# National Fire Codes®
# 1985

Codes and Standards National Fire Protection Association

# *National Fire Codes*

**A Compilation of NFPA Codes, Standards, Recommended Practices, Manuals and Guides**

**Volume 2**




This is one of 8 volumes of the *National Fire Codes* published by the National Fire Protection Association. The complete set contains the codes, standards, recommended practices, manuals and guides developed by the technical committees of the Association and processed in accordance with the NFPA Regulations Governing Committee Projects.

National Fire Protection Association
Batterymarch Park, Quincy, MA 02269

## NATIONAL FIRE PROTECTION ASSOCIATION

**Batterymarch Park, Quincy, MA 02269**

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the cooperation of its members in establishing proper safeguards against loss of life and property by fire. The Association is an international, charitable, technical and educational organization. Its membership includes over one hundred and fifty national and regional societies and associations and over thirty-two thousand individuals, corporations, and organizations. Anyone interested may become a member; membership information is available on request.

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# ALPHABETICAL LISTING — 1985 NFC CONTENTS

## ALPHABETICAL LISTING (Continued)



Rev. 11/84

## *National Fire Codes*

The *National Fire Codes* are annual compilations of the Codes, Standards, Recommended Practices, Manuals, Guides and Model Laws prepared by Technical Committees organized under NFPA sponsorship in accordance with the published procedures of the Association. Only those documents which have been adopted by the Association are included in the *National Fire Codes.*

The Board of Directors of the Association appoints persons from those vitally interested, qualified, and active in the areas with which the Committees are concerned so as to achieve a fair balance of affected interests. All service on these NFPA Technical Committees is contributed voluntarily in support of the Association's program for firesafety. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accept any liability resulting from compliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text. Users should realize that complete reliance for firesafety can never rest exclusively on any single safeguard.

The committees responsible for the various texts published herein are given in the introductory sections preceding each. Current committee lists are published in the NFPA *Yearbook,* which may be obtained from the Association. Official records of the adoption of each standard will be found in the NFPA *Technical Committee Reports,* the *Technical Committee Documentation* and *Fire Journal,* a bimonthly membership publication of the Association.

Volumes 1 through 6 contain documents which have been judged suitable for legal adoption and enforcement (Codes and Standards).

Volumes 7 and 8 contain Recommended Practices, Manuals and Guides which are generally referred to as good engineering practices. Also included in these volumes are such documents as model laws and enabling acts which will be found to be particularly helpful to enforcing agencies.

Many of the documents have been approved by the American National Standards Institute as American National Standards. Most of the documents contained in these volumes are also published by the Association in separate pamphlet form.

Users of this document should consult applicable Federal, State and local laws and regulations. NFPA does not, by the publication of this document, intend to urge action which is not in compliance with applicable laws and this document may not be construed as doing so.

### Policy adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

# Official NFPA Definitions

Extracted from the *Regulations Governing Committee Projects*

## Section 2. Terms and Definitions.

**2-2 Definitions.** Where the following terms, commonly found in the Association Committee Documents, are used or defined in the body of the text of a Standard, Code, Recommended Practice, Manual or Guide, they shall be consistent with the intent of these meanings, but these "definitions" may be altered by a Committee to fit the individual needs of the Document. Such altered definition shall be clear and unambiguous in the context in which it is used.

**Approved:** means "acceptable to the authority having jurisdiction."

NOTE: 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 or 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 concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

**Authority Having Jurisdiction:** The "authority having jurisdiction" is the organization, office, or individual responsible for "approving" equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA Documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local, or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances, the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

**Code:** A Document containing only mandatory provisions using the word "shall" to indicate requirements and in a form generally suitable for adoption into law. Explanatory material may be included only in the form of "fine print" notes, in footnotes, or in an appendix.

**Labeled:** Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization 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.

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

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which 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.

**Manual or Guide:** A Document which is informative in nature and does not contain requirements.

**Recommended Practice:** A Document containing only advisory provisions (using the word "should" to indicate recommendations) in the body of the text.

**Shall:** Indicates a mandatory requirement.

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

**Standard:** A Document containing only mandatory provisions using the word "shall" to indicate requirements. Explanatory material may be included only in the form of "fine print" notes, in footnotes, or in an appendix.

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*Notes and footnotes are informatory only and are not mandatory.*

## VOLUME 2

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**NFPA 385**

**Standard for**

# Tank Vehicles for Flammable and Combustible Liquids

**1985 Edition**

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, released by the Correlating Committee on Flammable Liquids, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 12-15, 1984 in San Diego, California. It was issued by the Standards Council on December 7, 1984, with an effective date of December 27, 1984, and supersedes all previous editions.

The 1985 edition of this standard has been approved by the American National Standards Institute.

## Origin and Development of NFPA 385

This standard was initiated in 1926, first officially adopted in 1929, and revised and issued in the following earlier editions: 1933, 1948, 1953, 1954, 1955, 1957, 1958, 1959, 1960, 1963, 1964, 1966, 1971, 1974 and 1979. Editions prior to 1948 had different titles.

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Dept. of State Police, MI
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(Nonvoting)

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**Michael P. Wilson,** American Insurance Assn.

**Alternates**

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(Alternate to C. J. Harvison)

**E. R. Smith,** American Petroleum Institute
(Alternate to H. M. Faulconer)

**Nonvoting**

**Paul Seay,** Dept. of Transportation

*This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.*

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.

## Contents

# NFPA 385

## Standard for

# Tank Vehicles for Flammable and Combustible Liquids

## 1985 Edition

## Chapter 1 General Provisions

### 1-1 Scope.

1-1.1 This standard applies to tank vehicles to be used for the transportation of asphalt or normally stable flammable and combustible liquids with a flash point below 200°F (93.4°C). It is intended to provide minimum requirements for the design and construction of cargo tanks and their appurtenances and to set forth certain matters pertaining to tank vehicles.

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

1-1.2 Additional safeguards may be necessary for tank vehicles used for the transportation of flammable and combustible liquids having characteristics introducing additional factors such as high rates of expansion, instability, corrosiveness, and toxicity.

1-1.3 Attention is directed to the fact that some cutback asphalts have flash points in the range of Class I liquids. Also, liquids having a flash point higher than 200°F (93.4°C), such as asphalt, may assume the characteristics of lower flash point liquids when heated. Under such conditions it shall be appropriate to apply the provisions of this standard unless otherwise specifically exempted.

1-1.4 The requirements for aircraft fuel servicing tank vehicles are contained in NFPA 407, *Standard for Aircraft Fuel Servicing*.

1-1.5 A tank vehicle transporting a flammable or combustible liquid in interstate service shall be considered to be in conformity with this standard while it is in interstate service if it meets the requirements of the U. S. Department of Transportation Hazardous Materials Regulations.

### 1-2 Definitions.

**Approved.** Acceptable to the "authority having jurisdiction."

NOTE: 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 or 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 concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

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

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

**Cargo Tank.** Any tank having a liquid capacity in excess of 110 gal (418 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.

**Compartment.** A liquidtight division in a cargo tank.

**Flash Point.** The minimum temperature of a liquid at which sufficient vapor is given off to form an ignitible mixture with the air near the surface of the liquid within the vessel as determined by appropriate test procedure and apparatus as specified.

The flash point of liquids having a viscosity less than 45 SUS at 100°F (37.8°C) and a flash point below 200°F (93.4°C) shall be determined in accordance with ASTM D-56-82, *Standard Method of Test for Flash Point by the Tag Closed Tester*.

The flash point of liquids having a viscosity of 45 SUS or more at 100°F (37.8°C) or a flash point of 200°F (93.4°C) or higher shall be determined in accordance with ASTM D-93-80, *Standard Method of Test for Flash Point by the Pensky-Martens Closed Tester*.

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

**Labeled.** Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization 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.

**Liquid.** For the purpose of this standard, liquid shall mean any material which has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D-5-78, *Test for Penetration for Bituminous Materials*. When not otherwise identified, the term liquid shall include both flammable and combustible liquids.

**Combustible Liquid.** A liquid having a flash point at or above 100°F (37.8°C).

Combustible liquids shall be subdivided as follows:

**Class II Liquids** shall include those having flash points at or above 100°F (37.8°C) and below 140°F (60°C).

**Class IIIA Liquids** shall include those having flash points at or above 140°F (60°C) and below 200°F (93.4°C).

**Class IIIB Liquids** shall include those having flash points at or above 200°F (93.4°C).

This standard does not cover Class IIIB liquids (*see 1-1.1*). Where the term combustible liquids is used in this standard, it shall mean only Class II and Class IIIA liquids.

NOTE: The upper limit of 200°F (93.4°C) is given because the application of this standard does not extend to liquids having flash points above 200°F (93.4°C) and this limitation should not be construed as indicating that liquids with higher flash points are noncombustible.

**Flammable Liquid.** A liquid having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 psi (absolute)(2068 mm Hg) at 100°F (37.8°C) shall be known as a Class I liquid.

**Class I Liquids** shall be subdivided as follows:

**Class IA** shall include those having flash points below 73°F (22.8°C) and having a boiling point below 100°F (37.8°C).

**Class IB** shall include those having flash points below 73°F (22.8°C) and having a boiling point at or above 100°F (37.8°C).

**Class IC** shall include those having flash points at or above 73°F (22.8°C) and below 100°F (37.8°C).

The volatility of liquids is increased when artificially heated to temperatures equal to or higher than their flash points. When so heated Class II and III liquids shall be subject to the applicable requirements for Class I or II liquids. This standard may also be applied to high flash point liquids when so heated even though these same liquids when not heated are outside of its scope.

NOTE: This classification does not apply to:

(a) Liquids without flash points that may be flammable under some conditions, such as certain halogenated hydrocarbons and mixtures containing petroleum fractions and halogenated hydrocarbons,
(b) Mists, sprays or foams.

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

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which 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.

**Tank Full-Trailer.** Any vehicle with or without auxiliary motive power, equipped with a cargo tank mounted thereon or built as an integral part thereof, and 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.

**Tank Semi-Trailer.** Any vehicle with or without auxiliary motive power, equipped with a cargo tank mounted thereon or built as an integral part thereof, and used for the transportation of flammable and combustible liquids 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.

**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.

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

**Vapor Pressure.** The pressure measured in psi (absolute) (mm Hg) exerted by a liquid, as determined by ASTM D-323-82, *Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method)*.

## Chapter 2 Tank Vehicle Design

### 2-1 General.

**2-1.1** 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. The metal thicknesses specified in this chapter are minimum thicknesses dictated by the structure of the tank itself, and it may be necessary that these thicknesses be increased where the tank shell is to be subjected to additional stress. The general design of the cargo tank and vehicle chassis shall be arranged to give the best combination of structural characteristics and vehicle performance. The design of the suspension system shall incorporate features to help assure lateral or tipping stability when turning corners.

**2-1.2** Any cargo tank designed for transporting materials at liquid temperatures above ambient temperatures shall have a metal warning plate not subject to corrosion located in a conspicuous place on the right side near the front. Such plate shall be permanently affixed to the tank or tank frame. Upon it shall be marked in characters at least ½ in. (1.2 cm) high by stamping, embossing, or other means of forming letters into or on the metal of the plate itself at least the following information:

"Maximum allowable cargo temperature is ____°F (____°C)."

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

**2-1.3** Cargo tanks used for transporting flammable and combustible liquids at temperatures equal to or above

their boiling points shall be constructed in accordance with Section 2-2.

NOTE: Possible temperature rise during transfer as well as the loading temperature and altitude must be considered when determining if the flammable and 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 which do not have a constant boiling point, the 10 percent point of a distillation performed in accordance with ASTM D-86-82, *Standard Method of Test for Distillation of Petroleum Products*, may be used as the boiling point of the liquid.

**2-1.4** Cargo tanks used for transporting flammable and combustible liquids at a temperature below their boiling points shall be constructed in accordance with the provisions of Section 2-3.

**2-1.5** The material used in the construction of the cargo tanks shall be compatible with the chemical characteristics of the flammable and combustible liquid to be transported.

NOTE: In case of doubt, the supplier or producer of the flammable and combustible liquid or other competent authority should be consulted as to the suitability of the material of construction to be used.

**2-1.6** A single cargo tank may be divided into compartments of different specification construction. Each such compartment shall conform to specification requirements concerned and be so identified with a permanent metal plate.

**2-2 Cargo Tanks, Piping and Connections Designed for Transporting Flammable and Combustible Liquids at Temperatures at or Above Their Boiling Points.** Cargo tanks, piping and connections designed for transporting flammable and combustible liquids above their boiling points shall be built in accordance with Specifications MC-307 or MC-331 of Part 178 of Title 49, *Code of Federal Regulations*, or in accordance with Chapter 6 of NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*. Continued use of cargo tanks constructed on or before December 1, 1967, to Specifications MC-304 and MC-330 shall be permitted.

**2-3 Cargo Tanks, Piping and Connections Designed for Transfer of Flammable and Combustible Liquids at Temperatures Below Their Boiling Points.**

**2-3.1 General.** Cargo tanks constructed after the effective date of this standard shall be constructed in accordance with Section 2-3 as contained herein. Continued use of existing cargo tanks constructed in accordance with the 1966 edition of NFPA 385 and earlier editions shall be permitted, but new construction is not permitted.

**2-3.2 Material.** All sheet and plate material for shell, heads, bulkheads and baffles for cargo tanks which are not required to be constructed in accordance with the ASME *Boiler and Pressure Vessel Code* shall meet the following minimum applicable requirements.

NOTE: Minimum requirements for materials listed below are duplicated from 49 CFR, Section 178.341, in effect as of January 1, 1974.

**(a) Aluminum Alloys (AL).** Only aluminum alloy material suitable for fusion welding and in compliance with one of the following ASTM specifications shall be used:

| | |
|---|---|
| ASTM B-209 Alloy 5052 | ASTM B-209 Alloy 5254 |
| ASTM B-209 Alloy 5086 | ASTM B-209 Alloy 5454 |
| ASTM B-209 Alloy 5154 | ASTM B-209 Alloy 5652 |

All heads, bulkheads, baffles, and ring stiffeners may use 0 temper (annealed) or stronger tempers. All shells shall be made of materials with properties equivalent to H32 or H34 tempers, except that lower ultimate strength tempers may be used if the minimum shell thicknesses in Table 2-2 are increased in inverse proportion to the lesser ultimate strength.

**(b) Steel.**

| | Mild steel (MS) | High strength low alloy steel (HSLA) | Austenitic stainless steel (SS) |
|---|---|---|---|
| Yield | 25,000 psi | 45,000 psi | 25,000 psi |
| Ultimate strength | 45,000 psi | 60,000 psi | 70,000 psi |
| Elongation, 2-in. samples | 20% | 25% | 30% |

**2-3.3 Thickness of Sheets, Heads, Bulkheads and Baffles.**

**2-3.3.1 Material Thickness.** The minimum thicknesses of tank material authorized shall be predicated on not exceeding the maximum allowable stress level but in no case less than those indicated in Tables 2-1 and 2-2.

**2-3.3.2 Product Density.** The material thicknesses contained in Tables 2-1 and 2-2 are minimums based on a maximum 7.2 lb per gal (3.24 kg) product weight. If the tank is designed to haul products weighing more than 7.2 lb per gal (3.24 kg), 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.

**2-3.3.3** When aluminum is used for cargo tanks intended to transport cargoes at liquid temperatures above 250°F (121.1°C) the minimum thicknesses shall be increased by 1 percent for each 10°F (5.56°C) or portion thereof above 250°F (121.1°C). When the liquid temperatures are above 500°F (260°C) there shall be an additional 1 percent for each 10°F (5.56°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).

**2-3.4 Structural Integrity.**

**2-3.4.1 Maximum Stress Values.** The maximum calculated stress value shall not exceed 20 percent of the minimum ultimate strength of the material as authorized except when ASME pressure vessel design requirements apply (see Section VIII, ASME *Boiler and Pressure Vessel Code*, 1983 edition).

**2-3.4.2 Loadings.** Cargo tanks shall be provided with additional structural elements as necessary to prevent resulting stresses in excess of those permitted in 2-3.4.1.

**Table 2-1 Minimum Thickness of Heads, Bulkheads and Baffles. Mild Steel (MS), High Strength Low Alloy Steel (HSLA), Austenitic Stainless Steel (SS), in U.S. Standard Gage; Aluminum Alloy (AL) — Expressed in Decimals of an Inch.**

| | Volume capacity in gal per in. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 or less | | | Over 10 to 14 | | | 14 to 18 | | | 18 and over | | |
| | | HSLA, | | | HSLA, | | | HSLA, | | | HSLA, | |
| | MS | SS | AL | MS | SS | AL | MS | SS | AL | MS | SS | AL |
| Thickness | 14 | 15 | 0.096 | 13 | 14 | 0.109 | 12 | 13 | 0.130 | 11 | 12 | 0.151 |

**Table 2-2 Minimum Thickness of Shell Sheets. Mild Steel (MS), High Strength Low Alloy Steel (HSLA), Austenitic Stainless Steel (SS), in U.S. Standard Gage; Aluminum Alloy (AL) — Expressed in Decimals of an Inch.**

| Distance between bulkheads, baffles, or ring stiffeners | | Volume capacity in gal per in. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 or less | | | Over 10 to 14 | | | 14 to 18 | | | 18 and over | | |
| | | | HSLA, | | | HSLA, | | | HSLA, | | | HSLA, | |
| | | MS | SS | AL | MS | SS | AL | MS | SS | AL | MS | SS | AL |
| Maximum shell radius | 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 | .087 | 14 | 15 | .096 | 13 | 14 | .109 | 12 | 13 | .130 |
| | | 54 in. through 60 in. | 14 | 15 | .096 | 13 | 14 | .109 | 12 | 13 | .130 | 11 | 12 | .151 |
| | 70 in. or more, less than 90 in. | 36 in. or less | 14 | 16 | .087 | 14 | 15 | .096 | 13 | 14 | .109 | 12 | 13 | .130 |
| | | Over 36 in. to 54 in. | 14 | 15 | .096 | 13 | 14 | .109 | 12 | 13 | .130 | 11 | 12 | .151 |
| | | 54 in. through 60 in. | 13 | 14 | .109 | 12 | 13 | .130 | 11 | 12 | .151 | 10 | 11 | .173 |
| | 90 in. or more, less than 125 in. | 36 in. or less | 14 | 15 | .096 | 13 | 14 | .109 | 12 | 13 | .130 | 11 | 12 | .151 |
| | | Over 36 in. to 54 in. | 13 | 14 | .109 | 12 | 13 | .130 | 11 | 12 | .151 | 10 | 11 | .173 |
| | | 54 in. through 60 in. | 12 | 13 | .130 | 11 | 12 | .151 | 10 | 11 | .173 | 9 | 10 | .194 |
| | 125 in. or more | 36 in. or less | 13 | 14 | .109 | 12 | 13 | .130 | 11 | 12 | .151 | 10 | 11 | .173 |
| | | Over 36 in. to 54 in. | 12 | 13 | .130 | 11 | 12 | .151 | 10 | 11 | .173 | 9 | 10 | .194 |
| | | 54 in. through 60 in. | 11 | 12 | .151 | 10 | 11 | .173 | 9 | 10 | .194 | 8 | 9 | .216 |

Consideration shall be given to forces imposed by each of the following loads individually, and where applicable a vector summation of any combination thereof:

(a) Dynamic loading under all product load configurations.

(b) Internal pressure.

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

(d) Reactions of supporting lugs and saddles or other supports.

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

**2-3.5 Joints.**

**2-3.5.1 Method of Joining.** 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.

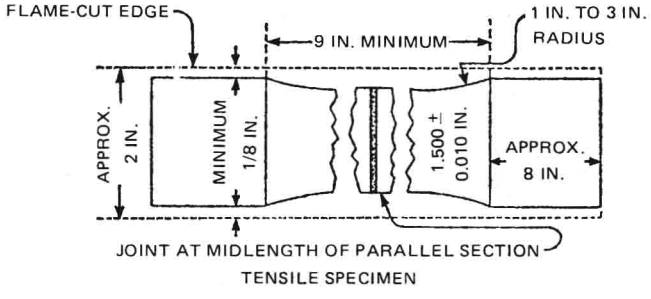
**2-3.5.2 Strength of Joints [Aluminum Alloy (AL)].** All welded aluminum alloy joints shall be made in accordance with recognized good practice, and the efficiency of a joint shall be not less than 85 percent of the properties of the adjacent material. Aluminum alloys shall be joined by an inert gas arc welding process using aluminum-magnesium type of filler metals which are consistent with the material supplier's recommendations.

**2-3.5.3 Strength of Joints [Mild Steel (MS), High Strength Low Alloy (HSLA), Austenitic Stainless Steel (SS)].** Joints shall be welded in accordance with recognized good practice, and the efficiency of any joint shall be not less than 85 percent of the mechanical properties of the adjacent metal in the tank.

2-3.5.4 Combinations of mild steel (MS), high strength low alloy (HSLA) and/or austenitic stainless steel (SS) may 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. 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 for use with the grade of stainless steel concerned according to the recommendations of the manufacturer of the stainless steel electrodes or filler rods.

**2-3.5.5 Compliance Test.** Compliance with the requirements contained in 2-3.5.2 or 2-3.5.3 for the welded joints indicated in 2-3.5.1 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 the figure as shown below and testing them to failure in tension. One pair of test specimens may 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 six months after the tests on such samples have been completed. The butt welded specimens tested shall be considered 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.




**2-3.6 Supports and Anchoring.**

**2-3.6.1** 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 frame which may 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 are permitted to cover the restraining devices.

**2-3.6.2** 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 2-3.4.1. The design calculations of the support elements shall include loadings imposed by stopping, starting, and turning in addition to those imposed as indicated in 2-3.4.2 using 20 percent of the minimum ultimate strength of the support material.

**2-3.7 Circumferential Reinforcement.**

**2-3.7.1** Tanks with shell thicknesses less than 3/8 of an in. (0.93 cm) shall, in addition to the reinforcement provided by the tank heads, be circumferentially reinforced with either bulkheads, baffles, or ring stiffeners. It is permissible to use any combination of the aforementioned reinforcements in a single cargo tank.

**2-3.7.2 Location.** Such reinforcement shall be located in such a manner that the maximum unreinforced portion of the shell be as specified in Table 2-2 and in no case more than 60 in. (150 cm). Additionally, such circumferential reinforcement shall be located within 1 in. (2.5 cm) 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 2-3.6.

**2-3.7.3 Baffles.** Baffles or baffle attaching rings if used as reinforcement members shall be circumferentially welded to the tank shell. The welding must not be 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.

**2-3.7.4 Double Bulkheads.** Whenever double bulkheads are provided, they shall be separated by an air space. This air space shall be vented and be equipped with drainage facilities which shall be kept operative at all times (*see 6-1.7*).

**2-3.7.5 Ring Stiffeners.** Ring stiffeners when used to comply with this section 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 formula:

$$\frac{I}{C} \text{ (Min)} = 0.00027\ WL \text{ (MS, HSLA \& SS ) Steel}$$

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

where

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

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.

**2-3.7.5.1** If 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 may 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 is as follows:

| Circumferential ring stiffener to tank shell welds | Distance between parallel circumferential ring stiffener to shell welds | Shell section credit |
|---|---|---|
| 1 | . . . . . | 20t |
| 2 | Less than 20t | 20t + W |
| 2 | 20t or more | 40t |

where

t = shell thickness;

W = distance between parallel circumferential ring stiffener to shell welds.

**2-3.7.5.2** If configuration of internal or external ring stiffener encloses an air space, this air space shall be arranged for venting and be equipped with drainage facilities which shall be kept operative at all times.

**2-3.8 Accident Damage Protection.**

**2-3.8.1** The design, construction, and installation of any appurtenance to the shell or head of the cargo tank must be such as to minimize the possibility of appurtenance damage or failure adversely affecting the product retention integrity of the tank.

**2-3.8.2** 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.

**2-3.8.3** Except as prescribed in 2-3.8.5, the welding of any appurtenance to a shell or head must be made by attachment to a mounting pad. The thickness of a mounting pad must not be less than that of the shell or head to which it is attached. A pad must extend at least 2 in. (5 cm) in each direction from any point of attachment of an appurtenance. Pads must have rounded corners or otherwise be shaped in a manner to preclude stress concentrations on the shell or head. The mounting pad must be attached by a continuous weld around the pad.

**2-3.8.4** The appurtenance must be attached to the mounting pad 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.

**2-3.8.5** 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, may be secured directly to the tank shell or head if each device is so designed and installed that damage to it will not affect the product retention integrity of the tank. These lightweight attachments must be secured to the tank shell by continuous weld or in such manner as to preclude formation of pockets, which may become sites for incipient corrosion.

**2-3.8.6 Rear Bumpers.** 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 minimize the possibility of any part of the colliding vehicle striking the tank. The bumper shall be located at least 6 in. (15 cm) to the rear of any vehicle component which is used for loading or unloading purposes or may at any time contain lading while in transit. Dimensionally, the bumper shall conform to 49 C.F.R. & 393.86. Structurally, the bumper shall be designed to successfully absorb (no damage which will cause leakage of product) the impact of the vehicle with rated payload, with a deceleration of 2 "g" using a factor of safety of two based on the ultimate strength of the bumper material. 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.

**2-3.8.7 Overturn Protection.** All closures for filling, manhole, or inspection openings shall be protected from damage which will 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.

**2-3.8.7.1** 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 may be considered independently. Ultimate strength of the material shall be used as a calculation base. If more than one guard is used each shall carry its proportionate share of the load. If protection other than guards are considered, the same design load criteria are applicable.

**2-3.8.7.2** Except for pressure actuated vents no overturn protection is required for nonoperating nozzles or fittings less than 5 in. (12.5 cm) 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 may be measured either from the shell or the top of an adjacent ring stiffener provided such stiffener is within 30 in. (75 cm) of the center of the nozzle or fitting.

**2-3.8.7.3** If the overturn protection is so constructed as to permit accumulation of liquid on the top of the tank, it shall be provided with drainage facilities directed to a safe point of discharge.

**2-3.8.8 Piping.**

**2-3.8.8.1** Product discharge piping shall be provided with protection in such a manner as to reasonably assure against the accidental escape of contents. Such protection may be provided by:

(a) A shear section located outboard of each emergency valve seat and within 4 in. (10 cm) of the vessel which 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. 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; or