.

2.3.3 ASTM Publications.

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

ASTM B 209, *Specification for Aluminum and Aluminum-Alloy Sheet and Plate*, 1996 edition.

ASTM D 5, *Test for Penetration for Bituminous Materials*, 1997 edition.

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

2.3.4 U.S. Government Publications.

U.S. Government Printing Office, Washington, DC 20402.

Title 49, Code of Federal Regulations, "Hazardous Materials Regulations," Parts 171–179.

Title 49, Code of Federal Regulations, "Rear Impact Guards and Rear End Protection," Part 393.86.

2.3.5 Other Publications.

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

2.4 References for Extracts in Mandatory Sections. (Reserved)

Chapter 3 Definitions

3.1 General.

The definitions contained in this chapter shall apply to the terms used in this standard. Where

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terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.3* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.3 General Definitions.

3.3.1 Baffle. A nonliquidtight transverse partition in a cargo tank.

3.3.2 Bulkhead. A liquidtight transverse closure between compartments of a cargo tank.

3.3.3 Cargo Tank. For the purposes of this standard, any tank having a liquid capacity in excess of 110 gal (415 L) used for carrying flammable and combustible liquids or asphalt and mounted permanently or otherwise upon a tank vehicle. The term *cargo tank* does not apply to any container used solely for the purpose of supplying fuel for the propulsion of the tank vehicle upon which it is mounted.

3.3.4* Combustible Liquid. Any liquid that has a flash point at or above 100°F (37.8°C) and below 140°F (60°C).

3.3.5 Compartment. For the purposes of this standard, a liquidtight division in a cargo tank.

3.3.6* Flammable Liquid. Any liquid that has a closed-cup flash point below 100°F (37.8°C) and a Reid vapor pressure not exceeding 276 kPa (40 psia or 2068 mm Hg).

3.3.7* Flash Point. The minimum temperature at which a liquid or a solid emits vapor sufficient to form an ignitible mixture with air near the surface of the liquid or the solid.

3.3.8 Head. A liquidtight transverse closure at the end of a cargo tank.

3.3.9 Liquid. Any material that has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D 5, *Test for Penetration for Bituminous Materials*.

3.3.10 Tank.

3.3.10.1 Full-Trailer Tank. Any vehicle with or without auxiliary motive power, equipped

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with a cargo tank mounted thereon or built as an integral part thereof, used for the transportation of flammable and combustible liquids or asphalt, and so constructed that practically all of its weight and load rests on its own wheels.

3.3.10.2 Semi-Trailer Tank. Any vehicle with or without auxiliary motive power, equipped with a cargo tank mounted thereon or built as an integral part thereof, used for the transportation of flammable and combustible liquid or asphalt, and so constructed that, when drawn by a tractor by means of a fifth wheel connection, some part of its load and weight rests upon the towing vehicle.

3.3.11 Tank Truck. Any single self-propelled motor vehicle equipped with a cargo tank mounted thereon and used for the transportation of flammable and combustible liquids or asphalt.

3.3.12 Tank Vehicle. Any tank truck, tank full-trailer, or tractor and tank semi-trailer combination.

3.3.13* Vapor Pressure. The pressure, measured in pounds per square inch, absolute (psia), exerted by a liquid, as determined by ASTM D 323, *Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method)*.

Chapter 4 Classification of Flammable and Combustible Liquids

4.1 Scope.

4.1.1 This chapter shall establish a uniform system of defining and classifying flammable and combustible liquids for the purpose of proper application of this standard.

4.1.2 Classifications of this chapter shall apply to any liquid within the scope of, and subject to, the requirements of this standard.

4.2 Classification of Liquids.

Any liquid within the scope of this standard and subject to the requirements of this standard shall be classified in accordance with this section.

4.2.1 Flammable liquids, as defined in 3.3.6, shall be classified as Class I liquids and shall be further classified in accordance with (1), (2), and (3), as follows:

(1) Class IA Liquid. Any liquid that has a flash point below 73°F (22.8°C) and a boiling point below 100°F (37.8°C).

(2) Class IB Liquid. Any liquid that has a flash point below 73°F (22.8°C) and a boiling point at or above 100°F (37.8°C).

(3) Class IC Liquid. Any liquid that has a flash point at or above 73°F (22.8°C) but below 100°F (37.8°C).

4.2.2 Combustible liquids, as defined in 3.3.4, shall be classified in accordance with (1) and

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(2), as follows.

(1) Class II Liquid. Any liquid that has a flash point at or above 100°F (37.8°C) and below 140°F (60°C).

(2) Class III Liquid. Any liquid that has a flash point at or above 140°F (60°C). Class III liquids shall be further classified in accordance with (a) and (b), as follows:

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

(b) Class IIIB Liquid. Any liquid that has a flash point at or above 200°F (93°C).

Chapter 5 Tank Vehicle Design

5.1 General.

5.1.1 Design of the tank vehicle shall give engineering consideration to the structural relationship between the cargo tank, the propulsion equipment, and the supporting members, if any, with due regard to the weight and temperature of the cargo, road performance, braking, and required ruggedness.

5.1.2 Metal thicknesses specified in this chapter shall be the minimum thicknesses dictated by the structure of the tank itself. These thicknesses shall be permitted to be increased where the tank shell is to be subjected to additional stress.

5.1.3 The general design of the cargo tank and vehicle chassis shall be arranged to give the best combination of structural characteristics and vehicle performance.

5.1.4 The design of the suspension system shall incorporate features to help ensure lateral or tipping stability when the tank vehicle is turning corners.

5.1.5 Any cargo tank designed for transporting materials at liquid temperatures above ambient temperatures shall have a metal warning plate located in a conspicuous place on the right side near the front.

5.1.5.1 The plate shall not be subject to corrosion.

5.1.5.2 The plate shall be permanently affixed to the tank or tank frame.

5.1.5.3 The following information shall be marked on the plate in characters at least ½ in. (12.5 mm) high by stamping, embossing, or other means of forming letters into or on the metal of the plate itself:

Maximum allowable cargo temperature is ___°F (___°C).

5.1.5.4 The maximum allowable cargo temperature shall be specified by the manufacturer of the cargo tank.

5.1.6* Cargo tanks used for transporting flammable or combustible liquids at temperatures at or above their boiling points shall be constructed in accordance with Section 5.2.

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5.1.7 Cargo tanks used for transporting flammable or combustible liquids at temperatures below their boiling points shall be constructed in accordance with the provisions of Section 5.3.

5.1.8* The material used in the construction of the cargo tanks shall be compatible with the chemical characteristics of the flammable or combustible liquid to be transported.

5.1.9 Where a single cargo tank is divided into compartments of different specification construction, each such compartment shall conform to the specification requirements concerned and be so identified with a permanent metal plate.

5.2 Cargo Tanks, Piping, and Connections Designed for Transporting Flammable or Combustible Liquids at Temperatures at or Above Their Boiling Points.

Cargo tanks, piping, and connections designed for transporting flammable or combustible liquids at or above their boiling points shall be constructed in accordance with the U.S. Department of Transportation's regulations in 49 CFR 178, "Hazardous Materials Regulations," in accordance with Chapter 6 of NFPA 58, *Liquefied Petroleum Gas Code*.

5.3 Cargo Tanks, Piping, and Connections Designed for Transfer of Flammable or Combustible Liquids at Temperatures Below Their Boiling Points.

5.3.1 General.

5.3.1.1 Cargo tanks constructed after the effective date of this standard shall be constructed in accordance with Section 5.3.

5.3.1.2 Continued use of existing cargo tanks constructed in accordance with prior editions of this standard shall be permitted, but new construction according to older standards shall not be permitted.

5.3.2* **Material.** All sheet and plate material for shell, heads, bulkheads, and baffles for cargo tanks that are not required to be constructed in accordance with the ASME *Boiler and Pressure Vessel Code* shall meet the following minimum applicable requirements:

(1) Aluminum Alloys (AL) — Only aluminum alloy material suitable for fusion welding and complying with ASTM B 209, *Specification for Aluminum and Aluminum-Alloy Sheet and Plate*, shall be used. Heads, bulkheads, baffles, and ring stiffeners shall be permitted to use 0 temper (annealed) or stronger tempers. Shells shall be made of materials with properties equivalent to H32 or H34 tempers, except that lower ultimate strength tempers shall be permitted to be used if the minimum shell thicknesses in Table 5.3.3.1(b) are increased in inverse proportion to the lesser ultimate strength.

(2) Steel — Steel shall meet the requirements of Table 5.3.2.

Table 5.3.2 Properties of Steel

Property	Mild Steel (MS)		High Strength Low Alloy Steel (HSLA)		Austenitic Stainless Steel (SS)	
Yield strength	25,000 psi	170 MPa	45,000 psi	310 MPa	25,000 psi	170 MPa

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Table 5.3.2 Properties of Steel

Property	Mild Steel (MS)		High Strength Low Alloy Steel (HSLA)		Austenitic Stainless Steel (SS)	
Ultimate strength	45,000 psi	310 MPa	60,000 psi	410 MPa	70,000 psi	480 MPa
Elongation [2 in. (50.8 mm) sample]	20%		25%		30%	

5.3.3 Thickness of Sheets, Heads, Bulkheads, and Baffles.

5.3.3.1 The minimum thicknesses of tank material shall be predicated on not exceeding the maximum allowable stress level, but in no case shall they be less than those indicated in Table 5.3.3.1(a) and Table 5.3.3.1(b).

Table 5.3.3.1(a) Minimum Thickness of Heads, Bulkheads, and Baffles in U.S. Standard Gauge (Steels) or Decimal Inches (Aluminum)

	Volume Capacity in Gallons per Inch											
	10 or Less			Over 10 to 14			14 to 18			18 and Over		
	MS	HSLA, SS	AL	MS	HSLA, SS	AL	MS	HSLA, SS	AL	MS	HSLA, SS	AL
Thickness	14	15	0.096	13	14	0.109	12	13	0.130	11	12	0.151

MS: mild steel. HSLA: high strength low alloy steel. SS: austenitic stainless steel. AL: aluminum.

Table 5.3.3.1(b) Minimum Thickness of Shell Sheets in U.S. Standard Gauge (Steels) or Decimal Inches (Aluminum)

		Volume Capacity in Gallons per Inch											
		10 or Less			Over 10 to 14			14 to 18			18 and Over		
Maximum Shell Radius	Distance Between Bulkheads, Baffles, or Ring Stiffeners	MS	HSLA, SS	AL	MS	HSLA, SS	AL	MS	HSLA, SS	AL	MS	HSLA, SS	AL
Less than 70 in.	36 in. or less	14	16	0.087	14	16	0.087	14	15	0.096	13	14	0.109
	Over 36 in. to 54 in.	14	16	0.087	14	15	0.096	13	14	0.109	12	13	0.130
	Over 54 in. through 60 in.	14	15	0.096	13	14	0.109	12	13	0.130	11	12	0.151

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Table 5.3.3.1(b) Minimum Thickness of Shell Sheets in U.S. Standard Gauge (Steels) or Decimal Inches (Aluminum)

		Volume Capacity in Gallons per Inch											
		10 or Less			Over 10 to 14			14 to 18			18 and Over		
Maximum Shell Radius	Distance Between Bulkheads, Baffles, or Ring Stiffeners	MS	HSLA, SS	AL	MS	HSLA, SS	AL	MS	HSLA, SS	AL	MS	HSLA, SS	AL
70 in. or more, less than 90 in.	36 in. or less	14	16	0.087	14	15	0.096	13	14	0.109	12	13	0.130
	Over 36 in. to 54 in.	14	15	0.096	13	14	0.109	12	13	0.130	11	12	0.151
	Over 54 in. through 60 in.	13	14	0.109	12	13	0.130	11	12	0.151	10	11	0.173
90 in. or more, less than 125 in.	36 in. or less	14	15	0.096	13	14	0.109	12	13	0.130	11	12	0.151
	Over 36 in. to 54 in.	13	14	0.109	12	13	0.130	11	12	0.151	10	11	0.173
	Over 54 in. through 60 in.	12	13	0.130	11	12	0.151	10	11	0.173	9	10	0.194
125 in. or more	36 in. or less	13	14	0.109	12	13	0.130	11	12	0.151	10	11	0.173
	Over 36 in. to 54 in.	12	13	0.130	11	12	0.151	10	11	0.173	9	10	0.194
	Over 54 in. through 60 in.	11	12	0.151	10	11	0.173	9	10	0.194	8	9	0.216

MS: mild steel. HSLA: high strength low alloy steel. SS: austenitic stainless steel. AL: aluminum.

5.3.3.2 The minimum material thicknesses contained in Table 5.3.3.1(a) and Table 5.3.3.1(b) shall be based on a maximum 7.2 lb per gal (0.86 kg/L) product weight. If the tank is designed to haul products weighing more than 7.2 lb per gal (0.86 kg/L), the gallon per inch value used to determine the minimum thickness of heads, bulkheads, baffles, or shell sheets shall be the actual section capacity required in gallons per inch multiplied by the actual product density in pounds per gallon divided by 7.2.

5.3.3.3 Where aluminum is used for cargo tanks intended to transport cargoes at liquid temperatures above 250°F (121°C), the minimum thicknesses shall be increased by 1 percent
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for each 10°F (5.6°C) or portion thereof above 250°F (121°C). Where the liquid temperatures are above 500°F (260°C), there shall be an additional 1 percent for each 10°F (5.6°C) or portion thereof above 500°F (260°C). Aluminum shall not be used for cargo tanks transporting cargoes at temperatures above 550°F (288°C).

5.3.4 Structural Integrity.

5.3.4.1 The maximum calculated stress value shall not exceed 20 percent of the minimum ultimate strength of the material as authorized except where ASME pressure vessel design requirements apply *(see ASME Boiler and Pressure Vessel Code, Section VIII)*.

5.3.4.2 Cargo tanks shall be provided with additional structural elements as necessary to prevent resulting stresses in excess of those permitted in 5.3.4.1. Consideration shall be given to forces imposed by each of the following loads individually and, where applicable, a vector summation of any combination thereof:

(1) Dynamic loading under all product load configurations

(2) Internal pressure

(3) Superimposed loads such as operating equipment, insulation, linings, hose tubes, cabinets, and piping

(4) Reactions of supporting lugs and saddles or other supports

(5) Effect of temperature gradients resulting from product and ambient temperature extremes (Thermal coefficients of dissimilar materials where used shall be accommodated.)

5.3.5 Joints.

5.3.5.1 All joints between tank shells, heads, baffles (or baffle attaching rings), and bulkheads shall be welded in accordance with the requirements contained in this section.

5.3.5.2 All welded aluminum alloy joints shall be made in accordance with accepted welding practices, and the efficiency of the joints shall not be less than 85 percent of the properties of the adjacent material. Aluminum alloys shall be joined by an inert gas arc welding process using aluminum-magnesium filler metals that are consistent with the material supplier’s recommendations.

5.3.5.3 All welded joints in mild steel (MS), high strength low alloy (HSLA) steel, and austenitic stainless steel (SS) shall be made in accordance with accepted welding practice, and the efficiency of the joints shall not be less than 85 percent of the mechanical properties of the adjacent metal in the tank.

5.3.5.4 Combinations of mild steel (MS), high strength low alloy (HSLA) steel, and austenitic stainless steel (SS) shall be permitted to be used in the construction of a single tank, provided that each material, where used, shall comply with the minimum requirements specified for the material used in the construction of that section of the tank.

5.3.5.4.1 Whenever stainless steel sheets are used in combination with sheets of other types of steel, joints made by welding shall be formed by the use of stainless steel electrodes or filler rods and the stainless steel electrodes or filler rods used in the welding shall be suitable

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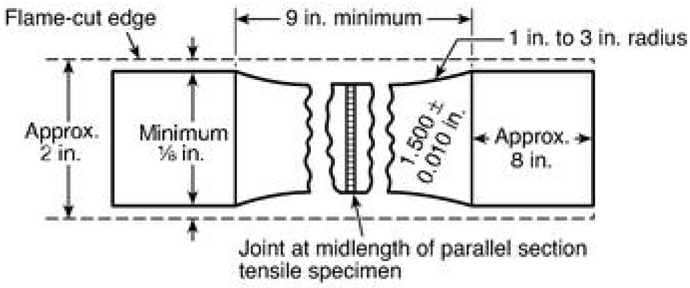
for use with the grade of stainless steel concerned according to the recommendations of the manufacturer of the stainless steel electrodes or filler rods.

5.3.5.5 Compliance with the requirements contained in 5.3.5.2 or 5.3.5.3 for the welded joints indicated in 5.3.5.1 shall be determined by preparing, from materials representative of those to be used in tanks subject to this specification and by the same technique of fabrication, two test specimens conforming to Figure 5.3.5.5 and testing them to failure in tension.



For SI units, 1 in. = 25.4 mm.

FIGURE 5.3.5.5 Tensile Test Specimen.

5.3.5.5.1 One pair of test specimens shall represent all the tanks to be made of the same combination of materials by the same technique of fabrication and in the same shop, within 6 months after the tests on such samples have been completed.

5.3.5.5.2 The butt welded specimens tested shall be considered as qualifying other types or combinations of types of weld using the same filler material and welding process as long as parent metals are of the same types of material.

5.3.6 Supports and Anchoring.

5.3.6.1 Cargo tanks with frames not made integral with the tank (as by welding) shall be provided with restraining devices to eliminate any relative motion between the tank and the frame that could result from the stopping, starting, or turning of the vehicle. Such restraining devices shall be readily accessible for inspection and maintenance, except that insulation and jacketing shall be permitted to cover the restraining devices.

5.3.6.2 Any cargo tank designed and constructed so that it constitutes in whole or in part the structural member used in lieu of a frame shall be supported in such a manner that the resulting stress levels in the cargo tank do not exceed those specified in 5.3.4.1. The design calculations of the support elements shall include loadings imposed by stopping, starting, and turning in addition to those imposed as indicated in 5.3.4.2 using 20 percent of the minimum ultimate strength of the support material.

5.3.7 Circumferential Reinforcement.

5.3.7.1 Tanks with shell thicknesses less than ⅜ in. (9 mm) shall, in addition to the reinforcement provided by the tank heads, be circumferentially reinforced with bulkheads, baffles, or ring stiffeners. Any combination of the aforementioned reinforcements shall be permitted to be used in a single cargo tank.

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5.3.7.2 Circumferential reinforcement shall be located in such a manner that the maximum unreinforced portion of the shell is as specified in Table 5.3.3.1(b) and in no case shall be more than 60 in. (1500 mm). Additionally, such circumferential reinforcement shall be located within 1 in. (25 mm) of points where discontinuity in longitudinal shell sheet alignment exceeds 10 degrees unless otherwise reinforced with structural members capable of maintaining shell sheet stress levels permitted in 5.3.6.2.

5.3.7.3 Baffles or baffle attaching rings, where used as reinforcement members, shall be circumferentially welded to the tank shell. The welding shall be not less than 50 percent of the total circumference of the vessel, and the maximum unwelded space on this joint shall not exceed 40 times the shell thickness.

5.3.7.4 Wherever double bulkheads are provided, they shall be separated by an air space. This air space shall be vented and equipped with means for drainage facilities that shall be kept operative at all times *(see 9.1.8)*.

5.3.7.5 Where ring stiffeners are used to comply with this section, they shall be continuous around the circumference of the tank shell and shall have a section modulus about the neutral axis of the ring section parallel to the shell at least equal to that determined by the following formulas:

$$\frac{I}{C} = 0.00027\ WL\ \text{(MS, HSLA steel, and SS)}$$

$$\frac{I}{C} = 0.000467\ WL\ \text{(AL)}$$

where:

$\frac{I}{C}$ = section modulus (in.^{3})

W = tank width or diameter (in.)

L = ring spacing (in.), i.e., the maximum distance from the midpoint of the unsupported shell on one side of the ring stiffener to the midpoint of the unsupported shell on the opposite side of the ring stiffener

5.3.7.5.1 Where a ring stiffener is welded to the tank shell (with each circumferential weld not less than 50 percent of the total circumference of the vessel and the maximum unwelded space on this joint not exceeding 40 times the shell thickness), a portion of the shell shall be permitted to be considered as part of the ring section for purposes of computing the ring section modulus. The maximum portion of the shell to be used in these calculations shall be as given in Table 5.3.7.5.1.

Table 5.3.7.5.1 Portion of Tank Shell Contributing to Ring Section Modulus

Circumferential Ring Stiffener–to–Tank Shell Welds	Distance Between Parallel Circumferential Ring Stiffener–to–Tank Shell Welds	Shell Section Credit
1	—	$20t$
2	Less than $20t$	$20t + W$
2	$20t$ or more	$40t$

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Table 5.3.7.5.1 Portion of Tank Shell Contributing to Ring Section Modulus

Circumferential Ring Stiffener–to–Tank Shell Welds	Distance Between Parallel Circumferential Ring Stiffener–to–Tank Shell Welds	Shell Section Credit

t: Shell thickness. *W*: Distance between parallel circumferential ring stiffener and shell welds.

5.3.7.5.2 If the configuration of an internal or external ring stiffener encloses an air space, this air space shall be arranged for venting and shall be equipped with means for drainage that shall be kept operative at all times.

5.3.8 Accident Damage Protection.

5.3.8.1 The design, construction, and installation of any appurtenance to the shell or head of the cargo tank shall be such as to minimize the possibility of appurtenance damage or failure adversely affecting the product retention integrity of the tank.

5.3.8.2 Structural members, such as the suspension subframe, overturn protection, and external rings, when practicable, shall be utilized as sites for attachment of appurtenances and any other accessories to a cargo tank.

5.3.8.3 Except as prescribed in 5.3.8.5, the welding of any appurtenance to a shell or head shall be made by attachment to a mounting pad.

5.3.8.3.1 The thickness of the mounting pad shall be not less than that of the shell or head to which it is attached.

5.3.8.3.2 The mounting pad shall extend at least 2 in. (50 mm) in each direction from any point of attachment of an appurtenance.

5.3.8.3.3 The mounting pad shall have rounded corners or otherwise be shaped in a manner to preclude stress concentrations on the shell or the head.

5.3.8.3.4 The mounting pad shall be attached by a continuous weld around the pad.

5.3.8.4 Appurtenances shall be attached to mounting pads so there will be no adverse affect upon the product-retention integrity of the tank if any force is applied to the appurtenance, in any direction, except normal to the tank, or within 45 degrees of normal.

5.3.8.5 Skirting structures, conduit clips, brakeline clips, and similar lightweight attachments, which are of a metal thickness, construction, or material appreciably less strong but not more than 72 percent of the thickness of the tank shell or head to which such a device is attached, shall be permitted to be secured directly to the tank shell or head, if each device is designed and installed so that damage to it will not affect the product retention integrity of the tank.

5.3.8.5.1 These lightweight attachments shall be secured to the tank shell by continuous weld or in such manner as to preclude formation of pockets, which could become sites for incipient corrosion.

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5.3.8.6 Every cargo tank shall be provided with a rear bumper to protect the tank and piping in the event of a rear-end collision and to minimize the possibility of any part of the colliding vehicle striking the tank.

5.3.8.6.1 The bumper shall be located at least 6 in. (150 mm) to the rear of any vehicle component that is used for loading or unloading purposes or might at any time contain lading while in transit.

5.3.8.6.2 Dimensionally, the bumper shall conform to U.S. Department of Transportation regulations in 49 CFR Part 393.86, "Rear Impact Guards and Rear End Protection." Structurally, the bumper shall be designed to successfully absorb the impact of the vehicle with rated payload (i.e., prevent damage that will cause leakage of product), with a deceleration of 2 g, using a factor of safety of 2 based on the ultimate strength of the bumper material.

5.3.8.6.3 For purposes of these regulations, such impact shall be considered uniformly distributed and applied horizontally (parallel to the ground) from any direction at an angle not exceeding 30 degrees to the longitudinal axis of the vehicle.

5.3.9 Overturn Protection.

5.3.9.1 All closures for filling, manholes, or inspection openings shall be protected from damage that would result in leakage of lading in the event of overturning of the vehicle by being enclosed within the body of the tank or dome attached to the tank or by guards.

5.3.9.2 When guards are required, they shall be designed and installed to withstand a vertical load of twice the weight of the loaded tank and a horizontal load in any direction equivalent to one-half the weight of the loaded tank. These design loads shall be permitted to be considered independently.

5.3.9.2.1 The ultimate strength of the material shall be used as a calculation base.

5.3.9.2.2 If more than one guard is used, each shall carry its proportionate share of the load.

5.3.9.2.3 If protection other than guards is considered, the same design load criteria shall be applicable.

5.3.9.3 Except for pressure-actuated vents, no overturn protection is required for nonoperating nozzles or fittings less than 5 in. (125 mm) in diameter (which do not contain product while in transit) that project a distance less than the inside diameter of the fitting. This projected distance shall be permitted to be measured either from the shell or from the top of an adjacent ring stiffener provided such stiffener is within 30 in. (750 mm) of the center of the nozzle or fitting.

5.3.9.4 If the overturn protection is constructed so as to permit accumulation of liquid on the top of the tank, it shall be provided with means for drainage directed to a safe point of discharge.

5.3.10 Piping.

5.3.10.1 Product discharge piping shall be provided with protection in such a manner as to reasonably ensure against the accidental escape of contents. Such protection shall be

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permitted to be provided by one of the following:

(1) A shear section shall be located outboard of each emergency valve seat and within 4 in. (100 mm) of the vessel. The shear section shall break under strain and leave the emergency valve seat and its attachment to the vessel and the valve head intact and capable of retaining product. The shear section shall be machined in such a manner as to abruptly reduce the wall thickness of the adjacent piping (or valve) material by at least 20 percent.

(2) Suitable guards shall be capable of successfully absorbing a concentrated horizontal force of at least 8000 lb (3630 kg) applied from any horizontal direction, without damage to the discharge piping that might adversely affect the product retention integrity of the discharge valve.

5.3.10.2 The minimum allowable road clearance of any cargo tank component or protection device located between any two adjacent axles on a vehicle or vehicle combination shall be at least ½ in. (12.5 mm) for each foot separating such axles and in no case less than 12 in. (300 mm).

5.3.10.3 Hose, piping, and fittings for tanks to be unloaded by pressure shall be designed for a bursting pressure of at least 100 psi (689.5 kPa) gauge pressure, but in no case less than four times the pressure to which it might be subjected in service by the action of any vehicle-mounted pump or other device (not including safety relief valves). Any coupling used on hose to make connections shall be designed for a working pressure not less than 20 percent in excess of the design pressure of the hose and shall be designed so that there will be no leakage when connected.

5.3.10.4 Suitable provisions shall be made in every case to allow for and prevent damage due to expansion, contraction, jarring, and vibration of all pipe. Slip joints shall not be used for this purpose.

5.3.10.5 Heater coils, when installed, shall be constructed so that the breaking off of their external connections will not cause leakage of contents of the tank.

5.3.10.6 Gauging, loading, and air-inlet devices, including their valves, shall be provided with adequate means for their secure closure, and means shall also be provided for the closing of pipe connection of valves.

5.3.11 Closures for Fill Openings and Manholes.

5.3.11.1 Each compartment in excess of 2500 gal (9500 L) capacity shall be accessible through a manhole of at least 11 in. × 15 in. (280 mm × 380 mm).

5.3.11.2 Manhole and fill opening covers shall be designed to provide secure closure of the openings.

5.3.11.3 Closures shall have the structural capability to withstand an internal fluid pressure of 9 psi gauge pressure (62 kPa gauge pressure) without permanent deformation.

5.3.11.4 Safety devices shall be provided to prevent manhole and fill covers from opening fully when internal pressure is present.

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5.3.12 Normal Vents for Cargo Tanks in Other Than Asphalt Service.

5.3.12.1 Each cargo tank compartment shall be provided with safety relief devices that communicate with the vapor space of the cargo tank in accordance with the requirements contained in this section.

5.3.12.1.1 Shutoff valves shall not be installed between the tank opening and any safety device.

5.3.12.1.2 Safety relief devices shall be mounted, shielded, or drained so as to eliminate the accumulation of water, the freezing of which could impair the operation or discharge capability of the device.

5.3.12.2 Each cargo tank compartment shall be provided with normal pressure and vacuum vents, each having a minimum net free cross-sectional area of 0.44 $in.^2$ (284 mm^2). Pressure vents shall be set to open at a gauge pressure of not more than 1 psi (6.9 kPa). Vacuum vents shall be set to open at 6 oz (170 g).

5.3.12.3 Pressure and vacuum vents shall be designed to prevent loss of liquid in the event of vehicle overturn.

5.3.12.4 Where a cargo tank compartment is designed to be loaded or unloaded with the dome cover closed, the vent or vents described in 5.3.12.2 or additional vents shall limit the vacuum to 1 psi (6.9 kPa) and the tank pressure to a gauge pressure of 3 psi (20.7 kPa) based on maximum product transfer rate.

5.3.12.4.1 Unless effective protection against overfilling is made, the pressure vent shall also have sufficient liquid capacity to prevent the pressure from exceeding a gauge pressure of 3 psi (20.7 kPa) in case of accidental overfilling.

5.3.12.4.2 This pressure vent shall be permitted to be pressure operated or interlocked with the tank loading device and shall be designed to prevent loss of liquid through the vent under any condition of vehicle rollover attitude.

5.3.13 Emergency Venting for Fire Exposure.

5.3.13.1 The total emergency venting capacity in cubic feet/hour (cubic meters/second) for each cargo tank compartment shall be not less than that determined from Table 5.3.13.1.

Table 5.3.13.1 Minimum Emergency Vent Capacity

Exposed Area (ft^2)	Free-Air Vent Capacity (ft^3/hr)*	Exposed Area (ft^2)	Free-Air Vent Capacity (ft^3/hr)*
20	15,800	275	214,300
30	23,700	300	225,100
40	31,600	350	245,700
50	39,500	400	265,000
60	47,400	450	283,200
70	55,300	500	300,600
80	63,300	550	317,300

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Table 5.3.13.1 Minimum Emergency Vent Capacity

Exposed Area (ft^2)	Free-Air Vent Capacity (ft^3/hr)*	Exposed Area (ft^2)	Free-Air Vent Capacity (ft^3/hr)*
90	71,200	600	333,300
100	79,100	650	348,800
120	94,900	700	363,700
140	110,700	750	378,200
160	126,500	800	392,200
180	142,300	850	405,900
200	158,100	900	419,300
225	191,300	950	432,300
250	203,100	1000	445,000

For SI units, 1 ft^2 = 0.093 m^2; 1 ft^3 = 0.028 m^3.
Note: Interpolate for intermediate sizes.
*At 14.7 psi (101.3 kPa) and 60°F (15.6°C)

5.3.13.2 Each cargo tank compartment shall be equipped with one or more pressure-actuated vents set to open at a gauge pressure of not less than 3 psi (20.7 kPa) and to close when the pressure drops below the 3 psi (20.7 kPa) set point.

5.3.13.2.1 The minimum venting capacity for the pressure-actuated vents shall be 6000 ft^3 (170 m^3) of free air per hour [measured at standard conditions of 14.7 psi (101.3 kPa) and 60°F (15.6°C)] at a gauge pressure of 5 psi (35 kPa).

5.3.13.2.2 Pressure-actuated devices shall be designed so as to prevent leakage of liquid past the device in case of surge or vehicle upset, except that they shall function in case of pressure rise under any condition of vehicle rollover attitude.

5.3.13.3 Where the pressure-actuated venting required by 5.3.13.2 does not provide the total venting capacity required by 5.3.13.1, additional capacity shall be provided by the addition of fusible venting devices, each having a minimum area of 1.25 $in.^2$(800 mm^2).

5.3.13.3.1 Such fusible elements shall be located so as not to be in contact with the tank lading under normal operating conditions.

5.3.13.3.2 The fusible vent or vents shall be actuated by elements that operate at a temperature not exceeding 250°F (120°C).

5.3.13.3.3 The venting capacity of these devices shall be rated at a gauge pressure of not more than 5 psi (35 kPa).

5.3.13.3.4 At least two such devices shall be used on any cargo tank or tank compartment over 2500 gal (9500 L) in capacity.

5.3.13.3.5 At least one such device shall be located close to each end of the cargo tank or tank compartment.

5.3.13.4* Each type and size of venting device shall be flow tested in the range specified in

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5.3.13.1 through 5.3.13.3.

5.3.13.4.1 The actual rated flow capacity of the vent, in cubic feet (ft^3) [cubic meters (m^3)] of free air per hour at the gauge pressure in pounds per square inch (psi) [kilopascals (kPa)] at which the flow capacity is determined, shall be stamped on the device.

5.3.13.4.2 The fusible vent or vents shall have their flow rating determined at 5 psi (35 kPa) differential.

5.3.13.4.3 Flow tests shall be permitted to be conducted by the manufacturer, if certified by a qualified impartial observer, or delegated to an outside agency.

5.4 Emergency-Discharge Control.

5.4.1 Liquids Having Viscosities Less Than 45 Standard Units Saybolt (SUS).

5.4.1.1* Each outlet of a cargo tank or compartment used for transportation of Class I liquid and trucks constructed hereafter for transportation of Class II and Class IIIA liquids, having a viscosity less than 45 SUS at 100°F (37.8°C), shall be equipped with a self-closing shutoff valve designed, installed, and operated so as to ensure against the accidental escape of contents.

5.4.1.2 The shutoff valve shall be located inside the tank or at a point outside the tank where the line enters or leaves the tank.

5.4.1.3 The valve seat shall be located inside the tank or within the welded flange, its companion flange, nozzle, or coupling and shall be designed so that the valve must be kept closed except during loading and unloading operations.

5.4.1.4 The operating mechanism for the valve shall be provided with a secondary control, remote from the fill openings and discharge connections, for use in the event of accidents or fire during delivery operations.

5.4.1.5 The control mechanism shall be provided with at least one fusible element that becomes effective at a temperature not over 250°F (120°C), permitting the valve to close automatically in case of fire.

5.4.1.5.1 At least one fusible element shall be in the open where it would be exposed to the heat of a fire under the vehicle.

5.4.1.6 Each shutoff valve shall be provided with a shear section, located outboard of each emergency valve seat and within 4 in. (100 mm) of the vessel, that will break under strain and leave the emergency valve seat and its attachment to the vessel and the valve head intact and capable of retaining product.

5.4.1.6.1 The shear section shall be machined in such a manner as to abruptly reduce the wall thickness of the adjacent piping (or valve) material by at least 20 percent.

5.4.2 Liquids of Viscosities of 45 SUS or More. Each outlet of a cargo tank or compartment used for the transportation of liquids having a viscosity equal to or greater than 45 SUS at 100°F (37.8°C) shall be equipped with one of the following:

(1) A suitable shutoff valve, located internally, designed so that the valve will remain

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operable if the external connection is sheared off

(2) A front- or rear-head mounted valve securely reinforced and protected against shock or road hazards

5.5 Tests.

5.5.1 At the time of manufacture, every cargo tank shall be tested by air or hydrostatically to a minimum gauge pressure of 3 psi (20.7 kPa) or at least equal to the tank design pressure, whichever is greater.

5.5.1.1 If compartmented, each individual compartment shall be similarly tested with adjacent compartments empty and at atmospheric pressure.

5.5.1.2 Air pressure, if used, shall be held for a period of at least 5 minutes during which the entire surface of all joints under pressure shall be coated with a solution of soap and water, heavy oil, or other material suitable for the purpose, foaming or bubbling of which indicates the presence of leaks.

5.5.1.3 Hydrostatic pressure, if used, shall be done by using water or other liquid having a similar viscosity, the temperature of which shall not exceed 100°F (37.8°C) during the test, and applying pressure as prescribed in 5.5.1 through 5.5.1.2, gauged at the top of the tank, at which time all joints under pressure shall be inspected for the issuance of liquid to indicate leaks.

5.5.1.4 All closures shall be in place while test by either method is made.

5.5.1.5 During these tests, operative relief devices shall be clamped, plugged, or otherwise rendered inoperative; such clamps, plugs, and similar devices shall be removed immediately after the test is finished.

5.5.2 The test in 5.5.1 shall be repeated following alteration or repairs that involve tank integrity.

5.5.2.1 If there is any leakage or undue distortion, or if failure impends or occurs, the cargo tank shall not be placed in service unless an adequate repair is made.

5.5.2.2 The adequacy of the repair shall be determined by the same method of test.

5.6 Separation to Prevent Intermixing.

Tank vehicles designed to transport Class I liquid in one or more compartments and Class II or Class III liquid in other compartment or compartments or to transport chemically noncompatible liquids shall be provided with double bulkheads and shall be equipped with separate piping, pumps, meters, and hoses for such classes of product.

5.7 Lighting.

5.7.1 Lighting circuits shall have suitable overcurrent protection (fuses or automatic circuit breakers).

5.7.2 The wiring shall have sufficient carrying capacity and mechanical strength and shall be

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secured, insulated, and protected against physical damage, in keeping with recognized good practice.

Chapter 6 Asphalt Tank Vehicles

6.1 General.

Cargo tanks shall be free of water or volatile liquids before they are loaded with hot asphalt.

6.2 Vents for Cargo Tanks in Asphalt Service.

6.2.1 Each cargo tank used in asphalt service shall be provided with a vent having an effective opening at least equivalent to a nominal 2 in. (50 mm) pipe.

6.2.2 Each cargo tank for asphalt service shall be provided with a manhole having a free opening of at least 15 in. (375 mm) in diameter designed to relieve internal pressure at gauge pressure between 2 and 3 psi (between 13.8 and 20.7 kPa) or an equivalent relief device.

6.3 Overflows and Drains for Asphalt Tank Vehicles.

6.3.1 Overflow protection for asphalt tank vehicles shall be provided in the form of reservoirs or flashing around fill and vent pipes.

6.3.2 Overflow and drain pipes shall have thicknesses heavier than the tank shell and shall be designed so that hot asphalt will not spill onto tires, brakes, burner equipment, or the vehicle's exhaust system.

6.4 Burner and Burner Tubes for Asphalt Tank Vehicles.

6.4.1 Burners shall be located remotely from fuel tanks for the vehicle engine and fuel tanks for the burners, or a noncombustible shield shall be provided between the burner and the fuel tanks to prevent flashback.

6.4.2 Burner tubes shall be properly installed and maintained.

6.4.3 The bottom of internal burner tubes shall be located as low in the tank as proper design and functioning permit.

6.4.4 Instructions for the proper method of operating the burner equipment and the pumping equipment, if so equipped, shall be provided. These instructions shall accompany the vehicle at all times.

6.4.5 A warning sign or label that meets the requirements of ANSI Z535.1, *Safety Color Code*, shall be permanently attached near the burners on any tank vehicle equipped with burners and shall include at least the following information:

> ***WARNING:*** *This burner equipment must not be operated while the vehicle is being loaded or is in transit or when the burner tubes are not completely submerged.*

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Chapter 7 Marking on Tank Vehicles

7.1 Marking.

7.1.1 Every tank vehicle used for the transportation of any flammable or combustible liquids, regardless of the quantity being transported or whether loaded or empty, shall be conspicuously and legibly marked in accordance with the requirements of the U.S. Department of Transportation regulations in 49 CFR 171–179, "Hazardous Materials Regulations."

7.1.2 Manufacturer's Certificate. A certificate shall be procured certifying that each such cargo tank is designed, constructed, and tested in compliance with this standard. The certificate shall be signed by a responsible official of the manufacturer of the cargo tank or from a competent testing agency and shall be retained in the files of the carrier during the time that such cargo tank is employed by the carrier, plus 1 year.

7.1.3 In addition to the certificate specified in 7.1.2, there shall be a metal plate on every cargo tank (or tank compartment if constructed to different specification).

7.1.3.1 The plate shall not be subject to corrosion.

7.1.3.2 The plate shall be located on the right side near the front, in a place readily accessible for inspection.

7.1.3.3 The plate shall be permanently affixed to the tank by soldering, brazing, welding, or other equally suitable means.

7.1.3.4 The plate shall be marked in characters at least $\frac{3}{16}$ in. (5 mm) high by stamping, embossing, or other means of forming letters into or on the metal of the plate itself at least the following information:

(1) Vehicle manufacturer

(2) Manufacturer's serial number

(3) Specification identification

(4) Date of manufacture

(5) Original test date

(6) Certificate date

(7) Design pressure (psi)

(8) Test pressure (psi)

(9) Head material

(10) Shell material

(11) Weld material

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(12) Lining material

(13) Nominal tank capacity by compartment (front to rear) (U.S. gal)

(14) Maximum product load (lb)

(15) Loading limits (gpm and/or psi)

(16) Unloading limits (gpm and/or psi)

7.1.3.5 The plate shall not be painted so as to obscure the markings thereon.

7.1.4 If a cargo tank is to be altered physically to meet another specification (or to accommodate a commodity not requiring a specification tank), such combinations shall be indicated beside the specification identification.

7.1.5 Where the cargo tank has a metal certification plate for MC 306 specification, the notation "NFPA 385" shall be permitted to be added to the specification identification line on the metal plate.

Chapter 8 Auxiliary Equipment

8.1 Auxiliary Internal Combustion Engines.

8.1.1 Internal combustion engines, other than those providing propulsive power, installed or carried on a tank vehicle transporting Class I liquids for the purpose of providing power for the operation of pumps or other devices, shall meet the requirements in 8.1.2 through 8.1.8.

8.1.2 The engine air intake shall be equipped with an effective flame arrester or an air cleaner having effective flame arrester characteristics, installed and capable of preventing emission of flame from the intake side of the engine in the event of backfiring.

8.1.3 The fuel system shall be located or constructed so as to minimize the fire hazard.

8.1.3.1 Where the fuel tank is located above or immediately adjacent to the engine, suitable shielding shall be provided to prevent spillage during the filling operation or leakage from the tank or fuel system from coming in contact with the engine or any parts of the ignition and exhaust systems.

8.1.3.2 All parts of the fuel system shall be constructed and installed in a proficient manner.

8.1.4 Pumps and other appurtenances shall be so located in relation to the engine that spillage or leakage from such parts is prevented from coming in contact with the engine or any parts of the ignition and exhaust system, or adequate shielding shall be provided to attain the same purpose.

8.1.5 The engine cooling fan shall be positioned, rotated, or shielded so as to minimize the possibility of drawing flammable vapors toward the engine.

8.1.6 Where the engine is located in a position that spillage from the cargo tank or its appurtenances or from side racks might constitute a hazard, shielding shall be provided to prevent such spillage from contacting the engine or engine exhaust system and for draining

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such spillage away from the vicinity of the engine.

8.1.7 Where the engine is carried within an enclosed space, provision shall be made for adequate air circulation at all times to prevent accumulation of explosive vapors and to avoid overheating.

8.1.8 The exhaust system shall be constructed and installed to be free from leaks.

8.1.8.1 The exhaust line and muffler shall have adequate clearance from combustible materials.

8.1.8.2 The exhaust gases shall be discharged at a location that shall not constitute a hazard.

8.1.8.3 Where engines are carried as in 8.1.7, the exhaust gases shall be discharged outside each such enclosed space.

8.1.9 The ignition wiring shall be installed with firm connections. Spark plug terminals and all other terminals shall be insulated to prevent sparking in the event of contact with conductive materials. The ignition switch shall be of the enclosed type.

8.2 Auxiliary Electric Generators and Motors.

8.2.1 Electrical equipment installed or carried on a tank vehicle transporting Class I liquids for the operation of pumps or other devices used for the handling of product, and operating product handling accessories shall meet the requirements of 8.2.2 through 8.2.6.

8.2.2 Generators that are mounted on the engine providing propulsive power for the vehicle or an auxiliary engine or located in the immediate vicinity of such engine or its exhaust system shall be permitted to have general-purpose enclosures. Generators located elsewhere shall be provided with explosionproof enclosures.

8.2.3 Motors having sparking contacts shall be provided with explosionproof enclosures.

8.2.4 Wiring shall be adequate for maximum loads to be carried and shall be installed so as to be protected from physical damage and contact with possible product spill either by location or by being enclosed in metal conduit or other oil-resistant protective covering. Junction boxes shall be sealed.

8.2.5 Switches, overload protection devices, and other sparking equipment shall be located and enclosed as provided for generators in 8.2.2.

8.2.6 Where the generator or motor is located within an enclosed space, provision shall be made for adequate air circulation to prevent overheating and possible accumulation of explosive vapor.

8.3 Pumps and Hose.

8.3.1 Where a pump is used to deliver products, automatic means shall be provided to prevent pressure in excess of the design working pressures of the accessories, piping, and hose.

8.3.2 Each length of hose used for delivery of product by pump shall be marked to indicate

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the manufacturer's recommended working pressure.

8.3.3 All pressure hoses and couplings shall be inspected at intervals appropriate to the service.

8.3.3.1 With the hose extended, pressure shall be applied to the hose and couplings to the maximum operating pressure.

8.3.3.2 Any hose showing material deteriorations, signs of leakage, or weakness in its carcass or at the couplings shall be withdrawn from service and repaired or discarded.

Chapter 9 Operation of Tank Vehicles

9.1 General Operating Conditions.

9.1.1 Drivers shall be thoroughly trained in the proper method of operating tank vehicles and in the proper procedures for loading and unloading tank vehicles.

9.1.2 Tank vehicles shall not be operated unless they are in proper repair; are devoid of accumulations of grease, oil, or other flammables; and are free of leaks.

9.1.3 Dome covers shall be closed and latched while the tank vehicle is in transit.

9.1.4 No tank vehicle shall be operated with a cargo temperature above the maximum allowable cargo temperature specified on the warning sign required by 5.1.5.

9.1.5 No material shall be loaded into or transported in a cargo tank at a temperature above its ignition temperature unless properly safeguarded in a manner approved by the authority having jurisdiction.

9.1.6 Flammable and combustible liquids that are loaded at or above their boiling points or that might reach their boiling point temperatures during transit shall be loaded only into cargo tanks constructed in accordance with Section 5.2.

9.1.7* Flammable and combustible liquids shall be loaded only into cargo tanks whose material of construction is compatible with the chemical characteristics of the liquid to be transported. The flammable or combustible liquid being loaded shall also be chemically compatible with the liquid hauled on the previous load unless the cargo tank has been cleaned.

9.1.8 Class II or Class III liquids shall not be loaded into a compartment adjacent to Class I liquids unless double bulkheads are provided.

9.1.9 Chemically noncompatible material shall not be loaded into adjacent compartments unless separated by double bulkheads.

9.1.10* To prevent a hazard from a change in the flash points of liquids, no cargo tank, or any compartment thereof, that has been utilized for Class I liquid shall be loaded with Class II or Class III liquid until such tank or compartment and all piping, pumps, meters, and hose connected thereto have been completely drained.

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9.1.10.1 A tank, compartment, piping, pump, meter, or hose that does not drain completely shall be flushed at the loading point with a quantity of Class II or Class III liquid equal to twice the capacity of piping, pump, meter, and hose, to clear any residue of Class I liquid from the system.

9.1.11 No repairs shall be made to any tank vehicle unless the repairs can be made without hazard, nor shall any loaded motor vehicle be repaired in a closed garage.

9.1.12 No cargo tank shall be repaired by any method employing a flame, arc, or other source of ignition unless the tank is maintained gas free or otherwise made safe in an approved manner.

9.2 Loading and Unloading Tank Vehicles.

9.2.1 Loading and unloading of tank vehicles shall be done only in approved locations.

9.2.2 The driver, operator, or attendant of any tank vehicle shall not remain in the vehicle but shall not leave the vehicle unattended during the loading or unloading process. Delivery hose, when attached to a tank vehicle, shall be considered to be a part of the tank vehicle.

9.2.3 During transfer of Class I liquids, motors of tank vehicles or motors of auxiliary or portable pumps shall be shut down during the making and breaking of hose connections.

9.2.3.1 Where loading or unloading is done without requiring the use of the motor of the tank vehicle, the motor shall be shut down throughout the transfer operations of Class I liquids.

9.2.4 Where portable pumps are used for transferring Class I liquids, the portable pumps shall comply with the applicable provisions of Section 8.1 or Section 8.2.

9.2.5 No cargo tank or compartment thereof used for the transportation of any flammable or combustible liquid or asphalt shall be loaded liquid full. Sufficient space (outage) shall be provided in every case to prevent leakage from such tank or compartment by expansion of the contents due to rise in temperature in transit and in no case less than 1 percent.

9.2.6 Delivery of Class I liquids to underground tanks of more than 1000 gal (3800 L) capacity shall be made by means of tight connections between the hose and the fill pipe.

9.2.6.1 In all cases where underground tanks are equipped with any type of vapor recovery system, all connections required to be made for the safe and proper functioning of the particular vapor recovery process shall be made.

9.2.6.2 Such connections shall be designed to prevent release of vapors at grade level and shall remain connected throughout the loading or unloading process.

9.2.7 Where a cargo tank is filled through bottom loading, a positive means shall be provided for loading a predetermined quantity of liquid, and an automatic secondary shutoff control shall be installed in each compartment to prevent overfill.

9.2.8 The secondary shutoff control system shall be labeled as to manufacturer and type.

9.2.8.1 Any electrical system used for secondary shutoff shall be in accordance with NFPA

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70, *National Electrical Code.*

9.2.9 Where bottom loading vehicles are equipped for vapor recovery and vapor recovery is not required, the tank vapor system shall be open to the atmosphere to prevent pressurization of the tank and the vapor system.

9.2.10 Where a dry disconnect vapor recovery adapter is used, provisions shall be made to ensure that the vapor recovery system is fully vented before unloading to prevent collapse of the tank. This requirement shall apply to both bottom and top loading.

9.2.11 During bottom loading of a tank equipped with a vapor recovery system, the vapor recovery connection shall be used to conduct vapor away from the loading area by using the terminal vapor recovery system or discharge standpipe or by opening the tank fill openings (manholes).

9.2.12 Where a cargo tank is filled through a top opening, the cargo tank shall be bonded to the fill stem or to some part of the rack structure that is electrically interconnected with the fill stem piping.

9.2.12.1 Bonding shall not be required when loading asphalt, crude oil, or any product containing substantial proportions of crude residuum.

9.2.12.2 Bonding shall not be required for tank vehicles used exclusively for transporting Class II or Class III liquids when loaded at locations where no Class I liquids are handled.

9.2.12.3* The bond-wire connection shall be made prior to the opening of the dome covers and shall be maintained in place during the entire filling operation.

9.2.12.4 The dome covers shall be securely closed before the bond wire is disconnected from the cargo tank.

9.2.13 No external bond-wire connection or bond-wire integral with a hose shall be required for the unloading of flammable and combustible liquids into underground tanks nor when a tank vehicle is loaded or unloaded through tight connections such as to an aboveground tank or through bottom connections.

9.2.14 Smoking on or about any tank vehicle while loading or unloading any flammable or combustible liquid shall be forbidden.

9.2.15 Extreme care shall be taken in the loading or unloading of any flammable liquid into or from any cargo tank to keep fire away and to prevent persons in the vicinity from smoking, lighting matches, or carrying any flame or lighted cigar, pipe, or cigarette.

9.2.16 No flammable or combustible liquid shall be transferred to or from any tank vehicle unless the parking brake is securely set and all other reasonable precautions have been taken to prevent motion of the vehicle.

9.3 Fire Extinguishers.

9.3.1 Each tank vehicle shall be provided with one portable fire extinguisher that has a minimum rating of 4-A: 40-B,C or with more than one portable fire extinguisher, each having a rating of 2-A: 20-B,C.

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9.3.2 Ratings shall be in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

9.3.3 Fire extinguishers shall be kept in good operating condition at all times and shall be located in an accessible place on each tank vehicle.

9.3.4 Extinguishers shall be maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.1 Normally stable materials are those having the relative capacity to resist changes in their chemical composition that would produce violent reactions or detonations despite exposure to air, water, or heat, including the normal range of conditions encountered in handling, storage, or transportation. Unstable (reactive) flammable and combustible liquids are liquids that in the pure state or as commercially produced or transported will vigorously polymerize, decompose, condense, or become self-reactive under conditions of shock, pressure, or temperature.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.4 Combustible Liquid. For classification of combustible liquids, see 4.2.2 of this standard and 1.7.3.1 of NFPA 30, *Flammable and Combustible Liquids Code*.

A.3.3.6 Flammable Liquid. For classification of flammable liquids, see 4.2.1 of this standard and 1.7.3.2 of NFPA 30, *Flammable and Combustible Liquids Code*. For information on test procedures and apparatus for determining flash point, see 1.7.4 of NFPA 30, *Flammable and Combustible Liquids Code*.

A.3.3.7 Flash Point. Flash point is a direct measure of a liquid's volatility, its tendency to vaporize. The lower the flash point, the greater the volatility and the greater the risk of fire. Flash point is determined using one of several different test procedures and apparatus that
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are specified in NFPA 30, *Flammable and Combustible Liquids Code*, 1.7.4.

A liquid that has a flash point at or below ambient temperature is easy to ignite and will burn quickly. On ignition, the spread of flame over the surface of such a liquid will be rapid, because it is not necessary for the fire to expend energy heating the liquid to generate more vapor. Gasoline is a familiar example. A liquid with a flash point above ambient temperature presents less risk because it must be heated to generate enough vapor to become ignitible; it is more difficult to ignite and presents less potential for the generation and spread of vapor. A common example is home heating oil (Fuel Oil No. 2), which must be atomized to a fine mist in order for it to be easily ignited.

Certain solutions of liquids in water exhibit a flash point using the standard closed-cup test procedures but will not burn and might even extinguish a fire. To assist identifying such solutions, the following standards are helpful: ASTM D 4207, *Standard Test Method for Sustained Burning of Low Viscosity Liquid Mixtures by the Wick Test*, and ASTM D 4206, *Standard Test Method for Sustained Burning of Liquid Mixtures by the Setaflash Tester (Open Cup)*. Liquid mixtures that do not sustain combustion for a specified time at a specified temperature are considered to be noncombustible. These tests provide additional data for determining proper storage and handling of such mixtures. In a confined space, such mixtures might still create an ignitible vapor–air mixture, depending on the amount of flammable liquid in the mixture and the quantity of the spill.

Related to the flash point is the fire point. The fire point of a liquid is the temperature at which ignition of vapors will result in continued burning. As the term *flash point* suggests, the vapors generated at that temperature will flash, but will not necessarily continue to burn. The difference between flash point and fire point has some significance when conducting flash point tests *(see ASTM D 92, Standard Test Method for Flash and Fire Points by Cleveland Open Cup, and U.S. Department of Transportation regulations in 49 CFR 173, Appendix H, "Hazardous Materials Regulations," Method of Testing for Sustained Combustibility).* However, a closed-cup flash point is used to classify the liquid and characterize its hazard.

For more information, see ASTM E 502, *Standard Test Method for Selection and Use of ASTM Standards for the Determination of Flash Point of Chemicals by Closed Cup Methods*, and the *ASTM Manual on Flash Point Standards and Their Use*.

A.3.3.13 Vapor Pressure. Vapor pressure is a measure of the pressure that the liquid exerts against the atmosphere above it. Just as the atmosphere exerts pressure on the surface of the liquid, the liquid pushes back. Vapor pressure is normally less than atmospheric pressure and is a measure of the liquid's tendency to evaporate, to move from the liquid to the gaseous state. This tendency is also referred to as volatility, thus the use of the term *volatile* to describe liquids that evaporate very easily. The higher the vapor pressure, the greater the rate of evaporation and the lower the boiling point. Simply put, this means more vapors and increased fire risk.

A.5.1.6 Possible temperature rise during transfer as well as the loading temperature and altitude must be considered when determining if the flammable or combustible liquid will be transported at or above its boiling point. Where an accurate boiling point is unavailable for the material in question or for mixtures that do not have a constant boiling point, the 20

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percent point of a distillation performed in accordance with ASTM D 86, *Standard Method of Test for Distillation of Petroleum Products*, can be used as the boiling point of the liquid.

A.5.1.8 In case of doubt, the supplier or producer of the flammable or combustible liquid or another competent authority should be consulted as to the suitability of the material of construction to be used.

A.5.3.2 Minimum requirements for the materials listed in Table 5.3.2 are duplicated from 49 CFR 178.345, in effect as of January 1, 1974.

A.5.3.13.4 Information on suitable methods for conducting the flow tests is provided in API 2000, *Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated*.

A.5.4.1.1 The 45-second viscosity limit is included for the purposes of requiring internal valves when transporting free-flowing distillate oils, such as kerosene, diesel oil, and domestic heating oil, and of excluding this requirement when transporting viscous oils such as residual fuel oil, bunker fuel oil, and asphalt products that can congeal and cause malfunctioning of the valve.

A.9.1.7 In case of doubt, the supplier or producer of the flammable or combustible liquid or other competent authority should be consulted.

A.9.1.10 To reduce the danger of static ignition when changing from Class I to Class II or Class III (switch loading), other precautions may be necessary. *(See Annex B for further information.)*

A.9.2.12.3 Bond wires can be insulated or noninsulated. A noninsulated wire permits ready visual inspection for continuity of bond. Insulated types should be electrically tested or inspected periodically for continuity of the entire bond circuit, including clamps and connectors.

Annex B Precautions Against Ignition by Static Electricity

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 General Information.

B.1.1 Chapter 9 of this standard includes requirements directed at preventing the occurrence of static-caused fires or explosions in the operation of tank vehicles. This annex provides background information concerning the generation, accumulation, and release of static charges (sparks) in such operations and explains the reasons for the required precautions.

B.1.2 For a more detailed discussion of static electricity and methods for its control for the purpose of eliminating or mitigating its fire hazard, see NFPA 77, *Recommended Practice on Static Electricity*.

B.2 Static Electricity.

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B.2.1 Generation. Static electricity almost always results from the intimate contact and subsequent separation of two substances, most often dissimilar substances. While the most widely recognized manifestations involve the separation of solids, liquid-solid separation is also a generating means and the one most important in the operation of tank vehicles.

The flow of any fluid (even water) past a surface, such as the wall of a pipe, results in the separation of electric charge. If the fluid is a conductor of electricity, such as water, the separated charges quickly reunite, and there is no conspicuous evidence that charge separation had ever occurred. But if the liquid is a poor conductor, as are many oils, this recombination may be hindered, and a persistent charge may accumulate.

If a metallic vessel insulated from its surroundings is filled in this manner, the charge carried by the liquid can be communicated to the vessel. In other words, the vessel can become "charged," or assume an electrical potential different from that of its surroundings. If a wire connected to some other body or to earth is brought close to the vessel being filled, this charge can be released in the form of a spark.

In a somewhat different but analogous manner, a charge may accumulate on the surface of the fluid in an area remote from the vessel walls, even though the vessel is itself "grounded," and this surface charge can, under certain circumstances, be released in the form of a spark.

Both of these means of spark production are important and will be dealt with separately.

B.2.2 Charging Tendency. The terms *charging tendency* and *static-generating ability* have come into use in describing the capability of a fluid to generate and hold a dangerous charge of static electricity. In this annex, the word *oil* is used to typify such a fluid irrespective of origin. Actually, such fluids range from pure chemicals to complex mixtures such as kerosene and other products of petroleum; some have a charging tendency, and some do not.

The static-generating capability of any oil is influenced in a complex manner by the presence of ionizable components and the oil's electrical resistivity, as discussed in detail in NFPA 77, *Recommended Practice on Static Electricity*. Product name is not a reliable means of distinguishing one oil from another in regard to static-generating capability. Hence, the precautions listed in this document are based on the concept that all oils are suspect, with the important exception that crude oil and all materials containing more than a very small amount of the heavy residuum of crude oil distillation are known to be nonaccumulators because of their relatively high conductivity. Alcohols or other chemicals containing appreciable amounts of dissolved water and certain chemicals with low resistivities fall into the same category.

Because all oils under handling conditions have at least some small conductivity such that a charge will eventually leak off, it obviously follows that the persistence of a charge must represent an equilibrium between the generating rate and the leakage rate. Generating rate depends on the rate of motion of the fluid.

In some cases, the linear velocity of flow in a pipe is considered important from the standpoint of static generation. A special case involves pumping oil through filters, where intimate contact between the oil and the filter element is known to produce a high degree of electrification.

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In either case, if the oil, after leaving the place of high generation, reaches a place involving a lesser degree of turbulence, some of the charge will leak away, or “relax.” “Relaxation time” has become a consideration in many instances.

B.3 Ignition Hazard.

The development of electrical charges does not of itself constitute a fire or explosion hazard. There must also be present a means of accumulating or storing the charge and some place (a spark gap) where the stored energy can be released in the form of a spark in the presence of a mixture that is ignitible. The hazard does not exist if any one of these three requirements — generation means, spark gap, or ignitible mixture — is absent. It follows naturally that no precautions need be taken if one of the three requirements is known to be absent and that where this is not assured, corrective measures must be directed toward eliminating one of them.

B.4 Examples.

The following are examples of proper bonding and grounding technique:

(1) In the filling of a tank vehicle through a top opening, a bond wire between the cargo tank and the fill stem *(see 9.2.12.)* will maintain the tank and the fill pipe at the same electrical potential and hence prevent a spark in an area where it is suspected that a flammable mixture is present *[see the exceptions in B.4(2)]*. It should be emphasized that this bond does not prevent the accumulation of a charge on the liquid surface, and additional precautions might be necessary *(see Section B.5)*.

(2) No such precaution (bond wire) is required under circumstances where it is ensured that there can be no ignitible mixture present. An example of such a situation is where tank vehicles are used exclusively for transporting Class II and Class III liquids *(see 9.2.12.2)*. Because Class II and Class III liquids do not produce ignitible mixtures at ordinary temperatures, there would be nothing to ignite in the tanks transporting such liquids. The word *exclusively* is important. There are many tank vehicles operated by fuel oil dealers that, by the nature of the operation, fall into this category. The exception “where no Class I liquids are handled” is included both to guard against inadvertent filling with a Class I liquid and to recognize the desirability of having uniform bonding practices at a terminal handling Class I as well as Class II or Class III liquids.

(3) No bond wire is necessary *(see 9.2.12.1)* during the loading or unloading of asphalt, crude oil, or a product containing substantial proportions of crude residuum or other liquids that are known to have low resistivities. These oils are not susceptible to accumulation of dangerous static charges on the liquid surface, nor do they produce dangerous charges on the container, because the conductivity of the liquid is high enough to permit rapid neutralization of any charges separated during transfer.

(4) Static protective practices are not necessary, irrespective of the liquid being handled, where the physical arrangement is such that there is no chance of a spark occurring in the presence of a flammable mixture. Paragraph 9.2.13 lists several such situations.

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Additional examples follow:

(a) Filling of underground tanks. The fill nozzle is invariably in contact with the fill opening. In these cases, the nozzle and tank are at the same electrical potential because of their contact. Furthermore, no spark gap exists.

(b) Loading or unloading through tight connections. Prior to making the connection, there is no flow and no generating mechanism exists. During transfer, there may be static generation within the flow system, but there is no place for a spark to occur in the presence of an ignitible mixture. Flow is shut down before the connection is broken, and there can be no potential difference to cause a spark because the two parts to be separated are in contact and at the same potential up to the instant of separation. Bottom filling is a special case of closed connection, and no bonding is necessary.

B.5 Switch Loading.

The term *switch loading (see A.9.1.10)* has come into use to describe a situation that warrants special consideration.

When a tank is emptied of a cargo of Class I liquid, there is left a mixture of vapor and air, which can be, and often is, within the flammable range. When such a tank is refilled with a Class I liquid, any charge that reaches the tank shell is bled off by the required bond wire *(see 9.2.12)*. Also, there is no flammable mixture at the surface of the rising oil level because the Class I liquid produces at its surface a mixture too rich to be ignitible. This is the situation that commonly exists in tank vehicles in gasoline service. If, as occasionally happens, a static charge does accumulate on the surface sufficient to produce a spark, it occurs in a too rich, nonignitible atmosphere and thus causes no harm.

A very different situation arises if the liquid is *switch loaded*, that is, a Class II or Class III liquid is loaded into a tank vehicle that previously contained a Class I liquid. Class II or Class III liquids are not necessarily more potent static generators than the Class I liquid previously loaded, but the atmosphere in contact with the rising oil surface is not enriched to bring it out of the flammable range. If circumstances are such that a spark occurs either across the oil surface or from the oil surface to some other object, it is in a mixture that can be within the flammable range, and an explosion can result.

It is emphasized that bonding the tank to the fill stem is not sufficient; a majority of the recorded explosions have occurred when it was believed the tank had been adequately bonded. The electrostatic potential responsible for the spark exists inside the tank on the surface of the liquid and cannot be removed by bonding. Measures to reduce the chance of such internal static ignition include the following:

(1) Avoid spark promoters. Conductive objects floating on the oil surface increase the chance of sparking to the tank wall. Metal gauge rods or other objects projecting into the vapor space can create a spark gap as the rising liquid level approaches the projection. A common precaution is to require that fill pipes (downspouts) reach as close to the bottom of the tank as practicable. Any operation such as sampling, taking oil temperature, or gaging that involves lowering a conductive object through an

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opening into the vapor space on the oil should be deferred until at least 1 minute after flow has ceased. Doing so permits any surface charge to relax.

(2) Reduce the static generation by one or more of the following:

(a) Avoid splash filling and upward spraying of oil where bottom filling is used.

(b) Employ reduced fill rates at the start of filling through downspouts, until the end of the spout is submerged. Some consider 3 ft/sec (0.9 m/sec) to be a suitable precaution.

(c) Where filters are employed, provide relaxation time in the piping downstream from the filters. A relaxation time of 30 seconds is considered by some to be a suitable precaution.

(3) Eliminate the flammable mixture by gas freeing or inerting before switching loads.

Annex C Informational References

C.1 Referenced Publications.

The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

C.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2007 edition.

C.1.2 Other Publications.

C.1.2.1 API Publications. American Petroleum Institute, 1220 L Street, NW, Washington DC 20005.

API 2000, *Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated*, 1998 edition.

C.1.2.2 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D 86, *Standard Method of Test for Distillation of Petroleum Products*, 1999 edition.

ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup*, 1990.

ASTM D 4206, *Standard Test Method for Sustained Burning of Liquid Mixtures by the Setaflash Tester (Open Cup)*, 1989 edition.

ASTM D 4207, *Standard Test Method for Sustained Burning of Low Viscosity Liquid Mixtures by the Wick Test*, 1991 edition.

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ASTM E 502, *Standard Test Method for Selection and Use of ASTM Standards for the Determination of Flash Point of Chemicals by Closed Cup Methods,* 1984.

ASTM Manual on Flash Point Standards and Their Use, 1992.

C.1.2.3 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 49, Code of Federal Regulations, Part 173, Appendix H, "Hazardous Materials Regulations," Method of Testing for Sustained Combustibility.

Title 49, Code of Federal Regulations, Part 178.345, 1974.

C.2 Informational References. (Reserved)

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