

ANSI/CGA G-2.1 — 2024

7TH EDITION

**REQUIREMENTS
FOR THE STORAGE
AND HANDLING OF
ANHYDROUS
AMMONIA**



DEDICATION

This publication is dedicated in the memory of Patrick “Pat” Hodges, who served as an active participant of the Consensus body that developed this publication and contributed his knowledge and expertise to the ammonia industry for over 40 years.

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Work Item 08-061
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NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendix A (Normative) is a requirement.

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Approved as an American National Standard on June 18, 2024.

FOREWORD

(This Foreword is not a part of American National Standard *Requirements for the Storage and Handling of Anhydrous Ammonia*.)

This standard represents the consensus of interested parties concerning minimum safety requirements for the storage, transportation, and handling of anhydrous ammonia. It is intended to serve as a guide for regulatory authorities in writing their own regulations as well as to assist designers of ammonia installations and others having an interest in its requirements such as safety engineers, insurance organizations, and transportation carriers.

The first edition of the K61.1 Standard was published in 1960 and was based on a standard of the Compressed Gas Association, Inc. (CGA) completed in 1950, and submitted to the then American Standards Association for adoption as an American Standard. CGA's standard was used to assist in developing regulations during the early period of the expanded use of anhydrous ammonia for agricultural purposes. This took place in the late 1940s and early 1950s.

In 1953 the Agricultural Ammonia Institute (AAI) published its first standard (M-1) for the storage and handling of agricultural ammonia, which has been revised at frequent intervals to remain current with progress in the agricultural ammonia industry.

When the first American Standard for ammonia was approved in 1960, it made available to those concerned two standards on ammonia from which to choose. Many of the states had already adopted as their regulations, the M-1 standard of the AAI, and from then on the ammonia industry was continually faced with the conflict of having two differing standards available dealing with safety requirements for anhydrous ammonia.

The American Standard was revised in 1966 under the sponsorship of CGA and the second edition was made available to interested parties along with revised editions of the similar standards of AAI.

In 1968 the Agricultural Nitrogen Institute (ANI), successor to AAI, requested cosponsorship of the K61 project. CGA supported cosponsorship to achieve the endorsement of a single American National Standard that could be supported jointly by ANI and CGA.

The ANI has since merged with the National Plant Food Institute to become The Fertilizer Institute (TFI).

As cosecretariats of the K61 Project, CGA and TFI reconciled the differences between the American National Standard K61.1-1966 and the M-1 Standard of The Fertilizer Institute. A revision was prepared and submitted to the K61 Committee for consideration.

The 1972 and subsequent editions of the K61.1 Standard not only replace the 1966 edition of the American National Standard K61.1, but also supersede the 1966 edition of CGA G-2.1 and the 1968 edition of The Fertilizer Institute M-1 Standard.

Following the 1984 revision of the 1981 edition of the K61.1 Standard, The Fertilizer Institute withdrew from cosponsorship of the K61.1 Standard in 1987, however, TFI elected to continue as an active participant on the K61 Committee.

The 1989 edition represented a substantial reorganization and expansion of material contained in prior editions with individual sections devoted to ammonia safety and the use of water in emergencies. A new section regarding tank cars was added in recognition of the importance of the rail transportation mode. Other sections were updated to reflect major changes in the areas of technology and regulatory matters.

The 1999 edition incorporated the International System of Units (SI) in recognition of the global harmonization movement. The Pressure Relief Device section underwent a major rewrite to provide consistency and account for excessive heat or fire protection. There were also some marking and labeling changes in the regulatory area.

The 2014 edition includes updated ammonia exposure information and extensive revision of the safety section to incorporate current regulatory and safety requirements and regulations. This edition also includes revised requirements for the re-installation of large pressure vessels, for the repair or alteration of pressure vessels, and for dealing with pressure vessels with missing dataplates by incorporating provisions of the National Board

Inspection Code (NBIC). A new section defines specifications and inspection requirements for pressure transfer hoses used specifically in ammonia service (Information about pressure transfer hose requirements was previously addressed in an appendix to the 1999 edition). Another new section defines the requirements for heating devices for containers. The refrigerated storage pressure relief valves section also underwent another rewrite to address abnormal operating conditions and fire scenarios with respect to relief requirements.

The 2023 edition includes new definitions, updates to information and valves and gaskets, updated requirements for pressure testing of hoses, and a new section addressing hydrostatic relief valves. This edition also combines information on applicator tanks and nurse tank systems mounted on farm wagons into one section with a separate section addressing ammonia application systems.

Suggestions for improvements of this standard will be welcome. They should be sent to the American National Standards Institute, Inc., 1180 Avenue of the Americas, 10th Floor, New York, NY 10036, or to the Compressed Gas Association, Inc., 8484 Westpark Drive, Suite 220, McLean, VA 22102.

This standard was revised and approved for submittal to ANSI by American National Standards Committee on Safety Requirements for the Storage and Handling of Anhydrous Ammonia. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the CGA G-2.1 ANS Consensus Body had the following voting members:

Organization Represented	Name of Representative
Agribusiness Association of Iowa.....	Neal Vaughn
Airgas Specialty Products	Blaine Davis, Chair
Ammonia Safety and Training Institute	Kent Anderson
CF Industries, Inc.	David Shea
CHS, Inc.	Ken Mueller
.....	Mary Blal (Alternate)
Circle K Manufacturing Company	Chuck Thompson
Continental NH ₃ Products.....	Judd Stretcher
Gas Equipment Company	Roy Nichols
Illinois Department of Agriculture	Chuck Cawley
Illinois Fertilizer and Chemical Association	John Rebholz
Koch Company Services	George Edwards
MaXfield, Inc.	Tyler Rishel
MFA Incorporated	Stanley Thessen
.....	David Imhoff (Alternate)
Minnesota Department of Agriculture.....	Ed Kaiser
The National Board of Boiler and Pressure Vessel Inspectors	Terrence Hellman
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.....	Cliff Hayes (Alternate)
Office of Indiana State Chemist	Danny Starke
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.....	Timothy Memmer (Alternate)
RegO Products.....	Cody Reeves
Safety with HELP, LLC.....	Mike Wollner
Squibb Taylor Inc.	Bruce Kasten
Tanner Industries, Inc	David Binder

Contents	Page
1 Introduction.....	1
1.1 Scope	1
1.2 General.....	1
1.3 Physical/chemical properties of ammonia	1
1.4 Ammonia exposure.....	3
1.5 Federal, state, and local regulations	4
1.6 Hazardous material classification	4
2 Definitions.....	4
3 Safety	9
3.1 Training.....	9
3.2 Normal conditions.....	9
3.3 Emergency planning and response coordination	9
3.4 Permanent storage installations	10
3.5 Cargo tanks	11
3.6 Leaks in transportation equipment	11
3.7 Cylinder and DOT portable tank installations	11
3.8 Site security	11
4 Use of water in emergencies.....	12
4.1 Human exposure	12
4.2 Accidental release	12
4.3 Fire exposure.....	12
4.4 Absorption in water.....	12
5 Basic rules.....	13
5.1 Equipment and systems	13
5.2 Requirements for new construction and original test, repair, and alterations of containers (including DOT portable tanks), other than refrigerated storage tanks	14
5.3 Location of containers	16
5.4 Markings of nonrefrigerated containers and systems other than DOT containers	17
5.5 Container appurtenances	19
5.6 Piping, tubing, fittings, valves, and gaskets.....	20
5.7 Hose specification	22
5.8 Pressure relief valves	26
5.9 Filling densities	29
5.10 Transfer of ammonia	31
5.11 Liquid level gauging devices.....	34
5.12 Painting of containers.....	34
5.13 Electrical equipment and wiring.....	34
5.14 Heating devices for containers and cylinders	35
6 Systems using stationary, pier-mounted or skid-mounted, aboveground or underground, nonrefrigerated storage.....	35
6.1 Design pressure and construction of containers	35
6.2 Container valves and accessories and discharge connections.....	35
6.3 Pressure relief valves	36
6.4 Installation of storage containers.....	37
6.5 Reinstallation of containers	38
6.6 Marking containers	38
6.7 Protection of container and appurtenances.....	39
6.8 Identification for emergency	39

7	Refrigerated storage.....	39
7.1	Design of tanks.....	39
7.2	Installation of storage tanks (aboveground)	40
7.3	Marking refrigerated containers.....	41
7.4	Tank valves, accessories, fill pipes, and discharge pipes	41
7.5	Pressure relief valves	42
7.6	Protection of containers and appurtenances.....	43
7.7	Reinstallation of containers	44
7.8	Refrigeration load and equipment	44
7.9	Safety equipment.....	46
7.10	Identification for emergency	46
8	Systems mounted on railcar structures (tank cars), other than DOT class 106A, for transportation of ammonia	46
8.1	Design and construction	46
8.2	Pressure relief valves	46
8.3	Marking and placarding	46
8.4	Tank car loading and unloading locations and operations	47
9	Systems mounted on trucks, semitrailers, and trailers for transportation of ammonia	48
9.1	Design pressure of containers.....	49
9.2	Container mounting	49
9.3	Container appurtenances	50
9.4	Piping, fittings, and hose	51
9.5	Pressure relief valves	51
9.6	Placarding and marking of containers	52
9.7	Transfer of liquids.....	52
9.8	Trailers and semitrailers	52
9.9	Electrical equipment and lighting.....	53
9.10	Protection against collision.....	53
9.11	Brakes	53
9.12	Portable tanks (including skid tanks).....	53
9.13	Safety equipment.....	53
10	Systems using DOT portable tanks and cylinders.....	54
10.1	Containers and cylinders.....	54
10.2	Container and cylinder valves and regulating equipment.....	54
10.3	Pressure relief devices	55
11	Applicator tank and nurse tank systems mounted on farm wagons (implements of husbandry)	55
11.1	Design pressure and construction of containers	55
11.2	Mounting of containers	55
11.3	Container appurtenances	56
11.4	Marking and placarding of containers.....	57
11.5	Farm wagons (implements of husbandry)	58
11.6	Transfer hose	58
11.7	Safety training and equipment.....	58
11.8	Safety water, decal, and safety data sheet	59
11.9	Compatibility.....	59
12	Ammonia application systems (implements of husbandry)	59
12.1	Ammonia application unit	59
12.2	Metering devices	59
12.3	Breakaway coupling devices and instructions.....	59
12.4	Control valves.....	59
12.5	Ball valves	59
12.6	Bleed valves	60
12.7	Withdrawal hose	60
12.8	Transfer system.....	60

12.9 Safety training and equipment.....	60
12.10 Compatibility.....	60
13 References	60

Tables

Table 1—Physical properties of ammonia	2
Table 2—Human physiological responses to various concentrations of ammonia in air	3
Table 3—Regulatory ammonia exposure limits	3
Table 4—Emergency response planning guideline exposure limits	4
Table 5—Minimum separation distances for location of ammonia storage containers	17
Table 6—Maximum permitted filling volumes for nonrefrigerated storage containers	30
Table 7—Ammonia container maximum heating limits	35

Appendix

Appendix A—Minimum required flow rate of pressure relief devices for fire protection (Normative)	63
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1 Introduction

1.1 Scope

This standard is intended to apply to the design, construction, repair, alteration, location, installation, maintenance, and operation of anhydrous ammonia systems including refrigerated ammonia storage systems.

This standard does not apply to:

- Ammonia manufacturing plants;
- Refrigeration systems where ammonia is used solely as a refrigerant. Such systems are covered in ANSI/International Institute of Ammonia Refrigeration (IIAR) 2, *American National Standard for Design of Safe Closed-Circuit Ammonia Refrigeration Systems* [1]¹;
- Ammonia transportation pipelines; and
- Ammonia barges and tankers.

1.2 General

Where certain provisions of this standard impose undue hardship or where literal adherence to such provisions fails to provide adequate safety in the opinion of the authority having jurisdiction (AHJ), the AHJ may permit deviation from the standard.

The values stated in customary units are to be regarded as standard. Metric equivalents where shown in this standard may not be exact, and meet the requirements of ANSI/Institute of Electrical and Electronics Engineers (IEEE) SI 10, *American National Standard for Metric Practice* procedures in this regard [2].

1.3 Physical/chemical properties of ammonia

1.3.1

Gaseous ammonia liquefies under pressure at ambient temperature. Ammonia is usually shipped or stored as a liquid under pressure. When refrigerated to or less than its normal boiling point of -28°F (-33.3°C), it may be shipped or stored as a liquid at or near atmospheric pressure.

1.3.2

Some physical properties of ammonia are listed in Table 1.

1.3.3

During liquid releases, ammonia aerosol can form. This aerosol can reach temperatures approaching -100°F (-73°C) near the point of release [3].

1.3.4

Ammonia is extremely hard to ignite and is a relatively stable compound. It begins to dissociate into nitrogen and hydrogen at approximately 850°F (454°C) at atmospheric pressure. Experiments conducted by a nationally recognized laboratory showed that an ammonia-air mixture in a standard quartz test container does not ignite at less than 1562°F (850°C). Ammonia gas is flammable in air in the range of 16% to 25% by volume. Conditions favorable for ignition are seldom encountered during normal operations due to the high ignition temperature required.

¹ References are shown by bracketed numerals and are listed in the order of appearance in the reference section.

However, the release of ammonia gas into a tightly enclosed or inadequately ventilated space can result in the accumulation of a flammable mixture that can cause a combustion explosion if a high temperature ignition source is present.

Table 1—Physical properties of ammonia [4]

	Customary Units	SI Units
Chemical formula	NH ₃	NH ₃
Molecular weight	17.031	17.031
Boiling point at 1 atm	−28 °F	−33.3 °C
Critical density	14.7 lb/ft ³	236 kg/m ³
Critical pressure	1657 psia	11 425 kPa, abs ²
Critical temperature	271.4 °F	133.0 °C
Density of liquid at 70 °F (21.1 °C)	38.00 lb/ft ³	608.7 kg/m ³
Density of the gas at 32 °F (0 °C) and 1 atm	0.0481 lb/ft ³	0.771 kg/m ³
Flammable limits (% in air, by volume)	16% to 25%	16% to 25%
Freezing point at 1 atm	−107.9 °F	−77.72 °C
Heat of solution extrapolated to 0% concentration by weight at 28% concentration by weight	347.4 Btu/lb 214.9 Btu/lb	8.081 x 10 ⁵ J/kg 4.999 x 10 ⁵ J/kg
Ignition temperature (in presence of iron catalyst) (in standard quartz container)	1204 °F 1562 °F	651.1 °C 850.0 °C
Latent heat of fusion at −107.9 °F (−77.72 °C)	142.8 Btu/lb	332.2 kJ/kg
Latent heat of vaporization at boiling point and 1 atm	589.3 Btu/lb	1371 kJ/kg
Liquid density at −28 °F (−33.3 °C) and 1 atm	42.57 lb/ft ³	681.9 kg/m ³
Solubility in water vol(liq.)/vol(liq.) at 68 °F (20.0 °C)	0.848	0.848
Specific gravity of liquid at −28 °F (−33.3 °C) [water at 39.2 °F (4 °C) = 1]	0.6819	0.6819
Specific gravity of the gas at 32 °F (0 °C) and 1 atm (air = 1)	0.5970	0.5970
Specific heat of gas at 59 °F (15.0 °C) and 1 atm constant pressure, C _p constant volume, C _v	0.5232 Btu/(lb °F) 0.3995 Btu/(lb °F)	2.191 kJ/(kg °C) 1.673 kJ/(kg °C)
Ratio of specific heats (C _p /C _v)	1.3096	1.3096
Specific volume of vapor at 32 °F (0 °C) and 1 atm	20.78 ft ³ /lb	1.297 m ³ /kg
Vapor density at −28 °F (−33.3 °C) and 1 atm	0.0555 lb/ft ³	0.8890 kg/m ³
Vapor pressure at 70 °F (21.1 °C)	114.1 psi	786.7 kPa
Triple point	−107.86 °F at 0.88 psia	−77.70 °C at 6.1 kPa, abs
Weight of liquid per gallon at 60 °F (15.6 °C)	5.147 lb/gal	616.8 kg/m ³

1.3.5

Under some circumstances, ammonia and ammonium compounds can react with other chemicals to form explosive products. Ammonia should never be combined with other chemicals unless the possible reactions have been adequately investigated and appropriate precautions taken. See National Fire Protection Association (NFPA) 45, *Standard on Fire Protection for Laboratories Using Chemicals* [6].

1.3.6

Although most metals are not attacked by ammonia, zinc, copper, and copper base alloys such as brass are subject to rapid deterioration by ammonia. Certain high tensile strength steels have developed stress corrosion cracking in ammonia contaminated with small quantities of air. Such cracking can be minimized by the consistent use of 0.2% water by weight in the ammonia as an inhibitor. Weld heat affected zones can be areas of high

² kPa shall indicate gauge pressure unless otherwise noted as (kPa, abs) for absolute pressure and (kPa, differential) for differential pressure. All kPa values are rounded off per CGA P-11, *Guideline for Metric Practice in the Compressed Gas Industry* [5].

hardness that are susceptible to stress corrosion cracking. U.S. Department of Transportation (DOT) regulations require that ammonia cargo tanks constructed of such steels be postweld heat treated. See Title 49 of the U.S. *Code of Federal Regulations* (49 CFR) 173.315 [7].

1.4 Ammonia exposure

1.4.1

At low concentrations, ammonia gas is irritating to the eyes, skin, and mucous membranes of the nose, throat, and lungs. At higher concentrations, ammonia is corrosive to human tissue and possibly life threatening. Table 2 indicates human physiological responses to various concentrations of ammonia in air. See 4.1 regarding exposure to liquid ammonia.

Table 2—Human physiological responses to various concentrations of ammonia in air

Concentration/Time	% Ammonia/Time	Effect
20 ppm to 50 ppm	0.002% to 0.005%	Mild discomfort, depending on whether an individual is accustomed to smelling ammonia
50 ppm to 80 ppm for 2 hr	0.005% to 0.008% for 2 hr	Perceptible eye and throat irritation
100 ppm for 2 hr	0.01% for 2 hr	Nuisance eye and throat irritation
134 ppm for 5 min	0.0134% for 5 min	Tearing of the eyes, eye irritation, nasal irritation, throat irritation, chest irritation
140 ppm for 2 hr	0.0140% for 2 hr	Severe irritation, need to leave exposure area
300 ppm to 500 ppm for 30 min [8]	0.03% to 0.05% for 30 min	Upper respiratory tract irritation; tearing of the eyes (lacrimation), hyperventilation
700 ppm to 1700 ppm	0.07% to 0.17%	Incapacitation from tearing of the eyes and coughing
5000 ppm to 10 000 ppm	0.5% to 1.0%	Rapidly fatal
10 000 ppm	1.0%	Promptly lethal

1.4.2 Ammonia exposure limits and guidelines

The pungent odor of ammonia is readily detectable by most people and serves as its own warning. Concentrations in the range of 5 ppm to 53 ppm as referenced in National Academies' *Acute Exposure Guideline Levels for Selected Airborne Chemicals* are readily detectable and it is therefore unlikely that any individual would become overexposed unknowingly [9]. Some exposure limits and guidelines for ammonia are shown in Tables 3 and 4. See National Institute for Occupational Safety and Health (NIOSH) *Pocket Guide to Chemical Hazards*, Title 29 of the *Code of Federal Regulations* (29 CFR) 1910.1000, and American Industrial Hygiene Association (AIHA) *Emergency Response Planning Guidelines* (ERPG) [10, 11, 12].

Table 3—Regulatory ammonia exposure limits

NIOSH Immediately dangerous to life or health (IDLH)	300 ppm [8]
NIOSH Recommended Exposure Limit (REL)	25 ppm (18 mg/m ³) 10 hr Time-Weighted Average (TWA) [10]
NIOSH Short-term exposure limit (STEL)	35 ppm (27 mg/m ³) 15 min TWA [10]
Occupational Safety and Health Administration (OSHA) Permissible exposure limit (PEL)	50 ppm (35 mg/m ³) 8 hr TWA [11]
NOTES	
1 IDLH, STEL, and PEL are defined in Section 2 of this standard.	
2 TWA—Time-Weighted Average concentration in contaminated air by volume for up to an 8 hr (OSHA) or 10 hr (NIOSH) workday during a 40 hr workweek.	

Table 4—Emergency response planning guideline exposure limits [12]

Ammonia (CAS No. 7664-41-7)		
ERPG-1	The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hr without experiencing other than mild, transient adverse health effects of without perceiving a clearly defined objectionable odor.	25 ppm
ERPG-2	The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.	150 ppm
ERPG-3	The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hr without experiencing or developing life-threatening health effects	750 ppm

1.5 Federal, state, and local regulations

Anhydrous ammonia is regulated by agencies including DOT, OSHA, Department of Homeland Security (DHS), Environmental Protection Agency (EPA), and state/local jurisdictions.

1.6 Hazardous material classification

DOT designates the hazard class for anhydrous ammonia as 2.2 for domestic shipments and lists ammonia as a hazardous substance with a reportable quantity (RQ) of 100 lb (45 kg). The words "Inhalation Hazard" shall be included on shipping papers and on containers and cylinders as required by special provision 13 noted in column 7 of the hazardous material table. See 49 CFR 172.101 and 172.102(c) [7]. The four-digit United Nations (UN) identification number for ammonia is 1005. In Canada, regulations are published in Transport Canada's *Transportation of Dangerous Goods Regulations* and *Regulations for the Transportation of Dangerous Commodities by Rail* [13, 14]. Under Canadian *Transportation of Dangerous Goods Regulations*, ammonia is classified as a Toxic Gas 2.3 (8) and may be transported to, through, and from the United States into Canada using this description with proper markings and placarding [13].

2 Definitions

For the purpose of this standard, the following definitions apply.

2.1 Publication terminology

2.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

2.1.2 Should

Indicates that a procedure is recommended.

2.1.3 May

Indicates that the procedure is optional.

2.1.4 Will

Is used only to indicate the future, not a degree of requirement.

2.1.5 Can

Indicates a possibility or ability.

2.2 Technical definitions

2.2.1 Actuation system

System, mechanical or otherwise, which is manually activated to cause the closing of emergency shutoff valves or internal valves stopping the flow of the product in the system.

2.2.2 Air-purifying respirator

Air-purifying device with full face piece approved by NIOSH under the provisions of Title 30 of the U.S. *Code of Federal Regulations* (30 CFR) Part II, Subpart I for use in an ammonia contaminated atmosphere in compliance with 29 CFR 1910.134 and selected in accordance with ANSI Z88.2, *Respiratory Protection* [15, 11, 16].

NOTE—A respirator of the air-purifying type shall be used only in an atmosphere containing 19.5% to 22.0% oxygen by volume.

2.2.3 Alteration

Change in any item described in the original manufacturer's data report that affects the pressure containing capability of the container.

NOTE—Rerating a container by increasing maximum allowable working pressure (MAWP) or by increasing or decreasing allowable working temperature is an alteration.

2.2.4 Ammonia application unit

Implement of husbandry used to apply ammonia below the soil surface with ammonia supplied by an applicator tank or nurse tank.

NOTE—Commonly known as an applicator or toolbar.

2.2.5 Ammonia or anhydrous ammonia

Compound formed by the chemical combination of the elements nitrogen and hydrogen in the molar proportion of 1 part nitrogen to 3 parts hydrogen.

NOTE—This relationship is shown by the chemical formula, NH_3 . On a weight basis, the ratio is 14 parts nitrogen to 3 parts hydrogen or approximately 82% nitrogen to 18% hydrogen. Ammonia can exist in a gaseous, liquid, or solid state. It is not to be confused with aqua ammonia (ammonium hydroxide), which is a solution of ammonia in water.

NOTE—These terms are used interchangeably in this standard.

2.2.6 Approved

- Listed by a recognized testing laboratory;
- Recommended by the manufacturer as suitable for use with anhydrous ammonia and so marked; or
- Accepted by the AHJ.

NOTE—The phrase "authority having jurisdiction" is used in a broad manner since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the AHJ 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 AHJ. In many circumstances, the property owner or his designated agent assumes the role of the AHJ; at government installations, the commanding officer or departmental official may be the AHJ.

2.2.7 Appurtenance

Devices such as pressure relief devices (PRDs), liquid level gauging devices, valves, pressure gauges, pressure regulators, fittings, metering, or dispensing devices designed to be attached to an ammonia container.

2.2.8 Backpressure check valve

Device that allows liquid or gas to flow in only one direction.

2.2.9 Breakaway coupling device

Automatic, self-closing device designed to disconnect and stop the flow of product from hose connection(s) in case of detachment.

2.2.10 Codes

2.2.10.1 American Petroleum Institute—American Society of Mechanical Engineers Code

Code that applies to the construction of unfired pressure vessels and per this standard refers to the American Petroleum Institute (API) and American Society of Mechanical Engineers (ASME) *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases* [17].

NOTE—The API-ASME Code, as a joint publication and interpretation service, was an alternative code of construction for pressure vessels that was discontinued as of December 31, 1956, and construction of containers to the API-ASME Code has not been authorized since July 1, 1961. See also 5.1.1 and 5.1.2.

2.2.10.2 American Society of Mechanical Engineers Code (ASME Code)

Code that applies to the construction of unfired pressure vessels and per this standard refers to either Paragraphs U-68, U-69, U-200, or U-201 of Section VIII of the ASME *Boiler and Pressure Vessel Code* 1949 Edition or Section VIII Division 1 of the ASME *Boiler and Pressure Vessel Code* 1950 Edition, through the current edition including addenda, Section VIII Division 2 addenda, and applicable Code Case Interpretations, and the applicable requirements of Sections II, V, and IX [18].

2.2.10.3 National Board Inspection Code (NBIC)

Code that applies to the repair and alteration of unfired pressure vessels and per this standard refers to the NBIC, the latest edition at the time the pressure vessel is repaired or altered [19].

NOTE—This code governs repairs and alterations to tanks of many different codes of construction but relative to this standard refers either to ASME or to API-ASME code pressure vessels, and to the edition of said codes in effect at the time of the tank's construction. All applicable sections of the NBIC apply [19]. See also 5.2.4.

2.2.11 Capacity

Total volume of the container measured in standard U.S. gallons unless otherwise specified.

2.2.12 Cargo tank

Any container designed to be permanently attached to, or forming a part of, a highway motor vehicle, or any container not permanently attached to a highway motor vehicle, that by reason of the container's size, construction, or attachment to a highway motor vehicle, shall be loaded or unloaded without being removed from the highway motor vehicle.

NOTE—This definition does not apply to cylinders and implements of husbandry or containers normally used for storage.

2.2.13 Chemical splash goggles (or goggles)

Flexible fitting chemical-protective goggles with a hooded indirect ventilation system to provide primary protection of the eyes and eye sockets from the splash of hazardous liquids that are designed to meet the requirements of ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection* [20].

NOTE—Direct vented goggles do not comply with this definition.

2.2.14 Container

All tanks, except cylinders as defined in 2.2.15, used for the transportation or storage of anhydrous ammonia.

2.2.15 Cylinder

Pressure vessel of 1000 lb (450 kg) water capacity or less constructed in accordance with DOT specifications for cylinders and authorized for the transportation of ammonia.

NOTE—This definition does not include storage tanks, cargo tanks, portable tanks, implements of husbandry, or tank cars.

2.2.16 Design pressure

Identical to the maximum allowable working pressure (MAWP) used in the ASME Code [18].

2.2.17 Department of Transportation regulations

Refers to the *Hazardous Materials Regulations* (HMR) of DOT.

NOTE—See 49 CFR Parts 100 to 180, including "Specifications for Shipping Containers" [7].

2.2.18 Emergency shower

Shower unit permanently connected to a source of clean water that enables the user to have water cascading over the entire body and otherwise meeting the requirements of ANSI Z358.1, *Emergency Eyewash and Shower Equipment* [21].

2.2.19 Emergency shutoff valve (ESV)

Valve with an actuation system designed to stop the flow of ammonia in an emergency situation.

2.2.20 Eye wash unit

Device used to irrigate and flush the eyes with clean water.

NOTE—Depending upon the requirements set forth in this standard, the device may be a plumbed unit, permanently connected to a source of clean water, or it may be a self-contained unit, not permanently installed that shall be refilled or replaced after use. Any eye wash device shall otherwise meet the requirements of ANSI Z358.1 [21].

2.2.21 Excess flow valve

Devices that are open to allow flow in either direction and designed to automatically shut off the flow of ammonia at a predetermined flow rate in one direction.

2.2.22 Filling density

Percent ratio of the weight of the ammonia permitted in a container to the weight of water at 60 °F (15.6 °C) that the container will hold when full.

NOTE—1 lb of water = 27.74 in³ (455 ml) at 60 °F (15.6 °C). For determining the water capacity of the tank in lbs, the weight of 1 gal (231 in³) (3.785 L) of water at 60 °F (15.6 °C) in air shall be 8.328 lb (3.778 kg).

2.2.23 Full face shield

Device meeting the requirements of ANSI Z87.1, designed to provide protection to all of the face from hazards but shall only be worn as secondary eye protection, supplementing the primary eye protection afforded by chemical splash goggles [20].

2.2.24 Hydrostatic relief valve (HRV)

Pressure relief device (PRD) for liquid service designed to prevent excessive pressure due to thermal expansion when a pipe or hose is filled with liquid such as between block valves or blinds.

2.2.25 Immediately dangerous to life or health (IDLH)

Maximum concentration from which unprotected persons are able to escape within 30 minutes without escape-impairing symptoms or irreversible health effects.

2.2.26 Implement of husbandry

System, including a nurse tank, with a capacity of 3000 gal (11.35 m³) or less or an applicator tank, used for transporting and applying anhydrous ammonia containing 0.2% water exclusively for agricultural purposes.

2.2.27 Internal valve

Container primary shutoff valve that can be closed remotely and incorporates an internal excess flow valve with the seat and seat disk located within the container in a manner to remain in place in the event of external damage to the valve and/or associated piping.

2.2.28 Mechanically secure point

Any mechanical connection point to be affixed to the ammonia application unit, other implement, and nurse tank wagon, and affixed to a towing implement for the attachment of hose(s).

NOTE—The mechanically secure point provides sufficient resistance allowing the breakaway coupling device to operate in the event of detachment.

2.2.29 Permissible exposure limit (PEL)

The limit developed by OSHA for the maximum airborne concentration of a contaminant to which an employee may be exposed over the duration specified by the type of PEL assigned to that contaminant.

NOTE—PELs are set forth in 29 CFR 1910.1000 [11].

2.2.30 Permanent storage installation

System employing a stationary (fixed) container used exclusively for storage or supply.

2.2.31 Portable tank

Bulk packaging (except a cylinder having a water capacity of 1000 lb [450 kg] or less) designed primarily to be loaded onto, or on, or temporarily attached to a transport vehicle or ship and equipped with skids, mountings, or accessories to facilitate handling of the tank by mechanical means.

NOTE—It does not include a cargo tank, tank car, multi-unit tank, or trailer carrying 3AX, 3AAX, or 3T cylinders (as referenced in 49 CFR 171.8) [7].

2.2.32 Positive pressure self-contained breathing apparatus (SCBA)

Full face piece respirator, approved by NIOSH/Mine Safety and Health Administration (MSHA), for respiratory protection for both entry into or escape from oxygen-deficient atmospheres or a concentration of gases or vapors that are immediately dangerous to life or health where the supply of air is carried by the wearer.

NOTE—The air pressure inside the face piece is positive in relation to the air pressure of the outside atmosphere during exhalation and inhalation.

2.2.33 Pressure relief valve (PRV)

Pressure relief device (PRD) designed to open to prevent an increase in internal fluid pressure in excess of a specified value due to an emergency or abnormal condition and to close and prevent further flow after normal conditions have been restored.

2.2.34 Protective gloves, boots, and suits

Items made of rubber or other material impervious to ammonia.

NOTE—Gloves refer to gauntlet-style of sufficient length to allow for cuffing, which provide thermal protection suitable for ammonia exposure.

2.2.35 Recommended exposure limit (REL)

Occupational exposure limits for airborne concentration of a contaminant to which an employee may be exposed over the duration specified and recommended by NIOSH.

2.2.36 Repair

Work necessary to restore a container, cylinder, or system to a safe and satisfactory operating condition provided there is, in all cases, no deviation from the original design.

NOTE—Repairs include the addition or replacement of pressure or nonpressure parts, which do not change the design temperature or pressure of the container, cylinder, or system.

2.2.37 Semitrailer

Any highway motor vehicle with or without motive power designed to be drawn by another motor vehicle and so constructed that some part of its weight and that of its load rests upon or is carried by the towing vehicle.

2.2.38 Short-term exposure limit (STEL)

15 minute Time-Weighted Average (TWA) exposure to an air contaminant that should not be exceeded at any time during a work day and should not be repeated more than four times a day.

NOTE—Exposures at the STEL should not occur at less than 60 minute intervals.

2.2.39 System

Assembly of equipment consisting essentially of the container or containers, hoses, appurtenances, pumps, compressors, and interconnecting piping.

2.2.40 Trailer

Any highway motor vehicle with or without motive power designed to be drawn by another motor vehicle and so constructed that no part of its weight except the towing device rests upon the towing vehicle.

NOTE—Normally called a “full trailer”.

2.2.41 Transfer, fill, and charge

These terms may be used interchangeably and mean movement of a quantity of ammonia from one container to another container or cylinder. This does not include feeding ammonia to an application device or process.

3 Safety

It is important that personnel understand the properties of ammonia and that they be thoroughly trained in safe practices for its storage and handling. Some of the important physical properties of ammonia are listed in Table 1.

3.1 Training

Prior to such activity, any person required to handle, transfer, transport, or otherwise work with ammonia shall be trained to understand the properties of ammonia, to become competent in safe operating practices, and to take appropriate actions in the event of a leak or an emergency. Federal, state, and/or local regulations as well as site specific requirements shall be followed for training content and frequency. Refresher training should be completed at least every 3 years.

3.2 Normal conditions

Any person making, breaking, or testing any ammonia connection, transferring ammonia, or performing maintenance or repair on an ammonia system under pressure, shall wear protective gloves and chemical splash goggles. A full face shield may be worn over the goggles. However, a face shield shall not be worn as a substitute for a primary eye protection device (goggles). Any person making, breaking, or testing any ammonia connection and transferring ammonia should do so in accordance with written operating procedures.

3.3 Emergency planning and response coordination

3.3.1 Training and personal protective equipment

Only personnel trained for and designated to handle emergencies should attempt to stop a leak. See 29 CFR 1910.120 [11]. Respiratory equipment of a type suitable for ammonia shall be worn. All persons not so equipped shall leave the affected area until the leak has been stopped. See Sections 8, 9 and 10 of CGA G-2, *Anhydrous Ammonia*, regarding recommended exposure, emergency, safety, security, and training procedures [22].

3.3.2 Planning and coordination

Sites handling anhydrous ammonia should preplan for emergencies. This planning should include local emergency planners and/or responders such as local fire departments, police/law enforcement, federal, state and/or local agencies and address release recognition, prevention, notification, coordination of response actions, and evacuation and/or shelter in place protections.

3.3.3 Notifications and reporting releases

3.3.3.1 Reporting

Unintentional releases over the RQ amount require certain immediate notifications which include, but are not limited to, the National Response Center (NRC), State Emergency Response Commission (SERC) and the Local Emergency Planning Committee (LEPC). The federal RQ for ammonia is 100 lb (45 kg) within a 24 hr time period. Some state regulations may have lower RQ values and/or more restrictive reporting requirements. There may be additional federal, state, and/or local agencies that require notifications.

Releases incidental to transportation are also subject to release reporting requirements under DOT and may require notification to the NRC. See sections 12.9 and 12.10 in CGA G-2 and 49 CFR 171.15 [22, 7].

For more information, see appropriate organizations' websites.

3.3.3.2 Notifications

Facilities that have 500 lb (227 kg) or more of ammonia on-site at any one time are required to initially notify SERC, LEPC, and the local fire department of this situation and identify a facility coordinator. For more information, see Title 40 of the U.S. *Code of Federal Regulations* (40 CFR) Part 355 [23].

3.3.4 Emergency plans

3.3.4.1 Facilities

Sites handling anhydrous ammonia should have an emergency action plan (EAP) or an emergency response plan (ERP). Elements of these plans can be found in 29 CFR 1910.38 for EAPs or 29 CFR 1910.120 (q) for ERPs [11]. Sites with anhydrous ammonia may also be subject to:

- OSHA's Process Safety Management (PSM) under 29 CFR 1910.119 [10];
- EPA's Risk Management Program (RMP) under 40 CFR 68 [23];
- DOT's Site Security under 49 CFR 172.800 [7]; and
- DHS' Chemical Facility Anti-Terrorism Standard (CFATS) under 6 CFR Part 27 [24].

These standards also have emergency planning requirements. Sites with less than threshold quantities may be subject to the OSHA and EPA General Duty Clause to maintain and operate a safe system.

3.3.4.2 Transportation

Transportation personnel should also be aware of what actions to take or not to take in the event of a release incidental to transportation. See 49 CFR 177.840 (I) [7].

3.4 Permanent storage installations

At a minimum, all permanent storage installations shall have on hand, readily accessible, and in a serviceable condition, the following equipment for personal protection and first aid purposes.

3.4.1

At indoor facilities, where ammonia is present and employees may be working, a minimum of two emergency escape-only respirators shall be provided at a prominent and marked location(s). The escape-only respirator and training shall be in compliance with 29 CFR 1910.134 [10]. For emergency response respiratory protection, see 3.3.1.

3.4.2

One pair of protective gloves impervious to ammonia for each of the maximum number of employees that may be storing, handling, transferring, or otherwise working with anhydrous ammonia at the same time, plus at least one spare pair of said protective gloves.

3.4.3

Chemical splash goggles or chemical splash goggles with full face shield to be worn over the device (goggles) for each of the maximum number of employees that may be involved with storing, handling, transferring, or otherwise working with anhydrous ammonia at the same time, plus at least one spare pair of said protective goggles.

NOTE—A full face shield, if used, shall only be worn as secondary eye protection supplementing the primary eye protection afforded by the chemical splash goggles. A face shield is not to be worn as a substitute for a proper primary eye protection device (goggles).

3.4.4

One pair of protective boots impervious to ammonia.

3.4.5

One protective slicker and/or protective pants and jacket, all impervious to ammonia.

3.4.6

Easily accessible emergency shower and a plumbed eye wash unit or at least 150 gal (570 L) of clean water in an open top container.

NOTE—It is recommended that the distance from the point of greatest potential exposure to ammonia to the emergency water supply should not exceed ten seconds travel time or 55 ft (16.8 m). Emergency water should be available at each transfer location at the facility and should not have any obstacles or impediments in the way of travel.

3.4.7

A reliable emergency communication system shall be easily accessible when employees are present, or transfer of ammonia occurs.

3.5 Cargo tanks

Each cargo tank transporting ammonia (except an implement of husbandry) shall carry and have readily accessible:

- For first aid purposes, at least 5 gal (20 L) of clean water in a container designed for flushing any area of the body contacted by ammonia;
- One pair of protective gloves impervious to ammonia;
- A full face piece air-purifying respirator with an ammonia canister and at least one spare canister or an escape-only respirator;
- Chemical splash goggles or chemical splash goggles with full face shield; and
- Emergency response information as required by DOT per 49 CFR 172.602 [7].

NOTE—A full face shield, if used, shall only be worn as secondary eye protection supplementing the primary eye protection afforded by the chemical splash goggles. A face shield is not to be worn as a substitute for a proper primary eye protection device (goggles).

3.6 Leaks in transportation equipment

If a leak occurs in transportation equipment and it is not practical to stop the leak, the driver should make every effort possible, including moving the vehicle to an isolated location downwind from populated communities or heavily traveled highways, to transfer the contents to another approved ammonia container. Local authorities should be notified and assistance requested as needed.

3.7 Cylinder and DOT portable tank installations

At ammonia installations comprising cylinders and DOT portable tanks, the employer shall provide ready access to a supply of clean, running water for emergency use or a self-contained eye wash unit with clean water, including provision for flushing of the eyes by an employee in the event of contact with ammonia.

3.8 Site security

Facilities should address and mitigate risks of a possible ammonia release from a wide range of threats such as vandalism, ammonia theft, sabotage, and terrorism, in order to protect the facility, employees and the surrounding community. See 6.7.1 and CGA P-50, *Standard for Site Security* for more information [25]. Facilities may be required to address site security under DOT and/or DHS regulations. This may entail a security vulnerability assessment (SVA) and a plan of action to assess the outcome of the SVA.

4 Use of water in emergencies

4.1 Human exposure

4.1.1

If liquid ammonia comes in contact with the skin or eyes, the affected area should be promptly and thoroughly flushed with clean water for at least 15 minutes or more (preferably 20 minutes to 30 minutes but not less than 15 minutes), with the eyes receiving first attention. Eyelids shall be held open during flushing. Skin irrigation should include the ears, chin, neck, armpits, and groin areas as appropriate. Contaminated clothing should be removed only after it is thawed. Do not use neutralizing solutions or ointments on the affected areas. Water used for flushing should be within a temperature range and at a controlled flow rate to avoid causing the patient additional injury or discomfort [21]. A physician should treat all cases of exposure to liquid ammonia. An ophthalmologist should be consulted immediately after flushing in the event of eye exposure.

4.1.2

If ammonia has entered the nose or throat and the person can swallow, have the person drink large quantities of water. Never give anything by mouth to an unconscious person.

4.2 Accidental release

In the event of an accidental release neither due to fire nor any other heat impingement, the concentration of ammonia vapor in the air can be reduced effectively by the use of adequate volumes of water applied through spray or fog nozzles. Control should be achieved from a safe location, outside the cloud, by directing water fog nozzles into the path of the ammonia plume in order to prevent the ammonia plume from moving away from the release area. See 3.3.

Water generally should not be directly applied to liquid ammonia spills as it generates heat and can increase vaporization. A water fog or spray can be used to control the vapor emanating from the pool.

In the event of a large vapor release from a container, the tank should not be sprayed with water. Under these circumstances, water fog or spray should be applied to the vapor.

4.3 Fire exposure

If an ammonia container is exposed to fire and cannot be moved, water fog or spray should be used to cool it. Use caution if flame impinges on the container because violent rupture of the container is possible. If the fire cannot be controlled and it appears the tank can rupture, the surrounding area should be evacuated to a safe distance in all directions.

4.4 Absorption in water

4.4.1

If ammonia is leaking from a container, the safest, practical means should be taken to stop or abate the leak. If the leak cannot be stopped, the liquid ammonia should be fed to the point of use or transferred to another suitable ammonia container and vapor ammonia captured or burned. Small quantities of ammonia from a leaking container can be absorbed by discharging into a vessel containing approximately 1 gal (4 L) of water for every 1 lb (0.5 kg) of ammonia. The ammonia should be injected into the water as near the bottom of the vessel as practical. If a hose is used to inject ammonia into water, the hose shall be weighted or secured so that the end of the hose will remain near the bottom of the vessel. An approved sparging device is recommended, if available.

4.4.2

Runoff of ammonia contaminated water into drains such as storm or sanitary, streams, or other bodies of water should be avoided when possible. Contaminated water should be contained and collected, if possible, to prevent environmental consequences. Releases of ammonia shall be reported to regulatory authorities as may be appropriate and required by law.

5 Basic rules

This section applies to all sections of this standard unless otherwise noted.

5.1 Equipment and systems

5.1.1

The provisions of 5.2 shall not be construed as prohibiting the continued use or reinstallation of containers constructed and maintained in accordance with the 1949, 1950, 1952, 1956, 1959, 1965, 1968, 1971, 1974, 1977, 1980, 1983, 1986, 1989, 1992, 1995, and 1998 editions of the ASME Code, or any revisions thereof, in effect at the time of fabrication. Reinstalled stationary pressure vessels of 10 000 gal minimum water capacity shall be subject to the following.

5.1.1.1

Any pressure vessel used as a storage tank shall have been registered with the National Board, or in lieu of National Board Registration, shall have available, direct from the manufacturer, an ASME manufacturer's data report or be subject to testing per the requirements of 5.1.1.5.

5.1.1.2

Any pressure vessel used as a storage tank shall have either a 250 psi (1724 kPa) maximum allowable working pressure (MAWP) or shall have been rerated for a 250 psi (1724 kPa) MAWP in full accordance with the *National Board Inspection Code* (NBIC) including, "Authorized Inspection".

5.1.1.3

Any pressure vessel used as a storage tank shall have:

- been stress relieved during fabrication in accordance with the code in effect at the time of fabrication;
- cold-formed heads that have been stress relieved; or
- been fabricated with hot-formed heads.

If the code in effect at the time of fabrication did not require one of the previous forms of heat treatment after fabrication, the vessel shall be subject to testing per the requirements of 5.1.1.5.

5.1.1.4

In addition to a fully-legible data plate, an ASME manufacturer's data report, including any applicable ASME manufacturer's partial data report, obtainable directly from the National Board, or in lieu of National Board Registration, ASME manufacturer's data report(s) obtainable directly from the manufacturer may be used by the AHJ to verify the pressure vessel identity (including its data plate information) through conformity with its specifications, to verify 5.1.1.1 through 5.1.1.3, and to detect post fabrication welding to the pressure vessel.

5.1.1.5

When testing is required by 5.1.1.1 or 5.1.1.3, it shall be performed before ammonia is introduced, and shall consist of:

- Nondestructive testing for weld defects [22];
- Nondestructive testing for weld defects within the heat-affected zones shall be required for at least 25% of vessel welds with emphasis on longitudinal welds. If indication of stress corrosion cracking is found, further testing of up to 100% of the welds is required;

- Storage containers with manways shall be examined internally by means of the wet fluorescent magnetic particle testing method. Persons performing magnetic particle testing and interpreting the results thereof shall be experienced and qualified in the proper procedures. See Section V of the ASME Code, *Nondestructive Examination* and see CGA P-26, *Guidelines for Inspection and Repair of MC-330 and MC-331 Anhydrous Ammonia Cargo Tanks*, for information regarding recommended equipment, inspection and repair procedures, and safe tank entry procedures [18, 26]. Alternate recognized evaluation techniques such as acoustic emission and fracture mechanics analysis may be substituted for internal inspection. See 6.5 of API 510, *Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair, and Alteration* for guidance [27]. Re-examination of such containers should be repeated at not more than 10 year intervals, except that an inspection frequency of more or less than 10 years may be assigned upon a vessel-specific basis through the use of a risk-based inspection (RBI) assessment performed in accordance with API RP 580, *Risk-Based Inspection* and API RP 581, *Risk-Based Inspection Technology* procedures by a qualified organization [28, 29]. The RBI recommendation shall be submitted in writing by the qualified organization. Acceptance-rejection criteria shall be in accordance with ASME Code Section VIII [18]; and
- Thickness testing [22]:
 - Thickness testing is required to confirm the minimum wall thickness of the shell and both heads to maintain a 250 psi (1724 kPa) rating
 - Corroded or abraded areas in the shell or heads of a container shall be thickness tested using suitable equipment and procedures. It is suggested that thickness measurements be made using an ultrasonic device capable of accurately measuring thickness to within at least 0.002 in (0.051 mm) and operated by a qualified person trained and skilled in procedures recommended by the equipment manufacturer. Indications below the minimum wall thickness shall be rejected.

5.1.1.6

The inspection company shall provide a written report detailing the results of the tests per 5.1.1.5, including indications that do not meet the acceptance criteria in 5.1.1.5. Storage containers with rejected indications from the tests in 5.1.1.5 shall not be placed into ammonia service unless suitable repairs and tests are performed. See the NBIC [19]. Prospected buyers of any storage tank tested in accordance with 5.1.1.5 shall be provided with a copy of all test reports.

5.1.2

Systems and components that were fabricated, installed, and maintained in accordance with the American National Standard K61.1, *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*, CGA G-2.1, *Standards for the Storage and Handling of Anhydrous Ammonia and Ammonia Solutions*, or The Agricultural Nitrogen Institute Standard M-1, *Standard for Storage and Handling of Agricultural Ammonia*, in effect at the time of installation, may be acceptable for continued use [30, 31, 32].³ Facilities with existing systems and components designed and constructed in accordance with earlier versions of the previously cited codes, standards, or practices that are no longer current, should determine and document that the equipment is safe to continue to use, taking into consideration risk reduction and physical and legal constraints.

Facilities with such systems and components are encouraged to conform to the current standard.

5.2 Requirements for new construction and original test, repair, and alterations of containers (including DOT portable tanks), other than refrigerated storage tanks

For refrigerated storage tanks, see 7.1.

5.2.1

Containers used with systems covered in Sections 6, 9, 11, and 12 shall be made of steel or other material compatible with ammonia and tested in accordance with the current ASME Code. An exception to the

³ These standards are no longer published.