



Storage and Handling of Anhydrous Ammonia — OSHA Standard 1910.111 ¹

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The Impact of Safety on Florida Agriculture

Florida agriculture, including forestry and fishing, made an annual economic impact of \$98 billion in 2004. More than 390,000 workers are directly employed in these industries in Florida, and another 380,000 people are employed in activities related to agriculture (Hodges 2006). The state's agricultural enterprises range from large citrus, vegetable and cattle operations to small family-operated farms.

In spite of the popular images of agriculture, it is a highly mechanized, industrial profession with one of the highest injury and death rates among U.S. industries. The last study of death rates in Florida agriculture (Liller 2000) found 240 deaths from 1989 to 1998. In 2005, the Bureau of Labor Statistics (BLS 2005a), reported that death due to injury in agriculture was 31.4 deaths per 100,000 full-time workers, which was the highest rate among all major occupational groups and an increase of 14% over 2004. Also in 2005, the Bureau of Labor Statistics reported 6,100 injuries per 100,000 full-time workers (BLS 2005b).

Safety in Florida agriculture is challenging because:

- the state's agricultural enterprises are diverse,
- safety knowledge among workers varies,
- manual labor is used extensively,
- the climate creates year-round heat stress.

Therefore, it is vital to assist the public in learning about OSHA documents related to agriculture. More information about the OSHA Standards and agricultural safety is available at the following Web sites:

- Florida AgSafe: <<http://www.flagsafe.ufl.edu>>
- OSHA Regulations: <<http://www.osha.gov/comp-links.html>>
- National Agricultural Safety Database: <<http://www.cdc.gov/nasd/>>

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Overview

This document, a condensation of Section 1910.111 of the Occupational Safety and Health Act (29 CFR), is not intended to be totally inclusive but rather to highlight the information and requirements in the complete OSHA standard that owners and managers of all agricultural businesses should understand. Refer to the OSHA Web site given above for the complete standard and for court interpretations of the standard.

Contents of OSHA Standard 1910.111

- Section 1910.111(a) — General Topics
- Section 1910.111(b) — Basic Rules
- Section 1910.111(c) — Systems Utilizing Stationary, Nonrefrigerated Storage Containers
- Section 1910.111(d) — Refrigerated Storage Systems
- Section 1910.111(e) — Systems Utilizing Portable DOT Containers
- Section 1910.111(f) — Tank Motor Vehicles for the Transportation of Ammonia
- Section 1910.111(g) — Systems Mounted on Farm Vehicles Other Than for the Application of Ammonia
- Section 1910.111(h) — Systems Mounted on Farm Vehicles for the Application of Ammonia

NOTE: Some sections of OSHA standards are labeled "Reserved." This label implies either that information has been deleted from the previous version of the standard or that additions to the standard are anticipated. Because standards often reference other standards, it is important that paragraph numbers remain consistent.

Secton 1910.111(a) — General Topics

1910.111(a)(1) — Scope

(i)-- This standard is intended to apply to the design, construction, location, installation, and operation of

anhydrous ammonia systems including refrigerated ammonia storage systems.

(ii)-- This standard does not apply to: Ammonia manufacturing plants. Refrigeration plants where ammonia is used solely as a refrigerant.

1910.111(a)(2) — Definitions

Terms used in this section are defined as follows:

Appurtenances — All devices such as pumps, compressors, safety-relief devices, liquid-level gaging devices, valves and pressure gages.

Capacity — Total volume of the container in standard U.S. gallons.

Cylinder — A container of 1,000 pounds of water capacity or less constructed in accordance with Department of Transportation specifications.

Code — The Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels of the American Society of Mechanical Engineers (ASME) — 1968.

Container — Includes all vessels, tanks, cylinders, or spheres used for transportation, storage, or application of anhydrous ammonia.

DOT — U.S. Department of Transportation.

DOT specifications — Regulations of the Department of Transportation published in 49 CFR Chapter I.

Design pressure — Identical to the term "Maximum Allowable Working Pressure" used in the Code.

Farm vehicle — (implement of husbandry) A vehicle for use on a farm on which is mounted a container of not over 1,200 gallons water capacity.

Filling density — The percent ratio of the weight of the gas in a container to the weight of water at 60 deg. F. that the container will hold.

Gas — Anhydrous ammonia in either the gaseous or liquefied state.

Gas masks — Gas masks must be approved by the National Institute for Occupational Safety and Health (NIOSH) under 42 CFR part 84 for use with anhydrous ammonia.

Section 1910.111(b) — Basic Rules

This discussion applies to all paragraphs of this section unless otherwise noted.

1910.111(b)(1) — Approval of Equipment and Systems. Each appurtenance shall be approved in accordance with paragraphs (b)(1)(i), (ii), (iii), or (iv) of this section.

(i)— It was installed before February 8, 1973, and was approved, tested, and installed in accordance with either the provisions of the American National Standard for the Storage and Handling of Anhydrous Ammonia, K61.1, or the Fertilizer Institute Standards for the Storage and Handling of Agricultural Anhydrous Ammonia, M-1, (both of which are incorporated by reference as specified in Sec. 1910.6) in effect at the time of installation; or

(ii)— It is accepted, or certified, or listed, or labeled, or otherwise determined to be safe by a nationally recognized testing laboratory; or

(iii)— It is a type which no nationally recognized testing laboratory does, or will undertake to, accept, certify, list, label, or determine to be safe; and such equipment is inspected or tested by any Federal, State, municipal, or other local authority responsible for enforcing occupational safety provisions of a Federal, State, municipal or other local law, code, or regulation pertaining to the storage, handling, transport, and use of anhydrous ammonia, and found to be in compliance with either the provisions of the American National Standard for the Storage and Handling of Anhydrous Ammonia, K61.1, or the Fertilizer Institute Standards for the Storage and Handling of Agricultural Anhydrous Ammonia, M-1, in effect at the time of installation; or

(iv)— It is a custom-designed and custom-built unit, which no nationally recognized testing laboratory, or Federal, State, municipal or local authority responsible for the enforcement of a Federal, State, municipal, or local law, code or regulation pertaining to the storage, transportation and use of anhydrous ammonia is willing to undertake to accept, certify, list, label or determine to be safe, and the employer has on file a document attesting to its safe condition following the conduct of appropriate tests. The

document shall be signed by a registered professional engineer or other person having special training or experience sufficient to permit him to form an opinion as to safety of the unit involved. The document shall set forth the test bases, test data and results, and also the qualifications of the certifying person.

(v)— For the purposes of this paragraph (b)(1), the word "listed" means that equipment is of a kind mentioned in a list which is published by a nationally recognized laboratory which makes periodic inspection of the production of such equipment, and states such equipment meets nationally recognized standards or has been tested and found safe for use in a specified manner. "Labeled" means there is attached to it a label, symbol, or other identifying mark of a nationally recognized testing laboratory which, makes periodic inspections of the production of such equipment, and whose labeling indicates compliance with nationally recognized standards or tests to determine safe use in a specified manner. "Certified" means it has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner, or is of a kind whose production is periodically inspected by a nationally recognized testing laboratory, and it bears a label, tag, or other record of certification.

(vi)— For the purposes of this paragraph (b)(1), refer to 1910.7 for definition of nationally recognized testing laboratory.

1910.111(b)(2) — Requirements for Construction, Original Test and Requalification of Nonrefrigerated Containers

(i)— Containers used with systems covered in (c), (f), (g), and (h) shall be constructed and tested in accordance with the Code except that construction under Table UW12 at a basic joint efficiency of under 80 percent is not authorized.

(ii)— Containers built according to the Code do not have to comply with Paragraphs UG125 to UG128 inclusive, and Paragraphs UG132 and UG133 of the Code.

(ii)— Containers exceeding 36 inches in diameter or 250 gallons water capacity shall be constructed to comply with one or more of the following:

- Containers shall be stress relieved after fabrication in accordance with the Code, or
- Cold-form heads when used, shall be stress relieved, or
- Hot-formed heads shall be used.

(iv)— Welding to the shell, head, or any other part of the container subject to internal pressure shall be done in compliance with the Code. Other welding is permitted only on saddle plates, lugs, or brackets attached to the container by the container manufacturer.

(v)— Containers used with systems covered in 1910.111(e) shall be constructed and tested in accordance with the DOT specifications.

(vi)— The provisions of subdivision (i) of 1910.111(b)(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, and 1962 editions of the Code or any revisions thereof in effect at the time of fabrication.

1910.111(b)(3) — Marking Nonrefrigerated Containers

(i) — System nameplates, when required, shall be permanently attached to the system so as to be readily accessible for inspection and shall include markings as prescribed in subdivision (ii) of this section.

(ii) — Each container or system covered in section 1910.111 (c), (f), (g), and (h) of this section shall be marked as specified in the following subsections:

- (a) With a notation "Anhydrous Ammonia."
- (b) With a marking identifying compliance with the rules of the Code under which the container is constructed. Under ground: Container and system nameplate. Above ground: Container.
- (c) With a notation whether the system is designed for underground or aboveground installation or both.

(d) With the name and address of the supplier of the system or the trade name of the system and with the date of fabrication. Underground and aboveground: System nameplate.

(e) With the water capacity of the container in pounds at 60 deg. F. or gallons, U.S. Standard. Underground: Container and system nameplate. Aboveground: Container.

(f) With the design pressure in pounds per square inch. Underground: Container and system nameplate. Aboveground: Container.

(g) With the wall thickness of the shell and heads. Underground: Container and system nameplate. Aboveground: Container.

(h) With marking indicating the maximum level to which the container may be filled with liquid anhydrous ammonia at temperatures between 20 deg. F. and 130 deg. F. except on containers provided with fixed level indicators, such as fixed length dip tubes, or containers that are filled with weight. Markings shall be in increments of not more than 20 deg. F. Above ground and under ground: System nameplate or on liquid-level gaging device.

(i) With the total outside surface area of the container in square feet. Underground: System nameplate. Aboveground: No requirement.

(j) Marking specified on the container shall be on the container itself or on a nameplate permanently attached to it.

1910.111(b)(4) — Marking Refrigerated Containers.

Each refrigerated container shall be marked with nameplate on the outer covering in an accessible place as specified in the following:

(i) — With the notation, "Anhydrous Ammonia."

(ii) — With the name and address of the builder and the date of fabrication.

(iii) — With the water capacity of the container in gallons, U.S. Standard.

(iv) — With the design pressure.

(v) — With the minimum temperature in degrees Fahrenheit for which the container was designed.

(vi) — The maximum allowable water level to which the container may be filled for test purposes.

(vii) — With the density of the product in pounds per cubic foot for which the container was designed.

(viii) — With the maximum level to which the container may be filled with liquid anhydrous ammonia.

1910.111(b)(5) — Location of Containers

(i) — Consideration shall be given to the physiological effects of ammonia as well as to adjacent fire hazards in selecting the location for a storage container. Containers shall be located outside of buildings or in buildings or sections thereof especially provided for this purpose.

(ii) — Permanent storage containers shall be located at least 50 feet from a dug well or other sources of potable water supply, unless the container is a part of a water-treatment installation.

(iii) — [Reserved]

(iv) — [Reserved]

(v) — Storage areas shall be kept free of readily ignitable materials such as waste, weeds, and long dry grass.

1910.111(b)(6) — Container Appurtenances

(i) — All appurtenances shall be designed for not less than the maximum working pressure of that portion of the system on which they are installed. All appurtenances shall be fabricated from materials proved suitable for anhydrous ammonia service.

(ii) — All connections to containers except safety-relief devices, gaging devices, or those fitted with No. 54 drill-size orifice shall have shutoff valves located as close to the container as practicable.

(iii) — Excess flow valves where required by these standards shall close automatically at the rated flows of vapor or liquid as specified by the manufacturer. The connections and line including valves and fittings being protected by an excess flow valve shall have a greater capacity than the rated flow of the excess flow valve so that the valve will close in case of failure of the line or fittings.

(iv) — Liquid-level gaging devices that require bleeding of the product to the atmosphere and which are so constructed that outward flow will not exceed that passed by a No. 54 drill-size opening need not be equipped with excess flow valves.

(v) — Openings from the container or through fittings attached directly on the container to which pressure gage connections are made need not be equipped with excess flow valves if such openings are not larger than No. 54 drill size.

(vi) — Excess flow and back pressure check valves where required by the standards in this section shall be located inside of the container or at a point outside as close as practicable to where the line enters the container. In the latter case installation shall be made in such manner that any undue strain beyond the excess flow or back pressure check valve will not cause breakage between the container and the valve.

(vii) — Excess flow valves shall be designed with a bypass, not to exceed a No. 60 drill-size opening to allow equalization of pressures.

(viii) — All excess flow valves shall be plainly and permanently marked with the name or trademark of the manufacturer, the catalog number, and the rated capacity.

1910.111(b)(7) — Piping, Tubing, and Fittings

(i) — All piping, tubing, and fittings shall be made of material suitable for anhydrous ammonia service.

(ii) — All piping, tubing, and fittings shall be designed for a pressure not less than the maximum pressure to which they may be subjected in service.

(iii) — All refrigerated piping shall conform to the Refrigeration Piping Code, American National Standards Institute, B31.5-1966 with addenda B31.1a-1968, which is incorporated by reference as specified in Sec. 1910.6, as it applies to ammonia.

(iv) — Piping used on non-refrigerated systems shall be at least American Society for Testing and Materials (ASTM) — A-53-69 Grade B Electric Resistance Welded and Electric Flash Welded Pipe, which is incorporated by reference as specified in Sec. 1910.6, or equal. Such pipe shall be at least

schedule 40 when joints are welded, or welded and flanged. Such pipe shall be at least schedule 80 when joints are threaded. Threaded connections shall not be back-welded. Brass, copper, or galvanized steel pipe shall not be used.

(v) — Tubing made of brass, copper, or other material subject to attack by ammonia shall not be used.

(vi) — Cast iron fittings shall not be used but this shall not prohibit the use of fittings made specifically for ammonia service of malleable, nodular, or high strength gray iron meeting American Society for Testing and Materials (ASTM) A47-68, ASTM 395-68, or ASTM A126-66 Class B or C, all of which are incorporated by reference as specified in Sec. 1910.6.

(vii) — Joint compounds shall be resistant to ammonia.

1910.111(b)(8) — Hose Specifications

(i) — Hose used in ammonia service shall conform to the joint Agricultural Ammonia Institute - Rubber Manufacturers Association Specifications for Anhydrous Ammonia Hose.

(ii) — Hose subject to container pressure shall be designed for a minimum working pressure of 350 p.s.i.g. and a minimum burst pressure of 1,750 p.s.i.g. Hose assemblies, when made up, shall be capable of withstanding a test pressure of 500 p.s.i.g.

(iii) — Hose and hose connections located on the low-pressure side of flow control of pressure-reducing valves shall be designed for a bursting pressure of not less than 5 times the pressure setting of the safety-relief devices protecting that portion of the system but not less than 125 p.s.i.g. All connections shall be so designed and constructed that there will be no leakage when connected.

(iv) — Where hose is to be used for transferring liquid from one container to another, "wet" hose is recommended. Such hose shall be equipped with approved shutoff valves at the discharge end. Provision shall be made to prevent excessive pressure in the hose.

(v) — On all hose one-half inch outside diameter and larger, used for the transfer of anhydrous ammonia liquid or vapor, there shall be etched, cast, or impressed at 5-foot intervals the following information: *Anhydrous Ammonia XXX p.s.i.g. (maximum working pressure), manufacturer's name or trademark, year of manufacture.*

In lieu of this requirement the same information may be contained on a nameplate permanently attached to the hose.

1910.111(b)(9) — Safety-Relief Devices

(i) — Every container used in systems covered by 1910.111 (c), (f), (g), and (h) shall be provided with one or more safety-relief valves of the spring-loaded or equivalent type. The discharge from safety-relief valves shall be vented away from the container upward and unobstructed to the atmosphere. All relief-valve discharge openings shall have suitable rain caps that will allow free discharge of the vapor and prevent entrance of water. Provision shall be made for draining condensate which may accumulate. The rate of the discharge shall be in accordance with the provisions of Table H-36.

(ii) — Container safety-relief valves shall be set to start-to-discharge according to Table 2, with relation to the design pressure of the container.

(iii) — Safety-relief devices used in systems covered by 1910.111 (c), (f), (g), and (h) shall be constructed to discharge at not less than the rates required in 1910.111 (b)(9)(i) before the pressure is in excess of 120 percent [not including the 10 percent tolerance referred to in 1910.111 (b)(9)(ii)] of the maximum permitted start-to-discharge pressure setting of the device.

(iv) — Safety-relief valves shall be so arranged that the possibility of tampering will be minimized. If the pressure setting adjustment is external, the relief valves shall be provided with means for sealing the adjustment.

(v) — Shutoff valves shall not be installed between the safety-relief valves and the container; except, that a shutoff valve may be used where the arrangement of this valve is such as always to afford full required capacity flow through the relief valves.

(vi) — Safety-relief valves shall have direct communication with the vapor space of the container.

(vii) — Each container safety-relief valve used with systems covered by 1910.111 (c), (f), (g), and (h) of this section shall be plainly and permanently marked with the symbol "NH₃" or "AA"; with the pressure in pounds-per-square-inch gage at which the valve is set to start-to-discharge; with the actual rate of discharge of the valve at its full open position in cubic feet per minute of air at 60 deg. F. and atmospheric pressure; and with the manufacturer's name and catalog number. Example: "NH₃ 250-4050 Air" indicates that the valve is suitable for use on an anhydrous ammonia container, is set to start-to-discharge at a pressure of 250 p.s.i.g., and that its rate of discharge at full open position [subdivisions (ii) and (iii) of this section] is 4,050 cubic feet per minute of air.

(viii) — The flow capacity of the relief valve shall not be restricted by any connection to it on either the upstream or downstream side.

(ix) — A hydrostatic relief valve shall be installed between each pair of valves in the liquid ammonia piping or hose where liquid may be trapped so as to relieve into the atmosphere at a safe location.

1910.111(b)(10) — General

(i) — [Reserved]

(ii) — Stationary storage installations must have at least two suitable gas masks in readily-accessible locations. Full-face masks with ammonia canisters that have been approved by NIOSH under 42 CFR part 84 are suitable for emergency action involving most anhydrous ammonia leaks, particularly leaks that occur outdoors. For respiratory protection in concentrated ammonia atmospheres, a self-contained breathing apparatus is required.

(iii) — Stationary storage installations shall have an easily accessible shower or a 50-gallon drum of water.

(iv) — Each vehicle transporting ammonia in bulk except farm applicator vehicles shall carry a container of at least 5 gallons of water and shall be equipped with a full face mask.

1910.111(b)(11) — Charging of Containers

(i) — The filling densities for containers that are not refrigerated shall not exceed the values given in Table 3.

(ii) — Aboveground uninsulated containers may be charged 87.5 percent by volume provided the temperature of the anhydrous ammonia being charged is determined to be not lower than 30 deg. F. or provided the charging of the container is stopped at the first indication of frost or ice formation on its outside surface and is not resumed until such frost or ice has disappeared.

1910.111(b)(12) — Transfer of Liquids

(i) — Anhydrous ammonia shall always be at a temperature suitable for the material of construction and the design of the receiving container.

(ii) — The employer shall require the continuous presence of an attendant in the vicinity of the operation during such time as ammonia is being transferred.

(iii) — Containers shall be charged or used only upon authorization of the owner.

(iv) — Containers shall be gaged and charged only in the open atmosphere or in buildings or areas thereof provided for that purpose.

(v) — Pumps used for transferring ammonia shall be those manufactured for that purpose.

- Pumps shall be designed for at least 250 p.s.i.g. working pressure.
- Positive displacement pumps shall have, installed off the discharged port, a constant differential relief valve discharging into the suction port of the pump through a line of sufficient size to carry the full capacity of the pump at relief valve setting, which setting and installation shall be according to the pump manufacturer's recommendations.
- On the discharge side of the pump, before the relief valve line, there shall be installed a pressure gage graduated from 0 to 400 p.s.i.

- Plant piping shall contain shutoff valves located as close as practical to pump connections.

(vi) — Compressors used for transferring or refrigerating ammonia shall be recommended for ammonia service by the manufacturer.

- Compressors shall be designed for at least 250 p.s.i.g. working pressure.
- Plant piping shall contain shutoff valves located as close as practical to compressor connections.
- A relief valve large enough to discharge the full capacity of the compressor shall be connected to the discharge before any shutoff valve.
- Compressors shall have pressure gages at suction and discharge graduated to at least one and one-half times the maximum pressure that can be developed.
- Adequate means, such as drainable liquid trap, shall be provided on the compressor suction to minimize the entry of liquid into the compressor.

(vii) — Loading and unloading systems shall be protected by suitable devices to prevent emptying of the storage container or the container being loaded or unloaded in the event of severance of the hose. Backflow check valves or properly sized excess flow valves shall be installed where necessary to provide such protection. In the event that such valves are not practical, remotely operated shutoff valves may be installed.

1910.111(b)(13) — Tank Car Unloading Points and Operations

- (i) — Provisions for unloading tank cars shall conform to the applicable recommendations contained in the DOT regulations.
- (ii) — The employer shall insure that unloading operations are performed by reliable persons properly instructed and given the authority to monitor careful compliance with all applicable procedures.

(iii) — Caution signs shall be so placed on the track or car as to give necessary warning to persons approaching the car from open end or ends of siding and shall be left up until after the car is unloaded and disconnected from discharge connections. Signs shall be of metal or other suitable material, at least 12 by 15 inches in size and bear the words "STOP - Tank Car Connected" or "STOP - Men at Work" the word, "STOP," being in letters at least 4 inches high and the other words in letters at least 2 inches high.

(iv) — The track of a tank car siding shall be substantially level.

(v) — Brakes shall be set and wheels blocked on all cars being unloaded.

1910.111(b)(14) — Liquid-Level Gaging Device

(i) — Each container except those filled by weight shall be equipped with an approved liquid-level gaging device. A thermometer well shall be provided in all containers not utilizing a fixed liquid-level gaging device.

(ii) — All gaging devices shall be arranged so that the maximum liquid level to which the container is filled is readily determined.

(iii) — Gaging devices that require bleeding of the product to the atmosphere such as the rotary tube, fixed tube, and slip tube devices shall be designed so that the maximum opening of the bleed valve is not larger than No. 54 drill size unless provided with an excess flow valve. (This requirement does not apply to farm vehicles used for the application of ammonia as covered in paragraph (h) of this section.)

(iv) — Gaging devices shall have a design pressure equal to or greater than the design pressure of the container on which they are installed.

(v) — Fixed tube liquid-level gages shall be designed and installed to indicate that level at which the container is filled to 85 percent of its water capacity in gallons.

(vi) — Gage glasses of the columnar type shall be restricted to stationary storage installations. They shall be equipped with shutoff valves having metallic handwheels, with excess-flow valves, and with extra

heavy glass adequately protected with a metal housing applied by the gage manufacturer. They shall be shielded against the direct rays of the sun.

1910.111(b)(15) — [Reserved]

1910.111(b)(16) — Electrical Equipment and Wiring

(i) — Electrical equipment and wiring for use in ammonia installations shall be general purpose or weather resistant as appropriate.

(ii) — Electrical systems shall be installed and maintained in accordance with subpart S of this part.

Section 1910.111(c) — Systems Utilizing Stationary, Nonrefrigerated Storage Containers

This section applies to stationary, nonrefrigerated storage installations utilizing containers other than those covered in 1910.111 (e). Section 1910.111(b) also applies here unless otherwise noted.

1910.111(c)(1) — Design Pressure and Construction of Containers. The minimum design pressure for nonrefrigerated containers shall be 250 p.s.i.g.

1910.111(c)(2) — Container Valves and Accessories, Filling and Discharge Connections

(i) — Each filling connection shall be provided with combination back-pressure check valve and excess-flow valve; one double or two single back-pressure check valves; or a positive shutoff valve in conjunction with either an internal back-pressure check valve or an internal excess flow valve.

(ii) — All liquid and vapor connections to containers except filling pipes, safety-relief connections, and liquid-level gaging and pressure gage connections provided with orifices not larger than No. 54 drill size as required in Section 1910.111 (b)(6)(iv) and (v) shall be equipped with excess-flow valves.

(iii) — Each storage container shall be provided with a pressure gage graduated from 0 to 400 p.s.i. Gages shall be designated for use in ammonia service.

(iv) — All containers shall be equipped with vapor return valves.

1910.111(c)(3) — Safety-Relief Devices

(i) — Every container shall be provided with one or more safety-relief valves of the spring-loaded or equivalent type in accordance with paragraph (b)(9) of this section.

(ii) — The rate of discharge of spring-loaded safety-relief valves installed on underground containers may be reduced to a minimum of 30 percent of the rate of discharge specified in Table H-36. Containers so protected shall not be uncovered after installation until the liquid ammonia has been removed. Containers which may contain liquid ammonia before being installed underground and before being completely covered with earth are to be considered aboveground containers when determining the rate of discharge requirements of the safety-relief valves.

(iii) — On underground installations where there is a probability of the manhole or housing becoming flooded, the discharge from vent lines shall be located above the high water level. All manholes or housings shall be provided with ventilated louvers or their equivalent, the area of such openings equaling or exceeding combined discharge areas of safety-relief valves and vent lines which discharge their content into the manhole housing.

(iv) — Vent pipes, when used, shall not be restricted or of smaller diameter than the relief-valve outlet connection.

(v) — If desired, vent pipes from two or more safety-relief devices located on the same unit, or similar lines from two or more different units may be run into a common discharge header, provided the capacity of such header is at least equal to the sum of the capacities of the individual discharge lines.

1910.111(c)(4) — Reinstallation of Containers

(i) — Containers once installed under ground shall not later be reinstalled above ground or under ground, unless they successfully withstand hydrostatic pressure retests at the pressure specified for the original hydrostatic test as required by the code under which constructed and show no evidence of serious corrosion.

(ii) — Where containers are reinstalled above ground, safety devices or gaging devices shall comply with Section 1910.111 (b)(9) of this section and this section respectively for aboveground containers.

1910.111(c)(5) — Installation of Storage Containers

(i) — Containers installed above ground, except as provided in Subparagraph (v) of this section shall be provided with substantial concrete or masonry supports, or structural steel supports on firm concrete or masonry foundations. All foundations shall extend below the frost line.

(ii) — Horizontal aboveground containers shall be so mounted on foundations as to permit expansion and contraction. Every container shall be supported to prevent the concentration of excessive loads on the supporting portion of the shell. That portion of the container in contact with foundations or saddles shall be protected against corrosion.

(iii) — Containers installed under ground shall be so placed that the top of the container is below the frost line and in no case less than 2 feet below the surface of the ground. Should ground conditions make compliance with these requirements impracticable, installation shall be made otherwise to prevent physical damage. It will not be necessary to cover the portion of the container to which manhole and other connections are affixed. When necessary to prevent floating, containers shall be securely anchored or weighted.

(iv) — Underground containers shall be set on a firm foundation (firm earth may be used) and surrounded with earth or sand well tamped in place. The container, prior to being placed under ground, shall be given a corrosion resisting protective coating. The container thus coated shall be so lowered into place as to prevent abrasion or other damage to the coating.

(v) — Containers with foundations attached (portable or semiportable tank containers with suitable steel "runners" or "skids" and commonly known in the industry as "skid tanks") shall be designed and constructed in accordance with Section 1910.111 (c)(1).

(vi) — Secure anchorage or adequate pier height shall be provided against container flotation wherever sufficiently high flood water might occur.

(vii) — The distance between underground containers of over 2,000 gallons capacity shall be at least 5 feet.

1910.111(c)(6) — Protection of Appurtenances

(i) — Valves, regulating, gaging, and other appurtenances shall be protected against tampering and physical damage. Such appurtenances shall also be protected during transit of containers.

(ii) — All connections to underground containers shall be located within a dome, housing, or manhole and with access thereto by means of a substantial cover.

1910.111(c)(7) — Damage from Vehicles. Precaution shall be taken against damage to ammonia systems from vehicles.

Section 1910.111(d) — Refrigerated Storage Systems

This section applies to systems utilizing containers with the storage of anhydrous ammonia under refrigerated conditions. All applicable rules of section 1910.111 (b) also apply here unless otherwise noted.

1910.111(d)(1) — Design of Containers

(i) — The design temperature shall be the minimum temperature to which the container will be refrigerated.

(ii) — Containers with a design pressure exceeding 15 p.s.i.g. shall be constructed in accordance with 1910.111 (b)(2), and the materials shall be selected from those listed in API Standard 620, Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks, Fourth

Edition, 1970, Tables 2.02, R2.2, R2.2(A), R2.2.1, or R2.3, which are incorporated by reference as specified in Sec. 1910.6.

(iii) — Containers with a design pressure of 15 p.s.i.g. and less shall be constructed in accordance with the applicable requirements of API Standard 620 including its Appendix R.

(iv) — When austenitic steels or nonferrous materials are used, the Code shall be used as a guide in the selection of materials for use at the design temperature.

(v) — The filling density for refrigerated storage containers shall be such that the container will not be liquid full at a liquid temperature corresponding to the vapor pressure at the start-to-discharge pressure setting of the safety-relief valve.

1910.111(d)(2) — Installation of Refrigerated Storage Containers

(i) — Containers shall be supported on suitable noncombustible foundations designed to accommodate the type of container being used.

(ii) — Adequate protection against flotation or other water damage shall be provided wherever high flood water might occur.

(iii) — Containers for product storage at less than 32 deg. F. shall be supported in such a way, or heat shall be supplied, to prevent the effects of freezing and consequent frost heaving.

1910.111(d)(3) — Shutoff Valves. When operating conditions make it advisable, a check valve shall be installed on the fill connection and a remotely operated shutoff valve on other connections located below the maximum liquid level.

1910.111(d)(4) — Safety-Relief Devices

(i) — Safety-relief valves shall be set to start-to-discharge at a pressure not in excess of the design pressure of the container and shall have a total relieving capacity sufficient to prevent a maximum pressure in the container of more than 120 percent of the design pressure. Relief valves for refrigerated storage containers shall be self-contained

spring-loaded, weight-loaded, or self-contained pilot-operated type.

(ii) — The total relieving capacity shall be the larger of:

- Possible refrigeration system upset such as (1) cooling water failure, (2) power failure, (3) instrument air or instrument failure, (4) mechanical failure of any equipment, (5) excessive pumping rates.
- Fire exposure determined in accordance with Compressed Gas Association (CGA) S-1, Part 3, Safety Relief Device Standards for Compressed Gas Storage Containers, 1959, which is incorporated by reference as specified in Sec. 1910.6, except that "A" shall be the total exposed surface area in square feet up to 25 foot above grade or to the equator of the storage container if it is a sphere, whichever is greater. If the relieving capacity required for fire exposure is greater than that required by (a) of this subdivision, the additional capacity may be provided by weak roof to shell seams in containers operating at essentially atmospheric pressure and having an inherently weak roof-to-shell seam. The weak roof-to-shell seam is not to be considered as providing any of the capacity required in (a) of this subdivision.

(iii) — If vent lines are installed to conduct the vapors from the relief valve, the back pressure under full relieving conditions shall not exceed 50 percent of the start-to-discharge pressure for pressure balanced valves or 10 percent of the start-to-discharge pressure for conventional valves. The vent lines shall be installed to prevent accumulation of liquid in the lines.

(iv) — The valve or valve installation shall provide weather protection.

(v) — Atmospheric storage shall be provided with vacuum breakers. Ammonia gas, nitrogen, methane, or other inert gases can be used to provide a pad.

1910.111(d)(5) — Protection of Container Appurtenances. Appurtenances shall be protected against tampering and physical damage.

1910.111(d)(6) — Reinstallation of Refrigerated Storage Containers. Containers of such size as to require field fabrication shall, when moved and reinstalled, be reconstructed and reinspected in complete accordance with the requirements under which they were constructed. The containers shall be subjected to a pressure retest and if rerating is necessary, rerating shall be in accordance with applicable requirements.

1910.111(d)(7) — Damage from Vehicles. Precaution shall be taken against damage from vehicles.

1910.111(d)(8) — Refrigeration Load and Equipment

(i) — The total refrigeration load shall be computed as the sum of the following:

- (a) Load imposed by heat flow into the container caused by the temperature differential between design ambient temperature and storage temperature.
- (b) Load imposed by heat flow into the container caused by maximum sun radiation.
- (c) Maximum load imposed by filling the container with ammonia warmer than the design storage temperature.

(ii) — More than one storage container may be handled by the same refrigeration system.

1910.111(d)(9) — Compressors

(i) — A minimum of two compressors shall be provided either of which shall be of sufficient size to handle the loads listed in 1910.111 (d)(8)(i)(a) and (b). Where more than two compressors are provided, minimum standby equipment equal to the largest normally operating equipment shall be installed. Filling compressors may be used as standby equipment for holding compressors.

(ii) — Compressors shall be sized to operate with a suction pressure at least 10 percent below the minimum setting of the safety valve(s) on the storage container and shall withstand a suction pressure at least equal to 120 percent of the design pressure of the container.

1910.111(d)(10) — Compressor Drives

(i) — Each compressor shall have its individual driving unit.

(ii) — An emergency source of power of sufficient capacity to handle the loads listed in 1910.111 (d)(8), subsections (i)' (a) and (b) shall be provided unless facilities are available to safely dispose of vented vapors while the refrigeration system is not operating.

1910.111(d)(11) — Automatic Control Equipment

(i) — The refrigeration system shall be arranged with suitable controls to govern the compressor operation in accordance with the load as evidenced by the pressure in the container(s).

(ii) — An emergency alarm system shall be installed to function in the event the pressure in the container(s) rises to the maximum allowable operating pressure.

(iii) — An emergency alarm and shutoff shall be located in the condenser system to respond to excess discharge pressure caused by failure of the cooling medium.

(iv) — All automatic controls shall be installed in a manner to preclude operation of alternate compressors unless the controls will function with the alternate compressors.

1910.111(d)(12) — Separators for Compressors

(i) — An entrainment separator of suitable size and design pressure shall be installed in the compressor suction line of lubricated compression. The separator shall be equipped with a drain and gaging device.

1910.111(d)(13) — Condensers. The condenser system may be cooled by air or water or both. The condenser shall be designed for at least 250 p.s.i.g. Provision shall be made for purging noncondensibles either manually or automatically.

1910.111(d)(14) — Receiver and Liquid Drain. A receiver shall be provided with a liquid-level control to discharge the liquid ammonia to storage. The receiver shall be designed for at least 250 p.s.i.g. and be equipped with the necessary connections, safety valves, and gaging device.

1910.111(d)(15) — Insulation. Refrigerated containers and pipelines which are insulated shall be covered with a material of suitable quality and thickness for the temperatures encountered.

Insulation shall be suitably supported and protected against the weather. Weatherproofing shall be of a type which will not support flame propagation.

Section 1910.111(e) — Systems Utilizing Portable DOT Containers

1910.111(e)(1) — Conformance. Cylinders shall comply with DOT specifications and shall be maintained, filled, packaged, marked, labeled, and shipped to comply with 49 CFR Chapter I and Marking Portable Compressed Gas Containers to Identify the Material Contained, ANSI Z48.1-1954 (R1970), which is incorporated by reference as specified in Sec. 1910.6.

1910.111(e)(2) — Storage. Cylinders shall be stored in an area free from ignitable debris and in such manner as to prevent external corrosion. Storage may be indoors or outdoors.

1910.111(e)(3) — Heat Protection. Cylinders filled in accordance with DOT regulations will become liquid full at 145 deg. F. Cylinders shall be protected from heat sources such as radiant flame and steampipes. Heat shall not be applied directly to cylinders to raise the pressure.

1910.111(e)(4) — Protection. Cylinders shall be stored in such manner as to protect them from moving vehicles or external damage.

1910.111(e)(5) — Valve Cap. Any cylinder which is designed to have a valve protection cap shall have the cap securely in place when the cylinder is not in service.

Section 1910.111(f) — Tank Motor Vehicles for the Transportation of Ammonia

1910.111(f)(1) — This paragraph applies to containers and pertinent equipment mounted on tank motor vehicles including semitrailers and full trailers used for the transportation of ammonia. This paragraph does not apply to farm vehicles. For

requirements covering farm vehicles, refer to 1910.111 (g) and (h) section 1910.111 (b) applied to this paragraph unless otherwise noted. Containers and pertinent equipment for tank motor vehicles for the transportation of anhydrous ammonia, in addition to complying with the requirements of this section, shall also comply with the requirements of DOT.

1910.111(f)(2) — Design Pressure and Construction of Containers

(i) — The minimum design pressure for containers shall be that specified in the regulations of the DOT.

(ii) — The shell or head thickness of any container shall not be less than three-sixteenth inch.

(iii) — All container openings, except safety-relief valves, liquid-level gaging devices, and pressure gages, shall be labeled to designate whether they communicate with liquid or vapor space.

1910.111(f)(3) — Container Appurtenances

(i) — All appurtenances shall be protected against physical damage.

(ii) — All connections to containers, except filling connections, safety-relief devices, and liquid-level and pressure gage connections, shall be provided with suitable automatic excess flow valves, or in lieu thereof, may be fitted with quick-closing internal valves, which shall remain closed except during delivery operations. The control mechanism for such valves may be provided with a secondary control remote from the delivery connections and such control mechanism shall be provided with a fusible section (melting point 208 deg. F. to 220 deg. F.) which will permit the internal valve to close automatically in case of fire.

(iii) — Filling connections shall be provided with automatic back-pressure check valves, excess-flow valves, or quick-closing internal valves, to prevent back-flow in case the filling connection is broken. Where the filling and discharge connect to a common opening in the container shell and that opening is

fitted with a quick-closing internal valve as specified in paragraph (ii) of this section, the automatic valve shall not be required.

(iv) — All containers shall be equipped for spray loading (filling in the vapor space) or with an approved vapor return valve of adequate capacity.

1910.111(f)(4) — Piping and Fittings

(i) — All piping, tubing, and fittings shall be securely mounted and protected against damage. Means shall be provided to protect hoses while the vehicle is in motion.

(ii) — Fittings shall comply with 1910.111(b)(6). Pipe shall be Schedule 80.

1910.111(f)(5) — Safety-Relief Devices

(i) — The discharge from safety-relief valves shall be vented away from the container upward and unobstructed to the open air in such a manner as to prevent any impingement of escaping gas upon the container; loose-fitting rain caps shall be used. Size of discharge lines from safety valves shall not be smaller than the nominal size of the safety-relief valve outlet connection. Suitable provision shall be made for draining condensate which may accumulate in the discharge pipe.

(ii) — Any portion of liquid ammonia piping which at any time may be closed at both ends shall be provided with a hydrostatic relief valve.

1910.111(f)(6) — Transfer of Liquids

(i) — The content of tank motor vehicle containers shall be determined by weight, by a suitable liquid-level gaging device, or other approved methods. If the content of a container is to be determined by liquid-level measurement, the container shall have a thermometer well so that the internal liquid temperature can be easily determined. This volume when converted to weight shall not exceed the filling density specified by the DOT.

(ii) — Any pump, except a constant speed centrifugal pump, shall be equipped with a suitable pressure-actuated bypass valve permitting flow from discharge to suction when the discharge pressure rises

above a predetermined point. Pump discharge shall also be equipped with a spring-loaded safety-relief valve set at a pressure not more than 135 percent of the setting of the bypass valve or more than 400 p.s.i.g., whichever is larger.

(iii) — Compressors shall be equipped with manually operated shutoff valves on both suction and discharge connections. Pressure gages of bourdon-tube type shall be installed on the suction and discharge of the compressor before the shutoff valves. The compressor shall not be operated if either pressure gage is removed or is inoperative. A spring-loaded, safety-relief valve capable of discharging to atmosphere the full flow of gas from the compressor at a pressure not exceeding 300 p.s.i.g. shall be connected between the compressor discharge and the discharge shutoff valve.

(iv) — Valve functions shall be clearly and legibly identified by metal tags or nameplates permanently affixed to each valve.

1910.111(f)(7) — [Reserved]

(i) — All full trailers shall be firmly and securely attached to the vehicle drawing them by means of suitable drawbars supplemented by a safety chain (or chains) or safety cables.

(ii) — Every full trailer or semitrailer shall have a reliable system of brakes, and adequate provision shall be made to operate the brakes from the driver's seat.

(iii) — Every full trailer shall be equipped with self-energizing brakes.

(iv) — Full trailers shall be so designed that the towed vehicle will follow substantially in the path of the towing vehicle and will not whip or swerve dangerously from side to side.

(v) — Where a fifth wheel is employed, it shall be ruggedly designed, securely fastened to both units, and equipped with a positive locking mechanism which will prevent separation of the two units except by manual release.

1910.111(f)(8) — [Reserved]

1910.111(f)(9) — Chock Blocks. At least two chock blocks shall be provided. These blocks shall be placed to prevent rolling of the vehicle whenever it is parked during loading and unloading operations.

1910.111(f)(10) — Portable Tank Containers (Skid Tanks). Where portable tank containers are used for farm storage they shall comply with Section 1910.111(c)(1). When portable tank containers are used in lieu of cargo tanks and are permanently mounted on tank motor vehicles for the transportation of ammonia, they shall comply with the requirements of this paragraph.

Section 1910.111(g) — Systems Mounted on Farm Vehicles Other Than for the Application of Ammonia

1910.111(g)(1) — Application. This paragraph applies to containers of 1,200 gallons capacity or less and pertinent equipment mounted on farm vehicles (implements of husbandry) and used other than for the application of ammonia to the soil. Section 1910.111 (b) also applies here unless otherwise noted.

1910.111(g)(2) — Design Pressure and Classification of Containers

(i) — The minimum design pressure for containers shall be 250 p.s.i.g.

(ii) — The shell or head thickness of any container shall be not less than three-sixteenths of an inch.

1910.111(g)(3) — Mounting Containers

(i) — A suitable "stop" or "stops" shall be mounted on the vehicle or on the container in such a way that the container shall not be dislodged from its mounting due to the vehicle coming to a sudden stop. Back slippage shall also be prevented by proper methods.

(ii) — A suitable "hold down" device shall be provided which will anchor the container to the vehicle at one or more places on each side of the container.

(iii) — When containers are mounted on four-wheel trailers, care shall be taken to insure that the weight is distributed evenly over both axles.

(iv) — When the cradle and the tank are not welded together suitable material shall be used between them to eliminate metal-to-metal friction.

1910.111(g)(4) — Container Appurtenances

(i) — All containers shall be equipped with a fixed liquid-level gage.

(ii) — All containers with a capacity exceeding 250 gallons shall be equipped with a pressure gage having a dial graduated from 0-400 p.s.i.

(iii) — The filling connection shall be fitted with combination back-pressure check valve and excess-flow valve; one double or two single back-pressure check valves; or a positive shutoff valve in conjunction with either an internal back-pressure check valve or an internal excess flow valve.

(iv) — All containers with a capacity exceeding 250 gallons shall be equipped for spray loading or with an approved vapor return valve.

(v) — All vapor and liquid connections except safety-relief valves and those specifically exempted by section 1910.111(b)(6)(v) shall be equipped with approved excess-flow valves or may be fitted with quick-closing internal valves which, except during operating periods, shall remain closed.

(vi) — Fittings shall be adequately protected from damage by a metal box or cylinder with open top securely fastened to the container or by rigid guards, well braced, welded to the container on both sides of the fittings or by a metal dome. If a metal dome is used, the relief valve shall be properly vented through the dome.

(vii) — If a liquid withdrawal line is installed in the bottom of a container, the connections thereto, including hose, shall not be lower than the lowest horizontal edge of the vehicle axle.

(viii) — Provision shall be made to secure both ends of the hose while in transit.

1910.111(g)(5) — Marking the Container. There shall appear on each side and on the rear end of the container in letters at least 4 inches high, the words, "Caution - Ammonia" or the container shall be marked in accordance with DOT regulations.

1910.111(g)(6) — Farm Vehicles

(i) — Farm vehicles shall conform with State regulations.

(ii) — All trailers shall be securely attached to the vehicle drawing them by means of drawbars supplemented by suitable safety chains.

(iii) — A trailer shall be constructed so that it will follow substantially in the path of the towing vehicle and will not whip or swerve dangerously from side to side.

(iv) — All vehicles shall carry a can containing 5 gallons or more of water.

Section 1910.111(h) — Systems Mounted on Farm Vehicles for the Application of Ammonia

1910.111(h)(1) — This paragraph applies to systems utilizing containers of 250 gallons capacity or less which are mounted on farm vehicles (implement of husbandry) and used for the application of ammonia to the soil. Section 1910.111(b) applies to this section also unless otherwise noted. Where larger containers are used, they shall comply with Section 1910.111(g).

1910.111(h)(2) — Design Pressure and Classification of Containers

(i) — The minimum design pressure for containers shall be 250 p.s.i.g.

(ii) — The shell or head thickness of any container shall not be less than three-sixteenths inch.

1910.111(h)(3) — Mounting of Containers. All containers and flow-control devices shall be securely mounted.

1910.111(h)(4) — Container Valves and Accessories

(i) — Each container shall have a fixed liquid-level gage.

(ii) — The filling connection shall be fitted with a combination back-pressure check valve and an excess-flow valve; one double or two single back-pressure check valves; or a positive shutoff valve in conjunction with an internal back-pressure check valve or an internal excess-flow valve.

(iii) — The applicator tank may be filled by venting to open air provided the bleeder valve orifice does not exceed seven-sixteenths inch in diameter.

(iv) — Regulation equipment may be connected directly to the tank coupling or flange, in which case a flexible connection shall be used between such regulating equipment and the remainder of the liquid withdrawal system. Regulating equipment not so installed shall be flexibly connected to the container shutoff valve.

(v) — No excess flow valve is required in the liquid withdrawal line provided the controlling orifice between the contents of the container and the outlet of the shutoff valve does not exceed seven-sixteenths inch in diameter.

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Table 1. (Table H-36). Minimum required rate of discharge in cubic feet per minute of air at 120 percent of the maximum permitted start to discharge pressure of safety relief valves

Surface area (sq. ft.)	Flow rate CFM air	Surface area (sq. ft.)	Flow rate CFM air	Surface area (sq. ft.)	Flow rate CFM air
20	258	185	1,600	900	5,850
25	310	190	1,640	950	6,120
30	360	195	1,670	1,000	6,380
35	408	200	1,710	1,050	6,640
40	455	210	1,780	1,100	6,900
45	501	220	1,850	1,150	7,160
50	547	230	1,920	1,200	7,410
55	591	240	1,980	1,250	7,660
60	635	250	2,050	1,300	7,910
65	678	260	2,120	1,350	8,160
70	720	270	2,180	1,400	8,410
75	762	280	2,250	1,450	8,650
80	804	290	2,320	1,500	8,900
85	845	300	2,380	1,550	9,140
90	885	310	2,450	1,600	9,380
95	925	320	2,510	1,650	9,620
100	965	330	2,570	1,700	9,860
105	1,010	340	2,640	1,750	10,090
110	1,050	350	2,700	1,800	10,330
115	1,090	360	2,760	1,850	10,560
120	1,120	370	2,830	1,900	10,800
125	1,160	380	2,890	1,950	11,030
130	1,200	390	2,950	2,000	11,260
135	1,240	400	3,010	2,050	11,490
140	1,280	450	3,320	2,100	11,720
145	1,310	500	3,620	2,150	11,950
150	1,350	550	3,910	2,200	12,180
155	1,390	600	4,200	2,250	12,400
160	1,420	650	4,480	2,300	12,630
165	1,460	700	4,760	2,350	12,850
170	1,500	750	5,040	2,400	13,080
175	1,530	800	5,300	2,450	13,300
180	1,570	850	5,590	2,500	13,520

Surface Area = total outside surface area of container in square feet. When the surface area is not stamped on the nameplate or when the marking is not legible the area can be calculated by using one of the following formulas:

(1) -- Cylindrical container with hemispherical heads: Area = (overall length in feet) times (outside diameter in feet) times 3.1416.

(2) -- Cylindrical container with other than hemispherical heads: Area = (overall length in feet plus 0.3 outside diameter in feet) times (outside diameter in feet) times 3.1416.

(3) -- Spherical container: Area = (outside diameter in feet) squared times 3.1416. Rate - CFM Air = cubic feet per minute of air required at standard conditions, 60 deg. F. and atmospheric pressure (14.7 p.s.i.a.).

The rate of discharge may be interpolated for intermediate values of surface area. For containers with total outside surface area greater than 2,500 square feet, the required flow rate can be calculated using the formula:

where A = outside surface area of the container in square feet.

$$\text{Flow Rate CFM Air} = 22.11 A^{0.82}$$

where A = outside surface area of the container in square feet.

Table 2. Container safety-relief valves start-to-discharge

Containers	Minimum (percent)	Maximum (percent)
ASME-U-68, U-69	110	125
ASME-U-200, U-201	95	100
ASME 1959, 1956, 1952, or 1962	95	100
API-ASME	95	100
U.S. Coast Guard	95	100

Table 3. Maximum filling densities for nonrefrigerated containers

Type of container	Percent by weight	Percent by volume
Above-ground-Uninsulated	56	82
Above-ground-Uninsulated	---	87.5
Above-ground-Insulated	57	83.5
Underground-Uninsulated	58	85
DOT In accord with DOT regulations	---	---