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NFPA 52 Compressed Natural Gas (CNG) Vehicular Fuel Systems 1992 Edition

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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.

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Errata

NFPA 52

Compressed Natural Gas (CNG) Vehicular Fuel Systems

1992 Edition

Reference: 2-11.5 and 6-1.2.6

The Committee on Natural Gas Vehicular Fuel Systems notes the following errors in the 1992 edition of NFPA 52, *Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems.*

1. Revise 2-11.5 to read:

2-11.5 Where refueling is available for use by the general public, a vehicle fueling connection complying with ANSI/AGA NGV1, *Standard for Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices*, shall be provided.

2. Change the reference in 6-1.2.6 to read:

6-1.2.6 AGA Publications. American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209.

ANSI/AGA NGV1, 1994, *Standard for Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices*

ANSI/AGA NGV2, 1992, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers*

Issue Date: March 16, 1994

NFPA 52

Standard for

Compressed Natural Gas (CNG) Vehicular Fuel Systems

1992 Edition

This edition of NFPA 52, *Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems*, was prepared by the Technical Committee on Compressed Natural Gas Vehicular Fuel Systems and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 18-21, 1992 in New Orleans, LA. It was issued by the Standards Council on July 17, 1992, with an effective date of August 14, 1992, and supersedes all previous editions.

The 1992 edition of this document has been approved by the American National Standards Institute.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 52

While CNG vehicles have been used extensively in other countries since the late 1940s, it was not until the late 1970s that their use in the United States became extensive enough to warrant preparation of a national consensus standard.

Between 1980 and 1982, a Committee of the American Gas Association developed a draft of a fire safety standard. This was based on existing worldwide standards and current U.S. practice.

In late 1981, the AGA petitioned the NFPA to establish a technical committee project on this subject. The normal NFPA solicitation of comments revealed sufficient interest from the varied interests necessary, and the Committee on Compressed Natural Gas Vehicular Fuel Systems was established by the Standards Council in July 1982.

The first edition of NFPA 52 was issued in 1984, and it was revised in 1988.

The 1992 edition contains extensive revisions to bring the standard into conformance with practices and equipment that have come into use since the standard was first developed.

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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

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Standard for

Compressed Natural Gas (CNG)

Vehicular Fuel Systems

1992 Edition

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

Information on referenced publications can be found in Chapter 6 and Appendix B.

Chapter 1 Introduction

1-1* Scope. This standard applies to the design and installation of compressed natural gas (CNG) engine fuel systems on vehicles of all types including aftermarket and OEMs and to their associated fueling (dispensing) systems.

Exception: Vehicles complying with Federal Motor Vehicle Safety standards covering the installation of CNG fuel systems on vehicles and certified by the manufacturer as meeting these standards shall not be required to comply with 2-8.4 and Chapter 3, Engine Fuel Systems (except 3-11, Labeling).

1-2 Alternate Provisions. It is recognized that advancement in technology and improvements in system design and equipment may result in equipment fabrication methods, component design requirements, and installation and operating practices that differ from those specifically called for in this standard. Such deviations or improvements may provide desirable safety and compatible operation meeting the intent of this standard. Such deviations may be accepted when the authority having jurisdiction has seen evidence that a special investigation of all factors has been made and, based on sound experience and engineering judgment, has concluded that the proposed deviations meet the intent of this standard.

1-3 Retroactivity. The provisions of this document are considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion. They reflect situations and the state of the art at the time the standard was issued.

Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the document, except in those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or adjacent property.

1-4 Metric Practice. Metric units in this standard are based on ASTM-380, *Standard for Metric Practice*.

1-5 Definitions.

ANSI. American National Standards Institute.

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.

ASME Code. The American Society of Mechanical Engineers' *Boiler and Pressure Vessel Code*.

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."

Bulk Storage. Storage in pressure vessels other than cylinders.

Capacity. The water volume of a container in standard cu ft (m^3) per gallons.

Cascade Storage System. Storage in multiple pressure vessels, cylinders, or containers.

Code. For new construction, "Code" shall mean the applicable edition of the ASME Code referenced in this edition of NFPA 52. For secondhand pressure vessels and existing installations, the term "Code" shall include those editions of the ASME Code that were current at the time that a pressure vessel was built.

Composite Container. A container fabricated of two or more materials that interact to facilitate the container design criteria.

Compressed Natural Gas (CNG). Mixtures of hydrocarbon gases and vapors, consisting principally of methane in gaseous form that has been compressed for use as a vehicular fuel.

Container. A pressure vessel or cylinder used to store CNG.

Container Appurtenances. Devices connected to container openings for safety, control, or operating purposes.

Container Valve. A valve connected directly to a container outlet.

Cylinder. A container constructed, inspected, and maintained according to DOT or TC regulations, ANSI/AGA NGV2, or CSA B51 standards.

Dew Point (at Container Pressure). The dew point value of the gas at the maximum anticipated container pressure of the CNG vehicular fuel system (usually measured in the container prior to pressure reduction). When presenting or referencing dew point, the value shall be given in terms of the container pressure, e.g., -4°F dew point at 3600 psig.

Dew Point Temperature. The temperature, referred to a specific pressure, at which water vapor begins to condense.

Dispensing Station. A natural gas installation that dispenses CNG from storage containers or a distribution pipeline by means of a compressor or pressure booster into fuel supply containers or into portable cylinders.

Enclosure. A structure whose purpose is to protect equipment from the environment or to provide noise attenuation.

Flexible Metal and Wire Braid Hose. A metal hose made from continuous tubing that is corrugated for flexibility and that, for pressurized applications, shall have an external wire braid.

Fuel Line. The pipe, tubing, or hose, including all related fittings, on a vehicle through which natural gas passes.

Fuel Supply Container. A container mounted on a vehicle to store CNG as the fuel supply to the internal combustion engine of this vehicle.

Installation. A system that includes natural gas containers, pressure booster, compressors, and all attached valves, piping, and appurtenances. When filling containers or transferring natural gas directly from distribution lines by means of a compressor, an installation includes the compressor and all piping and piping components beyond the shutoff valve between the distribution system and the compressor.

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.

Limited-Combustible Material. A material (as defined in NFPA 220, *Standard on Types of Building Construction*) not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu per lb (8141 kJ/kg) and complies with one of the following paragraphs (a) or (b). Materials subject to increase in combustibility or flame spread rating beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible. (*See NFPA 259, Standard Test Method for Potential Heat of Building Materials.*)

(a) Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 1/8 in. (3.2 mm) that has a flame spread rating not greater than 50.

(b) Materials, in the form and thickness used, other than as described in (a), having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread rating greater than 25 nor evidence of continued progressive combustion.

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.

Metallic Hose. A hose in which the strength of the hose depends primarily on the strength of metallic parts; it may have metallic liners and/or covers.

Natural Gas. Mixtures of hydrocarbon gases and vapors consisting principally of methane in gaseous form.

Noncombustible Material. A material (as defined in NFPA 220, *Standard on Types of Building Construction*) that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials reported as noncombustible, when tested in accordance with ASTM E-136, *Standard Method of Test for Behavior of Materials in a Vertical Tube Furnace at 750°C*, shall be considered noncombustible materials.

Point of Transfer. The point where the fueling connection is made.

Pressure Relief Device. A pressure and/or temperature activated device used to prevent the pressure from rising above a predetermined maximum and thereby prevent the rupture of a normally charged cylinder when subjected to a standard fire test as required by 49 CFR 173.34(d) or 73.34(d) of the TC Regulations. Pressure

relief devices for DOT/TC cylinders shall also include devices capable of protecting partially charged cylinders when subjected to these fire tests.

Pressure Relief Device Channels. The passage or passages beyond the operating parts of the pressure relief device through which fluid must pass to reach the atmosphere.

Pressure Vessel. A container or other component designed in accordance with the ASME Code.

SCF. Cu ft of gas determined at 14.7 psia and 60°F (101 kPa and 16°C).

Service Pressure. The settled pressure at a uniform gas temperature of 70°F (21°C) and full gas content. It is the pressure for which the equipment has been constructed, under normal conditions.

Service Valve. A valve operated by hand connected directly to the outlet of a container other than a cylinder not larger than $^3/_4$-in. pipe size and having an inlet diameter not exceeding the internal diameter of $^1/_2$-in., Schedule 80 pipe.

Settled Pressure. The pressure in a container at 70°F (21°C) that cannot exceed the marked service or design pressure on the container.

Shall. Indicates a mandatory requirement.

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

Sources of Ignition. Devices or equipment that, because of their modes of use or operation, are capable of providing sufficient thermal energy to ignite flammable compressed natural gas-air mixtures when introduced into such a mixture or when such a mixture comes into contact with them and that will permit propagation of flame away from them.

Chapter 2 General CNG and Equipment Qualifications

2-1* General. The provisions of this chapter apply only to pressurized system components handling CNG.

2-2* Gas Quality. Gas quality in the container shall comply with the following:

H_2S and soluble sulfides partial pressure .....0.05 psi, max
water vapor.....7.0 lb/MMCF, max
CO_2 partial pressure .....7 psi, max
O_2.....0.5 volume %, max

Exception: When the dew point of the gas entering the cylinder is below the lowest anticipated container temperature at the maximum anticipated container pressure, the above shall not apply.

NOTE: For additional information on gas quality see SAE J1616, *Surface Vehicle Recommended Practice for Natural Gas Vehicle Fuel Composition.*

Natural gas introduced into any system covered by this standard shall have a distinctive odor potent enough for its presence to be detected down to a concentration in air of not over $^1/_5$ of the lower limit of flammability.

2-3 Approval.

2-3.1 Systems and/or system components, as follows, shall be listed or approved:

(a) Containers

(b) Pressure relief devices, including pressure relief valves

(c) Pressure gauges

(d) Pressure regulators

(e) Valves

(f) Hose and hose connections

(g) Vehicle fueling connections

(h) Engine fuel systems

(i) Electrical equipment related to CNG systems.

2-3.2 Devices not otherwise specifically provided for shall be constructed to provide safety equivalent to that required for other parts of a system.

2-4* Design and Construction of Containers.

2-4.1 Containers shall comply with 2-4.2 through 2-4.6 or shall be designed, fabricated, tested, and marked using criteria that incorporate an investigation to determine that they are safe and suitable for the proposed service, are recommended for that service by the manufacturer, and are acceptable to the authority having jurisdiction.

2-4.1.1 Containers shall be fabricated of steel, aluminum, or composite materials.

The container shall be designed to be suitable for CNG service and permanently marked CNG by the manufacturer.

Containers manufactured prior to the effective date of this standard may be used in CNG service if recommended for CNG service by the container manufacturer or acceptable to the authority having jurisdiction.

2-4.2 Cylinders shall be manufactured, inspected, marked, tested, retested, equipped, and used in accordance with U.S. Department of Transportation (DOT) or Canada Transport (TC) regulations, exemptions, or special permits, or ANSI/AGA NGV2, *Basic Requirements of Type 3NG Fuel Containers*, specifically for CNG service and shall have a rated service pressure of not less than 2400 psig at 70°F (16.5 MPa at 21.1°C).

NOTE 1: Current DOT and TC specifications, exemptions, and specific permits do not address the use of cylinders as vehicle fuel containers. The intent of the reference in this standard is to permit only those cylinders that are approved for the transportation of natural gas to be used in CNG service.

NOTE 2: Four relevant cylinder inspection standards that are useful are Compressed Gas Association, Inc. pamphlets:

(a) C-6, *Standards for Visual Inspection of Compressed Gas Cylinders.*

(b) C-6.1, *Standards for Visual Inspection of High Pressure Aluminum Compressed Gas Cylinders.*

(c) C-6.2, *Guidelines for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders.*

(d) C-10, *Recommendations for Changes of Service for Compressed Gas Cylinders Including Procedures for Inspection and Contaminant Removal.*

2-4.3 Pressure vessels shall be manufactured, inspected, marked, and tested in accordance with the Rules for the Construction of Unfired Pressure Vessels, Section VIII (Division 1) or Section X, ASME *Boiler and Pressure Vessel Code.*

2-4.3.1 Adherence to applicable ASME Code case interpretations and addenda shall be considered as compliance with the ASME Code.

2-4.4 The "+" (plus) and "*" (star) markings on DOT and TC cylinders shall not apply in accordance with DOT and TC regulations for cylinders for flammable compressed gases. The star marking shall be removed/obliterated. The removal of the marking shall be done by peening and otherwise in accordance with DOT or TC regulations. Grinding is prohibited.

2-4.5 In addition to the marking required by documents cited in 2-4.2 and 2-4.3, such containers and any used under the provisions of 2-4.1 shall be labeled with the words "CNG ONLY" in letters at least 1 in. (25 mm) high in contrasting color and in a location that will be visible after installation. Decals or stencils are acceptable. (*See 3-11.1.*)

2-4.6 Welding or brazing for the repair or alteration of an ASME pressure vessel shall comply with the documents under which the pressure vessel was fabricated. Other welding or brazing is permitted only on saddle plates, lugs, or brackets attached to the pressure vessel by the pressure vessel manufacturer.

The exchange or interchange of pressure vessel appurtenances (*see definition*) intended for the same purpose is not considered a repair or alteration.

2-5 Pressure Relief Devices.

2-5.1 Each fuel supply cylinder complying with 2-4.2 shall be fitted with one or more pressure relief devices in accordance with 2-5.1.1 and 2-5.1.2.

2-5.1.1 Pressure relief devices for cylinders shall be in accordance with Compressed Gas Association (CGA) Pamphlet S-1.1, *Pressure Relief Device Standards - Part 1, Cylinders for Compressed Gases.*

Cylinders produced under DOT and TC exemptions or special permits that require fire tests for design qualification shall be equipped with pressure relief devices in accordance with CGA S-1.1 and of the type, temperature rating, pressure rating, number, and location used in the fire tests.

2-5.1.2 The pressure relief device shall be in direct communication with the fuel and be vented to the atmosphere by a method that will withstand the maximum pressure that will result.

The discharge flow rate of the pressure relief device shall not be reduced below that required for the capacity of the container upon which the device is installed.

Pressure relief devices shall be located so that the temperature to which they are subjected shall be representative of the temperature to which the cylinder is subjected.

2-5.2 Pressure vessels complying with 2-4.3 shall be provided with one or more springloaded pressure relief valves set to open in accordance with the ASME Code.

2-5.2.1 The minimum rate of discharge of pressure relief devices on containers shall be in accordance with CGA Pamphlet S-1.1, *Pressure Relief Device Standards - Part 1, Cylinders for Compressed Gases* or the ASME *Boiler and Pressure Vessel Code*, whichever is applicable.

2-5.2.2 Pressure relief valves for CNG service shall not be fitted with lifting devices. The adjustment, if external, shall be provided with means for sealing the adjustment to prevent tampering by unauthorized persons. If at any time it is necessary to break such seal, the valve shall be removed from service until it has been reset and sealed. Any adjustments necessary shall be made by the manufacturer or other companies having competent personnel and adequate facilities for the repair, adjustment, and testing of such valves. The organization making such adjustment shall attach a permanent tag with the setting, capacity, and date.

2-5.3 Containers and pressure vessels complying otherwise with 2-4.1 shall be provided with pressure relief devices approved by the authority having jurisdiction.

2-6 Pressure Gauges.

2-6.1 A pressure gauge, if provided, shall be capable of reading at least 1.2 times the system design pressure.

2-6.2 A gauge shall have an opening not to exceed 0.055 in. (1.4 mm) (No. 54 drill size) at the inlet connection.

2-7 Pressure Regulators.

2-7.1 A pressure regulator inlet and each chamber shall be designed for its maximum service pressure with a pressure safety factor of at least 4.

2-7.2 Low pressure chambers shall provide for overpressure relief or shall be able to withstand the service pressure of the upstream pressure chamber.

2-8 Piping.

2-8.1 Pipe, tubing, fittings, gaskets, and packing material shall be compatible with the fuel under the service conditions.

2-8.2 Pipe, tubing, fittings, and other piping components between a container and the first shutoff valve shall be capable of withstanding a hydrostatic test of at least four times the rated service pressure without structural failure.

2-8.3 Natural gas piping shall be fabricated and tested in accordance with ANSI/ASME B31.3, *American National Standard Code for Chemical Plant and Petroleum Refinery Piping.*

2-8.4 The following components shall not be used:

(a) Fittings, street ells, and other piping components of cast irons other than those complying with ASTM A-536 (Grade 60-40-18), A-395, and A-47 (Grade 35018),

(b) Plastic pipe, tubing, and fittings for high pressure service,

(c) Galvanized pipe and fittings,

(d) Aluminum pipe, tubing, and fittings,

Exception No. 1: Refueling connection may be made of nonsparking wrought aluminum alloy suitable for the pressure employed.

Exception No. 2: Aluminum pipe, tubing, and fittings may be used downstream of the first stage pressure regulator in an engine fuel system.

(e) Pipe nipples for the initial connection to a container, and

(f) Copper alloy with copper content exceeding 70 percent.

2-8.5 Piping components such as strainers, snubbers, and expansion joints shall be permanently marked by the manufacturer to indicate the service ratings.

2-9 Valves.

2-9.1 Valves, valve packing, and gaskets shall be suitable for the fuel over the full range of pressures and temperatures to which they may be subjected under normal operating conditions.

2-9.1.1 Shutoff valves shall have a rated service pressure not less than the rated service pressure of the entire system and shall be capable of withstanding a hydrostatic test of at least four times the rated service pressure without rupture. Leakage shall not occur at less than 1½ times the rated service pressure using dry air as the test medium.

2-9.2 Valves of cast irons other than those complying with ASTM A-536 (Grade 60-40-18), A-395, and A-47 (Grade 35018) shall not be used as primary stop valves.

2-9.3 Valves of a design that will allow the valve stem to be removed without removal of the complete valve bonnet or disassembly of the valve body shall not be used.

2-9.4 The manufacturer shall stamp or otherwise permanently mark the valve body to indicate the service ratings.

Exception: Container valves incorporating integral pressure relief devices marked in accordance with CGA S-1.1 need no additional marking.

2-10 Hoses and Hose Connections.

2-10.1 Hose and metallic hose shall be of or lined with materials that are resistant to corrosion and the actions of natural gas.

2-10.2 Hose, metallic hose, flexible metal hose, tubing, and their connections shall be suitable for the most severe pressure and temperature conditions expected under normal operating conditions with a burst pressure of at least four times the service pressure.

2-10.3 Hose assemblies shall be tested by the manufacturer or its designated representative prior to use to at least twice the service pressure.

2-10.4 Hose and metallic hose shall be distinctly marked by the manufacturer, either by the manufacturer's permanently attached tag or by distinct markings, indicating the manufacturer's name or trademark, applicable service identifier, and design pressure.

2-11 Vehicle Fueling Connection.

2-11.1 A vehicle fueling connection shall provide for the reliable and secure connection of the fuel system containers to a source of high pressure natural gas.

2-11.2 The fueling connection shall be suitable for the pressure expected under normal conditions and corrosive conditions that might be encountered.

2-11.3 The fueling connection shall prevent escape of gas when the connector is not properly engaged or becomes separated.

2-11.4 The refueling receptacle on an engine fuel system shall be firmly supported and shall:

(a) Receive the fueling connector and accommodate the service pressure of the vehicle fuel system,

(b) Incorporate a means to prevent the entry of dust, water, and other foreign material. If the means used is capable of sealing system pressure it shall be capable of being depressurized before removal, and

(c) Have a different fueling connection for each pressure base vehicle fuel system.

2-11.5 Where refueling is available for use by the general public, a vehicle fueling connection complying with ANSI/AGA NGV1, *Standard for Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices,* Requirement 1-90, shall be provided.

Chapter 3 Engine Fuel Systems

3-1* Application.

3-1.1 This chapter applies to the design, installation, inspection, and testing of CNG fuel supply systems for vehicular internal combustion engines.

3-1.2 Components shall be installed in accordance with their manufacturers' instructions.

3-2 System Component Qualifications.

3-2.1 System components shall comply with the appropriate provisions in Chapter 2 and with 3-2.2 through 3-2.4.

3-2.2 Components in the engine compartment shall be suitable for service over a range of temperatures from -40°F to 250°F (-40 to 121°C). All other components shall be suitable for service over a range of -40°F to 180°F (-40 to 82.2°C).

3-2.3 Aluminum or copper pipe, tubing, or fittings shall not be used between the fuel container and the first stage pressure regulator.

3-2.4 Fuel carrying components shall be labeled or stamped with the following:

(a) The manufacturer's name or symbol,

(b) The model designation,

(c) The design service pressure,

(d) Direction of fuel flow when necessary for correct installation, and

(e) Capacity or electrical rating as applicable.

Exception: Not applicable to container valves, tubing, and fittings.

3-3 Installation of Fuel Supply Containers.

3-3.1 Fuel supply containers on vehicles may be located within, below, or above the driver or passenger compartment provided all connections to the container(s) are external to, or sealed and vented from, these compartments.

3-3.2 Each fuel supply container shall be mounted in a location to minimize damage from collision. No part of a container or its appurtenances shall protrude beyond the sides or top of the vehicle at the point where it is installed.

3-3.2.1 The fuel system shall be installed with as much road clearance as practical but not less than the minimum road clearance of the vehicle when loaded to its gross vehicle weight rating. This minimum clearance shall be measured from the lowest part of the fuel system.

3-3.2.2 No portion of a fuel supply container or container appurtenance shall be located ahead of the front axle or behind the rear bumper mounting face of a vehicle. Container valves shall be protected from physical damage using the vehicle structure, valve protectors, or a suitable metal shield.

3-3.3 Each container rack shall be secured to the vehicle body, bed, or frame to prevent damage from road hazards, slippage, loosening, or rotation using a method capable of withstanding a static force in the six principal directions (*see Figure 3-3.3*) of eight times the weight of a fully pressurized container(s).

3-3.3.1 Each fuel supply container in the rack shall be secured to its cradle in such a manner that it is capable of withstanding a static force applied in the six principal directions (*see Figure 3-3.3*) of eight times the weight of the fully pressurized container with a maximum displacement of 1/2 in. (13 mm).

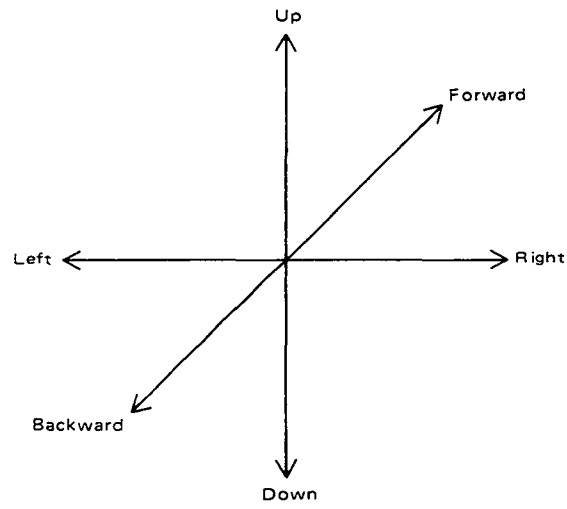

Figure 3-3.3 The six principal directions.

3-3.4 The container weight shall not be supported by outlet valves, manifolds, or other fuel connections.

3-3.5 Fuel supply containers located less than 8 in. (200 mm) from the exhaust system shall be shielded against direct heat.

3-3.6 The mounting system shall minimize fretting corrosion between the container and the mounting system.

3-3.7 Fuel supply containers shall not be installed so as to adversely affect the driving characteristics of the vehicle.

3-3.8 Metal clamping bands and their supports shall not be in direct contact with a container. A resilient non-water-retaining gasket shall be installed between the clamping bands and their supports and a container.

3-3.9 A container, when located in a vehicle compartment capable of accumulating natural gas, shall be installed such that:

(a) The pressure relief device for the protection of the container is installed in the same vehicle compartment as the container;

(b) The discharge from a pressure relief device referred to in (a) above is:

(i) Vented to the outside thorough a smooth walled metallic tube no smaller than the outlet diameter of the relief device , secured at 12-in. (300-mm) intervals when the tube exceeds 24 in. (610 mm) in length, and

(ii) Located so that the vent opening will not be blocked by debris thrown up from the road, such as snow, ice, mud, etc., or otherwise affected by the elements.

3-3.10 Where a container is installed above the operator or passenger compartment of a vehicle:

(a) The container, its piping, fittings, and valve shall be protected from damage by,

(i) A guard rail or similar device that is designed to absorb the impact of a collision with a stationary object when the vehicle is moving either forward or backward at 5 mph (8 kph), and the guard rail or similar device shall be free of projections that could damage a container, its valves and fittings, and

(ii) A shield designed to absorb impacts that may occur during loading, unloading, or use of the vehicle and the shield shall be free of projections that could damage a container, its valve, and fittings,

(b) The top of the container and any CNG piping, fitting, valve, housing, guard rail, or shield shall not be more than 13.5 ft (4.12 m) above the road surface.

(c) The cylinder shall be protected by metallic or nonmetallic covers from accidental contact with overhead electrical wiring,

3-3.11 The minimum clearance from the road to a container, its housing and fittings, whichever is lowest when the container is installed below the frame and between the axles of a CNG vehicle, shall not, with the vehicle loaded to its gross weight rating, be less than:

(a) 7 in. (175 mm) for a vehicle having a wheel base less than or equal to 127 in. (3230 mm), or

(b) 9 in. (225 mm) for a vehicle having a wheel base greater than 127 in. (3230 mm).

3-3.12 Containers that are installed behind a rear axle of a CNG vehicle shall be installed transversely.

Exception: Containers shall be permitted to be installed in other orientations when the container valve and fittings are located at the end of the container most protected from a source of impact.

3-4 Installation of Venting Systems.

3-4.1 All pressure relief devices and connections between pressure carrying components installed within a closed compartment (*see 3-3.1*) shall be vented to the outside of the vehicle in a suitable location.

NOTE: It is not permitted to terminate the vent outlet in the engine compartment.

3-4.2 The venting system for the discharge of pressure relief devices (pressure relief device channels) shall be constructed of metallic tubing with threaded, compression, or flare fittings and shall be secured at the outer end.

3-4.3 The vent or vents for the venting system shall not exit into a wheel well.

3-4.4 A vent shall not restrict the operation of a container pressure relief device or pressure relief device channel.

3-4.5 Vent outlets shall be protected by caps, covers, or other means to keep water, dirt, and insects from collecting in the lines. Protective devices shall not restrict the flow of gas.

3-4.6 The neck of the container and all CNG fittings within the compartment shall be enclosed in a gastight enclosure made of linear low density polyethylene having a minimum thickness of 8 mils (200 μm) or an equally gastight alternative enclosure that is vented directly outside of the vehicle.

3-5 Installation of Piping.

3-5.1 Manifolds connecting fuel containers shall be fabricated to minimize vibration and shall be installed in a protected location or shielded to prevent damage from unsecured objects.

3-5.2 A pipe thread jointing material impervious to the action of the natural gas used in the system shall be applied to all male pipe threads prior to assembly.

3-5.3 Piping and fittings shall be clear and free from cutting or threading burrs and scales, and the ends of all piping shall be reamed.

3-5.4 Where necessary to prevent abrasion, fuel lines passing through a panel shall be protected by grommets or similar devices.

3-5.5 Fuel lines shall have the maximum practical clearance from the engine exhaust system.

3-5.6 Fuel lines shall be mounted, braced, and supported to minimize vibration and protected against damage, corrosion, or breakage due to strain or wear. A fuel line shall be supported at least every 24 in. (610 mm).

3-5.7 A bend in piping or tubing is prohibited where such a bend weakens the pipe or tubing.

3-5.8 A joint or connection shall be located in an accessible location.

3-6 Installation of Valves.

3-6.1 Every container shall be equipped with a manual or normally closed remotely actuated shutoff valve connected directly to the container. Remotely actuated valves shall be equipped with a provision to manually bleed the container.

3-6.2 In addition to the valve required by 3-6.1, a manual shutoff valve shall be installed in an accessible location that will permit isolation of the container(s) from the remainder of the fuel system. The manual shutoff valve shall have no more than a 90-degree rotation from open to closed positions.

3-6.2.1 The valve shall be securely mounted and shielded or installed in a protected location to minimize damage from vibration and unsecured objects.

3-6.2.2 The valve location shall be marked with the words "MANUAL SHUTOFF VALVE." Decals or stencils are acceptable.

3-6.3 A valve shall be provided in the system that automatically prevents the flow of gaseous fuel to the engine when the engine is not running even if the ignition is switched on.

3-6.4 Where multiple fuel systems are installed on the vehicle, automatic valves shall be provided, as necessary, to shut off the fuel not being used.

3-6.5 The fueling system shall be equipped with a backflow check valve that will prevent the return flow of gas from the container(s) to the filling connection.

NOTE: Electronic fuel injectors are considered to be automatic valves.

3-7 Installation of Pressure Gauges.

3-7.1 A pressure gauge located within a driver or passenger compartment shall be installed in such a manner that no gas will flow through the gauge in the event of failure.

3-7.2 A pressure gauge installed outside a driver or passenger compartment shall be equipped with a limiting orifice, a shatterproof dial lens, and a body relief.

3-7.3 Gauges shall be securely mounted, shielded, and installed in a protected location to prevent damage from vibration and unsecured objects.

3-8 Installation of Pressure Regulators.

3-8.1 An automatic pressure reducing regulator(s) shall be installed to reduce the fuel container pressure to a level consistent with the service pressure required by the gas-air mixer.

3-8.2 Means shall be provided to prevent regulator malfunctions due to refrigeration effects.

3-8.3 Regulators shall be installed so that their weight is not placed on, or supported by, the attached gas lines.

3-9 Installation of Fueling Connection.

3-9.1 A fueling connection receptacle complying with Section 2-11 shall be installed in each vehicle.

3-9.2 The fueling connection receptacle shall be mounted to withstand the breakaway force specified in 4-11.8. The receptacle shall be installed in accordance with the manufacturer's instructions.

3-10 Wiring Installation.

3-10.1 All wiring shall be secured and protected from abrasion and corrosion to the same standard as the original wiring on the vehicle.

3-10.2 All wiring shall be sized and fuse-protected with the fuse rating adequate to the current draw.

3-11 Labeling.

3-11.1 A vehicle equipped with a CNG fuel system shall bear the following durable labels.

3-11.1.1 A label readily visible and located in the engine compartment shall include the following:

(a) CNG fueled vehicle,

(b) System service pressure,

(c) Installer's name or company,

(d) Container retest date(s) or expiration date,

(e) Total container water volume in gallons (liters).

3-11.1.2 A label located at the fueling connection receptacle shall include the following:

(a) CNG fueled vehicle,

(b) System working pressure,

(c) Container retest date or expiration date.

Exception: If both labels are located in one of the above areas, the labels can be combined into a single label.

3-11.2 Each vehicle shall be identified with a weather-resistant, diamond-shaped label located on an exterior vertical or near vertical surface on the lower right rear of the vehicle (on the trunk lid of a vehicle so equipped, but not on the bumper of any vehicle) inboard from any other markings. The label shall be a minimum of 4¾ in. (120 mm) long by 3¼ in. (83 mm) high. The marking shall consist of a border and the letters "CNG" [1 in. (25 mm) minimum height centered in the diamond] of silver or white reflective luminous material on a blue background.

3-12 System Testing.

3-12.1 The complete assembly shall be leak tested using natural gas or inert gas (carbon dioxide or nitrogen or a mixture of these).

3-12.2 Before use, every connection shall be checked with a nonammonia soap solution or a leak detector instrument after the equipment is connected and pressurized to its service pressure.

3-12.3 If the completed assembly is leak tested with natural gas, the testing shall be done under adequately ventilated conditions.

3-12.4* When a vehicle is involved in an accident or fire causing damage to the CNG container, the CNG container shall be replaced or removed, inspected, and retested in accordance with the document under which it was originally manufactured before being returned to service.

3-12.5 When a vehicle is involved in an accident or fire causing damage to any part of the CNG fuel system, the system shall be repaired and retested (*see Section 3-13*) before being returned to service.

3-13 Maintenance and Repair.

3-13.1 Damaged fuel lines shall be replaced, not repaired.

3-13.2 The owner or user or both shall maintain all containers, container appurtenances, piping systems, venting systems, and other components in a safe condition. The above individual(s) shall be responsible for verifying working pressure and container retest date or expiration date currentness.

3-13.3 Pressure relief devices on cylinder shall be maintained in accordance with CGA pamphlet S-1.1

Pressure relief devices on all other containers shall be maintained in accordance with the following:

(a) Pressure relief device channels or other parts that could interfere with the functioning of the device shall not be plugged by paint or accumulation of dirt.

(b) Compressed natural gas containers shall be stored so as to avoid damage.

(c) Only qualified personnel shall be allowed to service pressure relief devices.

(d) Only assemblies or original manufacturer's parts shall be used in the repair of pressure relief devices unless the interchange of parts has been proved by suitable tests.

Chapter 4 CNG Compression, Storage, and Dispensing Systems

4-1* Application. This chapter applies to the design, construction, installation, and operation of containers, pressure vessels, compression equipment, buildings and structures, and associated equipment used for storage and dispensing of CNG as an engine fuel in fleet and public dispensing operations.

4-2 System Component Qualification. System components shall comply with the appropriate provisions in Chapter 2 and with Sections 4-5 through 4-13.

4-3 General.

4-3.1 Where systems are served by a gas utility, the utility shall be notified of all CNG installations.

4-3.2 Equipment related to a compression, storage, or dispensing installation shall be protected to minimize the possibilities of physical damage and vandalism.

4-3.3 Control devices shall be installed so that internal or external icing or hydrate formation will not cause malfunction.

4-3.4 Vehicles shall not be considered a source of ignition with respect to the provisions of this chapter.

Exception: Vehicles containing fuel-fired equipment, e.g., recreational vehicles and catering trucks, shall be considered a source of ignition unless this equipment is shut off completely before entering an area in which ignition sources are prohibited.

4-3.5 The fueling connection shall prevent escape of gas where the connector is not properly engaged or becomes separated.

4-3.6 Compression equipment shall be designed for use with CNG and for the pressure and temperatures to which it may be subjected under normal operating conditions. It shall have pressure relief devices that shall limit each stage pressure to the maximum allowable service pressure for the compression cylinder and piping associated with that stage of compression.

4-3.7 When CNG compression equipment is operated unattended, it shall be equipped with a high discharge and low suction pressure automatic shutdown control.

4-3.8 Engine driven compressor installations shall conform, where applicable, to NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.*

4-3.9 Compression equipment shall incorporate an automatic condensate system to eliminate liquid carryover to the storage system.

4-4 Siting.

4-4.1 CNG compression, storage, and dispensing shall be located and conducted outdoors or indoors in compliance with 4-4.2 and 4-4.3.

4-4.2 Outdoors.

4-4.2.1 CNG storage containers charged with CNG not connected for use shall be located outdoors.

4-4.2.2 A facility in which CNG compression, storage, and dispensing equipment is sheltered by an enclosure constructed of noncombustible or limited-combustible materials that has at least one side predominantly open and a roof designed for ventilation and dispersal of escaped gas shall be regarded as outdoors.

4-4.2.3 Compression, storage, and dispensing equipment outdoors shall be located aboveground, not beneath electric power lines or where exposed by their failure, and a minimum of 10 ft (3.0 m) from the nearest important building or line of adjoining property that may be built upon or source of ignition.

4-4.2.4 Compression, storage, and dispensing equipment outdoors shall be located not less than 10 ft (3.0 m) from the nearest public street or sidewalk line and at least 50 ft (15 m) from the nearest rail of any railroad main track.

4-4.2.5 A clear space of at least 3 ft (1 m) shall be provided for access to all valves and fittings of multiple groups of containers.

4-4.2.6 Readily ignitable material shall not be permitted within 10 ft (3.0 m) of any stationary container.

4-4.2.7 The minimum separation between containers and aboveground tanks containing flammable or combustible liquids shall be 20 ft (6.1 m).

4-4.2.8 During outdoor fueling operations, the point of transfer (*see definition*) shall be located at least 10 ft (3.0 m) from any important building, mobile home, public sidewalk, highway, street, or road and at least 3 ft (1 m) from storage containers.

Exception: At the discretion of the authority having jurisdiction, the point of transfer may be located at a lesser distance from buildings or walls constructed of concrete or masonry materials, but at least 10 ft (3.0 m) from any building openings.

4-4.3 Indoors.

4-4.3.1 General. Compression, dispensing equipment, and storage containers connected for use may be located inside of buildings reserved exclusively for these purposes or in rooms within or attached to buildings used for other purposes in accordance with 4-4.3.

4-4.3.1.1 Storage shall be limited to not more than 10,000 cu ft (283 m^3) of natural gas in each building or room.

Exception: CNG stored in vehicle mounted fuel supply containers.

4-4.3.2 Deflagration Venting. Deflagration (explosion) venting shall be provided in exterior walls or roof only. Vents shall be permitted to consist of any one or any combination of the following:

(a) Walls of light material;

(b) Lightly fastened hatch covers;

(c) Lightly fastened, outward opening doors in exterior walls;

(d) Lightly fastened walls or roof.

NOTE: For information on venting of explosions see NFPA 68, *Guide for the Venting of Deflagrations.*

Where applicable, snow loads shall be considered.

4-4.3.3 Rooms within Buildings. Rooms within or attached to other buildings shall be constructed of noncombustible or limited-combustible materials. Interior walls or partitions shall be continuous from floor to ceiling, shall be securely anchored, and shall have a fire resistance rating of at least 2 hours. At least one wall shall be an exterior wall. Windows and doors shall be located so as to be readily accessible in case of emergency.

Exception: Window glazing shall be permitted to be plastic.

4-4.3.3.1 Explosion venting shall be provided in accordance with 4-4.3.2.

4-4.3.3.2 Access to the room shall be from outside the primary structure.

Exception: If such access is not possible, access from within the primary structure is permitted provided such access is made through a barrier space having two vapor-sealing, self-closing fire doors suitable for installation in a wall having the fire resistance rating selected.

4-4.3.4 Indoor locations shall be ventilated utilizing air supply inlets and exhaust outlets arranged to provide air movement as uniformly as practical. Inlets shall be uniformly arranged on exterior walls near floor level. Outlets shall be located at the high point of the room in exterior walls or the roof.

4-4.3.4.1 Ventilation shall be by a continuous mechanical ventilation system or by a mechanical ventilation system activated by a continuous monitoring natural gas detection system when a gas concentration of not more than one-fifth of the lower flammable limit is present. In either case, the system shall shut down the fueling system in the event of failure of the ventilation system.

4-4.3.4.2 The ventilation rate shall be at least 1 cu ft/min per 12 cu ft (1 m^3/min per 12 m^3) of room volume.

NOTE: This corresponds to 5 air changes per hour.

4-4.3.4.3 A ventilation system for a room within or attached to another building shall be separate from any ventilation system for the other building.

4-4.3.5 A gas detection system shall be equipped to sound an alarm when a maximum of one-fifth of the lower flammable limit is reached.

4-4.3.6 Reactivation of the fueling system shall be by manual restart conducted by trained personnel.

4-4.3.7 Buildings and rooms used for compression, storage, and dispensing shall be classified in accordance with Table 4-12 for installations of electrical equipment.

4-4.3.8 Sources of ignition, other than electrical as permitted by 4-4.3.7, shall be prohibited.

4-4.3.9 Pressure relief devices on storage systems shall have pressure relief device channels to convey escaping gas to the outdoors and then upward to a safe area so as not to impinge upon buildings, other equipment, or areas that could be occupied by the public, e.g., sidewalks.

4-4.3.10 Access doors shall have warning signs with the words "WARNING—NO SMOKING—FLAMMABLE GAS." Such wording shall be in plainly legible, bright red letters on a white background with letters not less than 1 in. high.

4-5 Installation of Containers and Container Appurtenances (Other than Pressure Relief Devices).

4-5.1* Storage containers shall be installed aboveground on stable, noncombustible foundations or in vaults with ventilation and drainage. Horizontal containers shall have no more than two points of support longitudinally. Where flooding can occur, they shall be securely anchored to prevent floating.

4-5.2 Containers shall be protected by painting or other equivalent means where necessary to inhibit corrosion. Horizontally installed containers shall not be in direct contact with each other.

Exception: Composite containers shall not be painted without prior permission from the container manufacturer.

4-5.3 Adequate means shall be provided to prevent the flow or accumulation of flammable or combustible liquids under containers, such as by grading, pads, or diversion curbs.

4-6 Installation of Pressure Relief Devices.

4-6.1 Pressure relief valves shall be so arranged that they will discharge to a safe area and so that escaping gas will not impinge upon buildings, other equipment, or areas that could be occupied by the public. (*See 4-4.3.9.*)

4-6.2 Pressure relief valves on pressure vessels shall be installed so that any discharge will be in a vertical position and shall be fitted with suitable raincaps.

4-6.3 A pressure relief device shall be provided in the transfer system to prevent overpressure in the vehicle.

4-7 Installation of Pressure Regulators. Regulators shall be designed, installed, or protected so their operation will not be affected by the elements (freezing rain, sleet, snow) or ice, mud, or debris. This protection may be integral with the regulator.

4-8 Installation of Pressure Gauges. Gauges shall be installed to indicate compression discharge pressure, storage pressure, and fuel supply container fill pressure.

4-9 Installation of Piping and Hoses.

4-9.1 Piping and hoses shall be run as directly as practical with adequate provisions for expansion, contraction, jarring, vibration, and settling. Exterior piping shall be either buried or installed aboveground and shall be well supported and protected against mechanical damage. Underground piping shall be buried not less than 18 in. (460 mm) below the surface of the ground unless otherwise protected. Underground and aboveground piping shall be protected from corrosion in compliance with present recognized practices. Threaded pipe and fittings shall not be used underground.

4-9.1.1 Manifolds connecting fuel containers shall be fabricated to minimize vibration and shall be installed in a protected location or shielded to prevent damage from unsecured objects.

4-9.1.2 A pipe thread jointing material impervious to the action of the natural gas used in the system shall be applied to all male pipe threads prior to assembly.

4-9.1.3 Piping and fittings shall be clear and free from cutting or threading burrs and scales, and the ends of all piping shall be reamed.

4-9.1.4 A bend in piping or tubing is prohibited where such a bend weakens the pipe or tubing.

4-9.1.5 A joint or connection shall be located in an accessible location.

4-9.2 Natural gas shall only be vented to a safe point of discharge. A vent pipe or stack shall have the open end suitably protected to prevent entrance of rain, snow, and solid material. Vertical vent pipes and stacks shall have provision for drainage.

4-9.3 The use of hose in an installation shall be limited to:

(a) A vehicle fueling hose;

(b) An inlet connection to compression equipment;

(c) A section of metallic hose not exceeding 36 in. (910 mm) in length in a pipeline to provide flexibility where necessary. Each section shall be so installed that it will be protected against mechanical damage and be readily visible for inspection. The manufacturer's identification shall be retained in each section.

4-10 Testing.

4-10.1 Piping, tubing and hoses, and hose assemblies shall be leak tested after assembly to prove them free from leaks at a pressure equal to at least the normal service pressure of that portion of the system.

4-10.2 Pressure relief valves shall be tested at least every five years.

4-11 Installation of Emergency Shutdown Equipment.

4-11.1 Manually operated container valves shall be provided for each container.

4-11.2 The fill line on a storage container shall be equipped with a back-flow check valve to prevent discharge of natural gas from the container in case of line, hose, or fittings rupture.

4-11.3 A manually operated shutoff valve shall be installed in a manifold as close to a container or group of containers as practical. This valve shall be downstream of the back-flow check valve referred to in 4-11.2.

4-11.4 Where excess-flow check valves are used, the closing flow shall be less than the flow rating of the piping system that would result from a pipeline rupture between the excess-flow valve and the equipment downstream of the excess-flow check valve.

4-11.5 Gas piping from an outdoor compressor or storage system into a building shall be provided with shutoff valves located outside the building.

4-11.6 An emergency manual shutdown device shall be provided at the dispensing area and also at a location remote from the dispensing area. This device, when activated, shall shut off the power supply and gas supply to the compressor and the dispenser.

4-11.6.1 Emergency shutdown devices shall be distinctly marked for easy recognition with a permanently affixed legible sign.

4-11.7 Breakaway protection shall be provided in a manner such that, in the event of a pullaway, natural gas will cease to flow at any separation.

4-11.8 A breakaway device shall be installed at every dispensing point. Such a device shall be arranged to separate by a force not greater than 44 lb (20 kg) when applied in any horizontal direction.

4-11.9 Control circuits shall be arranged such that when an emergency shutdown device is activated or electric power is cut off, systems that shut down shall remain down until manually activated or reset after a safe situation is restored.

4-11.10 Each line between a gas storage facility and a dispenser at a fast-fill station shall have a valve that will close when:

(a) The power supply to the dispenser is cut off, or

(b) Any emergency shutdown device at the refueling station is activated.

4-11.11 A fast closing, "quarter turn" manual shutoff valve shall be provided at a fast fill station upstream of the breakaway device referred to in 4-11.8, where it is readily accessible to a person dispensing natural gas unless:

(a) The self-closing valve referred to in 4-11.10 is located immediately upstream of the dispenser, or

(b) The dispenser is equipped with a self-closing valve that closes each time the control arm is turned to the "OFF" position or an emergency device is activated.

4-11.12 A self-closing valve shall be provided on the inlet of the compressor that will shut off the gas supply to the compressor when:

(a) An emergency shutdown device is activated;

(b) A power failure occurs; or

(c) The power to the compressor is switched off.

4-12* Installation of Electrical Equipment. Electrical equipment shall be installed in accordance with NFPA 70, *National Electrical Code*,® for Class I, Group D, Division 1 or 2 locations in accordance with Table 4-12.

Exception: Electrical equipment on internal combustion engines installed in accordance with NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.

Table 4-12 Electrical Installations

Location	Division	Extent of Classified Area*
Containers (other than mounted fuel supply containers)	2	Within 10 ft of container
Area containing compression and ancillary equipment		
Outdoors	2	Up to 15 ft from equipment
Indoors	2	Up to 15 ft from equipment
Dispensing equipment		
Outdoors**	1	Inside dispenser enclosure
Outdoors**	2	From 0 to 20 ft from the dispenser
Indoors	1	Inside the dispenser enclosure
Indoors	2	Entire room, with adequate ventilation (See 4-4.3)

*The classified area shall not extend beyond an unpierced wall, roof, or vaportight partition.

**Refer to Figure A-4-12 for an illustration of classified areas in and around dispensers.

NOTE: The electrical classification under Table 4-12 may be permitted to be reduced, or hazardous areas limited or eliminated, by adequate positive pressure ventilation from a source of clean air or inert gas in conjunction with effective safeguards against ventilator failure by purging methods recognized in NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*. Such changes should be subject to approval by the authority having jurisdiction.

4-13 Stray or Impressed Currents and Bonding.

4-13.1 When stray or impressed currents are used or may be present on dispensing systems (such as cathodic protection), protective measures to prevent ignition shall be taken in accordance with API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*.

4-13.2 Static protection is not required when CNG is loaded or unloaded by conductive or nonconductive hose, flexible metallic tubing, or pipe connections where both halves of the metallic couplings are in contact.

4-14 Operation.

4-14.1 A cylinder shall not be charged in excess of the design pressure at normal temperature for that cylinder. DOT and TC cylinders shall be charged in accordance with DOT and TC regulations.

DOT and TC cylinders shall not be subjected to pressure in excess of 125 percent of the marked service pressure even if on cooling it settles to the marked service pressure. Pressure vessels shall be charged in accordance with the requirements of ASME Code, Section VIII, Division 1.

4-14.1.1 A fuel supply container shall not have a settled pressure above the service pressure stamped on the container and displayed on a label near the filling connection, corrected for the ambient temperature at time of filling.

4-14.2 CNG dispensing systems shall be equipped to automatically stop fuel flow when a fuel supply container reaches the temperature-corrected fill pressure. (*See 4-6.3.*)

4-14.3 The transfer of CNG into a fuel supply container shall be performed in accordance with instructions posted at the dispensing station.

4-14.4 When CNG is being transferred to or from a motor vehicle, the engine shall be stopped.

4-14.5 During the transfer of CNG to or from cargo vehicles, the hand or emergency brake of the vehicle shall be set and chock blocks used to prevent rolling of the vehicle.

4-14.6 Transfer systems shall be capable of depressurizing to facilitate disconnection. Bleed connections shall lead to a safe point of discharge.

4-14.7 CNG shall not be used to operate any device or equipment that has not been designed or properly modified for CNG service.

4-14.8 Sources of ignition shall not be permitted within 10 ft (3 m) of any filling connection during a transfer operation. (*See 4-4.3.*)

4-14.9 Warning signs with the words "STOP MOTOR," "NO SMOKING," "FLAMMABLE GAS" shall be posted at dispensing station and compressor areas. The location of signs shall be determined by local conditions, but the lettering shall be large enough to be visible and legible from each point of transfer.

4-15 Fire Protection. A portable fire extinguisher having a rating of not less than 20-B:C shall be provided at the dispensing area.

4-16 Maintenance.

4-16.1 Containers and their appurtenances, piping systems, compression equipment, controls, and devices shall be maintained in proper operating condition.

4-16.2 After the original installation, vehicle fueling hoses shall be examined visually at such intervals as are necessary to assure that they are safe for use. Hose shall be tested for leaks at least annually, and any unsafe leakage shall be reason for rejection.

4-16.3 While in transit, fueling hose and flexible metal hose on a cargo vehicle to be used in a transfer operation, including their connections, shall be depressurized and protected from wear and injury.

4-16.4 Pressure relief valves shall be maintained in proper operating condition.

4-16.4.1 As a precaution to keep pressure relief devices in reliable operating condition, care shall be taken in the handling or storing of compressed natural gas containers to avoid damage. Care shall also be exercised to avoid plugging by paint or other dirt accumulation of pressure relief device channels or other parts that could interfere with the functioning of the device. Only qualified personnel shall be allowed to service pressure relief devices. Only assemblies or original manufacturer's parts shall be used in the repair of pressure relief devices unless the interchange of parts has been proved by suitable tests.

4-17 Vehicle Fueling Appliances in Commercial Applications.

4-17.1 Vehicle fueling appliances (VFAs) shall not exceed a gas flow of 10 scfm. VFAs shall be listed.

4-17.2 The installation of VFAs shall be exempt from the requirements of Sections 4-2, 4-3, 4-4, 4-6, and 4-8 through 4-16. The VFA shall be exempt from Sections 2-5 through 2-10.

4-17.3 A VFA installed with storage containers shall comply with the provisions of Chapters 2 and 4.

4-17.4 The installation of VFAs shall comply with the requirements of Chapter 5, other than those for gas flow.

4-17.5 Where more than one VFA are located in a common area, spacing between the VFAs shall not be less than 3 ft (1 m) unless permitted in the installation instructions.

4-17.6 Unless specifically permitted in the installation instructions, multiple VFAs shall not be manifolded together on the discharge side.

4-17.7 VFAs shall not be installed within 10 ft (3 m) of any storage.

Exception: Storage in the vehicle fuel supply container.

Chapter 5 Residential Fueling Facility

5-1 Scope.

5-1.1 A residential fueling facility (RFF) is an assembly used for the compression and delivery of natural gas into vehicles with its associated equipment and piping. The capacity of an RFF shall not exceed 5 SCFM of natural gas. Storage of CNG, except in the vehicle fuel supply container, is prohibited.

5-1.2 This chapter applies to the design, construction, installation, and operation of an RFF as defined in 5-1.1.

5-1.3 The provisions of this chapter shall apply to all residential refueling installations except where prohibited by local laws.

5-2 System Component Qualifications.

5-2.1 System components not part of a listed fueling appliance shall comply with the appropriate provisions in Chapter 2.

5-2.2* Fueling appliances shall be listed.

5-2.3 VFAs shall be exempt from the requirements for Sections 4-2, 4-3, 4-4, 4-6, 4-8 through 4-16, and 2-5 through 2-9.

5-3 General.

5-3.1 All equipment related to RFF installation shall be protected to minimize the possibilities of physical damage and vandalism. This requirement may be met by enclosing the compressor package in an enclosure, similar to that of a central air conditioner.

5-3.2 All equipment related to RFF installation shall be designed for the pressure, temperature, and service expected.

5-3.3 Vehicles shall be considered as unclassified electrically with respect to Article 500 of NFPA 70, *National Electrical Code*.

Exception: Vehicles containing fuel-fired equipment, e.g., recreational vehicles, shall be considered a source of ignition unless this equipment is shut off completely before entering an area in which ignition sources are prohibited.

5-3.4 Natural gas shall not be vented to the atmosphere under normal operation.

Exception: Leakage of 1.0 standard cu in. of gas shall be permitted to be released to the atmosphere per filling during disconnection of the fueling hose.

5-3.5 Unless specifically permitted in the installation instructions of a listed VFA, multiple VFAs shall not be manifolded together on the discharge side.

5-3.6 Where more than one VFA are installed in a common area, spacing between the VFAs shall not be less than 3 ft (1 m) unless the installation instructions of a listed VFA permit spacing less than 3 ft (1 m).

5-4 Installation.

5-4.1 General.

5-4.1.1 Approval of residential refueling installations shall be obtained from the authority having jurisdiction and the natural gas distribution company.

5-4.1.2 The primary concern for the location of the refueling system shall be based solely upon its safety, whether it be indoors or outdoors. CNG compression and dispensing shall be located and conducted outdoors wherever practicable. However, where not practicable, e.g., where inclement weather is common, compression and dispensing can be located indoors.

5-4.1.3 All RFF equipment shall be installed in accordance with the equipment manufacturer's instructions.

5-4.1.4 The RFF shall have a nameplate marked with minimum and maximum gas inlet pressure and flow rate, gas outlet maximum pressure, and electrical requirements.

5-4.2 Indoor Installations.

5-4.2.1 Where it is necessary to install the compression equipment and refueling connection indoors, the compression unit shall be mounted to or otherwise located adjacent to an outside wall to facilitate the rapid venting of released gases. The room or garage shall be considered for an acceptable site when the compressor enclosure is vented to the outside.

5-4.2.2 When the RFF or the vehicle being fueled is located indoors, a gas detector set to operate at one-fifth the lower limit of flammability of natural gas shall be installed in the room. The detector shall be located within 6 in. (150 mm) of the ceiling or highest point in the room. The detector shall stop the compressor and operate an audible or visual alarm.

5-4.3 Outdoor Installations. The RFF shall be installed on a firm, noncombustible support to prevent undue stress on piping and conduit.

5-5 Installation of Pressure Relief Valves. Pressure relief valves shall have pressure relief device vents or vent lines to convey escaping gas to outdoors and then upwards to a safe area so as not to impinge on buildings, other equipment, or areas that could be occupied by the public, e.g., sidewalks.

5-6 Installation of Pressure Gauges. For measurement and test purposes, pressure gauges may be installed but are not required.

5-7 Pressure Regulation. An RFF shall be equipped to automatically stop fuel flow when container(s) reach temperature corrected fill pressure.

5-8 Piping and Hose.

5-8.1 All piping and hose from the outlet of the compressor shall be supplied as part of the RFF.

5-8.2 All gas piping to the RFF shall be installed in accordance with NFPA 54, *National Fuel Gas Code*.

5-8.3 The use of hose in an installation is restricted to:

(a) A fueling hose that shall be limited to a maximum length of 25 ft (7.6 m) and shall be supported above the floor/ground level or otherwise protected from mechanical damage from abrasion and being driven over.

(b) A maximum of 3 ft (1 m) in length when used to prevent abrasion damage, resulting from vibration on the inlet and/or outlet.

5-8.4 Transfer systems shall be capable of depressurizing to facilitate disconnection. Bleed connections shall lead to a safe point of discharge.

5-9 Testing. All piping and tubing shall be tested after assembly to prove free from leaks at a pressure equal to the maximum service pressure of that portion of the system.

5-10 Installation of Emergency Shutdown Equipment.

5-10.1 An RFF shall be equipped with emergency manual shutdown of the gas supply and electric power. The emergency electrical switch shall be at least 5 ft (1.5 m) from the RFF and in view of the RFF.

5-10.2 Break-away protection shall be provided in a manner such that, in the event of a pull-away, natural gas will cease to flow.

5-10.2.1 A breakaway device shall be installed at every dispensing point. Such a device shall be arranged to separate by a force not greater than 44 lb (20 kg) when applied in any horizontal direction.

5-11 Operation.

5-11.1 An RFF shall be operated in accordance with the manufacturer's instructions.

5-11.2 A fuel supply container shall not be charged in excess of its maximum allowable service pressure at normal temperature. DOT and TC containers shall be charged in accordance with DOT and TC regulations.

5-11.3 When CNG is being transferred to a motor vehicle, the engine shall be stopped.

5-12 Maintenance and Inspection.

5-12.1 All RFF equipment shall be inspected and maintained in accordance with the manufacturer's instructions.

5-12.2 After installation, all hoses shall be examined visually as part of this inspection. Hoses that are kinked or worn shall be replaced.

5-12.3 All safety relief valves shall be maintained in proper operating condition, in accordance with manufacturer's/supplier's recommendation.

Chapter 6 Referenced Publications

6-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

6-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 1990 edition

NFPA 54, *National Fuel Gas Code*, 1992 edition

NFPA 70, *National Electrical Code*, 1993 edition

NFPA 220, *Standard on Types of Building Construction*, 1992 edition

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 1987 edition

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 1989 edition.

6-1.2 Other Publications.

6-1.2.1 ASME Publications. American Society of Mechanical Engineers, 345 East 47th St., New York, NY 10017.

ANSI/ASME B31.3 (1980), *American National Standard Code for Chemical Plant and Petroleum Refinery Piping*

Boiler and Pressure Vessel Code (1986).

6-1.2.2 ASTM Publications. American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103.

ASTM A-47-1984, *Specification for Malleable Iron Castings*

ASTM A-395-1986, *Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*

ASTM A-536-1984, *Specification for Ductile Iron Castings*

ASTM E-136-1982, *Standard Method of Test for Behavior of Materials in a Vertical Tube Furnace at 750°C*

ASTM 380, *Standard for Metric Practice.*

6-1.2.3 CGA Publication. Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202.

CGA S-1.1, *Cylinders for Compressed Gases* (1979).

6-1.2.4 U.S. DOT and TC container data is available from the U.S. Department of Transportation, 400 7th St., SW, Washington, DC 20590 and the Canadian Transport Commission, Transport Canada Building, Place de Ville, Ottawa, Ontario, K1A ON5.

6-1.2.5 API Publication. American Petroleum Institute, 2101 L St., NW, Washington, DC 20037.

API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents*, Fourth Edition, 1982.

6-1.2.6 AGA Publications. American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209.

ANSI/AGA NGV1, 1994, *Standard for Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices*

ANSI/AGA NGV2, 1992, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers*

6-1.2.7 CSA Publication. Canadian Standards Association, 55 Scarsdale Rd., Don Mills, Ontario, Canada M3B 2R3.

CSA B51-1991, *Boiler, Pressure Vessel and Pressure Piping Code.*

Appendix A Explanatory Material

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only.

A-1-1 Properties of CNG. Natural gas is a flammable gas. It is colorless, tasteless, and nontoxic. It is a light gas, weighing about two-thirds as much as air. As used in the systems covered by this standard, it tends to rise and diffuses rapidly in air when it escapes from the system.

Natural gas burns in air with a luminous flame. At atmospheric pressure, the ignition temperature of natural gas-air mixtures has been reported to be as low as 900°F (482°C). The flammable limits of natural gas-air mixtures at atmospheric pressure are about 5 percent to 15 percent by volume natural gas.

Natural gas is nontoxic but can cause anoxia (asphyxiation) when it displaces the normal 21 percent oxygen in air in a confined area without adequate ventilation.

A-2-1 Vehicle Fuel Systems. A typical vehicle fuel system consists of one or more (if more than one, the containers are manifolded together) fuel supply containers holding CNG at high pressure and fitted with pressure relief devices and manual shutoff valves, a filling connection with a check valve to prevent flow back out of the connection, a manual valve downstream from the container valve or valves, a valve that will automatically close if the engine stops for any reason, a pressure regulator to reduce fuel supply container pressure to a low engine service pressure, a gas-air mixer to produce a flammable mixture, and a pressure gauge to show fuel supply container pressure.

Systems are designed to operate at fuel supply container pressures of 2400, 3000, or 3600 psi (16.5, 20.6, or 25 MPa). Fueling connections are designed to accommodate compatible filling nozzles suitable only for the proper pressure.

Fuel supply containers are installed on either the outside of the vehicle or inside the vehicle. If inside, all connections to the containers are either external to a driver or passenger compartment or inside a compartment that is gastight with respect to a driver or passenger compartment. The compartment is vented to outside the vehicle.

See Figure A-2-1.

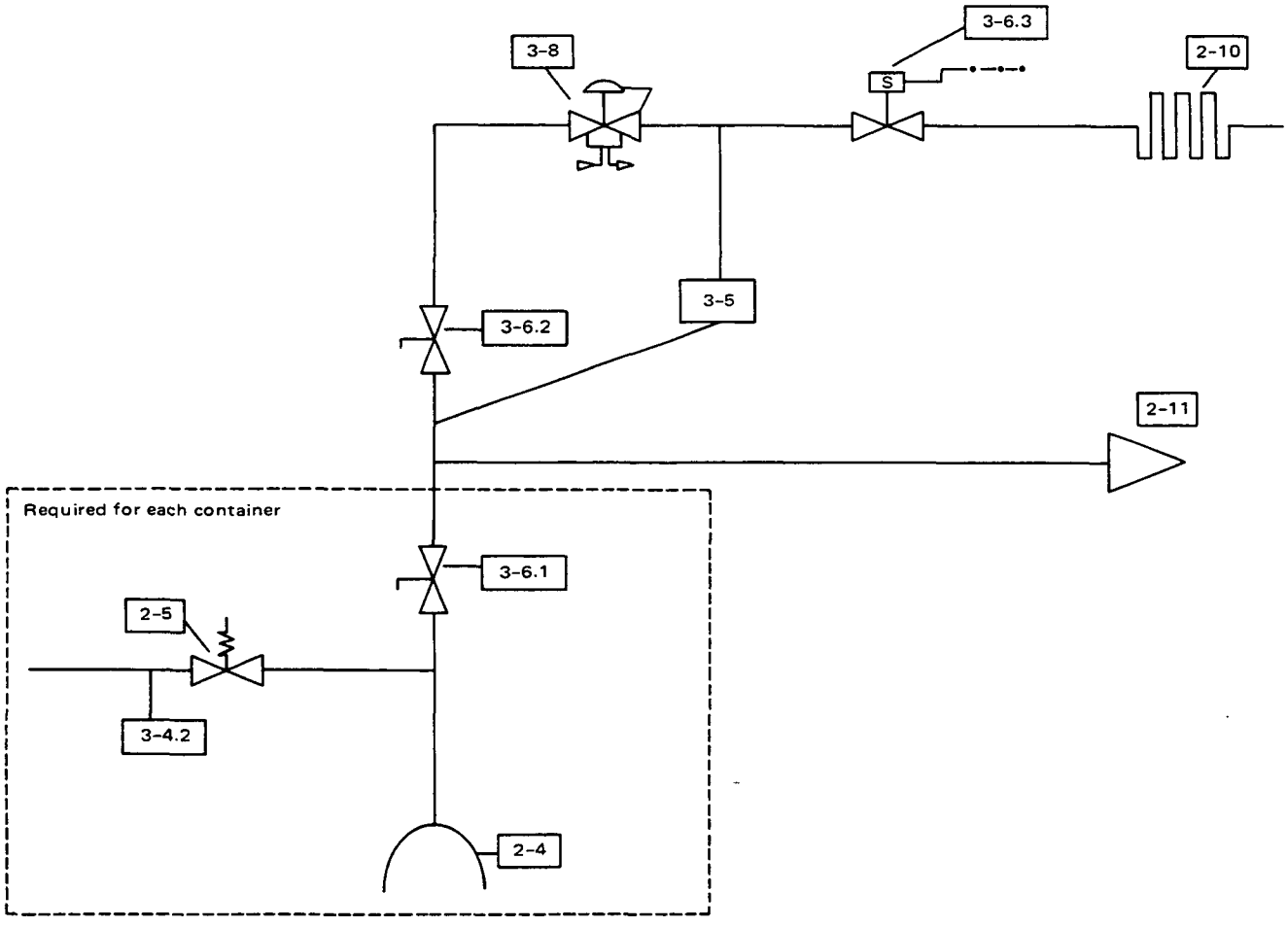

Figure A-2-1 Typical vehicular fuel system components.

A-2-2 Natural gas is not a unique, specific substance with a common composition at all times and in all places. While, as noted in the definition of Compressed Natural Gas in Section 1-5, natural gas consists principally of methane, it also contains ethane, small amounts of propane, butane, and higher hydrocarbons and may contain small amounts of nitrogen, carbon dioxide, hydrogen sulfide, and helium. The quantity of nitrogen, carbon dioxide, hydrogen sulfide, and helium will vary from zero to a few percent depending upon the source, seasonal effects, etc.

As distributed in the extensive gas transmission and distribution piping network in the United States and Canada, natural gas also contains water vapor. This "pipeline quality" gas can contain up to 7 lb or more of water per million cu ft of gas.

Some constituents of natural gas, especially carbon dioxide and hydrogen sulfide in the presence of liquid water, can be corrosive to carbon steel, and the corrosive effect is increased by pressure. The pressures used in CNG systems covered by NFPA 52 are substantial and well above those used in transmission and distribution piping and in other natural gas consuming equipment. As excessive corrosion can lead to sudden explosive rupture of a container, this hazard must be controlled.

As a result of such a failure in a cylinder comprising one of several such in a tube trailer in 1978, the U.S. Department of Transportation has specified CNG composition for CNG being transported in interstate commerce. The limits for carbon dioxide, hydrogen sulfide, and water are very low, e.g., the limit for water is 0.5 lb per million cu ft.

There is a substantial body of opinion on the Committee that the DOT-stipulated composition is intentionally conservative and would require expensive, sophisticated gas conditioning equipment to be used. This view is supported by experience of up to 15 years' duration with no failure of either storage or fuel supply containers in CNG vehicle applications. This experience has largely been with carbon steel cylinders fabricated to DOT 3A or 3AA specification and, therefore, relatively subject to internal corrosion if the conditions are present.

Corrosion protection can also be addressed by the use of materials that are corrosion resistant. A number of exemptions and special permits have been issued by DOT and TC for cylinders made of materials other than carbon steel. However, the impetus for these materials has come from other considerations, principally lighter weight.

The Committee encouraged the conducting of a research program to explore this gas quality/material matter and the research work was performed by Southwest Research Institute in San Antonio, Texas. Funding was provided by the New York State Energy Research and Development Authority (NYSERDA), the New York Gas Group (NYGAS), and the U.S. Department of Energy (DOE). The Committee gratefully acknowledges both the financial support of NYSERDA, NYGAS, and DOE and the cooperation and contributions of management, engineering, and operating personnel of the gas transmission companies, gas distribution companies, and CNG container manufacturers who supplied technical data, used gas cylinders, test materials, and test gases for this research program.

The principal objective of the research program was to define natural gas contaminant concentration limits necessary to insure that internal corrosion of CNG containers does not constitute a hazard over the lifetimes of the containers. A secondary objective included definition of the effects of materials variables, container fabrication procedures, and other CNG system parameters on internal corrosion of CNG containers and container materials. Accomplishment of the research program objectives permitted the Committee to define the limiting concentrations of corrosive contaminants in CNG necessary to prevent corrosion or corrosion-related damage to vehicle fuel and storage containers.

As a control of the amount of hydrogen sulfide and sulfides, water, carbon dioxide, and oxygen, Section 2-2 reflects a Committee consensus that if the water content is limited the other potentially corrosive constituents should not be a major concern.

A-2-4 Container Capacity. Containers are described by their liquid capacity and the design and allowable service pressures. The liquid capacity (cu ft of water) is the volume of liquid that would be required to fill the container. The allowable service pressure is the maximum pressure at which the container should be operating. From the liquid capacity and allowable service pressure, the gas storage capacity can be calculated.

The amount of gas being stored in a cylinder can be calculated by applying the "ideal gas law" taking account of the "compressibility factor" (or "supercompressibility") of the specific gas being stored.

The ideal gas law states that, if the absolute pressure of a certain volume of gas is doubled, the volume will decrease to half (at a constant temperature). However, natural gas does not follow the ideal gas law exactly. The term "supercompressibility," as it relates to natural gas, simply indicates that more natural gas can be stored in a given volume [below about 5,000 psig (35 MPa)] than would be indicated by the ideal gas law.

A-3-1 Fueling Systems. A typical fueling system consists of one or more compressors taking suction from a natural gas transmission or distribution pipeline or a building piping system connected to a transmission or distribution pipeline with the compressor discharging into either one or more storage containers or to a dispensing system, and a dispensing system consisting of a hose and nozzle and sometimes a meter. Where a storage container is present, it discharges to a dispensing system.

Where storage containers are used, the system is known as a "fast-fill" system with a vehicle filling time of about 3-5 minutes. Where storage containers are not used, the system is known as a "slow-fill" system, and filling times can be several hours.

The suction pressure for compressors ranges from about 2-500 psig (13.7 kPa-3.4 MPa) with most being under 60 psig (40 kPa). The delivery pressure is more than the vehicle system pressure but less than 5000 psi (35 MPa), with most around 3600 psi (25 MPa).

CNG is stored in two types of storage systems — bulk storage and cascade storage. They differ in the manner in which the CNG is withdrawn from them.

A-3-12.4

1. Before a CNG vehicle is returned into service following an accident that caused damage or dislocation to the CNG fuel system, or following the repair or replacement of any part of a CNG fuel system that is subject to container pressure, the system should be tested in compliance with Section 3-12.

2. Prior to maintenance or repair of a CNG fuel system:

(a) The supply of CNG should be shut off before commencing the work by closing the shutoff valves and operating the engine until the engine stops running and ensure that the valves remain shut off throughout the entire inoperative period.

(b) CNG should not be vented indoors.

(c) Upon completion of the work, leak test the CNG fuel system in accordance with the requirements of Section 3-12.

3. Prior to making repairs to gasoline related equipment on a CNG vehicle, to other than the CNG fuel system, the following should be done:

(a) Prior to removal of the natural gas mixer, shut off the supply of CNG by closing the shut off valves and operating the engine until the engine stops running and ensure that the valves remain off throughout the entire inoperative period; and

(b) Upon completion of the work, replace the natural gas mixer in its original location without any change or adjustment before the CNG shutoff valves are reopened.

4. Prior to making collision repairs on a CNG vehicle to other than the CNG fuel system shall the following should be done:

(a) Close the shutoff valve at the outlet of the CNG container before commencing the work and ensure that the valve remains off throughout the entire inoperative period; and

(b) The CNG vehicle owner or operator should be instructed to take the vehicle to a vehicle conversion center for inspection of the CNG fuel system before the shut off valve referenced in (a) above is reopened.

A-4-1 Bulk storage of CNG can be accomplished with one large container or a number of smaller containers manifolded together. As vehicles draw CNG from bulk storage, all containers draw down (reduce in pressure) at the same rate.

Bulk storage provides less "available" CNG storage than the cascade system.

Storage containers arranged in a cascade can provide more "available" CNG storage than a bulk system for the same size containers. A brief description of the operation of a typical cascade system is as follows:

A cascade is usually arranged in at least three banks of containers with the containers in any one bank manifolded together so that each bank acts as one large container. The banks are separated by automatic switching valves. The valve sequencing is controlled automatically by a sequencing control panel.

The cascade banks are initially filled with CNG in sequence by the compressor to the normal service pressure of the system. The highest pressure bank is refilled first ("Bank 1"), followed by successively lower pressure banks ("Bank 2," "Bank 3," etc.). This sequence is called "priority fill."

Vehicles can then be fueled from the cascade, beginning with Bank 3 (for a three-bank cascade).

If there is insufficient CNG in Bank 3 to pressurize the vehicle fuel supply container(s), Bank 3 will be valved off and Bank 2 will "top up" the vehicle container(s). Successive vehicles will draw from Banks 3 and 2 as above, until Bank 1 is required to "top up" the vehicle container(s). When Bank 1 pressure is reduced to a preset value, the compressor will bypass the cascade and fill the vehicle directly. At the completion of the last vehicle fill, the compressor will continue running, and refill the cascade by priority fill.

Cascade valving can be arranged to provide more available storage than the system described.

A-4-5.1 Where space is at a premium or not available, consideration should be given to installation of storage containers on a roof made of noncombustible material at fueling stations.

A-4-12 See Figure A-4-12.

A-5-2.2 For information on standards for listing fueling appliances see AGA *Requirements for Natural Gas Vehicle (NGV) Fueling Appliances*, No. 2-90 (November 1, 1990).

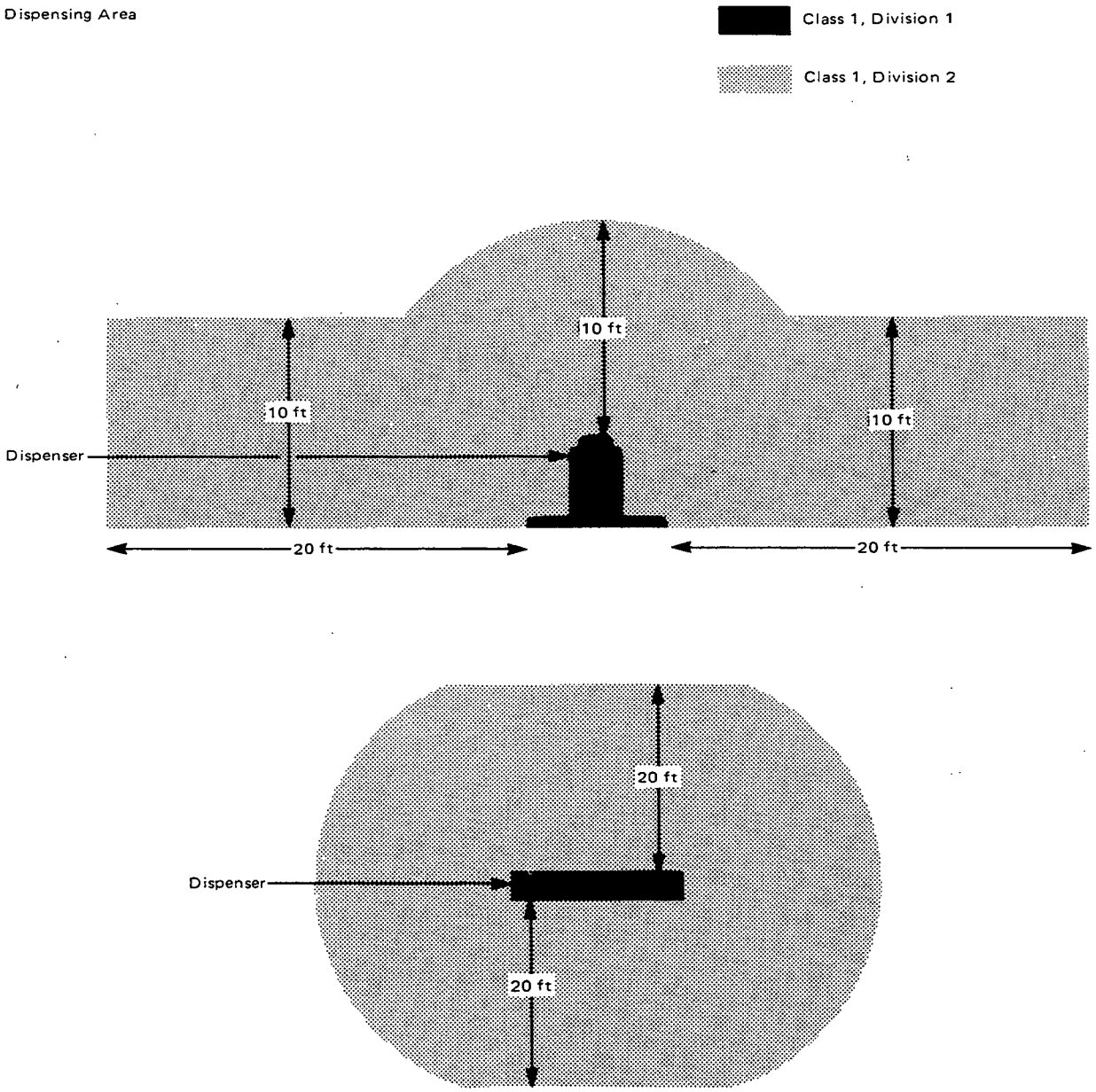

Figure A-4-12 Classified areas in and around dispensers as detailed in Table 4-12.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

B-1.1 CGA Publications. Compressed Gas Association, 1235 Jefferson Davis Highway, Arlington, VA 22202.

C-6 *Standards for Visual Inspection of Compressed Gas Cylinders* (1984)

C-6.1 *Standards for Visual Inspection of High Pressure Aluminum Compressed Gas Cylinders* (1984)

C-6.2 *Guidelines for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders* (1982)

C-10 *Recommendations for Changes of Service for Compressed Gas Cylinders Including Procedures for Inspection and Contaminant Removal* (1985).

B-1.2 SAE Publication. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J1616, *Surface Vehicle Recommended Practice for Natural Gas Vehicle Fuel Composition.*