## 5.1 DESCRIPTION

Viton gasket material should not be used in ammonia service. Use only Teflon or natural rubber. Technical data for anhydrous ammonia is included in Exhibit 5.1-A. Exhibit 5.1-B contains standards from the American National Standard Institute, Inc. on ammonia storage and handling. A draft Executive Summary of safety procedures for this Plant Crist SCR project, which includes data for ammonia, is shown in Appendix D.

### 5.1.1 Ammonia/Air Flow Measuring and Control

Ammonia comsumption depends upon the flue gas flow and $NH_3/NOx$ ratio. For a $NH_3/No_x$ range of 0.6 to 1.1, the ammonia consumption ranges for the large and small reactors are 2.12 to 10.19 lb/hr, and 0.20 to 0.90 lb/hr, respectively. Based on the following reactions

$$4NO + 4NH_3 + O_2 \;\text{-->}\; 4N_2 + 6H_2O$$
$$2NO_2 + 4NH_3 + O_2 \;\text{-->}\; 3N_2 + 6H_2O$$

the equation for the calculation of the ammonia consumption is given by:

$$\dot{m}\,NH_3 = \frac{\Delta NOx}{46.005} * \frac{\in NO + \in NO_2 {}^{*}2}{100} {}^{*}17.031 + NH_3\text{-slip} \;{}^{*}\; \dot{v}\;{}^{*}10^{-6}$$

| | |
|---|---|
| $\dot{m}\,NH_3$ | ammonia mass flow (kg/h) |
| $\Delta NOx$ | $NO_x$ in - $NO_x$ out ($mg/m^3_N$, dry, standard $O_2$), as $NO_2$ |
| $\in NO$ | NO - share on $NO_x$ content (%) |
| $\in NO_2$ | $NO_2$ - share on $NO_x$ content (%) |
| $NH_3$-slip | ($mg/m^3_N$) |
| $\dot{v}$ | flue gas flow ($m^3_N/h$, dry, standard $O_2$) |

Mass flow measurement devices are recommended for accurately metering ammonia vapor because of the following advantages:

- temperature independent
- pressure independent
- wide measurement ranges
- electric output signal

The mass flow meter is sensitive to small amounts of liquid water and oil, which decreases the accuracy. Installing a coalescing filter upstream of the mass flow meter to collect water and oil will be considered. Mass flow meter measurements are also sensitive to the meter orientation.

Depending upon the final range of $NH_3$/NOx ratios to be used throughout the test program, ammonia flow measurements may require as many as 3 flow measurements, one each for low, medium, and high flows. If the $NH_3$/NOx ratios were to range from near 0.1 to 1.0, a factor of 10, and flue gas flow ranges from 3000- to 7500-cfm, a factor of 2.5, the ammonia flow availability is a factor of 25. The multiple flow measurements would allow more accuracy over a specific, narrow flow range.

The ammonia dilution air flow is also measured to determine the amount of air/$NH_3$ added to the reactor. Since the air/$NH_3$ injection is downstream of the reactor inlet venturi, the total flow of the reactor will not be known unless the dilution air flow is measured. The dilution air supply should always be in operation, even with no ammonia injection, to avoid injection nozzle plugging by fly ash.

### 5.1.2 Ammonia Injection System

Maintaining a relatively low value for ammonia slip is a major consideration in SCR operations. Ammonia slip is governed by the catalyst design and volume, and the effectiveness of the ammonia injection system. The basic design of the ammonia injection system, from the ammonia flowing from the accumulator tank to the $NH_3$/air injection into the reactor inlet ducting is shown in Figure 5.1-1. This injection system comprises the control and stop valves for ammonia, dilution air supply and heaters, static mixer, the isolation, throttling and adjusting valves, and the array of pipes with nozzles in the flue gas duct.

### 5.1.3 Ammonia Dilution Air Suppply and Electric Heaters

Description

The ammonia dilution air utilizes a common centrifugal fan with a common dilution air heater to furnish heated dilution air for all reactors. The heater will utilize a silicon control rectifier, to adjust heater power output with any combination of reactors in or out of service. Specifications for the fan are given in EXHIBIT 5.1-C.

The ammonia dilution air heater will be used to heat the ambient dilution air above the ammonium bisulfate (ABS) dew point, approximately 500°F, to prevent formation of ABS and pluggage of the ammonia injection nozzles. By raising the temperature of the dilution air above the ABS dew point, the heaters also raise the temperature of the air above the acid dew point, which minimizes corrosion. See Figures 5.1-2 and 5.1-3 for graphical representation of expected dewpoints.

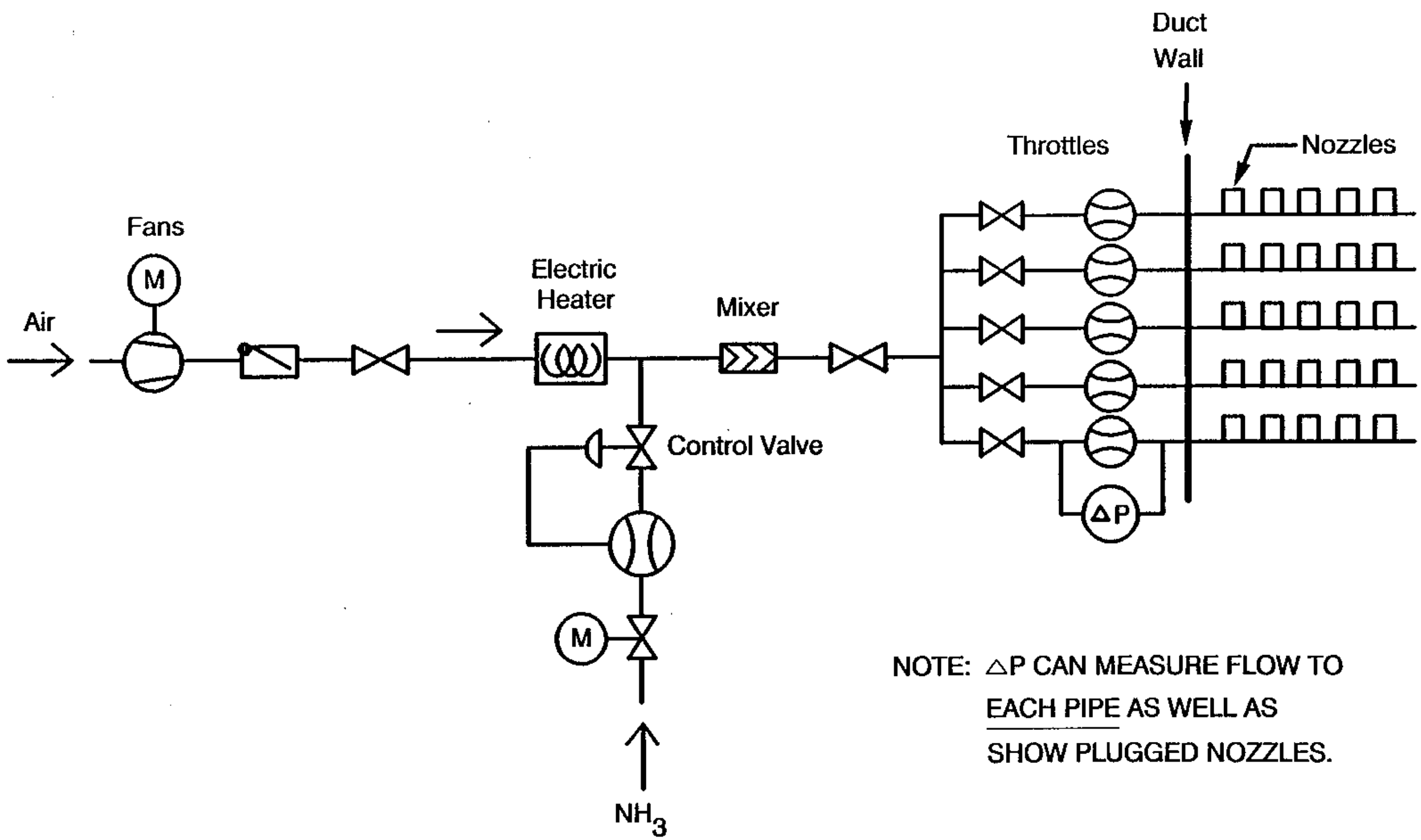
The ammonia dilution air electric heaters will be required to heat ambient air from a temperature of 30°F to 500°F. This will also aid in reducing erroneous $NH_3$/NOx measurements caused by loss of ammonia by condensation of ABS.

Size

The ammonia dilution air electrical heater loads were grossly estimated using the following formula:

$$kW = [CFM \times Delta\ T]/3000$$

Where: CFM is the flow rate of air at standard conditions, 70°F and 1 atm




NOTE: ΔP CAN MEASURE FLOW TO EACH PIPE AS WELL AS SHOW PLUGGED NOZZLES.

Figure 5.1-1. Basic design of the ammonia injection system.

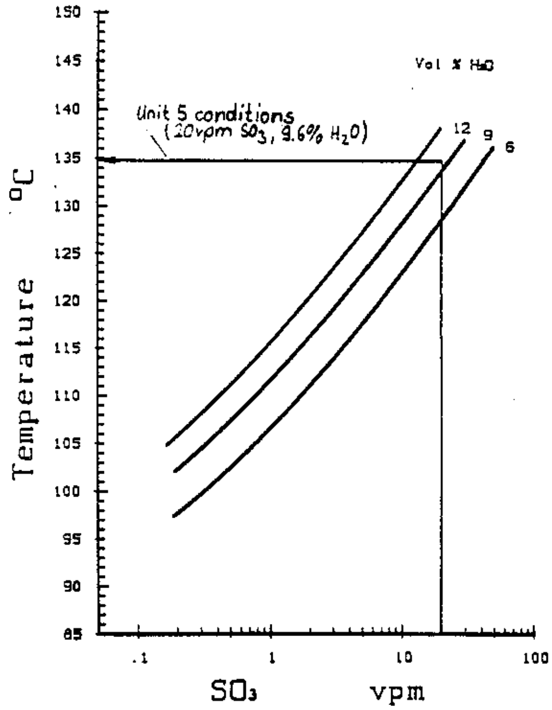



Figure 5.1-2. Graphic representation of expected dewpoint

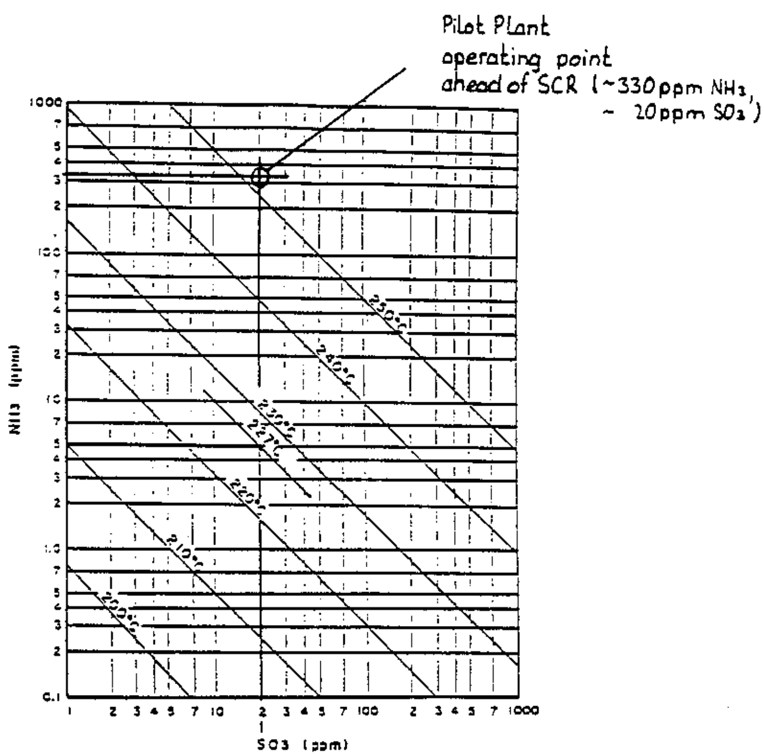



Figure 5.1-3. Graphic representation of expected dewpoint

The large reactor ammonia dilution air flow is 32-scfm. Therefore, maximum electrical load for the large reactor dilution air heaters would be approximately:

$$(32)\ (500-30)/3000 = 5\ kW$$

The small reactor ammonia dilution air flow is 2.5-scfm. Therefore, maximum electrical load for the small reactor dilution air heaters would be approximately:

$$(2.5)(500-30)/3000 = 0.4\ kW$$

The common ammonia dilution air heater load would be the sum of the above calculated loads:

$$(3)(5) + (6)(.4) = 17.5\ kW$$

The common ammonia dilution air heater would be required to have controls capable of accommodating any combination of reactors in or out of service.

Location

The ammonia dilution air heater has not been physically located. It is assumed that it will be conveniently located in the small bore air piping.

The location of the ammonia dilution air heater will be downstream of the air fan and upstream of the ammonia addition to the carrier air stream.

Operation

The ammonia dilution air electric heaters will be heating ambient air with a temperature ranging between 30° and 100°F. The maximum required dilution air temperature leaving the electric heaters is 500°F.

Control

The ammonia dilution air heater control shall be capable of maintaining the ammonia dilution air temperature to within ± 2°F of the desired setpoint. The pilot plant distributed control system (DCS) will output one 4-20 MA DC to control the heater. Heater control shall be staged into service based on the value of the 4-20 MA DC signal (4 MA = zero heater and 20 MA = maximum heater output). The heater control shall be proved with overload protection, flow detection, and over-temperature protection.

Electrical

The pilot plant has 480-volt, 3-phase, 60-hz power, available for the ammonia dilution air electric heaters. The heaters should utilize high temperature cables to protect from overheating of wires and/or melting insulation. It is desired that overtemperature control be incorporated into the heater design to prevent the heaters from burning out when no flow conditions occur. External heater components should be enclosed in a NEMA 4- or 4X-type enclosure for weather protection. The heaters should be electrically isolated from the pilot plant or host unit electrical supply to prevent any noise from causing problems in the upstream side of the electrical supply. The number of multiple heaters (or heater banks) shall be divisible by 3 to minimize phase distortions.

5.1.4 Miscellaneous Requirements

It is desired that the ammonia dilution air heaters be furnished with changeable heater elements, versus welded elements, rather than replacing the entire heater. Provisions should be made to minimize the occurrence of ceramic insulator damage due to moisture or overheating. Standard heater element materials are acceptable for this service.

### 5.1.5 Ammonia Injection Grid

The ammonia injection grid is a set of pipes installed horizontally across the duct cross-section at the outlet of the transition from circle to square transition, which also serves as resistance pipes to improve flue gas velocity profiles. This is located so as not to interfere with the flow venturi reading, while allowing ample distance for proper mixing of the ammonia in the flue gas.

The injection nozzle for the small SCR reactors will be a single point. For the large reactors, the grid will consist of five horizontal pipes across the duct, with a five by five array of nozzles, or a total of 25 total nozzles. (See Figure 5.1-4 for a sketch of the injection grid orientation for the large reactors, and EXHIBIT 5.1-D for DynaGen's work on nozzle number versus distance required for adequate mixing.)

The ammonia should be injected at a velocity as near that of the flue gas flow as possible. The pressure drop in the nozzel also assists in minimizing differences in volumetric flow over the length of the injection pipe. Injection may be parallel to the flue gas flow direction or slightly inclined. However, injection against the flue gas flow should be avoided, especially in high dust cases where the ash loading may plug the nozzle openings, particularly upon loss of the dilution air supply.

It has been recommended by some vendors that the deviation of the $NH_3$/NOx molar ratio at the catalyst inlet should not exceed 5 percent. Subsequently, the reduction rate over the reactor cross-section should also not deviate by more than 5 percent. This is required also in order to minimize the residual ammonia content downstream of the reactor throughout the catalyst life. The system will be planned so that it is possible to set individually defined areas. For coarse adjustment of ammonia distribution, the NOx mass flow profile upstream of injection should be measured and ammonia throttles set accordingly.

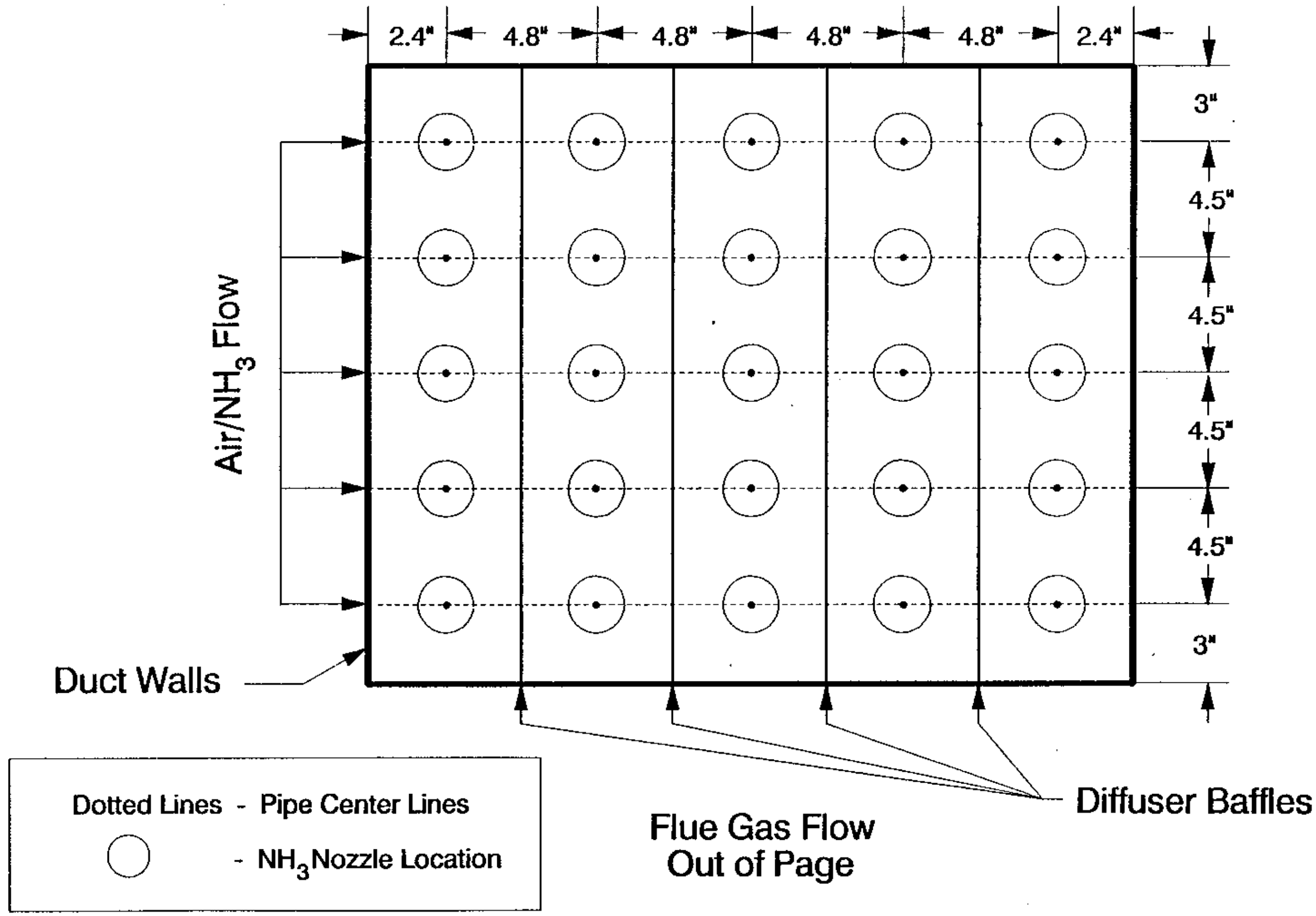



Figure 5.1-4. Sketch of the injection grid orientation for large reactors.

Fine adjustment of the system is made after NOx grid measurements are made downstream of the final catalyst element layer, where simulation of the injection cross-section over the reactor cross-section is possible in most cases. A final measurement of ammonia slip on a grid, or at selected points, confirms the required uniform distribution. Requirements are considered to have been met when:

$$NO_{xout} < x \cdot ETA \cdot NO_{xin}$$

where: $NO_{xout}$ is the measured, individual deviations from the mean value $NO_{xout}$, times the prescribed maximum deviation ETA, the current reduction rate, and $NO_{xin}$ as the raw gas value.

5.1.6 Ammonia Vent System

The ammonia system will be designed to prevent an uncontrolled release of gaseous ammonia from either the storage tank or the piping system. This will be accomplished by venting all units through a water trap, as shown in Figure 5.1-5.

Air purge connections will be furnished on the ammonia system piping, allowing several pipe volumes of air to purge the lines before maintenance is performed on the ammonia system.

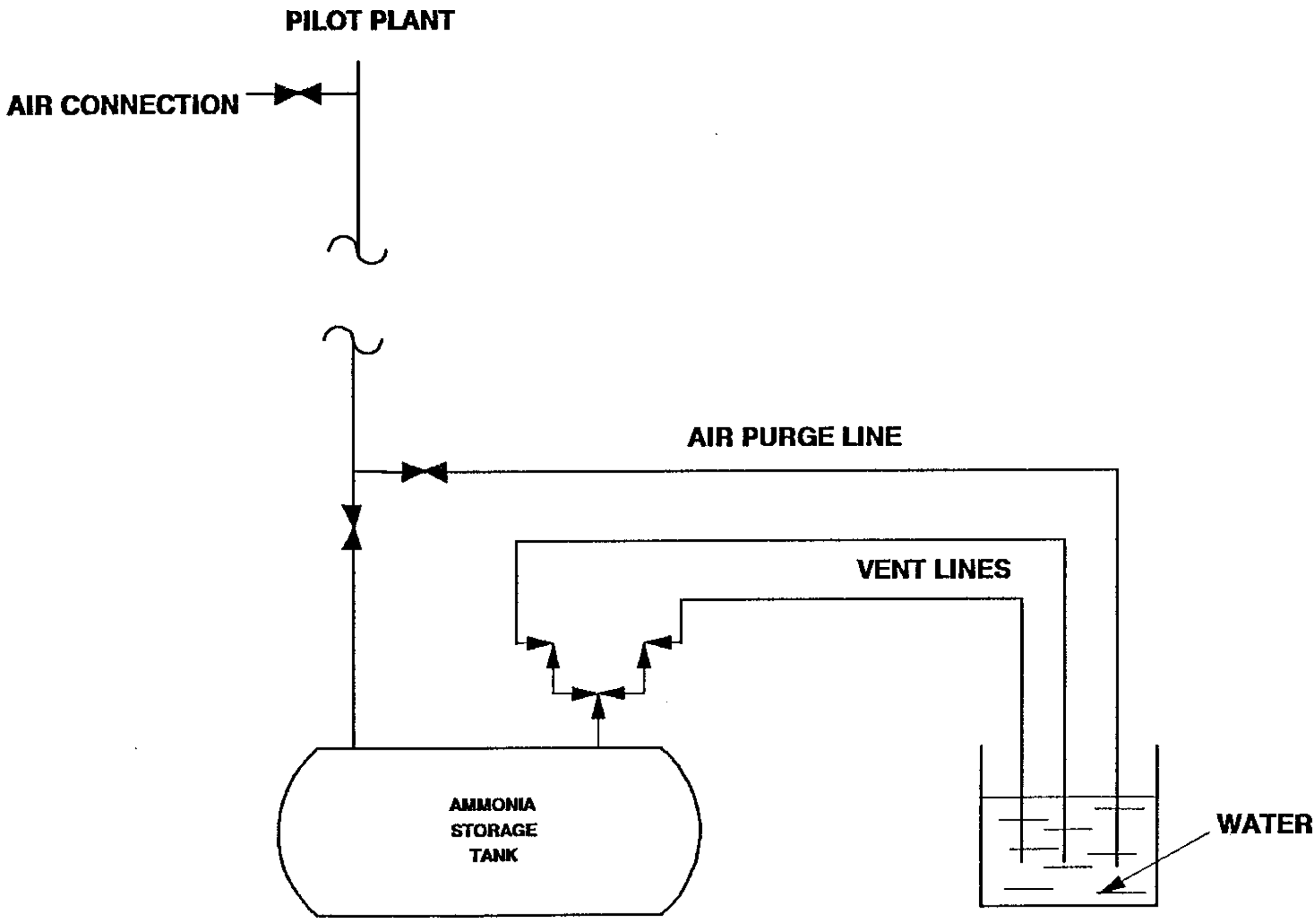



Figure 5.1-5. Ammonia vent line concept.

# EXHIBIT 5.1-A

## ANHYDROUS AMMONIA TECHNICAL DATA

## INTRODUCTION

The purpose of this brochure is to provide customer operating and maintenance personnel with sufficient information to assure continuous, economical and safe use of their ammonia storage system.

ANHYDROUS AMMONIA is classified by the U. S. Department of Transportation as a hazardous material; however, by using proper procedures and care in handling, the possibility of a hazardous situation occurring can be virtually eliminated.

First read the literature contained herein and familiarize yourself with the properties of ammonia and the general information pertaining to its safe handling.

Next, study the National Ammonia Company/Bower Ammonia and Chemical Company drawing which shows typical tank appurtenances.

Examine your tank and system and identify each component. Become familiar with its location, operation and purpose.

This brochure should be studied and retained for reference. Don't wait for a malfunction or emergency condition to occur before learning how the system operates. A knowledge of system operation and a knowledge of the purpose of each piece of equipment will enable you to look for potential problems before they occur, determine what action is necessary and to be prepared for an unexpected or emergency situation.

If you have any questions or require assistance, contact your local National/Bower Ammonia and Chemical Co. representative or the company central office.

For assistance call:

Local Representative: ____________________

Telephone Number: ____________________

Company Central Office: 215-535-7530
215-831-1717

(Ask for Manager of Technical Service)

## PROPERTIES

ANHYDROUS AMMONIA is the compound formed by the combination of the two gaseous elements, nitrogen and hydrogen, in the proportion of one part of nitrogen to three parts of hydrogen by volume. Since one volume of nitrogen weighs fourteen times as much as one volume of hydrogen on a weight basis the ratio is fourteen parts of nitrogen to three parts of hydrogen, or about 82% nitrogen to 18% hydrogen. This relationship is shown in the chemical symbol for Ammonia, $NH_3$.

At atmospheric temperatures and pressure ANHYDROUS AMMONIA is a pungent colorless liquid which, at atmospheric pressure, boils at - 28F. and freezes to a white crystalline mass at - 107.9 F. When heated above its critical temperature of 271.4 F., ammonia exists only as a vapor regardless of the pressure. Between the melting and critical points liquid ammonia exerts a vapor pressure which increases with rising temperature. When liquid ammonia in a closed container is in equilibrium with ammonia vapor, the pressure within the container bears a definite relationship to the temperature.

Ammonia liquid is lighter than water having a density of 42.57 pounds per cubic foot at - 28 F., while as a vapor, ammonia is lighter than air, its relative density being 0.5970 compared to air at atmospheric pressure and a temperature of 32 F. Under the latter conditions one pound of ammonia vapor occupies a volume of 20.78 cubic feet. At 70 F. and atmospheric pressure, one pound of ammonia occupies a volume of 22.5 cubic feet and yields 45 cubic feet of dissociated gas at a ratio of 25% nitrogen and 75% hydrogen.

## PHYSICAL CONSTANTS OF AMMONIA

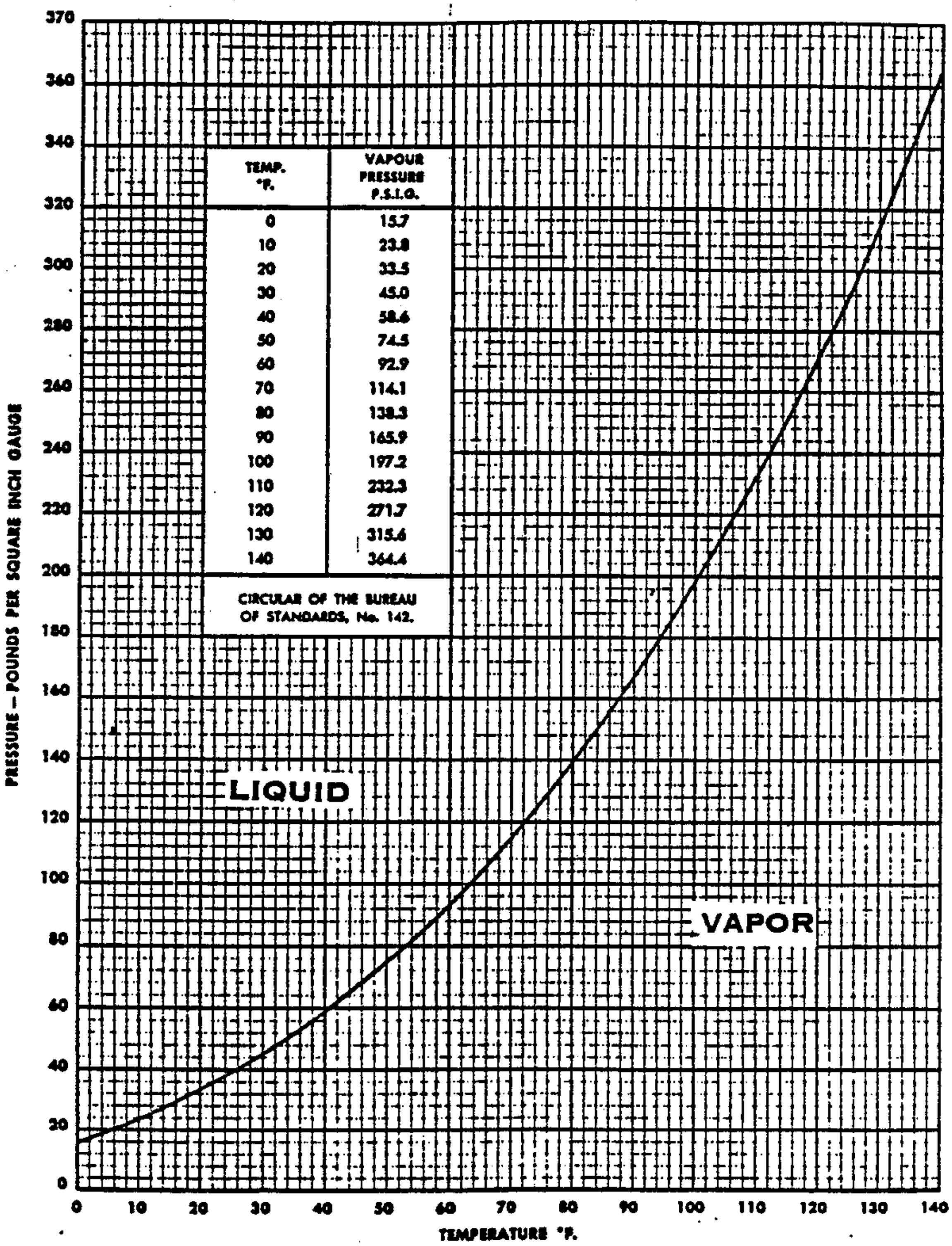
| | |
|---|---|
| Molecular symbol | $NH_3$ |
| Molecular weight | 17.032 |
| Boiling point at one atmosphere | -28°F (-33.3°C) |
| Freezing point at one atmosphere | -107.9°F. (-77.8°C) |
| Critical temperature | 271.4°F. (133°C) |
| Critical pressure | 1657 psia.<br>(116.5 kgs/sq.cm.) |
| Vapor density at - 28 F. and one atmosphere | 0.05555 lbs./cu.ft.<br>or 0.88991 kgs/cu. meter |

## PROPERTIES OF LIQUID AMMONIA AT VARIOUS TEMPERATURES

| Temperature Degrees F | Vapor Pressure (psig) | Liquid Density | | Specific Gravity of Liquid (Compared to Water at 4 C.) | Latent Heat (Btu per pound) |
|---|---|---|---|---|---|
| | | Pounds Per Cubic Foot | Pounds Per U.S. Gallon | | |
| -28 | 0.0 | 42.57 | 5.69 | .682 | 589.3 |
| -20 | 3.6 | 42.22 | 5.64 | .675 | 583.6 |
| -10 | 9.0 | 41.78 | 5.59 | .669 | 576.4 |
| 0 | 15.7 | 41.34 | 5.53 | .663 | 568.9 |
| 10 | 23.8 | 40.89 | 5.47 | .656 | 561.1 |
| 20 | 33.5 | 40.43 | 5.41 | .648 | 553.1 |
| 30 | 45.0 | 39.96 | 5.34 | .641 | 544.8 |
| 40 | 58.6 | 39.49 | 5.28 | .633 | 536.2 |
| 50 | 74.5 | 39.00 | 5.21 | .625 | 527.3 |
| 60 | 92.9 | 38.50 | 5.14 | .617 | 518.1 |
| 65 | 103.1 | 38.25 | 5.11 | .613 | 513.4 |
| 70 | 114.1 | 38.00 | 5.08 | .609 | 508.6 |
| 75 | 125.8 | 37.74 | 5.04 | .605 | 503.7 |
| 80 | 138.3 | 37.48 | 5.01 | .600 | 498.7 |
| 85 | 151.7 | 37.21 | 4.97 | .596 | 493.6 |
| 90 | 165.9 | 36.95 | 4.94 | .592 | 488.5 |
| 95 | 181.1 | 36.67 | 4.90 | .588 | 483.2 |
| 100 | 197.2 | 36.40 | 4.87 | .583 | 477.8 |
| 105 | 214.2 | 36.12 | 4.83 | .579 | 472.3 |
| 110 | 232.3 | 35.84 | 4.79 | .573 | 466.7 |
| 115 | 251.5 | 35.55 | 4.75 | .570 | 460.9 |
| 120 | 271.7 | 35.26 | 4.71 | .565 | 455.0 |
| 125 | 293.1 | 34.96 | 4.67 | .560 | 448.9 |
| 130 | 315.6 | 34.66 | 4.63 | .555 | (443) |
| 135 | 339.4 | 34.35 | 4.59 | .550 | (436) |
| 140 | 364.4 | 34.04 | 4.55 | .545 | (430) |

Under normal conditions ammonia is a very stable compound. It takes excessive temperatures (about 840-930 F.) to cause it to dissociate slightly at atmospheric pressure. When this happens the dissociation products are nitrogen and hydrogen. Ammonia gas burns in a mixture with air within a limited range. The flammable limits at atmospheric pressure are 16% to 25% by volume of ammonia in air. Experiments conducted by the Underwriters Laboratories indicate that an ammonia-air mixture in a standard quartz bomb will not ignite at temperatures below 850 C. (1562 F.). When an iron bomb, having catalytic effect was used, the ignition temperature of the ammonia-air mixture was 651 C. (1203.8 F.).

## VAPOUR PRESSURE – TEMPERATURE RELATIONSHIP LIQUID ANHYDROUS AMMONIA




| TEMP. °F. | VAPOUR PRESSURE P.S.I.G. |
|---|---|
| 0 | 15.7 |
| 10 | 23.8 |
| 20 | 33.5 |
| 30 | 45.0 |
| 40 | 58.6 |
| 50 | 74.5 |
| 60 | 92.9 |
| 70 | 114.1 |
| 80 | 138.3 |
| 90 | 165.9 |
| 100 | 197.2 |
| 110 | 232.3 |
| 120 | 271.7 |
| 130 | 315.6 |
| 140 | 364.4 |

CIRCULAR OF THE BUREAU OF STANDARDS, No. 142.

CM-3A

The dewpoint of dissociated ammonia is related to the moisture content. Dewpoints measured on dissociated gas correspond to moisture content as follows:

| DEWPOINT °F | MOISTURE CONTENT PPM |
|---|---|
| -10 | 1831 |
| -15 | 1786 |
| -20 | 1384 |
| -25 | 1072 |
| -30 | 826 |
| -35 | 648 |
| -40 | 487 |
| -45 | 370 |
| -50 | 281 |
| -55 | 210 |
| -60 | 159 |
| -65 | 114 |
| -70 | 83 |
| -75 | 60 |
| -80 | 43 |
| -85 | 30 |
| -90 | 17 |
| -95 | 15 |
| -100 | 9 |

The common metals are not affected by dry ammonia. Moist ammonia will not corrode iron or steel, but will react rapidly with copper, brass, zinc, and many alloys, especially those containing copper. Only steel or ductile iron should be used for ammonia containers, valves, fittings and piping; except that fabricated equipment made of certain non-ferrous alloys may be used.

The preceding information on the properties of ANHYDROUS AMMONIA has been taken from Pamphlet G-2 publised by the Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202. Phone: 703-979-0900.

# technical data

## CHEMICAL RESISTANCE CHART

BECAUSE CONDITIONS VARY, PERFORM FIELD TESTS BEFORE MAKING FINAL MATERIAL SELECTION

**RATINGS – CHEMICAL EFFECT**

A – No effect – Excellent
B – Minor effect – Good
C – Moderate effect – Fair
D – Severe effect – Not recommended

**EXPLANATION OF FOOTNOTES**

1. Satisfactory to 72° F.
2. Satisfactory to 120°F.

| | ANHYDROUS AMMONIA | AMMONIUM HYDROXIDE |
|---|---|---|
| CPVC | A | A |
| EPOXY | A | A1 |
| POLYPROPYLENE | A | A |
| POLYETHYLENE | B2 | A1 |
| PVC | A2 | A |
| CYCOLAC (ABS) | – | B |
| PHENOLIC | A | A |
| NYLON | A1 | A |
| NORYL | B1 | A |
| DELRIN (ACETAL) | D | C1 |
| RYTON to 200°F | A1 | A |
| KYNAR (PVDF) | A | A |
| TEFLON | A | A |
| STAINLESS STEEL (316) | A1 | A1 |
| STAINLESS STEEL (304) | A | A1 |
| STAINLESS STEEL (440) | A | B |
| TITANIUM | C | A |
| CARPENTER 20 | A | A |
| CAST BRONZE | D | D |
| CAST IRON | A | A |
| ALUMINUM | A1 | B2 |
| HASTELLOY C | B | B |
| CARBON/CERAMIC | C | A |
| VITON | D | B |
| BUNA N | B | D |
| NEOPRENE | C | A |
| NITRILE | B | D |
| NATURAL RUBBER | D | D |
| HYPALON | D | A |
| EPDM | A | A |
| KEL-F | A | A |
| TYGON | A | B |
| SILICONE | D | A |
| CERAMIC | A | A |
| CARBON/GRAPHITE | A | A |

Delrin, Hypalon, Neoprene, Teflon, Viton—Reg TM E I du Pont de Nemours & Co
Kel-F—Reg TM Minnesota Mining and Mfg Co
Ryton—Reg TM Phillips Petroleum Co
Tygon—Reg TM Norton Co
Noryl—Reg TM General Electric Co
Kynar—Reg TM Pennwalt Corp
Cycolac—Reg TM Mar-Bon Corp

# MATERIAL SAFETY DATA SHEET

**ANHYDROUS AMMONIA**

Northeastern

NATIONAL

BOWER BB BRAND

DISTRIBUTORS:

**NATIONAL AMMONIA COMPANY**
**BOWER AMMONIA & CHEMICAL COMPANY**
**NORTHEASTERN AMMONIA COMPANY, INC.**
**AL WELLS, INC.**

TACONY & VANKIRK STS., PHILADELPHIA, PA 19135

CORPORATE EMERGENCY TELEPHONE NUMBER: 215-535-7530 CHEMTREC (CMA) 800-424-9300

## DESCRIPTION

CHEMICAL NAME: Ammonia, anhydrous
CAS REGISTRY NO.: 7664-41-7
SYNONYMS: Ammonia, liquefied
CHEMICAL FAMILY: Ammonia
FORMULA: $NH_3$
MOL. WT.: 17.03
COMPOSITION: 99+% ammonia

## STATEMENT OF HEALTH HAZARD

HAZARD DESCRIPTION: Irritant and corrosive to skin, eye, respiratory tract and mucous membranes. May cause severe burns, eye and lung injuries. Skin and respiratory related diseases aggravated by exposure.
Not recognized by OSHA as a carcinogen.
Not listed in the National Toxicology Program annual report.
Not listed as a carcinogen by the International Agency for Research on Cancer.

EXPOSURE LIMITS: Vapor - 50 ppm, 35 mg/m³ PEL (OSHA)
25 ppm, 18 mg/m³ TLV (ACGIH)

## EMERGENCY TREATMENT

EFFECTS OF OVEREXPOSURE: Eye: lachrymation, edema, blindness. Moist skin: irritation, corrosive burns, blister formation. Contact of liquid with skin freezes the tissue, then produces a caustic burn. Inhalation: heavy, acute exposure may result in severe irritation of the respiratory tract, glottal edema, bronchospasm, pulmonary edema, respiratory arrest. Chronic effects: bronchitis. Extreme exposure (5000 ppm) can cause immediate death from spasm, inflammation or edema of larynx.

EMERGENCY AID: Eye: Flush with copious amount of water for 15 min. Eyelids should be held open and away from eyeball to ensure thorough rinsing. SPEED AND THOROUGHNESS IN RINSING THE EYE IS MOST IMPORTANT IN PREVENTING LATENT PERMANENT INJURIES. Inhalation: move to fresh air. Administer oxygen or artificial respiration if necessary. Skin: flush affected area with copious amount of water for 15 min. Remove contaminated clothing while flushing. Do not rub affected area. Do not apply ointments to skin burns. IF SYMPTOMS PERSIST OR EXPOSURE IS SEVERE, SEEK PROMPT MEDICAL HELP.

NOTE TO PHYSICIAN: Eye injury may appear as delayed phenomenon. Pulmonary edema may follow chemical bronchitis. Supportive treatment with necessary ventilatory actions, including oxygen, may warrant consideration.

## PHYSICAL DATA

BOILING PT.: -33°C (-28°F)
VAPOR PRESSURE: @ 25.7°C: 10 atm
SPECIFIC GRAVITY: 0.618

PERCENT VOLATILE: 100%

APPEARANCE AND ODOR: Colorless gas, pungent odor.

FREEZING PT.: -78°C (-108°F)
VAPOR DENSITY (Air=1): 0.6
SOLUBILITY IN WATER: 0°C: 89.9g/100cc;
100°C: 7.4g/100cc
EVAPORATION RATE (Water=1): faster than water if in liquid form

## FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: None

AUTOIGNITION TEMP.: 651°C (1204°F) catalyzed by iron;
850°C (1562°F) uncatalyzed

FLAMMABLE RANGE IN AIR: 16% to 25% by Volume
EXTINGUISHING MEDIA: Water spray or fog
SPECIAL FIRE-FIGHTING PROCEDURES: Must wear protective clothing and respiratory protection. See PROTECTIVE EQUIPMENT. Stop source if possible. Cool fire-exposed containers with water spray. Stay upwind and use water spray to knock down vapor and dilute. Let fire burn.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Not generally a fire hazard. If relief valves are inoperative, heat-exposed storage containers may become explosion hazards. Contact of ammonia with chemicals such as mercury, chlorine, iodine, bromine, silver oxide, or hypochlorites can form explosive compounds. Special hazard with chlorine to form chloramine gas, also a primary skin irritant and sensitizer, Combustion may form toxic nitrogen oxides.

Revision: June, 1987

## ANHYDROUS AMMONIA VAPOR WITHDRAWAL

Ammonia is shipped and stored in its liquid form, but it is often utilized in the form of a gas. You will note from the listing of physical properties that a certain amount of heat, called "Latent Heat of Vaporization" is necessary to convert each pound of liquid ammonia into a gas. If sufficient heat (approximately 500 Btu's/lb) is not available from the ambient air surrounding the tank to provide the latent heat of vaporization required for a given gas withdrawal rate,this heat will be taken from the liquid remaining in the tank and the liquid temperature will drop. When the temperature drops, the vapor pressure also drops and a point can be reached where there is insufficient pressure available to operate the system.

The problem is further compounded when the outside temperature of the tank reaches freezing and the moisture in the surrounding air freezes on the tank surface. This ice acts as an insulator, further preventing heat from entering the tank.

To counteract this condition in situations when withdrawal rates are so high that the ambient heat available is not sufficient to sustain the flow, a vaporizer must be used.

## VAPORIZER

To understand how the vaporizer operates, refer to National Ammonia Company Drawing 8010. As gas is removed from the top of the tank, the pressure in the tank is reduced and liquid ammonia vaporizes to replace the gas which has been withdrawn. Heat is required to accomplish this vaporization.

If heat from the surrounding air is not sufficient or cannot flow through the walls of the tank into the liquid ammonia fast enough to maintain the vaporizing rate, the pressure will continue to drop.

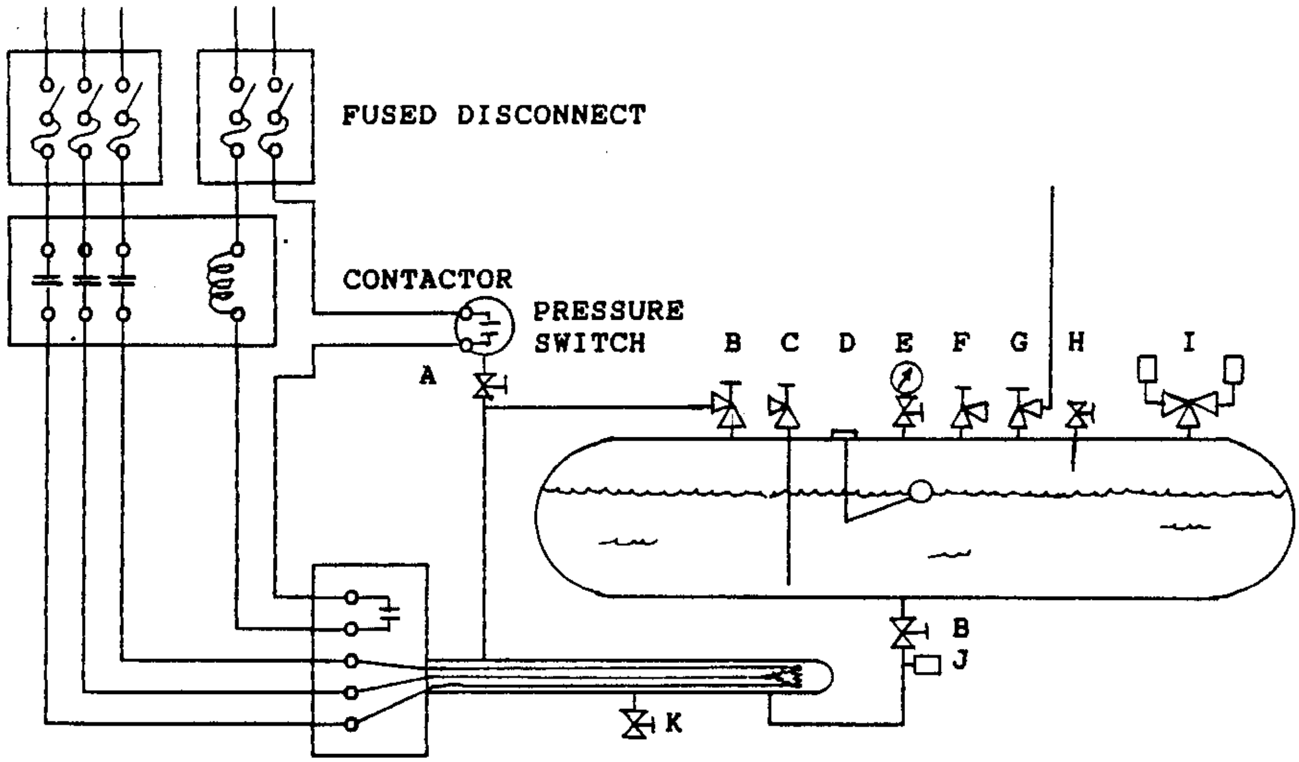
At some point, depending on the setting of the pressure switch, this pressure drop closes the pressure switch electrical contacts, turning on the heaters in the vaporizer. Liquid ammonia then flows out of the bottom of the tank into the vaporizer where it is converted to a gas. The gas then flows into the top of the tank where it can be withdrawn to satisfy the needs of the system.

The requirement or need for this supplemental heat is dependent on the ambient temperature around the tank, the air movement around the tank, the volume of liquid within the tank and the rate of withdrawal of vapor.

An auxiliary thermostat located within the vaporizer is used to prevent overheating. The setting of this thermostat is not critical; it is set at approximately 70° ± 10°F. The auxiliary thermostat is connected in series with the pressure switch and limits the operating temperature of the vaporizer.

Power should not be applied to the vaporizer when it does not contain liquid ammonia. This can happen before the tank is filled, if the vaporizer isolating valves are not open or if the system is allowed to run dry or completely empty. If power is applied under these circumstances, the heating elements could be burned out. Responsibility for the cost of replacing elements damaged in this manner lies with the user or customer.

The auxiliary thermostat will not protect the heating elements under the above circumstances because heat will not travel from the heating elements to the thermostat without the liquid ammonia present to act as a transfer media.




A: PRESSURE SWITCH ISOLATING VALVE
B: VAPORIZER ISOLATING VALVE
C: LIQUID FILL CONNECTION
D: FLOAT GAUGE
E: PRESSURE GAUGE WITH ISOLATING VALVE
F: FILL CONNECTION, VAPOR RETURN
G: CUSTOMER SERVICE CONNECTION
H: 85% OUTAGE GAUGE
I: SAFETY RELIEF VALVES & 3-WAY VALVE
J: HYDROSTATIC RELIEF VALVE
K: VAPORIZER DRAIN VALVE

## NOTES ON OPERATION

1. VAPORIZER ISOLATING VALVES MUST BE OPEN AND LIQUID AMMONIA IN THE TANK BEFORE POWER IS APPLIED TO THE HEATERS.
2. THE PRESSURE SWITCH LOWER SET POINT SHOULD BE SET SLIGHTLY ABOVE THE MINIMUM OPERATING PRESSURE REQUIRED. THE UPPER SET POINT SHOULD BE SET ABOUT 10 PSI ABOVE THE LOWER SET POINT. THE PRESSURE SWITCH ISOLATING VALVE MUST BE OPEN.
3. THE THERMOSTAT SHOULD BE SET TO ITS MAXIMUM TEMPERATURE SETTING.
4. SHOULD ONE OF THE SAFETY RELIEF VALVES START TO LEAK, IT MAY BE ISOLATED USING THE 3-WAY VALVE. THE OTHER SAFETY RELIEF VALVE IS ADEQUATE, BY ITSELF, TO PROTECT THE TANK.
5. TANKS THAT ARE EQUIPPED WITH VAPORIZERS SHOULD BE ELECTRICALLY GROUNDED.

NATIONAL AMMONIA COMPANY
BOWER AMMONIA & CHEMICAL COMPANY
NORTHEASTERN AMMONIA COMPANY

TYP. STORAGE TANK W/ VAPORIZER

| Date: 02/14/89 | Dwg.No. 8010 |
| --- | --- |

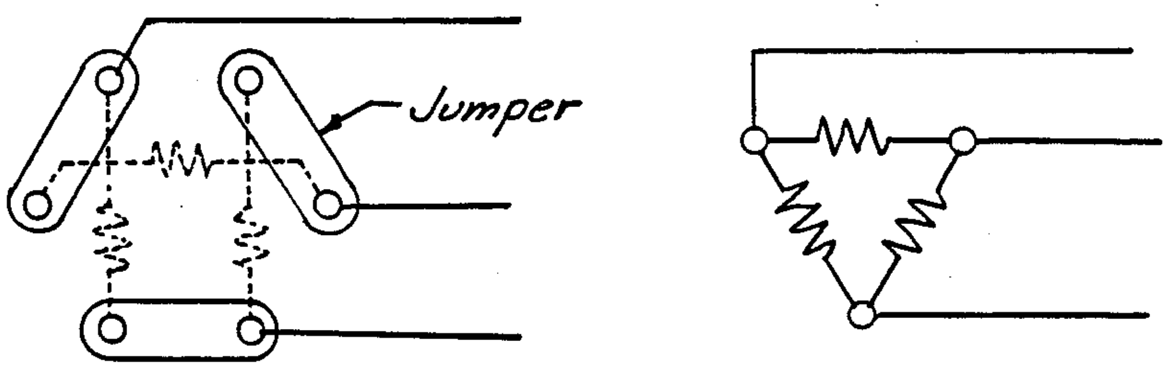
## ELECTRICAL CONNECTIONS - VAPORIZER HEATING ELEMENTS

In general, vaporizer heating elements are mounted in a group of three; each element having a heating capacity of 2.5 kw and operating on either 240 or 480 volts. The resulting 7.5 kw capacity is adequate to vaporize 50 pounds of ammonia per hour.

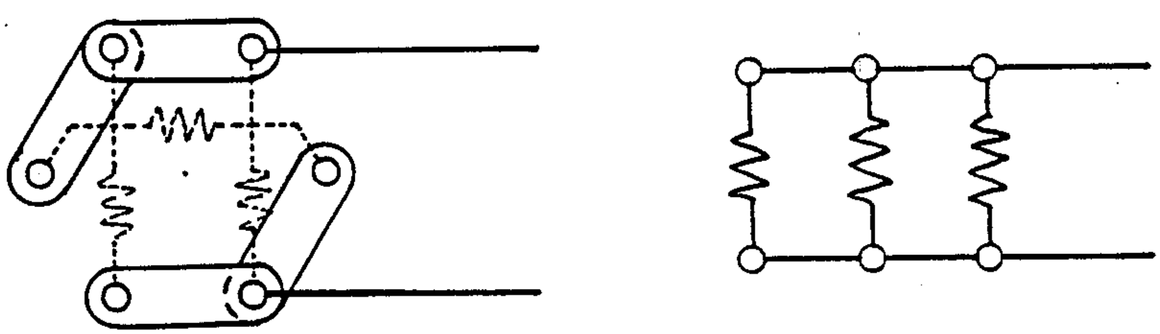
Higher killowatt ratings are occasionally used.

The heating elements can be connected (electrically) in various arrangements for single or three phase operation by the use of plate type jumpers. Jumper arrangements may be changed for different operating conditions; however, voltage requirements are fixed. Lower voltages may be used; however, reduced heat output will result.

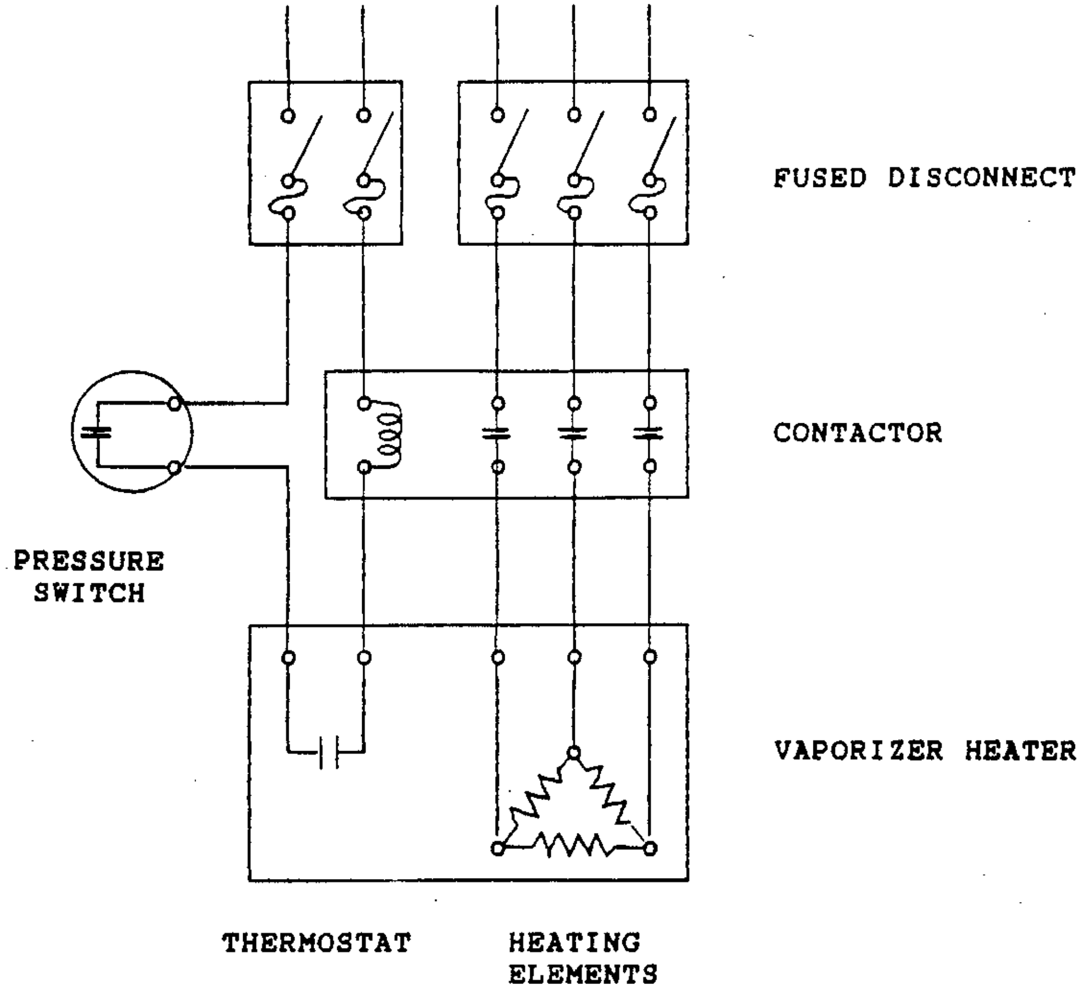
The diagrams below show jumper arrangement for three phase and single phase operation.




240 or 480 V. 3 phase



240 or 480 V. 1 phase




NOTES:

1. 115 VOLTS, 60 CYCLES IS REQUIRED FOR THE CONTROL CIRCUIT. THE THE VAPORIZER HEATING ELEMENTS ARE DESIGNED FOR 240 VOLT OR 480 VOLT, 3 PHASE OPERATION AND ARE USUALLY RATED FOR 7.5 KW. THE FUSE REQUIREMENTS UNDER THESE CONDITIONS ARE 20 AMPS FOR 240 VOLT OPERATION AND 10 AMPS FOR 480 VOLT OPERATION.
2. THE FUSED DISCONNECT AND CONTACTOR ARE TO BE SUPPLIED BY THE CUSTOMER
3. THE PRESSURE SWITCH CLOSES ON LOW PRESSURE. SET THE LOWER SET POINT ABOUT 10 PSI HIGHER THAN THE LOWEST PRESSURE REQUIRED. SET THE UPPER SET POINT ABOUT 10 PSI ABOVE THE LOWER SET POINT.
4. IMPORTANT - POWER MUST NOT BE APPLIED TO THE VAPORIZER HEATER UNLESS THE VAPORIZER CONTAINS LIQUID AMMONIA. OTHERWISE, HEATER BURNOUT WILL OCCUR. CUSTOMER WILL BE CHARGED FOR HEATER ELEMENT REPLACEMENT.
5. THE THERMOSTAT SHOULD BE SET TO ITS HIGHEST TEMPERATURE SETTING.
6. VAPORIZER EQUIPPED STORAGE TANKS SHOULD BE ELECTRICALLY GROUNDED.

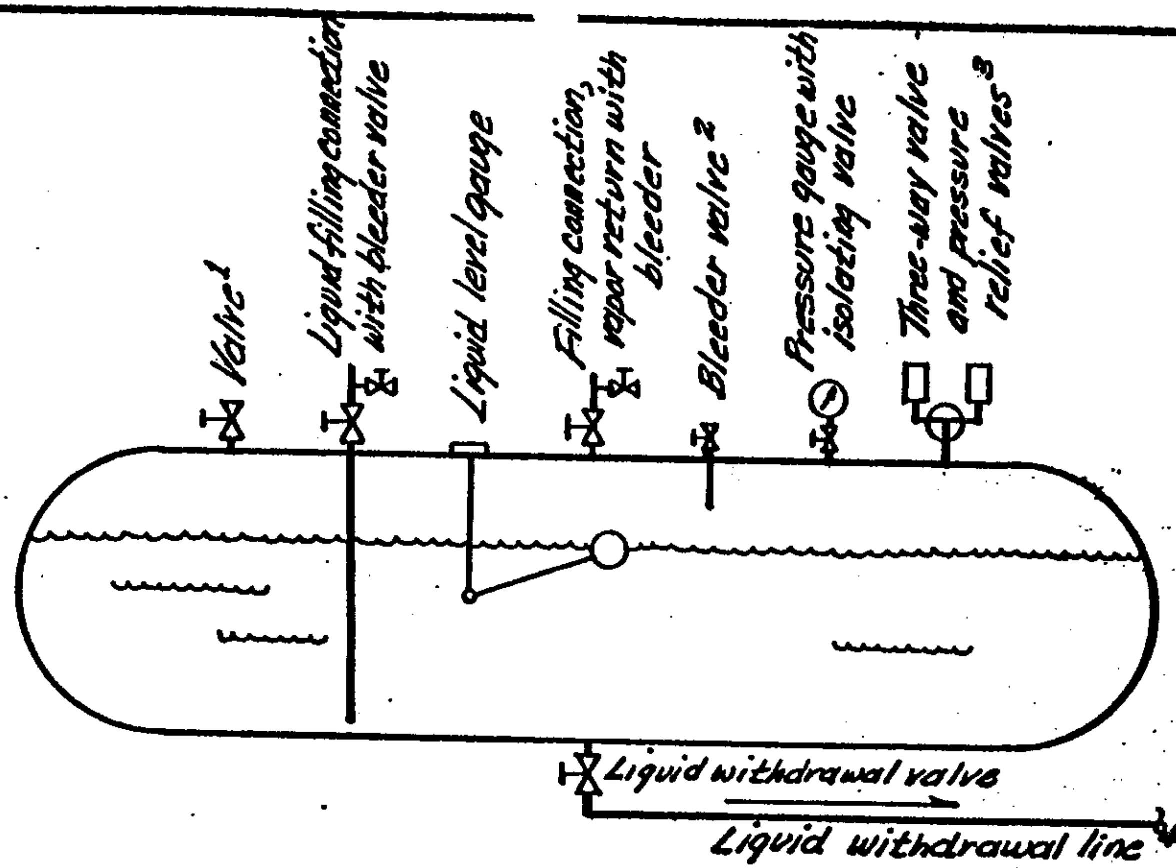
| | |
|---|---|
| NATIONAL AMMONIA COMPANY<br>BOWER AMMONIA & CHEMICAL COMPANY<br>NORTHEASTERN AMMONIA COMPANY | |
| VAPORIZER WIRING DIAGRAM | |
| Date: 10/18/88 | Dwg.No. 8011 |

ANHYDROUS AMMONIA; LIQUID WITHDRAWAL

ANHYDROUS AMMONIA is shipped and stored in liquid form. Some applications require that the material be converted to a gas before use and some applications, such as refrigeration systems, utilize the ammonia as a liquid. In liquid systems, the ammonia is withdrawn from the bottom of the tank, either by a connection directly at the bottom of the tank or by a connection at the top of the tank with a dip tube inside the tank running down to the tank bottom.

Care should be exercised in designing liquid systems to be sure that a hydrostatic relief valve is used wherever there is the possibility that liquid could be trapped within a closed system. Liquid ammonia's large coefficient of expansion with temperature will produce high pressures which can cause piping to rupture without such protection.

Reference Drawing Number 8012.




Exact location & relationship of tank accessories may vary

Notes:
1. Not used on liquid withdrawal installations.
2. Used to detect 85% liquid fill.
3. Pressure relief valves are set at 250 psig. Three-way valve may be used to isolate either, but not both, valves.
4. A hydrostatic relief valve must be installed between each pair of valves where liquid may be trapped.

NATIONAL AMMONIA COMPANY
BOWER AMMONIA & CHEMICAL CO.

Typical Ammonia Storage Tank

## MAINTENANCE

The responsibility for the maintenance of the ammonia storage tank, piping and appurtenances lies with the user. Little maintenance is required on a well installed ammonia storage system. The tanks and piping should be visually inspected at least once a month. All pipe joints and appurtenances should be examined for signs of corrosion, damage, wear and possible leaks.

Areas of corrosion should be cleaned, primed and painted. The tank itself should be painted with a good grade of white gloss enamel. All markings, warnings, identification signs, etc. should be legible and should be replaced as needed. Do not paint over the tank nameplate and do not paint over, or remove, markings, warnings, identification signs, etc., unless it is necessary.

Replacement decals may be obtained by contacting either our Sales Representative or our Home or Branch Office.

Minor leaks may often be repaired by tightening screws, packing nuts or closing valves tighter. Where replacement of components are necessary, contact our Sales Representative or the Home or Branch Office.

When bleeding down ammonia systems prior to dismantling for repair or alteration, advantage may be taken of ammonia's great affinity for water. Vapors from the bleed point can be conducted by means of a hose to a container of water. The water should be replaced when the vapors are no longer absorbed or become too concentrated.

A well maintained system will insure a continuous, economical and safe source of ammonia supply.

Our truck drivers are trained to supplement your inspection procedures; and upon request, they or our technical personnel will lend assistance in any inspection or maintenance problems you encounter.

## AMMONIA STORAGE TANKS

Stationary tanks for ANHYDROUS AMMONIA storage are designed for at least 250 psig pressure and built in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII.

Refer to National Ammonia Company/Bower Ammonia & Chemical Company Drawing 8014.

Tanks should be located in an area where they will not be exposed to damage by vehicle traffic; however, access to within 50 feet is required for tank truck delivery. The area should be clear of debris, weeds or any combustible materials.

If the tank is located where summer sun conditions are severe, provision should be made for sun shielding. In some areas, local codes require that an automatic sprinkler system be installed. Check the codes in your area for both sprinkler system and diking requirements.

Tanks should be mounted on substantial concrete, masonry or structural steel supports or on firm concrete or masonry foundations. All foundations should extend below the frost line.

In the event of an emergency, access to the tank must be provided. If the tank is fenced in, two to four feet clearance is recommended as a working area for maintenance purposes. Entrance gates should be located for easy entrance and exit.

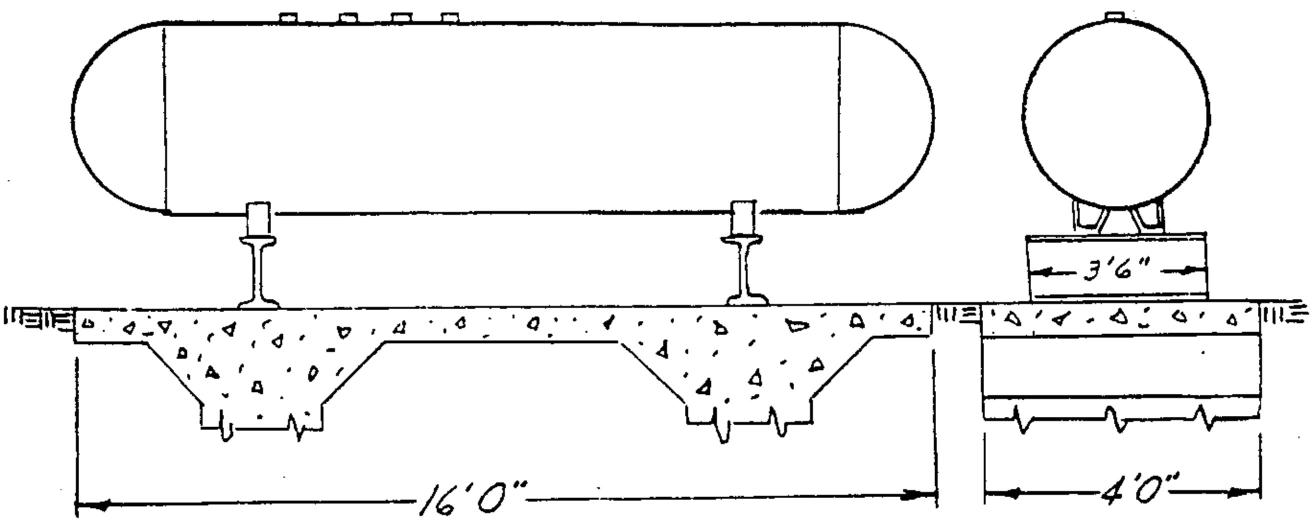
All pipe and hose connections to the tank proper are protected by excess flow valves to prevent massive leakage in the event of a line break.

Gauge connections and the 85% "dip tube" gauge are not so equipped but do have a .054 restriction to limit flow.

The tank is equipped with a dual safety relief valve system consisting of a three-way valve and two pressure relief valves. The three-way valve is installed to permit replacement of either of the relief valves without emptying the tank. The design of the three-way valve permits shutting off one or the other but not both pressure relief valves at a time.

Different designs of the three-way valves are used. The "Shank" type valve has a hand wheel. To shut off Port #1, turn valve hand wheel clockwise to stop. To shut off Port #2, turn valve hand wheel counter clockwise to stop. With the valve hand wheel centered, both pressure relief valves are operational. The "Frick" and "Henry" style valves have a conical cap covering the valve stem. Use caution when removing this cap as it may be under a slight pressure. Turning the exposed stem clockwise will shut off the port furthest from the stem. Turning it counter clockwise will shut off the port nearest to the stem. With the stem centered, both ports are open and both pressure relief valves operational.

PROVIDE A 2 FT. MINIMUM CLEARANCE ON ALL SIDES FOR INSPECTION AND MAINTENANCE PURPOSES.




THE DISTANCE BETWEEN THE TANK LEGS (APPROXIMATELY 9 FT.) WILL VARY WITH TANK MANUFACTURER. CONTACT THE MGR. TECHNICAL SERVICE IF EXACT DIMENSION IS NECESSARY.

APPROX. OVERALL DIMENSIONS: 3'-6" DIA. x 16'-1" LONG

APPROX. WEIGHT EMPTY: 2750 LBS.

APPROX. WEIGHT FULL: 7000 LBS.

## TYPICAL 1000 GALLON ANHYDROUS AMMONIA TANK

INSTALLATION NOTES:

1. INSTAL THE TANK IN A LOCATION WHERE IT WILL NOT BE SUBJECTED TO DAMAGE BY VEHICLES, CORROSIVE MATERIALS OR FALLING OBJECTS.
2. A PROTECTIVE ENCLOSURE (CHAIN LINK FENCE) SHOULD BE PROVIDED IF THE TANK COULD BE SUBJECTED TO VANDALISM.
3. THE TANK SHOULD BE LOCATED AWAY FROM BUILDING AIR INTAKES, OPEN WINDOWS OR ANYWHERE THAT THE ODOR OF AMMONIA COULD CAUSE PROBLEMS.
4. PIPING CONNECTIONS TO THE TANK SHOULD ALLOW FOR TANK MOVEMENT DUE TO SETTLING, EXPANSION OR CONTRACTION ETC.
5. TANKS EQUIPPED WITH VAPORIZERS SHOULD BE ELECTRICALLY GROUNDED.

| NATIONAL AMMONIA COMPANY<br>BOWER AMMONIA & CHEMICAL COMPANY<br>NORTHEASTERN AMMONIA COMPANY | |
|---|---|
| TANK INSTALLATION DRAWING | |
| Date: 10/18/88 | Dwg.No. 8014 |

## INSPECTION CHECK LIST

Inspection to be performed at least every three months

| | YES | NO |
|---|---|---|
| 1. Is ammonia tank free of leaks? | ○ | ○ |
| 2. Are tank supports in good condition? | ○ | ○ |
| 3. Is paint in good condition? | ○ | ○ |
| 4. Are valves and fittings free of leaks and in good condition? | ○ | ○ |
| 5. Are openings on valves free of dirt and rust with protective caps in place? | ○ | ○ |
| 6. Are safety relief valves free of debris with rain caps installed? | ○ | ○ |
| 7. Are gauges for pressure and liquid level operative? | ○ | ○ |
| 8. Are connecting pipes properly supported, free of physical damage and rust and properly painted? | ○ | ○ |
| 9. Is facility protected against tampering? | ○ | ○ |
| 10. Is the area free of weeds, trash and other unsafe conditions? | ○ | ○ |
| 11. Are the necessary precautions and warning signs displayed and in good condition? | ○ | ○ |
| 12. Is personnel safety equipment readily available, in good working condition and filled with usable, fresh contents as required? | ○ | ○ |
| 13. If the tank is equipped with a vaporizer, is it functioning correctly? | ○ | ○ |

## PIPING SYSTEMS FOR ANHYDROUS AMMONIA

Ammonia corrodes copper, silver, zinc and their alloys. It is essential, therefore, that iron or steel be used in piping and fittings. The usual types of pressure regulators and gauges having bronze parts; brass valves, bronze-seated unions and galvanized fittings and pipes are not suitable.

Metallic and non-metallic gasket materials, such as compressed asbestos, carbon or stainless steel spiral-wound asbestos-filled and aluminum are suitable for ammonia service.

All ammonia piping should be extra heavy (Schedule 80) steel when screwed joints are used. Standard weight (Schedule 40) steel may be used when joints are either welded or joined by welding type flanges. Galvanized piping should never be used.

Crane Packing Company FLS2 paste type pipe thread and gasket sealer along with Teflon tape has been used successfully as a pipe thread lubricant and sealer and is highly recommended.

Provision should be made to protect pipe against the effects of expansion, contraction, jarring, vibration and settling.

All piping should be tested for leaks after assembly by introducing ammonia vapor. Do not introduce liquid ammonia because if it is subsequently necessary to disassemble the piping to fix the leak, minimal bleed down will be necessary. Refer to section titled "Ammonia Leaks".

All fittings must be extra heavy and non-malleable metals must not be used in their construction. Forged or cast steel valves and fittings should be used where there is significant strain or vibration.

Any portion of liquid piping or hose which at any time may be closed at each end must be provided with a hydrostatic relief valve to prevent excessive hydrostatic pressure. This hydrostatic relief valve must not have an intervening shut-off valve installed.

Only all steel gauges should be used. For normal applications the 0-400 psig gauge is recommended and for low pressure work, the range for the gauge should be one and one-half times the maximum service pressure.

The above information is taken from Pamphlet G-2 "ANHYDROUS AMMONIA" published by the Compressed Gas Association Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202, Phone Number: 703-979-0900.

# AMMONIA LEAKS

An ammonia leak is easily detected by the sharp, pungent odor of the vapor. All leaks should be approached with caution. When a leak is detected, the first step should be to determine the size of the leak, its location, and whether it is continuous or a single release such as would occur when a hose is vented before being disconnected.

If the leak is large and continuous, personnel in the area should be evacuated and help summoned. No attempt will be made here to provide instructions covering this situation except that a plan should be formulated and all personnel should be instructed in its execution. National Ammonia Company/Bower Ammonia & Chemical Company will be pleased to assit you in planning these emergency measures.

Where small leaks are detected, they can usually be repaired with a minimum of effort and concern.

If the installation is outdoors, the leak area should be approached from up wind, if possible. If the leak location is not immediately apparent, it can usually be located using moist litmus paper which turns color on exposure to ammonia fumes or by using sulfur dioxide which forms a heavy white smoke when mixed with ammonia vapor. Sulfur dioxide can be generated by burning a sulfur taper. Sulfur tapers should not be used near an ammonia dissociator. Once the general area has been determined, a bubble test using a soap solution can be used to pinpoint the actual location.

In an emergency, if you are unable to contact National Ammonia Company/Bower Ammonia & Chemical Company, the Chemical Manufacturers Association in Washington, DC will provide advice through CHEMTREC, the Chemical Transportation Emergency Center, by calling 800-424-9300. In the District of Columbia, call 483-7616.

The leak can usually be corrected by tightening a nut or bolt as in the case of an ammonia flange or by tightening a packing nut as in the case of a valve or applying a little extra torque on the valve handle. Note that cylinder valve packing nuts have left-hand threads. Valve stem packing glands are usually down stream of the valve seat and if tightening the packing nut does not stop the leak, closing the valve will. This, of course, is a temporary fix and the valve packing would require attention.

Escaping ammonia vapors can be conveniently disposed of by taking advantage of ammonia's great affinity for water. A spray of water will absorb large quantities of gas and reduce vapor concentrations to tolerable levels.

## SAFETY

Ammonia vapor is not poisonous, but due to its high solubility in water, it does have a very irritating action on the mucous membrane of the eyes, nose, throat and lungs. Fortunately, since its sharp pungent odor serves as a warning signal, very small concentrations of ammonia in air are readily detected. Prolonged exposure to air containing 100 parts per million of ammonia is not harmful, but breathing air containing from 5,000 to 10,000 ppm of ammonia may cause sudden death from spasm or inflammation of the larynx. Concentrations exceeding 700 ppm of ammonia vapor will cause irritation of the eyes and permanent injury may result if immediate remedial measures are not taken. Ammonia's high solubility in water causes it to irritate any skin surface where moisture has accumulated.

Since liquid ammonia vaporizes readily and has a great affinity for water, it may cuase severe injury to the skin by freezing the tissue and subjecting it to caustic action. The symptoms are practically the same as those of a burn.

Persons having chronic lung diseases, heart disease or persons who have shown evidence of hypersensitivity to ammonia should not be employed where they will be exposed to it.

Any person who has been burned or overcome by ammonia should be placed under a physician's care immediately.

Persons responsible for first aid services should be familiar with the special procedures required in cases of ammonia exposure.

The above information has been taken from and is covered more fully in Pamphlet G-2 "ANHYDROUS AMMONIA" published by the Compressed Gas Association Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202. Phone: 703-979-0900.

## SAFETY EQUIPMENT

Should personnel be exposed to liquid ANHYDROUS AMMONIA, it is most important that the body area affected be immediately flooded with water. For this purpose, easily accessible showers, preferably of the treadle type, should be provided. These showers should be capable of supplying large quantities of water. Bubbler type fountains for irrigation of the eyes should also be available.

Personnel who are responsible for taking corrective action, should an accidental release occur, should have available gas masks and protective clothing. OSHA requires that all ammonia storage installations have at least two full face gas masks available.

Gas masks should be of a type approved by the U. S. Bureau of Mines. They should be stored where they are easily accessible and in a location where a leak will not prevent access to them.

Protective clothing to be provided should include hat, gloves, suit and boots, all garments to be of rubber. Garments worn beneath the rubber outer clothing should be made of cotton. Some protection to the skin may be obtained by applying protecting oils. Approved eye goggles should be supplied if the eyes are not protected by a full face mask.

PLEASE NOTE:

The information contained in this brochure was obtained from sources believed to be reliable and is based on technical information excerpted, in part, from Pamphlet G-2 published by the Compressed Gas Association and Pamphlet K61.1-1972 published by the American National Standards Institute, Inc. Supplemental information pertinent to ammonia storage tank installation and maintenance has been added.

We believe the information contained in this brochure to be accurate and reliable. However, National Ammonia Company and Bower Ammonia and Chemical Company (the "Companies") assume no liability or responsibility in connection with the information or suggestions herein contained. Moreover, it should not be assumed that every acceptable test or safety procedure or method, precaution, equipment or device is contained within, or that abnormal or unusual circumstances may not warrant or suggest further requirements or additional procedures. The Companies neither represent nor warrant that the excerpted material from said pamphlets contains everything stated in the pamphlets, and the pamphlets themselves should be read for a complete statement of their contents.

The information contained in this brochure should not be confused with state, municipal, or insurance requirements, or with national safety codes, and no representatives nor warranties are made with respect thereto.

# EXHIBIT 5.1-B

## SAFETY REQUIREMENTS FOR THE STORAGE AND HANDLING OF ANHYDROUS AMMONIA

*CGA—G-2.1 — 1989*

*ANSI K 61.1 — 1989*

American National Standard

*ANSI K 61.1 — 1989*

# *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*


ANSI American National Standards Institute

*1430 Broadway*

*New York, New York*

*10018*

ANSI
K-61.1-1989
Revision of
K61.1-1981

# American National Standard Safety Requirements for the Storage and Handling of Anhydrous Ammonia

Secretariat
Compressed Gas Association, Inc.
1235 Jefferson Davis Highway
Arlington, VA 22202

CGA Pamphlet G-2.1 — 1989

Approved March 17, 1989
American National Standards Institute, Inc.

## AMERICAN NATIONAL STANDARD

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether he has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review and users are cautioned to obtain the latest editions.

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Published by

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Printed in the United States of America

**IN CASE OF A TRANSPORTATION EMERGENCY INVOLVING A COMPRESSED GAS**

In the UNITED STATES, ask for advice through CHEMTREC, the Chemical Transportation Emergency Center at the Chemical Manufacturers Association in Washington, D.C.

| | |
|---|---|
| 48 contiguous states, Puerto Rico, Virgin Islands, Alaska, Hawaii, and if transporting Canadian products in the United States (toll free) | (800) 424-9300 |
| District of Columbia, and foreign locations (exclusive of Canada) | (202) 483-7616 |
| For non-emergency information only, call The Chemical Referral Center | (800) 262-8200 |
| (If in District of Columbia, or (collect) if foreign location other than Canada | (202) 887-1315 |

In CANADA, ask for advice through CANUTEC, Transport of Dangerous Goods Branch, Transport Canada, Ottawa, Ontario.

| | |
|---|---|
| In an emergency, from all points within Canada, call collect 24 hours a day | (613) 996-6666 |
| For non-emergency information only, call | (613) 992-4624 |

## PLEASE NOTE:

The information contained in this document was obtained from sources believed to be reliable and is based on technical information and experience currently available from members of the ANSI K61 Committee, Compressed Gas Association, Inc. and others. However, the Compressed Gas Association or its members, jointly or severally, make no guarantee of the results and assume no liability or responsibility in connection with the information or suggestions herein contained. Moreover, it should not be assumed that every acceptable commodity grade, test or safety procedure or method, precaution, equipment or device is contained within, or that abnormal or unusual circumstances may not warrant or suggest further requirements or additional procedure.

This document is subject to periodic review and users are cautioned to obtain the latest edition. Comments and suggestions are invited from all users for consideration by the ANSI K61 Committee in connection with such review; any such comments or suggestions will be fully reviewed by the Committee after giving the party, upon request, a reasonable opportunity to be heard.

This document should not be confused with federal, state, provincial, or municipal specifications or regulations, insurance requirements or national safety codes. While the Compressed Gas Association recommends reference to or use of this document by government agencies and others, this document is purely voluntary and not binding.

## FOREWORD

(This Foreword is not a part of American National Standard Safety Requirements for the Storage and Handling of Anhydrous Ammonia, K61.1-1989.)

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. The CGA 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 the Compressed Gas Association, Inc., 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 co-sponsorship of the K61 project. CGA supported co-sponsorship in order to achieve the endorsement of a single American National Standard that could be supported jointly by ANI and CGA.

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

As co-secretariats 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.

A meeting of the K61 Committee was held on February 22, 1984 to initiate work toward revision of the 1981 edition of the K61.1 Standard which replaced the 1972 edition. The present edition represents a substantial reorganization and expansion of material contained in prior editions with individual sections now being devoted to ammonia safety and the use of water in emergencies. A new section regarding tank cars has been added in recognition of the importance of the rail transportation mode. Other sections have been updated to reflect major changes in the areas of technology and regulatory matters.

In 1987, The Fertilizer Institute withdrew from co-sponsorship of the K61.1 Standard, however TFI elected to continue as an active participant on the K61 Committee.

The K61 Committee and the Secretariat extend grateful acknowledgment to past chairman Ford B. West, and past secretary Harrison T. Pannella, for their contributions to the work of the Committee.

Suggestions for improvement gained in the use of this Standard will be welcome. They should be sent to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018, or to the ANSI K61 Committee Secretariat, Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Safety Requirements for the Storage and Handling of Anhydrous Ammonia (ANSI K61.1). 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 K61 Committee had the following members:

John S. Krol, Chairman
Leo R. Elwell, Secretary

| Organization Represented | | Name of Representative |
|---|---|---|
| American Institute of Chemical Engineers | | Maurice L. Greiner |
| American Society of Agricultural Engineers | | Mansel M. Mayeux, P.E. |
| American Water Works Association | | Jack C. Dice |
| Association of American Plant Food Control Officials, Inc. | | Robert C. Rund |
| Association of Reproduction Materials Manufacturers, Inc. | | Lucas A. Seeman |
| | (Alternate) | Philip P. Nowers |
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| | (Alternate) | Stephen B. Tanner |
| Corrosion Technology (Consulting Engineer) | | Alexei W. Loginow |
| Industrial Safety Equipment Association, Inc. | | F. Earl Ganzenmuller |
| | (Alternate) | Frank E. Wilcher, Jr. |
| National Safety Council | | Gary L. Smith |
| Rubber Manufacturers Association | | Steven Butcher |
| | (Alternate) | Edward J. McCarthy |
| The Fertilizer Institute | | William C. Boettcher |
| The National Board of Boiler and Pressure Vessel Inspectors | | Michael F. Sullivan |
| U.S. Coast Guard (Liaison member without vote) | | Phillip Olenik |
| U.S. Dept. of Transportation | | James K. O'Steen |
| (Liaison member without vote) | (Alternate) | Jose S. Pena |

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TABLES

# 1. INTRODUCTION

## 1.1 Scope

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

**1.1.2** This standard does not apply to:

**1.1.2.1** Ammonia manufacturing plants.

**1.1.2.2** Refrigeration systems where ammonia is used solely as a refrigerant. Such systems are covered in ANSI/ASHRAE 15-78, *American National Standard Safety Code for Mechanical Refrigeration* [1][1]. The provisions of ANSI/ASHRAE 15-78 are not appropriate to refrigerated ammonia storage systems as covered in this standard.

**1.1.2.3** Ammonia transportation pipelines.

**1.1.2.4** Ammonia barges and tankers.

[1]NOTE: References in this document are shown by bracketed numerals and are listed in the order of appearance. See Section 13, References.

## 1.2 General

**1.2.1** 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, the authority having jurisdiction may permit deviation from the standard.

**1.2.2** The values stated in customary units are to be regarded as standard. Metric equivalents where shown in this standard may not be exact, and follow ANSI *Metric Practice* (ANSI/IEEE Standard 268-1982) 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 below its normal boiling point of -28.17°F (-33.43°C), it can 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.

**TABLE 1**

**PHYSICAL PROPERTIES OF AMMONIA**

| | |
|---|---|
| Chemical formula | $NH_3$ |
| Molecular weight | 17.031 |
| Boiling point at one atmosphere* | -28.17°F (-33.43°C) |
| Freezing point at one atmosphere | -107.93°F (-77.74°C) |
| Critical temperature | 270.32°F (132.40°C) |
| Critical pressure | 1636 psia (11 280 kPa (abs)) |
| Latent heat of vaporization at -27.7°F (-33.2°C) and 1.012 atm (102.6 kPa) | 588.2 Btu/lb (1.367 x $10^6$J/kg) |
| Relative density of vapor (calculated) compared to dry air at 32°F (0°C) and one atmosphere | 0.597 |
| Vapor density calculated for -28°F (-33.3°C) and one atmosphere | 0.0549 lb/ft$^3$ (0.879 kg/m$^3$) |
| Specific gravity of liquid at -28°F (-33.3°C) compared to water at 39.2°F (4°C) | 0.682 |
| Liquid density at -28°F (-33.3°C) and one atmosphere | 42.6 lbs/ft$^3$ (682 kg/m$^3$) |
| Specific volume of vapor at 32°F (0°C) and one atmosphere | 20.78 ft$^3$/lb (1.297m$^3$/kg) |
| Flammable limits by volume in air at atmospheric pressure | 16% to 25% |
| Auto ignition temperature (in the presence of an iron catalyst) | 1204°F (651°C) |
| Auto ignition temperature (in a standard quartz container) | 1562°F (850°C) |
| Specific heat, gas, at 59°F (15°C) and one atm at constant pressure $C_p$ | 0.5232 Btu/lb °F (2.189 kJ/kg °C) |
| At constant volume, $C_v$ | 0.3995 Btu/lb °F (1.672 kJ/kg °C) |

*One atmosphere = 14.696 psia = 101.325 kPa (abs)

**1.3.3** Ammonia is extremely hard to ignite and is a relatively stable compound. It begins to dissociate at approximately 850°F (454°C) and 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%-25% by volume. Conditions favorable for ignition are seldom encountered during normal operations due to the high lower limit, narrow range, and the high ignition temperature required. However, the release of ammonia gas into a tightly enclosed or inadequately ventilated space may result in the accumulation of a flammable mixture that can cause a combustion explosion if a high temperature ignition source is present.

**1.3.4** 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. Refer to NFPA 45, *Hazardous Chemical Data.* [3]

**1.3.5** 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 avoided by the consistent use of 0.2 percent water by weight in the ammonia as an inhibitor. Weld heat affected zones can be areas of high hardness, which are susceptible to stress-corrosion cracking. U.S. Department of Transportation (DOT) regulations require that ammonia cargo tanks constructed of such steels be post-weld heat treated. See 49 CFR 173.15. [4]

## 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.

**1.4.2** The U.S. Occupational Safety and Health Administration (OSHA) has adopted a short term exposure limit (STEL) of 35 parts per million (ppm) (27 mg/m$^3$). This is for an employee's 15 minute time-weighted average (TWA) exposure which may not be exceeded at any time during a work day. See 29 CFR 1910.1000. [5] At 35 ppm, the pungent odor of ammonia is readily detectable by most people and serves as its own warning. No person will voluntarily remain in concentrations which are hazardous or injurious to health.

## 1.5 Federal, State, and Local Regulations

**1.5.1** Regulations of the U.S. Department of Transportation (DOT) and the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), are referenced in this standard.

**TABLE 2**
**HUMAN PHYSIOLOGICAL RESPONSE TO VARIOUS CONCENTRATIONS OF AMMONIA IN AIR**

| Response | Concentration (ppm) |
|---|---|
| First perceptible odor[1] | equal to or greater than 5 |
| Immediate throat irritation[2] | equal to or greater than 400 |
| Eye irritation[2] | equal to or greater than 700 |
| Coughing[2] | equal to or greater than 1700 |
| Life threatening for short exposure (0.5 hr)[2] | 2500-6500 |
| Rapidly fatal for short exposure (0.5 hr)[2] | 5000-10 000 |

[1] *Guide for Short Term Exposures of the Public to Air Pollutants. IV: Guide for Ammonia.* Committee on Toxicology of the National Academy of Sciences—National Research Council, November 1972, Environmental Protection Agency, Washington, DC, page 3. Odor threshold of 5 ppm in air.

[2] *Ammonia,* by the Subcommittee on Ammonia, Committee on Medical and Biological Effects of Environmental Pollutants of the National Research Council Copyright© 1979 by University Park Press, Baltimore, MD.

Prior to April 1, 1967, the DOT regulations were promulgated by the Interstate Commerce Commission (ICC). This standard or any part thereof shall not be construed by the user as recommending action in any manner which is not in full compliance with applicable federal, state, and local laws and regulations as are in effect at any given time.

### 1.6 Hazardous Material Classification

**1.6.1** The Hazardous Material Table of the United States Department of Transportation designates the hazard class for ammonia as "Nonflammable Gas" and lists ammonia as a hazardous substance with a reportable quantity (RQ) of 100 pounds (45 kg). [4] The 4-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.* [6] and [7]

## 2. DEFINITIONS

**2.1 Alteration.** A change in any item described in the original manufacturer's data report which affects the pressure-containing capability of the container. Rerating a container by increasing maximum allowable working pressure or by increasing or decreasing allowable working temperature shall be considered an alteration.

**2.2 Ammonia or Anhydrous Ammonia.** (These terms are used interchangeably in this standard.) The compound formed by the chemical combination of the elements nitrogen and hydrogen in the molar proportion of one part nitrogen to three parts hydrogen. This relationship is shown by the chemical formula, $NH_3$. On a weight basis, the ratio is 14 parts nitrogen to three parts hydrogen or approximately 82% nitrogen to 18% hydrogen. Ammonia may exist in either a gaseous or a liquid state. It is not to be confused with aqua ammonia or ammonium hydroxide which are solutions of ammonia in water sometimes called ammonia.

**2.3 Approved.** In this standard the word "approved" means:

(1) Listed by a recognized testing laboratory

(2) Recommended by the manufacturer as suitable for use with anhydrous ammonia and so marked

(3) Accepted by the authority having jurisdiction

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 "authority having jurisdiction" may be a federal, state, local, or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances, the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

**2.4 Appurtenance.** Refers to all devices such as pressure relief devices, liquid level gauging devices, valves, pressure gauges, pressure regulators, fittings, metering, or dispensing devices designed to be attached to an ammonia container.

**2.5 ASME Code.** Refers to (1) Paragraphs U-68, U-69, U-200, or U-201 of Section VIII of the *Boiler and Pressure Vessel Code* of the American Society of Mechanical Engineers, 1949 Edition, or (2) Section VIII Division I of the *Boiler and Pressure Vessel Code* of the American Society of Mechanical Engineers, 1950 Edition, through the current edition including addenda and applicable Code Case Interpretations. Where referenced in this standard only Division I of the ASME Code shall apply except that paragraph UG-90(c)(2) and paragraphs UG-125 through UG-136 and paragraph UW-2 shall not apply. [8]

**2.5.1 API-ASME Code.** Refers to the *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases* of the American Petroleum Institute and the American Society of Mechanical Engineers (API-ASME). The API-ASME Code, as a joint publications and interpretation service, was discontinued as of December 31, 1956, and construction of containers to the API-ASME Code has not been authorized after July 1, 1961.

**2.6 Capacity.** The total volume of the container measured in standard U.S. gallons, unless otherwise specified.

**2.7 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, which by reason of the container's size, construction, or attachment to a highway motor vehicle, must be loaded or unloaded without being removed from the highway motor vehicle. This definition does not apply to cylinders and implements of husbandry or containers normally used for storage.

**2.8 Chemical Splash Goggles (or Goggles).** Flexible fitting protective eyewear designed to provide primary protection of the eyes and eye sockets from the splash of hazardous liquids and meeting the requirements of ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection.* [9] Direct vented goggles do not comply with this definition.

**2.9 Container.** All tanks, except cylinders as defined in 2.10, used for the transportation or storage of anhydrous ammonia.

**2.10 Cylinder.** A pressure vessel of 1000 lbs (450 kg) water capacity or less constructed in accordance with United States Department of Transportation Specifications for cylinders and authorized for the transportation of ammonia. This definition does not include storage tanks, cargo tanks, portable tanks, nurse tanks, or tank cars.

**2.11 Design Pressure.** Identical to the term "Maximum Allowable Working Pressure" used in the ASME Code.

**2.12 DOT Regulations.** Refers to the Hazardous Materials Regulations of the Department of Transportation (See the *Code of Federal Regulations* Title 49, Parts 100 to 199, Transportation, including "Specifications for Shipping Containers.") [4]

**2.13 Emergency Shower.** A 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.* [10]

**2.14 Eye Wash Unit.** A device used to irrigate and flush the eyes with clean water. 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 which must be refilled or replaced after use. Any eyewash device must otherwise meet the requirements of ANSI Z358.1, *Emergency Eyewash and Shower Equipment.* [10]

**2.15 Filling Density.** The 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. One pound of water = 27.74 cubic inches (455 mL) at 60°F (15.6°C). For determining the water capacity of the tank in pounds, the weight of one gallon (231 cubic inches) (3.785 L) of water at 60°F (15.6°C) in air shall be 8.328 pounds (3.778 kg).

**2.16 Full Face Shield.** A device meeting the requirements of ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection* [9], designed to provide protection to all of the face from hazard, but which shall only be worn as secondary eye protection, supplementing the primary eye protection afforded by chemical splash goggles.

**2.17 Gas Mask.** An air-purifying device with full facepiece approved by NIOSH/MSHA under 30 CFR Part II, Subpart I for use in an ammonia contaminated atmosphere in compliance with 29 CFR 1910.134. [5]

**2.18 Hydrostatic Relief Valve.** A pressure relief device 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.

**2.19 Immediately Dangerous to Life or Health, (IDLH).** Any atmosphere that poses an immediate hazard to life or produces irreversible debilitating effects on health.

**2.20 Implement of Husbandry.** A system, including a nurse tank, with a capacity of 3000 gallons (11.35m$^3$) or less, or an applicator tank, used for transporting and applying anhydrous ammonia exclusively for agricultural purposes.

**2.21 National Board Inspection Code.** Refers to the manual published by the National Board of Boiler and Pressure Vessel Inspectors which provides the rules and guidelines for inspection by an authorized inspector of the repair, alteration, and rerating of ASME Code containers after being placed into service. [11]

**2.22 Permanent Storage Installation.** A system employing a stationary (fixed) container used exclusively for storage or supply.

**2.23 Positive Pressure Self-Contained Breathing Apparatus.** A full facepiece respirator approved by NIOSH/MSHA for respiratory protection for both entry into or escape from oxygen-deficient atmospheres or concentration of gases, or vapors which are immediately dangerous to life or health where the supply of air is carried by the wearer. The air pressure inside the facepiece is positive in relation to the air pressure of the outside atmosphere during exhalation and inhalation.

**2.24 Pressure Relief Valve.** A device 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. Refer to ANSI B95.1, *Terminology for Pressure Relief Devices.* [12]

**2.25 Protective Gloves, Boots, and Suits.** Items made of rubber or other material impervious to ammonia. Gloves refer to gauntlet-style of sufficient length to allow for cuffing, and which provide thermal protection suitable for ammonia exposure.

**2.26 psig and psia.** Refers to pounds per square inch gauge and pounds per square inch absolute, respectively.

**2.27 Repair.** The work necessary to restore a container or system to a safe and satisfactory operating condition, provided that in all cases the container or system design shall continue to comply with the requirements of this standard or the standard in effect at the time of installation. In addition, the original design of the container or system shall not be altered by the repair. Repairs include the addition or replacement of pressure or nonpressure parts which do not change the design temperature or pressure of the container or system.

**2.28 Semi-trailer.** 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.

**2.29 Shall or Must.** A mandatory requirement.

**2.30 Should.** A recommendation or that which is advised, but not required.

**2.31 Short Term Exposure Limit.** A 15-minute time weighted average exposure to an air contaminant which should not be exceeded at any time during a work day and which should not be repeated more than four times a day. Exposures at the STEL should not occur at less than 60-minute intervals.

**2.32 System.** Refers to an assembly of equipment consisting essentially of the container or containers, hoses, appurtenances, pumps, compressors, and interconnecting piping.

**2.33 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. Normally called a "full trailer."

**2.34 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, as contrasted to feeding ammonia to a use or application device.

## 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

**3.1.1** 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.

### 3.2 Normal Conditions

**3.2.1** 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 faceshield may be worn over the goggles. However, a faceshield shall not be worn as a substitute for a primary eye protection device (goggles).

### 3.3 Emergency Conditions

**3.3.1** If a leak occurs in a permanent storage installation, the personnel trained for and designated to act in such emergencies shall:

(1) See that persons not required to deal with an emergency are evacuated from the contaminated area and limit access to the contaminated area
(2) Put on suitable respiratory protection
(3) Wear protective gloves, suits and boots in contaminated areas
(4) Shut off the appropriate valves
(5) Notify local, state, or federal governmental regulatory authorities as may be appropriate and required by law

### 3.4 Permanent Storage Installations

**3.4.1** All permanent storage installations shall have on hand, as a minimum, the following equipment for emergency and rescue purposes:

**3.4.1.1** Two full face gas masks, each with one spare ammonia canister in a readily accessible location for use in ammonia concentrations less than the IDLH. See 2.19.

NOTE: A full facepiece ammonia gas mask will provide effective respiratory protection in concentrations of ammonia in air that are not immediately dangerous to life or health for short periods of time. A gas mask is not recommended for respiratory protection in concentrations exceeding the IDLH except for escape purposes only. Facepiece fitting should be used to determine the ability of each individual gas mask wearer to obtain a satisfactory fit. If ammonia vapor is detected within the gas mask facepiece, the facepiece fit is improper, the ambient concentration is excessive, or the canister is exhausted, the wearer should return to fresh air immediately to take appropriate corrective measures. The life of a canister in service is controlled by many factors including the concentration of ammonia vapor to which it is exposed.

Canisters should not be opened until ready for use and should be discarded after use. Canisters should be discarded and replaced when the shelf life expiration date marked on the canister is exceeded. When canisters include an end-of-service indicator, the manufacturer's expiration instructions are to be followed. In addition to this protection, an independent air-supplied, positive-pressure, self-contained breathing apparatus, approved by NIOSH/MSHA, should be used for entry into concentrations of ammonia vapor that are unknown or immediately dangerous to life or health. The American National Standard Z88.2, *Practices for Respiratory Protection*, should be referred to wherever respirators may be used. [13]

**3.4.1.2** One pair of protective gloves impervious to ammonia.

**3.4.1.3** One pair of protective boots impervious to ammonia.

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

**3.4.1.5** Easily accessible emergency shower and a plumbed eyewash unit or in lieu of these, at least 150 gallons (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 10 seconds travel time or 100 feet (30 m).

**3.4.1.6** Chemical splash goggles or chemical splash goggles with full faceshield to be worn over the device (goggles).

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

### 3.5 Cargo Tanks

**3.5.1** Each cargo tank transporting ammonia, except an implement of husbandry, shall carry:

**3.5.1.1** For first aid purposes, at least 5 gallons (20 L) of clean water in a container designed to provide ready access to the water for flushing any area of the body contacted by ammonia.

**3.5.1.2** One pair of protective gloves impervious to ammonia.

**3.5.1.3** A full facepiece gas mask with an ammonia canister and at least one spare canister.

**3.5.1.4** Chemical splash goggles, or chemical splash goggles with full faceshield, to be worn over the goggles.

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

### 3.6 Leaks in Transportation Equipment

**3.6.1** 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

**3.7.1** 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, including provision for flushing of the eyes by an employee in the event of contact with ammonia, or a self-contained eyewash unit with clean water.

## 4. USE OF WATER IN EMERGENCIES

### 4.1 Human Exposure

**4.1.1** If liquid ammonia contacts the skin or eyes, the affected area should be promptly and thoroughly flushed with clean water for at least 15 minutes total, with the eyes receiving first attention. Eyelids must be held open during flushing. Skin irrigation should include the ears, chin, neck, armpit, 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. [10] A physician should treat all cases of exposure to liquid ammonia.

An opthalmologist should be consulted immediately after flushing in the event of eye exposure.

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

### 4.2 Accidental Release

**4.2.1** In the event of an accidental release, 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. Downwind control should be achieved by directing water fog nozzles toward the point of ammonia release from a downwind position. See 3.3.1.

**4.2.2** Water should not be used on liquid ammonia spills. Water should only be directed in the form of fog or spray at the cloud emanating from the liquid pool. See 3.3.1.

**4.2.3** 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 following the procedures outlined in 4.2.1.

### 4.3 Fire Exposure

**4.3.1** If an ammonia container is exposed to fire and cannot be moved, water fog or spray (preferably 500 gal/min [$2m^3$/min] or more) should be used to cool it. Use caution if flame impinges on the vapor space of the container; violent rupture of the container is possible. Water fog or spray should always be applied to the tank from the sides, as the heads usually are first to rupture. If the fire cannot be controlled and it appears the tank may rupture, the surrounding area should be evacuated to a minimum distance of 2000 feet (600 m) 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 ammonia should be fed to the point of use or transferred to another suitable ammonia container. Small quantities of ammonia from a leaking container may be discharged into a vessel containing sufficient water to absorb it. Sufficient water may be taken to be ten parts of water to one part 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 must be weighted or secured so that the end of the hose will remain near the bottom of the vessel.

**4.4.2** Runoff of ammonia contaminated water into streams or other bodies of water should be avoided when possible. Releases of ammonia shall be reported to environmental protection and/or other 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, and 1986 editions of the ASME Code, or any revisions thereof, in effect at the time of fabrication.

**5.1.2** Systems and components which were fabricated, installed and maintained in accordance with the American National Standard K61.1, *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*, or the Compressed Gas Association *Standards for the Storage and Handling of Anhydrous Ammonia and Ammonia Solutions—Part 1 Anhydrous Ammonia*, or The Agricultural Nitrogen Institute, Standard M-1, *Standard for Storage and Handling of Agricultural Ammonia*, in effect at the time of installation, are acceptable for continued use.

NOTE: The latter two standards are no longer published.

### 5.2 Requirements for New Construction and Original Test of Containers (Including DOT Portable Tanks), Other Than Refrigerated Storage Tanks (see exception in 7.1.3).

**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 ASME Code requirements is that construction under Table UW 12 at a basic joint efficiency of under 80% is not authorized. Containers shall not be inspected and tested under the provisions of UG-90(c)(2) of the ASME Code.

**5.2.2** Containers designed and constructed in accordance with the ASME Code, other than refrigerated storage containers, shall comply with the following additional requirements:

**5.2.2.1** The entire container shall be post-weld heat treated after completion of all welds in and/or to the shells and heads. The method employed shall be as prescribed in the ASME Code. It is recommended that post-weld heat treatment be performed in a furnace of a size sufficient to accommodate the entire container. Welded attachments to pads may be made after post-weld heat treatment. [8]

5.2.2.2 Steels used in fabricating pressure-containing parts of a container shall have a tensile strength no greater than a nominal 70 000 psi (480 MPa) (does not apply to Sections 8, 9, and 10).

5.2.3 All containers, except refrigerated storage tanks with a design pressure of 15 psig (100 kPa) and less, and cylinders and containers covered in Section 8, shall be inspected by a person who holds a valid National Board Commission as an Authorized Inspector or as an Owner-User Inspector as defined in the National Board Inspection Code. [11]

5.2.4 Welding for the repair or alteration of pressure-containing parts of a container shall be performed in compliance with the applicable provisions of the current edition of the National Board Inspection Code. [11] Where specific procedures are not given, it is intended that subject to acceptance of the Inspector, all repair or alteration shall conform insofar as possible to the ASME Code section and edition to which the container was constructed.

### 5.3 Location of Containers

5.3.1 Selection of a location for a storage container shall be made considering the potential physiological and environmental effects of ammonia on the surroundings adjacent to the proposed site. Containers shall be located outside of buildings except in buildings or sections thereof especially approved for the purpose.

5.3.2 Containers shall be located at least 50 feet (15 m) from a dug well or other sources of potable water supply, unless the container is a part of a water treatment installation.

5.3.3 The minimum distance of a storage container to dwellings or to population centers shall be in accordance with the requirements of the local jurisdiction having authority.

5.3.4 Container locations shall comply with Table 3.

5.3.5 Container storage areas shall be accessible to emergency vehicles and personnel.

5.3.6 Areas within 10 feet (3 m) of a storage container shall be maintained clear of dry grass and weeds and other combustible materials.

### 5.4 Markings of Non-Refrigerated Containers and Systems Other than DOT Containers

5.4.1 Each system nameplate, when required, shall be made of a noncorroding metal permanently attached to the system by continuous welding around its perimeter, and located so as to be readily accessible for inspection. Nameplates shall be maintained in legible condition and include markings as prescribed in 5.4.2.

**TABLE 3**

**MINIMUM DISTANCES FOR LOCATION OF AMMONIA STORAGE CONTAINERS**
**(Customary Units and SI Units)**

| Nominal Capacity of Container (Gallons or Cubic Meters) | Minimum Distances (in feet or meters) from Each Container to: | | |
|---|---|---|---|
| | Line of Adjoining Property which may be built upon, Highways & Mainline of Railroad | Place of Public Assembly | Institution Occupancy |
| *Over 500 to 2000 gals | 25 ft | 150 ft | 250 ft |
| Over 2000 to 30 000 gals | 50 ft | 300 ft | 500 ft |
| Over 30 000 to 100 000 gals | 50 ft | 450 ft | 750 ft |
| Over 100 000 gals | 50 ft | 600 ft | 1 000 ft |
| Over 2 to 8 $m^3$ | 8 m | 45 m | 75 m |
| Over 8 to 110 $m^3$ | 15 m | 90 m | 150 m |
| Over 110 to 400 $m^3$ | 15 m | 140 m | 230 m |
| Over 400 $m^3$ | 15 m | 180 m | 300 m |

*NOTE: For 500 gallons ($2m^3$) or less, see 5.3.1 and 5.3.3.

5.4.2 Each container or system covered in Sections 6, 9, 10 (except "ton containers" and cylinders), 11, and 12 shall be marked as specified in the following:

5.4.2.1 With a marking as required by paragraph UG-116 of the ASME Code and identifying compliance with the rules of the ASME Code under which the container is constructed

5.4.2.2 With National Board of Boiler and Pressure Vessel Inspectors stamping to indicate registration of the container with this organization

5.4.2.3 With a notation on the container and system nameplate to indicate whether the system is designed for aboveground or underground installation or both

5.4.2.4 With the minimum and maximum temperatures in degrees Fahrenheit (°F) or degrees Celsius (°C) for which the container is designed

5.4.2.5 With the wall thickness of the container shell and heads in inches or millimeters (mm)

5.4.2.6 With the water capacity of the container in pounds or kilograms (kg), or U.S. standard gallons or cubic meters ($m^3$) at 60°F (15.6°C)

5.4.2.7 With the outside surface area of the container in square feet or square meters ($m^2$)

5.4.2.8 Marking required by paragraph UG-116 of the ASME Code shall be arranged in accordance with the requirements of UG-118(b). Marking required by 5.4.2.2 through and including 5.4.2.7 must be stamped on the nameplate required in 5.4.1. following the marking arrangement specified by UG-118(b) on a separate nameplate immediately adjacent to the ASME Code nameplate. Requirements of 5.4.1 shall also apply to the separate nameplate.

5.4.3 Each container or system covered in Sections 6, 9, 10 (except cylinders), 11, and 12 shall be fitted with a liquid level gauge indicating the maximum level to which the container may be filled with liquid anhydrous ammonia at temperatures between 20°F (-7°C) and 100°F (38°C), except on containers provided with fixed maximum level indicators, such as fixed length dip tubes or containers that are filled by weight. Marks shall be in increments of not more than 20°F (10°C). (See 5.9.3 regarding requirement for thermometer well and thermometer.)

5.4.4 All container openings except for pressure relief valves, pressure indicating devices, thermometer wells, or liquid level indicators shall be marked, stenciled, tagged, or decaled to indicate whether the opening is in contact with the liquid or vapor phase when the container is filled to the maximum allowable filling density.

### 5.5 Container Appurtenances

5.5.1 All appurtenances of each system shall be approved. See 2.3.

5.5.2 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.

5.5.3 All connections to containers except those for pressure relief devices, thermometer wells, liquid level gauging devices, or those fitted with a No. 54 (0.055 in or 1.40 mm) drill size orifice, or those plugged, shall have shut-off valves located as close to the container as practical.

5.5.4 Excess flow valves 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.

5.5.5 Liquid level gauging 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 (0.055 in or 1.40 mm) drill size opening, need not be equipped with excess flow valves.

5.5.6 An opening in a container to which a pressure gauge connection is made need not be equipped with an excess flow valve, if such an opening is not larger than No. 54 (0.055 in or 1.40 mm) drill size.

5.5.7 An excess flow or back pressure check valve, where required by this standard, shall be installed directly in the container opening.

5.5.8 Excess flow valves shall be designed with a by-pass, not to exceed a No. 60 (0.040 in or 1.02 mm) drill size opening, to allow equalization of pressures.

5.5.9 Shut-off valves with an integral excess flow valve shall be designed for proper installation in a container opening so that the excess flow valve will close in the event that the valve body, extending above the coupling, is sheared or broken off.

5.5.10 All excess flow valves shall be plainly and permanently marked with the name or trade-mark of the manufacturer, the catalog number, and the rated capacity.

**5.5.11** Each liquid filling connection shall have a positive shut-off valve in conjunction with either an internal back-pressure check valve or an internal excess flow valve. Vapor connections shall have a positive shut-off valve together with an internal excess flow valve.

**5.5.12** Quick opening (1/4 turn) valves are not recommended for use on transfer lines.

### 5.6 Piping, Tubing and Fittings

**5.6.1** All piping, tubing, and fittings shall be made of steel or other material suitable for anhydrous ammonia service.

**5.6.2** 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.

**5.6.3** All piping shall be supported in accordance with good piping practices and provisions shall be made as necessary for expansion, contraction, impact, vibration, and for settling. All non-refrigerated ammonia piping shall conform to ANSI/ASME B31.3, *American National Standard for Chemical Plant and Petroleum Refinery Piping;* all refrigerated ammonia piping used with refrigerated systems shall conform to ANSI/ASME B31.5, *American National Standard for Refrigeration Piping,* sections of the American Standard Code for Pressure Piping, as they apply to ammonia. [14] and [15]

**5.6.4** Piping used on non-refrigerated systems shall be at least ASTM A-53 Grade B seamless or Electric Resistance Welded Pipe. [16] Pipe joints shall be threaded, welded or flanged. Pipe shall be at least Schedule 40 when joints are welded, or welded and flanged. Pipe shall be at least Schedule 80 when joints are threaded. Brass, copper, or galvanized steel pipe or tubing shall not be used. Threaded nipples shall be seamless. Welding shall be done by a welder certified in accordance with the ASME Code, Section IX, "Welding Qualifications." [17] Tubing joints shall be flared and made up with flare type fittings complying with ANSI/SAE J513f. [18]

**5.6.5** All metal flexible connections for permanent installations shall have a minimum working pressure of 250 psig (1700 kPa) (safety factor of 4). For temporary installations, hose meeting the requirement of 5.7 may be used.

**5.6.6** Cast iron fittings shall not be used. Those parts of valves which are subjected to gas pressure should be made of steel, ductile (nodular) iron, or malleable iron. Valves in this case include shut-off valves, excess flow valves, back check valves, emergency shut-off valves, and remotely controlled valves. Ductile iron shall meet the requirements of ANSI/ ASTM A395 and malleable iron the requirements of ANSI/ASTM A47. [19]

**5.6.7** Adequate provisions shall be made to protect all exposed piping from physical damage that might result from impact by moving machinery, automobiles or trucks, or any other equipment at the facility.

**5.6.8** Joint compounds shall be resistant to ammonia at the maximum pressure and temperature to which they may be subjected in service.

**5.6.9** After assembly, all piping, hose, and tubing shall be tested and proved to be free from leaks at a pressure not less than the normal operating pressure of the system.

### 5.7 Hose Specification

**5.7.1** Hose used in ammonia service and subject to container pressure shall conform to the American National Standard RMA IP-14, *Specifications for Anhydrous Ammonia Hose* (see Appendix A).

**5.7.2** Hose subject to container pressure shall be designed for a minimum working pressure of 350 psig (2400 kPa) and a minimum burst pressure of 1750 psig (12 000 kPa). Hose assemblies, when made up, shall be capable of withstanding a test pressure of 500 psig (3400 kPa).

**5.7.3** Hose and hose connections located on the low pressure side of flow control, or pressure reducing valves on devices discharging to atmospheric pressure, shall be designed for the maximum low side working pressure. All connections shall be designed, constructed, and installed so that there will be no leakage when connected. Shut-off valves on the end of liquid and vapor transfer hoses shall be equipped with bleed valves to enable the operator to bleed off pressure prior to disconnecting the hoses.

**5.7.4** Where liquid transfer hose is not drained of liquid upon completion of transfer operations, such hose shall be equipped with an approved shut-off valve at the discharge end. Provision shall be made to prevent excessive hydrostatic pressure in the hose. See 5.8.11.

**5.7.5** On all hose one-half inch (13 mm) O.D. and larger, used in ammonia service and subject to container pressure, there shall be etched, cast, or impressed at five foot (1.5 m) intervals on the outer hose cover the following information:

Anhydrous Ammonia
XXX psig (Maximum Working Pressure)
Manufacturer's Name or Trademark
Year of Manufacture

5.7.6 Hose in service shall be requalified periodically in accordance with requirements specified in CGA P-7, *Standard for Requalification of Cargo Tank Hose Used in the Transfer of Compressed Gases.* [20]

### 5.8 Pressure Relief Devices

5.8.1 Every container used in systems covered by Sections 6, 11, and 12 shall be provided with one or more pressure relief valves of the spring-loaded type conforming with the applicable requirements of UL 132, *Standard on Safety Relief Valves for Anhydrous Ammonia and LP-Gas*, or other equivalent pressure relief valve standard. [21]

5.8.2 Pressure relief valves shall be in direct communication with the vapor space of the container.

5.8.3 The discharge from pressure relief valves shall be vented away from the container, upward and unobstructed to the atmosphere. All pressure relief valve discharge openings shall have suitable rain caps that will allow free discharge of the vapor and prevent the 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 Appendix B.

5.8.4 Container pressure relief valves with relation to the design pressure of the container shall be set to start-to-discharge as follows:

| Containers | Minimum | Maximum* |
|---|---|---|
| ASME U-68, U-69 | 110% | 125% |
| ASME U-200, U-201 | 95% | 100% |
| ASME 1952, 1956, 1959, 1962, 1965, 1968, 1971, 1974, 1977, 1980, 1983, 1986, and 1989. | 95% | 100% |
| API-ASME | 95% | 100% |
| U.S. Coast Guard (As required by USCG regulations) | | |
| DOT (As required by DOT regulations) | | |

*A relief valve manufacturer's tolerance of plus 10% is permitted.

5.8.5 Pressure relief valves used on containers covered by Sections 6, 11, and 12 shall be constructed to discharge at not less than the rates required in 5.8.3 before the pressure is in excess of 120% (not including the 10% tolerance referred to in 5.8.4) of the maximum permitted start-to-discharge pressure setting of the device.

5.8.6 Pressure 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.

5.8.7 Shut-off valves shall not be installed between the pressure relief valves and the containers or systems covered by Sections 6, 11, and 12, except that a shut-off valve may be used where the arrangement of the shut-off valve is such as always to afford the full capacity flow specified in 5.8.3 through a nonisolated pressure relief valve(s) which shall remain operative.

NOTE: The above exception is made to cover such cases as a three-way valve installed under two pressure relief valves, each of which has the required rate of discharge and is so installed as to allow either of the pressure relief valves to be closed off, but does not allow both pressure relief valves to be closed off at the same time. Another exception to this may be where two separate pressure relief valves are installed with individual shut-off valves. In this case, the two shut-off valve stems shall be mechanically interconnected in a manner which will allow full required flow of one pressure relief valve at all times. Still another exception is a pressure relief valve manifold which allows one valve to be closed off with the remaining unblocked valve or valves providing not less than the rate of discharge shown on the manifold nameplate.

5.8.8 Each pressure relief valve used with systems covered by Sections 6, 11, and 12 shall be plainly and permanently marked as follows:

(1) With the letters "AA" or the symbol "$NH_3$"

(2) The pressure in pounds per square inch gauge (psig) at which the valve is set to start-to-discharge

(3) The rate of discharge of the valve in cubic feet per minute of air at 60°F (15.6°C) and atmospheric pressure

(4) The manufacturer's name and catalog number

For example, a pressure relief valve marked AA-250-4200 (air) would mean that this valve is suitable for use on an anhydrous ammonia container; that it is set to start-to-discharge at 250 psig (1700 kPa); and that its rate of discharge (see 5.8.1, 5.8.3, and 5.8.4) is 4200 cubic feet per minute (120m$^3$/min) of air.

5.8.9 The flow capacity of the pressure relief valve shall not be restricted by any connection to it on either the upstream or downstream side.

5.8.10 The manufacturer or supplier of a pressure relief valve manifold shall publish complete data showing the flow rating through the combined assembly of the manifold with pressure relief valves installed. The manifold flow rating shall be determined by testing the manifold with all but one valve discharging. If one or more openings have restrictions not present in the remaining openings, the restricted opening or openings, or those having the lowest flow, shall be used to establish the flow rate marked on the manifold nameplate. The marking shall be similar to that required in 5.8.8 for individual valves.

**5.8.11** A hydrostatic relief valve or equivalent shall be installed in each section of piping (including hose) in which liquid ammonia can be isolated between shut-off valves to relieve the pressure which could develop from the trapped liquid. If an equivalent pressure relieving device is used, the maximum accumulative pressure possible within the system shall not exceed the limits of the system.

**5.8.12** The discharge opening from any pressure relief valve shall not terminate inside any building or below the highest roof line of any such building.

**5.8.13** A pressure relief device shall be subject to a systematic, periodic visual external inspection at least annually, to determine that it:

(1) Meets the applicable requirements specified in 5.8

(2) Is free of evidence of tampering, damage, corrosion, or foreign matter that might prevent proper operation

(3) Is free of leakage when subject to pressures below the minimum allowable start-to-discharge setting

(4) Has a properly installed rain cap or other device to avoid entry of moisture or other matter into the relief valve outlet

(5) Has an open weep hole to permit moisture to escape

**5.8.14** Any deficiency as may be found in 5.8.13 shall require immediate corrective action, replacement, or repair of the pressure relief device as may be appropriate.

**5.8.15** No container pressure relief device shall be used after the replacement date as specified by the manufacturer of the device. If no date is specified, a pressure relief valve shall be replaced no later than five years following the date of its manufacture or last repair unless it has first been disassembled, inspected, repaired, and tested by the manufacturer, or by a qualified repair organization in a manner such that the valve's condition and performance is certified as being equivalent to the standards for the original valve.

### 5.9 Filling Densities. (See 2.15)

**5.9.1** The filling densities for non-refrigerated containers shall not exceed the following:

| | Aboveground | Underground |
|---|---|---|
| (1) Uninsulated | 56%* | 58% |
| (2) Insulated | 57% | |

(3) DOT containers and cylinders shall be filled in accordance with DOT regulations.

*NOTE: This corresponds to 82% by volume at -28°F (-33.3°C), 85% by volume at 5°F (-15°C), 87.5% by volume at 30°F (-1.1°C), and 90.6% by volume at 60°F (15.6°C).

**5.9.2** The filling density for refrigerated storage tanks shall be such that the tanks will not be liquid full at a liquid temperature corresponding to the vapor pressure at the start-to-discharge pressure setting of the pressure relief valve.

**5.9.3** If containers are to be filled according to liquid level by any gauging method other than a fixed length dip tube gauge, each container should have a thermometer well and thermometer so that the internal liquid temperature can be easily determined and the amount of liquid and vapor in the container corrected to a 60°F (15.6°C) basis.

### 5.10 Transfer of Liquids

**5.10.1** Anhydrous ammonia shall always be at a temperature suitable for the material of construction and design of the receiving containers. Certain steels are not suitable for refrigerated ammonia. See Appendix R of API Standard 620, *Recommended Rules for Design and Construction of Large Welded Low-Pressure Storage Tanks*, for materials for low temperature service. [22]

**5.10.2** At least one qualified operator experienced in the procedures shall monitor the transfer of ammonia from the time the connections are first made until they are finally disconnected. Such monitoring may be performed by a person on site, or from a remote location, or by electronic means. Capability shall be provided to halt the transfer in the event of an emergency.

**5.10.3** Cargo tanks and tank cars shall not be unloaded with gas pressure other than from an ammonia source.

**5.10.4** Containers and cylinders shall be filled or used only upon the owner's authorization.

**5.10.5** Containers and cylinders shall be gauged and charged only in the open atmosphere or in buildings provided for that purpose.

**5.10.6** Pumps used for transferring ammonia shall be recommended and labeled for ammonia service by the manufacturer.

**5.10.6.1** Positive displacement pumps shall be equipped with a pressure actuated by-pass valve on the discharge side of the pump. This valve shall operate to limit the pressure developed by the pump to the maximum for which the pump is rated. Piping or tubing sized to carry the full capacity of the pump at the actuation pressure of this valve shall connect the discharge of this valve with the container from which ammonia is being pumped. If this line is capable of being closed off by a valve, an additional by-pass device shall be incorporated in the pump to by-pass back to the suction port. The pressure actuated by-pass valve and the return piping or tubing shall be installed in accordance with the pump manufacturer's recommendations.

**5.10.6.2** On the discharge side of the pump, before the by-pass valve line, install a pressure gauge graduated from 0 to 400 psig (0-2800 kPa).

**5.10.6.3** Plant piping shall contain shut-off valves located as close as practical to pump connections.

**5.10.7** Compressors used for transferring or refrigerating ammonia shall be recommended and labeled for ammonia service by the manufacturer.

**5.10.7.1** Compressors, except those used for refrigeration, shall be designed for at least 250 psig (1700 kPa) working pressure. Crank cases of compressors not designed to withstand system pressure shall be protected with a suitable pressure relief valve.

**5.10.7.2** Plant piping shall contain shut-off valves located as close as practical to compressor connections.

**5.10.7.3** A pressure relief valve large enough to discharge the full capacity of the compressor shall be connected to the discharge side before any shut-off valve.

**5.10.7.4** Compressors shall have pressure gauges at suction and discharge graduated to at least one and one-half times the maximum pressure that can be developed.

**5.10.7.5** Adequate means, such as a drainable liquid trap, shall be provided on the compressor suction to minimize the entry of liquid into the compressor.

**5.10.7.6** Where necessary to prevent contamination, an oil separator shall be provided on the discharge side of the compressor.

**5.10.8** Loading lines shall be protected by a suitable backflow check valve, and unloading lines shall be protected by a suitable in-line excess flow valve. Piping shall be sized so as not to restrict flow rates to the extent that protective devices will not function.

**5.10.8.1** By December 31, 1990, all stationary storage installations shall have an approved emergency shut-off valve installed in the fixed piping of the transfer system within 5 lineal feet (1.5 m) of where the hose or swivel piping is attached to the fixed piping. This requirement does not apply to a line feeding a fixed process system. The emergency shut-off valve shall be installed in the facility piping so that any break will occur on the side of the hose or swivel connection.

NOTE: This may be accomplished by concrete bulkheads or equivalent anchorage, or by the use of a weakness or shear fitting. Such anchorage is not required for tank car unloading.

**5.10.8.2** An approved emergency shut-off valve shall incorporate a manually activated shut-off from a remote location, and a manually activated shut-off at the installed location.

**5.10.9** Meters used for the measurement of liquid anhydrous ammonia shall be recommended and labeled for ammonia service by the manufacturer.

**5.10.9.1** Liquid meters shall be designed for minimum working pressure of 250 psig (1700 kPa).

**5.10.9.2** The metering system shall incorporate devices that will prevent the inadvertent measurement of vapor.

### 5.11 Liquid Level Gauging Devices

**5.11.1** Each container except those filled by weight shall be equipped with an approved liquid level gauging device.

**5.11.2** All gauging devices shall be arranged so that the maximum liquid level to which the container is filled is readily determined. See 5.4.3

**5.11.3** Gauging 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 (0.055 in or 1.40 mm) 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 Section 12)

**5.11.4** Gauging devices shall have a design pressure equal to or greater than the design pressure of the container on which they are installed.

**5.11.5** Fixed maximum liquid level gauges shall be designed and installed to indicate a volumetric level not to exceed 85% of the container's water capacity. Refer to 5.9.1 NOTE in regard to volumetric limits at various temperatures.

NOTE: This does not apply to refrigerated storage.

**5.11.6** Gauge glasses of the columnar type shall be restricted to stationary non-refrigerated storage installations. They shall be equipped with shut-off valves having metallic hand wheels, with excess-flow valves, and with extra heavy glass adequately protected with a metal housing applied by the gauge manufacturer. They shall be shielded against the direct rays of the sun.

### 5.12 Painting of Containers

**5.12.1** Aboveground uninsulated containers should have a reflective surface maintained in good condition. White is recommended for painted surfaces, but other colors having similar reflecting characteristics are acceptable.

NOTE: Caution should be exercised to ensure that graphic designs, company logos, etc. do not significantly reduce the necessary reflective characteristics of the container surface.

### 5.13 Electrical Equipment and Wiring

**5.13.1** Electrical equipment and wiring for use in ammonia installations shall be general purpose or weather resistant as appropriate.

**5.13.2** Where concentrations of ammonia in air in excess of 16% by volume are likely to be encountered, electrical equipment, and wiring shall be installed to comply with the requirements specified for use in hazardous locations, Class I, Group D, of NFPA 70, *National Electrical Code*, Articles 500 and 501. [23]

## 6. SYSTEMS UTILIZING STATIONARY, PIER-MOUNTED OR SKID-MOUNTED ABOVEGROUND OR UNDERGROUND, NON-REFRIGERATED STORAGE

This section applies to stationary, pier-mounted, skid-mounted, aboveground or underground, non-refrigerated storage installations utilizing containers other than those constructed in accordance with U.S. Department of Transportation Specifications. All Basic Rules of Section 5 apply to this section unless otherwise noted.

### 6.1 Design Pressure and Construction of Containers

**6.1.1** The minimum design pressure for non-refrigerated containers shall be 250 psig (1700 kPa). See 5.1.2.

NOTE: Existing U-68 and U-69 ASME Code containers with a design pressure of 200 psig (1400 kPa) are acceptable for reinstallation if re-certified to 250 psig (1700 kPa) in accordance with National Board Inspection Code procedures and if approved by the local jurisdictional authority. [11]

### 6.2 Container Valves and Accessories, and Discharge Connections

**6.2.1** All vapor and liquid connections, except for pressure relief valves and those specifically exempted in 5.5.5 and 5.5.6, shall be equipped with approved excess flow valves; or in lieu thereof, may be fitted with approved quick-closing internal valves which, except during operating periods, shall remain closed.

**6.2.2** Each storage container shall be provided with a pressure gauge graduated from 0 to 400 psig (0-2800 kPa). Gauges shall be designated for use in ammonia service.

**6.2.3** All containers shall be equipped with a suitable vapor equalizing connection.

**6.2.4** All containers shall be equipped with a fixed maximum liquid level gauge.

### 6.3 Pressure Relief Devices

**6.3.1** Every container shall be provided with one or more pressure relief valves of spring-loaded or equivalent type which shall comply with the following:

**6.3.1.1** Relief valves shall be installed in a manifold or other suitable device so that they can be replaced while the container remains pressurized. See 5.8.7 NOTE.

**6.3.1.2** The discharge from pressure relief valves shall be vented away from the container, upward and unobstructed to the open air to an area such that persons, property, and the environment will not be harmed. Vent pipes shall not be restrictive or smaller in size than the pressure relief valve outlet connection. All pressure relief valves shall have suitable rain caps that will allow free discharge of the vapor and prevent the entrance of water. Suitable provision shall be made for draining condensate which may accumulate.

**6.3.1.3** If desired, vent pipes from two or more pressure relief devices located on the same unit, or similar lines from one or more different units, may be run into a common header, provided the cross-sectional area of such header is at least equal to the sum of the cross-sectional areas of the individual vent pipes.

**6.3.2** The rate of discharge of spring-loaded pressure relief valves installed on underground containers may be reduced by not more than 30 percent of the rate of discharge specified in Appendix B. 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 pressure relief valves.

**6.3.3** 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 equalling or exceeding the combined discharge areas of the pressure relief valves and vent lines which discharge their content into the manhole housing.

### 6.4 Installation of Storage Containers

**6.4.1** Containers installed aboveground shall be provided with substantial reinforced concrete footings and foundations, or structural steel supports mounted on reinforced concrete foundations. In either case, the reinforced concrete foundations or footings shall extend below the established frost line and shall be of sufficient width and thickness to support the total weight of the containers and contents adequately. Where required by local codes, seismic loads shall be considered in the design of the footings and foundations. The foundation shall maintain the lowest point of the tank not less than 18 inches (0.5 m) above the ground. Floating type foundations shall also be acceptable providing the foundations are designed to adequately support the tank, contents, and piping. See 5.6.

**6.4.2** Horizontal aboveground containers shall be mounted on foundations in such a manner as to permit expansion and contractions. Every container shall be supported so as to prevent the concentration of excessive loads. The bearing afforded by the saddles shall extend over at least one third of the circumference of the shell. Suitable means for preventing corrosion shall be provided on that portion of the container in contact with the foundations or saddles.

**6.4.3** The location and installation of an underground container, and the type of corrosion control employed must have approval of the appropriate jurisdictional authority. Containers buried underground shall be placed so that the top of the container is at least one foot (0.3 m) below the surface. Should ground conditions make compliance with these requirements impractical, precautions shall be taken to prevent physical damage to the container. It is not necessary to cover the portion of the container to which a manhole and other connections are affixed. When necessary to prevent floating, containers shall be securely anchored or weighted.

**6.4.4** As a minimum, underground containers shall be set on firm foundations (firm earth may be used) and be surrounded by at least six inches of noncorrosive, inert materials, such as soft earth, sand, or gravel well compacted into place. As a further means of resisting corrosion, the container and its piping, prior to placement in the ground, shall be provided with the following:

(1) a suitable protective coating applied after proper surface preparation in accordance with the coating manufacturer's recommendations

(2) cathodic protection

(3) electrical isolation of the container from ancillary equipment

Corrosion-resistant materials of construction may be used as an option. A container which has been coated shall be lowered into place in a manner to prevent abrasion or damage to the coating. Selection of the type of protection should be based upon the judgment of a qualified engineer having knowledge of the corrosion history of the area.

**6.4.5** The horizontal distance between aboveground and underground containers of over 1200 gallons (4.5 $m^3$) capacity shall be at least 5 feet (1.5 m).

**6.4.6** Secure anchorage or adequate pier height shall be provided against container flotation wherever sufficiently high flood water might occur.

**6.4.7** A groundwater monitoring program meeting local, state, or federal regulatory requirements shall be established at the storage site by the owner of the underground storage system.

### 6.5 Reinstallation of Containers

**6.5.1** Containers, once installed underground, shall not later be reinstalled aboveground or underground, unless they successfully withstand hydrostatic pressure retests at the pressure specified for the original hydrostatic test as required by the ASME Code under which the tank was constructed, and show no evidence of serious corrosion.

**6.5.2** Where containers are reinstalled underground, the corrosion resistant coating, if used, shall be put in good condition; see 6.4.4. Where containers are reinstalled aboveground, pressure relief devices or gauging devices shall comply with 5.8, 5.11, and 6.3 as applicable to aboveground containers.

### 6.6 Marking Containers

**6.6.1** Each container or group of containers shall be marked on at least two sides that are visible with the words, "ANHYDROUS AMMONIA," or "CAUTION — AMMONIA," in sharply contrasting colors with letters not less than 4 inches high (100 mm).

**6.6.2** Each container or group of containers shall be conspicuously marked with a hazard warning label complying with 29 CFR 1910.1200. [5]

**6.6.3** Each container or group of containers which are installed underground shall have a sign bearing marks and labeling as required in 6.6.1 and 6.6.2 located adjacent to the cover described in 6.7.2.

### 6.7 Protection of Container and Appurtenances

**6.7.1** Containers and appurtenances shall be located or protected by suitable barriers so as to avoid damage by trucks or other vehicles. Main container shut-off valves shall be kept closed and locked when the installation is unattended. If the facility is protected against tampering by fencing or other suitable means, valve locks are not required.

**6.7.2** All connections to underground containers should be located within a suitable dome, housing, or manhole fitted with a substantial removable cover.

**6.7.3** Storage containers need not be electrically grounded.

### 6.8 Identification

**6.8.1** A legible sign shall be displayed on the premises at which a storage system is located, so as to be readily visible to emergency response personnel, stating the name, address, and telephone number of the nearest representative, agent, or owner of the storage system.

## 7. REFRIGERATED STORAGE

This section applies specifically to systems utilizing tanks for the storage of anhydrous ammonia under refrigerated conditions. All Basic Rules of Section 5 apply to this section unless otherwise stated.

### 7.1 Design of Tanks

**7.1.1** Tanks may be designed for any storage pressure desired as determined by economical design of the refrigerated system.

**7.1.2** The design temperature shall be the minimum temperature to which the container will be refrigerated and shall be so designated.

**7.1.3** Containers with a design pressure exceeding 15 psig (100 kPa) shall be constructed in accordance with 5.2 and the material shall be selected from those listed in API Standard 620, *Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, Tables 2.02, R.2.2, R.2.3, or R.2.4. [22]

**7.1.4** Tanks with a design pressure of 15 psig (100 kPa) and less shall be constructed in accordance with the general requirements of API Standard 620, including Appendix R. [22]

**7.1.5** When austenitic stainless steels or nonferrous metals are used, the ASME Code shall be used as a guide in selection of materials for use at the design temperature. [15]

### 7.2 Installation of Storage Tanks (Aboveground)

**7.2.1** Tanks shall be supported on suitable noncombustible foundations designed to accommodate the type of tank being used.

**7.2.2** Adequate protection against flotation or other water damage shall be provided wherever high flood water might occur.

**7.2.3** Tanks storing product which is at less than 32°F (0°C) shall be supported in such a way, or heat shall be supplied, to prevent the effects of freezing and subsequent frost heaving of the soil.

**7.2.4** The area surrounding a refrigerated tank or group of such tanks shall be provided with drainage, or shall be diked or provided with other secondary containment systems to prevent accidental discharge of liquid from spreading to uncontrolled areas.

**7.2.5** When drainage is employed, a slope of not less than one percent shall be provided. The drainage system shall terminate in an impounding basin having a capacity as large as the largest tank served.

**7.2.6** Provision shall be made for the drainage of rain water from the dike or impounding area. Such drainage shall be provided with a positive means to stop the flow.

**7.2.7** Where a dike is employed, the capacity of the diked enclosure shall be 110% of the capacity of the largest tank served. When computing the volume of the dike, allowance shall be made for the volume displaced by all other containers in the diked area.

7.2.8 The walls of a diked enclosure or the wall of an impounding basin used in a drainage system shall be of earth, steel, or concrete designed to be liquid tight and to withstand the hydrostatic pressure and temperature. Earth walls shall have a flat top at least 2 feet (0.6 m) wide. The slope shall be stable and consistent with the angle of repose of the earth used.

7.2.9 The ground in an impounding basin or within a diked enclosure, should be graded so that small spills or the early part of a large spill will accumulate at one side or corner, thereby contacting only a relatively small area of ground and exposing a relatively small surface area for heat gain. Shallow channels in the ground surface or low curbs of earth can help guide the liquid to these low areas without contacting a large ground area.

### 7.3 Marking Refrigerated Containers

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

7.3.1.1 With the name and address of the builder and the date of fabrication

7.3.1.2 With the maximum volume or weight of the product whichever is most meaningful to the user

7.3.1.3 With the design pressure

7.3.1.4 With the minimum temperature in degrees Fahrenheit (°F) or degrees Celsius (°C) for which the container was designed

7.3.1.5 With the maximum allowable water level to which the container may be filled for the test purposes

7.3.1.6 With the density of the product in pounds per cubic foot or kilograms per cubic meter (kg/m$^3$) for which the container was designed

7.3.1.7 With the maximum level to which the container may be filled with liquid anhydrous ammonia

7.3.1.8 Each refrigerated container shall be marked on two directly opposite sides at near eye level with the words, "ANHYDROUS AMMONIA", in sharply contrasting colors with letters not less than 4 inches (101.6 mm) high

7.3.1.9 Each refrigerated container shall be conspicuously marked with a hazard warning label complying with 29 CFR 1910.1200. [5]

### 7.4 Tank Valves, Accessories, Fill Pipes, and Discharge Pipes

7.4.1 Shut-off valves shall be:

(1) Provided for all connections except those with a No. 54 (0.055 in or 1.40 mm) drill size restriction, plugs, pressure relief valves, and thermometer wells

(2) Located as close to the tank as practical

7.4.2 A check valve shall be installed on the fill connection and a remotely operated shut-off valve on other connections located below the maximum liquid level. See 5.10.8.

7.4.3 Each refrigerated container shall be equipped with an approved liquid level gauging device and high liquid level alarm.

### 7.5 Pressure Relief Valves

7.5.1 Pressure relief valves shall be set to start-to-discharge at a pressure not in excess of the design pressure of the tank and shall have a total relieving capacity sufficient to prevent a maximum pressure in a tank of more than 120% of the design pressure.

7.5.2 The total relieving capacity of pressure-relief valves shall be the larger requirement of 7.5.2.1 or 7.5.2.2.

7.5.2.1 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
(6) Changing atmospheric conditions

7.5.2.2 Either one of the following formulas for fire exposure:

(1) For valve manufacturers who classify valves on the basis of the weight of the vapors to be relieved:

$$W = \frac{34\,500\ F\ A^{0.82}}{L}$$

(2) For valve manufacturers who classify valves on the basis of air flow:

$$Qa = \frac{633\,000\ F\ A^{0.82}}{L\ C} \sqrt{\frac{Z\ T}{M}}$$

Where W = weight of vapors to be relieved in pounds/hour at relieving conditions

Qa = air flow in cubic feet per minute at standard conditions (60°F and 14.7 psi)

F = fireproofing credit. Use F = 1.0 except when an approved fireproofing material of recommended thickness is used, in which case use F = 0.2
A = total surface area in square feet up to 25 feet above grade or to the equator of a sphere, whichever is greater
Z = compressibility factor of ammonia at relieving condition (if not known, use Z = 1.0)
T = temperature in degrees R (460 + temperature in degrees F of gas at relieving conditions)
M = molecular weight = 17 for ammonia
L = latent heat of ammonia at relieving conditions in Btu per pound
C = constant based on relation of specific heats
(C may be obtained from the following table)
(If K is not known use C = 315)

| K | C | K | C | K | C |
|---|---|---|---|---|---|
| 1.00 | 315 | 1.26 | 343 | 1.52 | 366 |
| 1.02 | 318 | 1.28 | 345 | 1.54 | 368 |
| 1.04 | 320 | 1.30 | 347 | 1.56 | 369 |
| 1.06 | 322 | 1.32 | 349 | 1.58 | 371 |
| 1.08 | 324 | 1.34 | 351 | 1.60 | 372 |
| 1.10 | 327 | 1.36 | 352 | 1.62 | 374 |
| 1.12 | 329 | 1.38 | 354 | 1.64 | 376 |
| 1.14 | 331 | 1.40 | 356 | 1.66 | 377 |
| 1.16 | 333 | 1.42 | 358 | 1.68 | 379 |
| 1.18 | 335 | 1.44 | 359 | 1.70 | 380 |
| 1.20 | 337 | 1.46 | 361 | 2.00 | 400 |
| 1.22 | 339 | 1.48 | 363 | 2.20 | 412 |
| 1.24 | 341 | 1.50 | 364 | | |

Where $K = \frac{C_p}{C_v}$ at atmospheric conditions

and $C_p$ = Specific heat of vapor at constant pressure

$C_v$ = Specific heat of vapor at constant volume

**7.5.3** Shut-off valves of adequate flow capacity may be provided and used to facilitate inspection and repair of pressure relief valves. When a shut-off valve is provided it shall be so arranged that it can be locked or sealed open, and it shall not be closed except by an authorized person who shall remain stationed there while the valve remains closed, and who shall again lock or seal the valve open when leaving the station.

**7.5.4** Pressure relief valves shall comply with the following:

**7.5.4.1** If stacks are used they shall be suitably designed to prevent obstruction by rain, snow, ice, or condensate. The outlet size shall not be smaller than the nominal size of the pressure relief valve outlet connection.

**7.5.4.2** Discharge lines may be used if desired. Multiple pressure relief valves on the same storage unit may be run into a common discharge header. The discharge line and header shall be designed to accommodate the maximum flow and a back pressure not exceeding 10% of the design pressure of the storage container. This back pressure shall be included in the 120% total maximum pressure given in 7.5.1. No other container or system shall exhaust into this discharge line or header. The vent lines shall be installed to prevent accumulation of liquid in the lines.

**7.5.5** Atmospheric storage shall be provided with vacuum breakers of adequate capacity to respond to anticipated rates of liquid withdrawal and to rapid atmospheric changes so as to avoid damage to the container. Ammonia gas may be used to provide a pad.

**7.5.6** Pressure relief valves used to protect other systems at refrigerated storage installations shall discharge to the open air.

### 7.6 Protection of Containers and Appurtenances

**7.6.1** Refrigerated storage containers and appurtenances shall comply with the provisions of 6.7.

### 7.7 Reinstallation of Containers

**7.7.1** Containers of such size as to require a field fabrication shall, when moved and reinstalled, be reconstructed and reinspected in complete accordance with the original requirements under which they were constructed. The containers shall be subjected to a pressure retest, and if rerating is necessary, it shall be done in accordance with the applicable pressure of the original requirements.

### 7.8 Refrigeration Load and Equipment

**7.8.1** The total refrigeration load shall be computed as the sum of the following:

**7.8.1.1** Load imposed by heat flow into the container caused by the temperature differential between the ambient temperature and the storage temperature

**7.8.1.2** Load imposed by heat flow into the tank caused by maximum sun radiation

7.8.1.3 Maximum load imposed by filling the tank with ammonia warmer than the design storage temperature

7.8.2 More than one storage tank may be handled by the same refrigeration system.

7.8.3 **Compressors** (see also 5.10.7)

**7.8.3.1** A minimum of two compressors shall be provided, either of which is of sufficient size to handle the loads listed in 7.8.1.1 and 7.8.1.2. Where more than two compressors are provided, minimum standby equipment equal to the largest normally operating equipment shall be installed. Compressors required for 7.8.1.3 may be used as standby equipment for compressors required in 7.8.1.1 and 7.8.1.2.

**7.8.3.2** Compressors shall be sized to operate with a suction pressure at least 10% below the minimum setting of the pressure relief valve(s) on the storage tank and shall withstand a suction pressure at least equal to 120% of the design pressure of the tank. Discharge pressure will be governed by condensing conditions.

**7.8.3.3** Where facilities are provided to safely dispose of vented vapor to an automatic flare or to a process unit, a single compressor of sufficient size to handle the load listed in 7.8.1.1 and 7.8.1.2 shall be allowed.

### 7.8.4 Compressor Drives

**7.8.4.1** Each compressor shall have its own drive unit.

**7.8.4.2** Any standard drive consistent with good design may be used.

**7.8.4.3** An emergency source of power of sufficient capacity to handle the loads listed in 7.8.1.1 and 7.8.1.2 shall be provided, unless facilities are provided to safely dispose of vented vapors while the refrigeration system is not operating.

### 7.8.5 Automatic Control Equipment

**7.8.5.1** 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).

**7.8.5.2** An emergency alarm system shall be installed to function in the event the pressure in the container(s) rises to the maximum or falls to the minimum allowable operating pressure.

**7.8.5.3** An emergency alarm and shut-off shall be located in the condenser system to respond to excess discharge pressure caused by failure of the cooling medium.

**7.8.5.4** All automatic controls shall be installed in a manner to preclude operation of alternate compressors unless the controls will function with the alternate compressors.

### 7.8.6 Separators

**7.8.6.1** An entrainment separator of suitable size and design pressure shall be installed in the compressor suction line. The separator shall be equipped with a drain and gauging device. A maximum liquid level control with alarm should be installed.

**7.8.6.2** An oil separator of suitable size shall be installed in the compressor discharge line. It shall be designed for at least 250 psig (1700 kPa) and shall be equipped with a gauging device and drain valve. A maximum oil level control with alarm should be installed.

**7.8.6.3** A separator shall be equipped with a pressure relief valve if the separator can be isolated with shut-off valves.

### 7.8.7 Condensers

**7.8.7.1** The condenser system may be cooled by air or water or both. The condenser shall be designed for at least 250 psig (1700 kPa). Provision shall be made for purging non-condensibles either manually or automatically.

**7.8.7.2** The condenser shall be equipped with a pressure relief valve if the condenser can be isolated with shut-off valves.

### 7.8.8 Receiver and Liquid Drain

**7.8.8.1** A condenser effluent receiver shall be provided which is equipped with an automatic float valve to discharge the liquid ammonia to storage, or with a high pressure liquid drain trap of suitable capacity. The receiver shall be designed for at least 250 psig (1700 kPa) operating pressure and be equipped with the necessary connections, pressure relief valves, and gauging device.

### 7.8.9 Insulation

**7.8.9.1** 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 and insulation shall be of a type which will not support flame propagation and will not cause corrosion when wet.

## 7.9 Safety Equipment

**7.9.1** Each refrigerated storage installation shall have on hand the minimum safety equipment required in 3.4.

**7.9.2** In addition to the safety equipment requirement in 7.9.1, each refrigerated storage installation shall have on hand at least two independently supplied, positive-pressure self-contained breathing apparatus, and at least two approved encapsulating corrosive chemical suits impervious to ammonia. Each shall be designed to accommodate a self-contained breathing apparatus.

### 7.10 Identification

**7.10.1** A legible sign shall be displayed on the premises at which a refrigerated storage system is located so as to be readily visible to emergency response personnel stating the name, address, and telephone number of the nearest representative, agent, or owner of the storage system.

## 8. SYSTEMS MOUNTED ON RAILCAR STRUCTURES (TANK CARS) OTHER THAN DOT CLASS 106A FOR TRANSPORTATION OF AMMONIA

This section applies specifically to systems utilizing DOT single unit pressure tank car tanks mounted on railcar structures and used for the rail transportation of ammonia. Systems for tank cars transporting ammonia, in addition to complying with the requirements of these standards, must comply where required, with the requirements of the U.S. Department of Transportation and also be approved by the Association of American Railroads.

### 8.1 Design and Construction

**8.1.1** Tank car tanks and tank cars shall be designed, constructed, and tested in compliance with current DOT specifications as are applicable and must receive approval from the Association of American Railroads Committee on Tank Cars, before being placed into service.

### 8.2 Pressure Relief Valves

**8.2.1** Tank cars shall be provided with a pressure relief valve as required by DOT regulations.

**8.2.2** Pressure relief device equipment used on DOT containers shall be inspected, repaired, or replaced in accordance with applicable DOT regulations.

### 8.3 Marking and Placarding

**8.3.1** Each tank car, whether empty or loaded, must be marked with the proper shipping name, "ANHYDROUS AMMONIA," in letters at least 4 inches (100 mm) in height with at least a ⅝ inch (15 mm) stroke. Separation between each letter must be at least ¾ inch (20 mm). The markings must be displayed on a background of sharply contrasting color on both sides of the tank car and near the stenciled DOT specification markings. Each tank car must also be marked with the UN indentification number, 1005, on each side and each end in a manner prescribed by DOT regulations. [4]

**8.3.2** Each tank car transporting ammonia must be provided with placarding in accordance with DOT requirements on each side and each end in accordance with DOT regulations. A tank car transporting a residue of ammonia must be provided with "RESIDUE" placards on each side and each end in accordance with DOT regulations. [4]

**8.3.3** Each tank car transporting ammonia shall be marked with a hazard warning label complying with 29 CFR 1910.1200 unless such label is provided with the shipping document for the tank car conforming with 49 CFR Part 172, subpart C as appropriate. [4] and [5]

### 8.4 Tank Car Loading and Unloading Locations and Operations

**8.4.1** The loading, unloading, and shipping of tank cars shall conform with the requirements of DOT regulations. [4]

**8.4.2** Anhydrous ammonia tank cars shall be loaded and unloaded only at approved locations meeting the requirements of 3.4.1 and 5.10.1 through and including 5.10.9.2.

**8.4.3** Loading and unloading operations shall be performed by qualified personnel meeting the requirements of 3.1.1 and properly trained in the procedures involved and made responsible for careful compliance with such procedures.

**8.4.4** Rail track at tank car loading and unloading positions shall be essentially level.

**8.4.5** Brakes shall be set and the wheels blocked in both directions on all tank cars being loaded or unloaded.

**8.4.6** Caution signs shall be so placed on the track or car to give necessary warning to persons approaching the car from the open end or ends of the siding. The signs must be of metal or other comparable material at least 12 inches (300 mm) high by 15 inches (400 mm) wide 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 (100 mm) high.

Other words should be in letters at least 2 inches (50 mm) high. The letters must be white on blue background. A car so protected must not be coupled or moved. The signs must remain in place until the tank car valves have been closed and the transfer lines have been disconnected.

**8.4.7** A standard derail must be properly set and secured in the derailing position between the car being loaded or unloaded and other cars being moved on the same track.

**8.4.8** A tank car must not be loaded or shipped unless it meets DOT specifications for the shipment of ammonia.

**8.4.9** A tank car which has been loaded must not be shipped unless it has been loaded by or with the consent of the tank car owner or owner's agent.

**8.4.10** A tank car used to transport a commodity other than ammonia must be purged completely of the previous commodity before being loaded with ammonia. Markings and placarding must be changed correspondingly.

**8.4.11** Before connecting loading lines to a tank car and/or before releasing a tank car to the carrier, a visual inspection for obvious defects should be made for the following conditions:

**8.4.11.1** To determine whether the tank car undercarriage, safety appliances (handrails, grab irons, etc.), walk surfaces, ladders, steps, air and hand brake systems, trucks, head shields, and couplers are in a safe condition

**8.4.11.2** To determine if the tank car tank and pressure relief valve periodic retest dates are current

**8.4.11.3** To determine if the tank car tank, or jacket if the tank is insulated, shows evidence of abrasion, dents, gouges, severe corrosion, or other damage

**8.4.11.4** To determine whether manway bolts and gaskets, external valves, pressure relief valves, gauges, and fittings appear to be in serviceable condition and free of leakage

**8.4.12** If leakage occurs at any manway, valve, gauge, gasket, or fitting during loading, the loading must stop and the cause of the leak corrected before loading can be resumed. If necessary to effect leak repairs, the tank car shall be emptied and repairs made at the loading terminal or qualified repair facility.

**8.4.13** A damaged or defective tank car must be forwarded to a carrier repair track or to a qualified repair shop before it is returned to service. Structural repairs to a tank car, including welding repairs on the tank car tank must be performed only at a repair facility authorized by the Association of American Railroads and by a qualified welder following authorized procedures.

**8.4.14** An ammonia tank car must be consigned for delivery and unloaded on a private track. State and local regulations regarding unloading operations must be observed.

**8.4.15** If a private track is unavailable, an ammonia tank car equipped with excess flow valves may be consigned for delivery and unloaded on a carrier track, provided it is unloaded into permanent storage of sufficient capacity to receive the entire contents of the car.

**8.4.16** After loading or unloading a tank car, all valves must be closed and transfer lines disconnected. Caps or plugs on tank car sample valves, liquid valves, vapor valves, and gauging device valves must be replaced and made wrench tight. Slip tube gauging devices must be secured and gauge housings screwed in place. Protective housing covers must be secured, pinned, and proper seals put in place when required. Leaks from any source on a tank car must be stopped before a car may be released to the carrier.

**8.4.17** Each tank car loading and unloading location shall have on hand as a minimum, for emergency and rescue purposes, all of the equipment specified in 3.4.

## 9. SYSTEMS MOUNTED ON TRUCKS, SEMI-TRAILERS, AND TRAILERS FOR TRANSPORTATION OF AMMONIA

This section applies specifically to systems mounted on trucks, semi-trailers and trailers (other than those covered under Sections 11 and 12) used for the transportation of ammonia. All Basic Rules of Section 5 apply to this section unless otherwise noted.

Systems for trucks and trailers for transportation of anhydrous ammonia, in addition to complying with the requirements of these standards, shall also comply where required, with the requirements of the U.S. Department of Transportation and those of any other regulatory body which may apply.

### 9.1 Design Pressure of Containers

**9.1.1** Containers used in interstate commerce shall be designed and constructed in accordance with the ASME Code, have a minimum design pressure of 265 psig (1830 kPa), and meet other applicable requirements of DOT regulations. Containers designed and constructed in accordance with earlier ASME Code editions having a minimum design pressure of 250 psig (1700 kPa) and meeting certain limiting conditions prescribed by DOT regulations, are authorized for use in intrastate commerce. [8] and [4]

**9.1.2** The shell or head thickness of any container shall not be less than 3/16 inch (4.8 mm).

**9.1.3** All container openings, except pressure relief valves, liquid level gauging devices, and pressure gauges, shall be labeled to designate whether they communicate with liquid or vapor space when the container is filled to the maximum permitted filling density. Labels must be readily visible and may be on or adjacent to the valves closing the openings.

**9.1.4** Baffles are not required for cargo tanks.

### 9.2 Container Mounting

**9.2.1** The means of attachment of any container to the cradle, frame, or chassis of a vehicle shall be designed on a basis of two "g" loading in either direction, using a safety factor of not less than 4, based on the ultimate strength of the material used. For the purpose of this requirement, two "g" of load support is equivalent to three times the static weight of the articles supported; two "g" of loading and bending, acceleration, and torsion is equivalent to twice the static weight support applied horizontally at the road surface.

**9.2.2** "Hold-down" devices, when used, shall anchor the container to the cradle, frame or chassis in a suitable and safe manner that will not introduce undue concentration of stresses. These devices shall incorporate positive means for drawing the container down tight, and suitable stops or anchors shall be provided to prevent relative movement between container and framing due to stopping, starting, or changes in direction.

**9.2.3** Vehicles designed and constructed so that the cargo tanks constitute in whole or in part the stress member used in lieu of the frame, shall be supported by external cradles subtending at least 120° of the shell circumference. The design calculation shall include beam stress, shear stress, torsion stress, bending moment, and acceleration stress, in addition to those covered by the code under which the cargo tank was designed.

**9.2.4** 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 motor vehicle axle.

**9.2.5** Provision shall be made to secure both ends of the hose while in transit.

**9.2.6** When the cradle and the container are not welded together, suitable material shall be used between them to eliminate metal-to-metal friction.

### 9.3 Container Appurtenances

**9.3.1** Non-recessed container fittings and appurtenances shall be protected against physical damage by either:

(1) A protected location
(2) The vehicle frame or bumper
(3) A protective housing

The protective housing, if used, shall comply with the requirements under which the containers are fabricated with respect to design and construction, and shall be designed to withstand static loadings in any direction equal to twice the weight of the container and attachments when filled with the lading, using a safety factor of not less than 4, based on the ultimate strength of the material to be used. The protective housing, if used, shall be protected with a weather cover, if necessary, to ensure proper operation of valves and pressure relief devices.

**9.3.2** With the exception of pressure relief valves, liquid level gauges, pressure gauges, and thermometer wells, every opening in each container shall be:

**9.3.2.1** Closed with a plug, cap, bolted flange or plate, or

**9.3.2.2** Provided with an excess flow valve and manual shut-off valve or

**9.3.2.3** Provided with a back flow check valve and manual shut-off valve or

**9.3.2.4** Provided with a remotely controlled internal shut-off valve as described in 9.3.3.

**9.3.3** Every liquid or vapor discharge opening in each container shall be provided with a remotely controlled internal shut-off valve. For every such opening of less than 1¼ inches NPT, an excess flow valve with a manual shut-off valve may be used instead. The internal shut-off valve may be operated by mechanical means, by hydraulic means, or by air or gas pressure.

**9.3.3.1** On a container of 3500 gallons (13 $m^3$) water capacity or less, each internal shut-off must be provided with at least one remote control station and the actuating means may be mechanical. This station must be at one end of the tank, away from the discharge connection area.

9.3.3.2 On a container over 3500 gallons (13 $m^3$) water capacity, each internal shut-off valve must be provided with remote means of closure, both mechanical and thermal, that are installed at the ends of the tank in at least two, diagonally opposite locations. If the discharge connection at the tank is not in the general vicinity of one of the two locations specified above, one additional fusible element must be installed so that heat from a fire in that area will activate the emergency control system. Fusible elements may not have a melting point exceeding 250°F (120°C).

9.3.4 The requirements of 9.3.3 do not apply to a 1¼ inch NPT liquid or vapor discharge opening equipped with an excess flow valve and manually operated shut-off valve installed before October 1, 1984.

9.3.5 All containers shall be equipped with an approved vapor equalizing valve of adequate capacity.

9.3.6 All containers shall be equipped with a fixed maximum liquid level gauge.

9.3.7 All containers shall be equipped with a pressure gauge having a dial graduated from 0—400 psig (0—2800 kPa).

### 9.4 Piping, Fittings, and Hose

9.4.1 All piping, tubing, and fittings shall be securely mounted and protected against physical damage.

9.4.2 Piping used on non-refrigerated systems shall be at least ASTM A-53 Grade B seamless or Electric Resistance Welded Pipe. Pipe joints shall be threaded, welded, or flanged. Pipe shall be at least Schedule 40 when joints are welded, or welded and flanged. Pipe shall be at least Schedule 80 when joints are threaded. Brass, copper, or galvanized steel pipe or tubing shall not be used. [16] Threaded nipples shall be seamless. Welding shall be done by a welder certified in accordance with the ASME Code, Section IX, "Welding Qualifications." [17] Tubing joints shall be flared and made up with flare type fittings complying with ANSI/SAE J513f. [18]

9.4.3 The truck unloading line shall be provided with an excess flow valve at the hose connection unless an approved quick closing internal valve is provided in the container unloading connection. See 9.3.2.

9.4.4 Liquid propane hose shall not be used for ammonia service. See 5.7.

### 9.5 Pressure Relief Valves

9.5.1 The discharge from container pressure 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 to prevent moisture or foreign material from entering the relief valve outlet. The size of discharge lines from pressure relief valves shall not be smaller than the nominal size of the pressure relief valve outlet connection. Suitable provision shall be made for draining condensate which may accumulate in the discharge pipe.

9.5.2 Pressure relief device equipment used on DOT containers shall be inspected, repaired, or replaced in accordance with applicable DOT regulations.

### 9.6 Placarding and Marking of Container

9.6.1 Every container, whether loaded or empty, shall be conspicuously and legibly marked on each side and each end thereof, on a background of sharply contrasting color with the words, "ANHYDROUS AMMONIA" in letters at least two inches (50 mm) high. Each container must also be marked with the UN identification number for ammonia, 1005, on each side and each end in a manner prescribed by DOT regulation. [4]

9.6.2 Each container, whether empty or loaded, must be provided with placarding on each side and on each end in accordance with DOT regulations. [4]

9.6.3 Each container must be marked with a hazard warning label complying with 29 CFR 1910.1200 unless such label is provided with the shipping papers for the cargo tank conforming with 49 CFR Part 172 subpart C as appropriate. [4] and [5]

### 9.7 Transfer of Liquids

9.7.1 The content of a cargo tank container shall be determined by weighing, by suitable liquid level gauging device, or other approved method.

NOTE: If the volume content of a container is to be determined by liquid level measurement, the container shall have a thermometer well and thermometer 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 U.S. Department of Transportation regulations. [4]

9.7.2 Pumps or compressors shall be designed and installed in accordance with 5.10, and protected against physical damage when mounted upon ammonia tank trucks and trailers.

**9.7.3** A cargo tank container of greater than 3500 gallons (13 $m^3$) water capacity shall be unloaded only at approved locations meeting the requirements of 3.4.1 and 5.10.8.

### 9.8 Trailers and Semi-Trailers

**9.8.1** When two or more vehicles are operated in combination, the vehicles shall be designed and constructed, and the coupling devices connecting the vehicles shall be designed, constructed, and installed, so that when the combination is operated in a straight line on a smooth, level, paved surface, the path of the towed vehicle shall not vary more than three inches (80 mm) from the path of the towing vehicle.

**9.8.2** Each trailer and semi-trailer shall be equipped with an emergency braking system to be activated in the event of separation from the towing vehicle.

**9.8.3** Each trailer shall be equipped with a tow-bar and means of attaching the tow-bar to the towed and towing vehicles. The tow-bar and means of attachment must be structurally adequate, properly and securely mounted, provide for adequate articulation, and be provided with a locking device to prevent accidental separation of the towed and towing vehicles.

**9.8.3.1** One or more safety devices such as a safety chain(s) or safety cable(s) must also be properly installed to prevent the towed vehicle from breaking loose in the event of tow-bar failure or disconnection.

**9.8.4** Where a fifth wheel assembly is employed for towing a semi-trailer, the lower half of the assembly must be properly and securely attached to the frame of the towing vehicle. The upper half of the assembly must be fastened to the towed vehicle in a manner providing at least the same security required for installation of the lower half. Each fifth wheel assembly must have a positive locking mechanism which shall apply automatically on coupling, and which will prevent separation of the upper and lower halves except by activation of a manual release.

### 9.9 Electrical Equipment and Lighting

**9.9.1** Tank trucks, tank trailers, and tank semi-trailers may not be equipped with any artificial light other than electric light. Electric lighting circuits shall have suitable overcurrent protection (fuses or automatic circuit breakers). The wiring shall have sufficient carrying capacity and mechanical strength, and shall be suitably secured, insulated and protected against physical damage.

**9.9.2** Tank trucks, tank trailers, and tank semi-trailers must be provided with lighting devices and reflectors in accordance with the applicable provisions of 49 CFR 393 Subpart B. [24]

### 9.10 Protection Against Collision

**9.10.1** Each tank motor vehicle shall be provided with properly attached bumpers or chassis extensions arranged to protect the tank, piping, valves, and fittings from physical damage in case of collision.

### 9.11 Brakes

**9.11.1** No ammonia shall be loaded into or unloaded from any tank truck, tank semi-trailer, or tank trailer unless the handbrake and/or other brake mechanism and wheel chocks on both sides of at least one drive wheel are securely set to prevent motion of the vehicle during the loading or unloading process.

### 9.12 Portable Tanks (Including Skid Tanks)

**9.12.1** When portable tanks are used in lieu of cargo tanks and are permanently mounted on highway motor vehicles for the transportation of ammonia, they shall comply with the requirements of Section 9. Where portable tanks, including those built to DOT Specification 51 or 106A are used for farm storage they shall comply with Section 6. When portable tanks are used as shipping containers in interstate commerce they shall comply with Section 10.

### 9.13 Safety Equipment

**9.13.1** All tank trucks, trailers, and semi-trailers (or attached power units) shall be furnished with the equipment specified in 3.5 for emergency purposes.

## 10. SYSTEMS UTILIZING DOT PORTABLE TANKS AND CYLINDERS

This section applies specifically to systems utilizing cylinders (see 2.10), portable tanks (DOT-51), or "ton containers" (DOT-106A) constructed in accordance with U.S. Department of Transportation Specifications. All Basic Rules of Section 5 apply to this section, unless otherwise noted.

### 10.1 Containers and Cylinders

**10.1.1** Containers and cylinders shall comply with current DOT specifications and shall be maintained, filled, packaged, marked, labeled, and shipped to comply with current DOT regulations, OSHA regulations, and CGA C-4, *American National Standard Method of Marking Portable Compressed Gas Containers to Identify the Material Contained* (ANSI/CGA C-4. [25]

**10.1.2** Containers and 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. Cylinders stored outdoors should be protected against accumulation of ice and snow. Cylinders in hot climates should be protected from the continuous direct rays of the sun.

**10.1.3** Containers and cylinders shall not be buried below ground.

**10.1.4** Containers and cylinders shall be set upon firm, level surfaces or otherwise firmly secured. The possible effect of settling or frost heave on the outlet piping shall be guarded against by appropriate use of a flexible connection or special fitting.

**10.1.5** Containers and cylinders shall be protected from heat sources such as radiant flame and steam pipes. Heat shall not be applied directly to containers or cylinders to raise the pressure. A cylinder filled in accordance with DOT regulations will become liquid full at 145°F (63°C) and will rupture upon further temperature rise.

**10.1.6** Containers and cylinders shall be stored in a manner such as to protect them from moving vehicles or external damage.

**10.1.7** Any container or cylinder which is designed to have a valve protection cap or device shall have the cap or device securely in place when the container or cylinder is not in service. This requirement need not apply at a facility specifically designated for filling containers or cylinders.

**10.1.8** Any process system connected to a container or cylinder shall be equipped with a suitable trap or back-pressure check valve to prevent the entry of foreign matter into the container or cylinder.

### 10.2 Container and Cylinder Valves and Regulating Equipment

**10.2.1** Container and cylinder valves and pressure regulating equipment shall be protected against tampering when installed for use.

**10.2.2** Container and cylinder valves shall be protected while in transit, in storage, and while being moved prior to connection to the process line, as follows:

**10.2.2.1** By setting them into a recess of the container, or

**10.2.2.2** By ventilated metal cap or collar, fastened to the container, capable of withstanding a blow from any direction equivalent to that of a 30 lb (14 kg) weight dropped four feet (1.2 m). Construction must be such that a blow will not be transmitted to the valves or other connections.

**10.2.2.3** A valve on a cylinder which is enclosed in a suitable box or crate of sufficient strength to protect the valve from damage during transit or storage need not be provided with a protective cap or collar.

**10.2.3** When containers or cylinders are not connected for service, the outlet valves shall be kept tightly closed and protected even though containers are considered empty. This requirement need not apply at a facility specifically designated for filling containers or cylinders.

**10.2.4** Cylinder valves shall be in accordance with the connection standard for ammonia as contained in CGA V-1, *American National, Canadian, and Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* (ANSI/CSA/CGA V-1). [26]

### 10.3 Pressure Relief Devices

**10.3.1** Containers shall be provided with pressure relief devices as required by DOT regulations. A cylinder containing less than 165 pounds (75 kg) of ammonia is not required to have a pressure relief device.

**10.3.2** Pressure relief device equipment used on DOT containers shall be inspected, repaired, or replaced in accordance with applicable DOT regulations.

## 11. SYSTEMS MOUNTED ON FARM WAGONS (IMPLEMENTS OF HUSBANDRY) FOR THE TRANSPORTATION OF AMMONIA

This section applies to containers of 3000 gallons (11 $m^3$) water capacity or less, and pertinent equipment mounted on farm wagons (implements of husbandry) which are used for the transportation of ammonia. All Basic Rules of Section 5 apply to this section unless otherwise noted.

### 11.1 Design of Containers

**11.1.1** Containers shall be constructed in accordance with 5.2.

## 11.2 Mounting of Containers

**11.2.1** A suitable "stop" or "stops" shall be mounted on the farm wagon or on the container in such a way that the container shall not be dislodged from its mounting due to the farm wagon coming to a sudden stop. Back slippage shall also be prevented by proper methods.

**11.2.2** A suitable "hold-down" device shall be provided which will anchor the container to the farm wagon at one or more places on each side of the container.

**11.2.3** When containers are mounted on four-wheel farm wagons, care shall be taken to ensure that the weight is distributed evenly over both axles.

**11.2.4** When the cradle and the container are not welded together, suitable material shall be used between them to eliminate metal-to-metal friction. See 5.2.2.1 and 5.2.4 with regard to welding on a container.

## 11.3 Container Appurtenances

**11.3.1** All containers shall be equipped with a fixed maximum liquid level gauge.

**11.3.2** All containers shall be equipped with a pressure gauge having a dial graduated from 0-400 psi (0-2800 kPa).

**11.3.3** The filling connection of each container shall comply with the requirements of 5.5.11.

**11.3.4** All containers shall be equipped with an approved vapor equalizing valve unless equipped for spray loading.

**11.3.5** All vapor and liquid connections, except pressure relief valves and those specifically exempt in 5.5.5 and 5.5.6, shall be equipped with approved excess flow valves or may be fitted with quick-closing internal valves, which shall remain closed except during operating periods.

**11.3.6** Fittings shall be protected from physical damage by means of a rigid guard designed to withstand static loading in any direction equal to twice the weight of the container and lading using a safety factor of four (4) based upon the ultimate strength of the material used. If the guard encloses the pressure relief valve, the valve shall be properly vented through the guard.

**11.3.7** 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 farm wagon axle. The hose shall be drained and depressurized prior to the container being moved or towed on a public road.

**11.3.8** Provision shall be made to secure both ends of the hose in transit.

**11.3.9** Systems covered under Section 11 must comply with all requirements as prescribed in 49 CFR 173.315(m). [4]

## 11.4 Placarding and Marking of Containers

**11.4.1** There shall appear on each side and on each end of the container in letters at least two inches (50 mm) high, the words, "ANHYDROUS AMMONIA" and placarding in accordance with DOT requirements.

**11.4.2** Slow moving (25 mph (40 km/h) or less) farm wagons operating on public roads shall be provided with an emblem consisting of a fluorescent orange triangle with a red reflective border. For information regarding construction, location and mounting of the emblem, refer to ASAE S276.4, *Slow-Moving Vehicle Identification Emblem.* See also 29 CFR 1910.145(d)(10). [27] and [5]

## 11.5 Farm Wagons (Implements of Husbandry)

**11.5.1** Farm wagons (implements of husbandry) shall conform with state regulations.

**11.5.2** All farm wagons shall be securely attached to the vehicle drawing them by means of drawbars supplemented by suitable hitch pins and safety chains which meet the requirements of ASAE S338.1, *Safety Chain for Towed Equipment.* [28]

**11.5.3** A farm wagon shall be constructed so that it will follow substantially in the path of the towing vehicle and will prevent the towed farm wagon from whipping or swerving dangerously from side to side.

**11.5.4** A farm wagon shall not be towed in public places such as school yards, malls, or hospital grounds without approval of local authorities.

## 11.6 Safety Equipment

**11.6.1** Each person operating, repairing appurtenances, or inspecting a nurse tank must comply with the following requirements:

(1) 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.

(2) 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 impervious to ammonia, and chemical splash goggles. A full faceshield may be worn over the goggles. However, a faceshield shall not be worn as a substitute for a primary eye protection device (goggles).

**11.6.2** Each nurse tank shall be equipped with the following safety equipment and features:

**11.6.2.1** For first aid purposes, at least 5 gallons (20 L) of clean water in a container designed to provide ready access to the water for flushing any area of the body contacted by ammonia

**11.6.2.2** A legible decal depicting step-by-step ammonia transfer instructions

**11.6.2.3** A legible decal listing first-aid procedures to follow if injured by ammonia

**11.6.2.4** A hazard warning label complying with the requirements of 29 CFR 1910.1200 [5]

### 11.7 Chemical Additive Compatibility

**11.7.1** Prior to the addition of a chemical additive, its compatibility with system components must be verified by the manufacturer of the additive.

## 12. SYSTEMS MOUNTED ON FARM EQUIPMENT (IMPLEMENTS OF HUSBANDRY) FOR THE APPLICATION OF AMMONIA

This section applies to systems mounted on farm equipment and used for the field application of ammonia. All Basic Rules of Section 5 apply to this section unless otherwise noted.

### 12.1 Design of Containers

**12.1.1** The minimum design for containers shall be in accordance with 5.2.

### 12.2 Mounting of Containers

**12.2.1** All containers shall be securely mounted.

### 12.3 Container Valves and Appurtenances

**12.3.1** Fixed maximum liquid level gauges shall be used that are designed to indicate when the container has been filled to 85% of its water capacity. The dip tube of this gauge must be installed in such a manner that it cannot be readily removed.

**12.3.2** The filling connection of each container shall comply with the requirements of 5.5.11.

**12.3.3** An excess-flow valve is not required in the vapor connection, provided the controlling orifice is not in excess of 7/16 inch (10 mm) in diameter and the valve is a hand-operated (attached hand wheel or equivalent) shut-off valve. To assist in filling applicator tanks, it is permissible to bleed vapors to the open air, provided the preceding requirements are met.

**12.3.4** Metering devices may be connected directly to the tank withdrawal valve. A union-type connection is permissible between the tank valve and the metering device. Remote mounting of metering devices is permissible using hose which meets with specifications set out in Appendix A.

**12.3.5** When the applicator or nurse tank is trailed and the metering device is remotely mounted, such as on the tractor tool bar, an automatic break-a-way, self-closing coupling device shall be used. The coupling device shall be made from or coated with a corrosion resistant material. The coupling device shall be mounted in a manner that will permit the device to swivel freely. A coupling device shall be maintained in accordance with the manufacturer's recommendations.

NOTE: An angle valve shall not be used as a hose end valve connecting to the coupling device.

**12.3.6** 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 shut-off valve (see 5.5.3) does not exceed 7/16 inch (10 mm) in diameter.

**12.3.7** Any control valve installed between the regulator and the break-a-way coupling device shall indicate whether the valve is open or closed.

### 12.4 Safety Equipment

**12.4.1** Each person operating, repairing appurtenances, or inspecting an applicator tank must comply with the following requirements:

(1) 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.

(2) 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 impervious to ammonia, and chemical splash

goggles. A full faceshield may be worn over the goggles. However, a faceshield shall not be worn as a substitute for a primary eye protection device (goggles).

**12.4.2** Each applicator tank shall be equipped with the following safety equipment and features:

**12.4.2.1** For first aid purposes, at least 5 gallons (20 L) of clean water in a container designed to provide ready access to the water for flushing any area of the body contacted by ammonia

**12.4.2.2** A legible decal depicting step-by-step ammonia transfer instructions

**12.4.2.3** A hazard warning label complying with the requirements of 29 CFR 1910.1200 [5]

**12.4.3** Instructions for connecting and disconnecting the coupling device shall be displayed in a manner as to be readily visible near the break-away coupling device.

## 13. REFERENCES

[1] ANSI/ASHRAE 15-78, *American National Standard Safety Code for Mechanical Refrigeration*, American Society of Heating, Refrigerating and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329.

[2] ANSI/IEEE Std 268-1982, *METRIC PRACTICE*, American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

[3] NFPA 45, *Hazardous Chemicals Data*, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

[4] *Code of Federal Regulations*, Title 49 CFR Parts 100-199 (Transportation), Chapter I—Research and Special Programs Administration, U.S. Department of Transportation. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[5] *Code of Federal Regulations*, Title 29 CFR Parts 1900-1910 (Labor), Chapter XVII—Occupational Safety and Health Administration, U.S. Department of Labor. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[6] *Transportation of Dangerous Goods Regulations*, Supply and Services Canada, Canadian Publications Centre, Ottawa, Ontario, Canada K1A 0S9.

[7] *Regulations for the Transportation of Dangerous Commodities by Rail*, Supply and Services Canada, Canadian Publications Centre, Ottawa, Ontario, Canada K1A 0S9.

[8] ASME *Boiler and Pressure Vessel Code*, Section VIII, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017-2392.

[9] ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*, American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

[10] ANSI Z358.1, *Emergency Eyewash and Shower Equipment*, American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

[11] *National Board Inspection Code*, (ANSI/NB-23) National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, OH 43229.

[12] ANSI B95.1, *Terminology for Pressure Relief Devices*, American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

[13] ANSI Z88.2, *Practices for Respiratory Protection*, American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

[14] ANSI/ASME B31.3, *American National Standard for Chemical Plant and Petroleum Refinery Piping*, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017-2392.

[15] ANSI/ASME B31.5, *American National Standard for Refrigeration Piping*, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017-2392.

[16] ASTM Specification A53, *Annual Book of ASTM Standards*, ASTM, 1916 Race Street, Philadelphia, PA 19103.

[17] ASME *Boiler and Pressure Vessel Code*, Section IX, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017-2392.

[18] ANSI/SAE J513f, *Refrigeration Tube Fittings*, Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, PA 15096-0001.

[19] ASTM Specification A47 and Specification A395, *Annual Book of ASTM Standards*, ASTM, 1916 Race Street, Philadelphia, PA 19103.

[20] CGA P-7, *Standard for Requalification of Cargo Tank Hose Used in the Transfer of Compressed Gases*, Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202.

[21] UL 132, *Standard on Safety Relief Valves for Anhydrous Ammonia and LP-Gas*, Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

[22] API Standard 620, *Recommended Rules for Design and Construction of Large Welded Low-Pressure Storage Tanks*, American Petroleum Institute, 1220 L Street, N.W., Washington, DC 20005.

[23] ANSI/NFPA 70, *National Electrical Code*, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

[24] *Code of Federal Regulations*, Title 49 CFR Parts 300-399 (Transportation) Chapter III—Federal Highway Administration, U.S. Department of Transportation. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[25] CGA C-4, *American National Standard Method of Marking Portable Compressed Gas Containers to Identify the Material Contained* (ANSI/CGA C-4), Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202.

[26] CGA V-1, *American National, Canadian, and Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* (ANSI/CSA/CGA V-1), Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202.

[27] ASAE S276.4, *Slow-Moving Vehicle Identification Emblem*, American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, MI 49085.

[28] ASAE S338.1, *Safety Chain for Towed Equipment*, American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, MI 49085.

# APPENDIX A
## ANSI Standard RMA IP-14 (1986)
## SPECIFICATIONS FOR ANHYDROUS AMMONIA HOSE

### 1. SCOPE

This specification covers hose, 3-inch inside diameter and smaller, commonly referred to as "pressure transfer hose," used to convey anhydrous ammonia liquid or to convey anhydrous ammonia gas where the gas is in contact with liquid ammonia.

### 2. PRESSURE RATING psi (MPa)

| | | |
|---|---|---|
| Working Pressure, Maximum | 350 psi | ( 2.4 MPa) |
| Burst Pressure, Minimum | 1,750 psi | (12.1 MPa) |

**Note:** These figures should not be misconstrued to mean that they are the maximum pressures to which anhydrous ammonia hose is built, since higher pressure hose is available for special applications.

### 3. DIMENSIONS AND TOLERANCES

Anhydrous ammonia hose shall be made with the following dimensions and tolerances.

**3.1 Table I — Rubber Covered Hose for Use with Two-Piece Screw Type Couplings**

| Nominal I.D. | | Tolerance I.D. ± | | Nominal O.D. | | Tolerance O.D. ± | |
|---|---|---|---|---|---|---|---|
| Inch | mm | Inch | mm | Inch | mm | Inch | mm |
| ½ (0.500) | 12.7 | 0.031 | 0.79 | 15/16 (0.938) | 23.9 | 0.031 | 0.79 |
| ¾ (0.750) | 19.1 | 0.031 | 0.79 | 1¼ (1.250) | 31.8 | 0.031 | 0.79 |
| 1 (1.000) | 25.4 | 0.063 | 1.59 | 1½ (1.500) | 38.0 | 0.063 | 1.59 |

**3.2 Table II — Hose for Use with Other Types of Couplings***

| Nominal I.D. | | Tolerance I.D. ± | |
|---|---|---|---|
| Inch | mm | Inch | mm |
| ½ (0.500) | 12.7 | 0.031 | 0.79 |
| ¾ (0.750) | 19.1 | 0.031 | 0.79 |
| 1 (1.000) | 25.4 | 0.063 | 1.59 |
| 1¼ (1.250) | 31.8 | 0.063 | 1.59 |
| 1½ (1.500) | 38.0 | 0.063 | 1.59 |
| 2 (2.000) | 51.0 | 0.063 | 1.59 |
| 2½ (2.500) | 64.0 | 0.063 | 1.59 |
| 3 (3.000) | 76.0 | 0.063 | 1.59 |

*The O.D. dimensions and tolerances were intentionally omitted from this tabulation to provide for developments in both hose and couplings.

### 4. CONSTRUCTION

**4.1 Inner Tube.** The tube shall be made from elastomeric material resistant to hardening or other deterioration due to the action of ammonia and meeting the physical tests and requirements of Section 5.

**4.2 Reinforcement.** The reinforcement shall consist of any material not adversely affected by permeating ammonia. The reinforcement shall be applied evenly and uniformly, and in such a way that it will meet the physical requirements of Section 5. In constructions utilizing a ply or plies of wire reinforcement, the composition of the wire shall be a suitable corrosion resistant stainless steel.

**4.3 Cover.** A rubber cover, if used, shall be uniform in quality and thickness and free from injurious defects. It shall meet the physical requirements of Section 5. The cover shall be so compounded or constructed that it will not blister in service, and will be resistant to deterioration due to the action of ammonia. A gas tight cover shall be pricked to relieve pressure buildup between inner tube and cover. The cover shall be resistant to deterioration due to exposure and the elements.

## 5. PHYSICAL TESTS AND REQUIREMENTS

**5.1 Acceptance Tests.** A 24 inch (610 mm) sample of each size and type hose, representative of the lot, shall be selected from each lot manufactured at one time, or from each 25,000 feet, whichever is smaller. Tests to be run from this sample follow.

| | Property | Requirements | Method of Test |
|---|---|---|---|
| 5.1.1 | **Hydrostatic Burst** | 1750 psi (12.1 MPa) Minimum | ASTM D380 (Straight Burst Test) |
| 5.1.2 | **Low Temperature** | No breaks and no cracks in tube or cover | 24 inch long hose conditioned straight 5 hours at -40°F (-40°C) then bent within two seconds around a mandrel 12 times the nominal inside diameter of the hose. |
| 5.1.3 | **Tensile Strength** | | |
| | Tube | 800 psi (5.5 MPa) min. | ASTM D380 |
| | Cover | 1200 psi (8.3 MPa) min. | ASTM D380 |
| 5.1.4 | **Elongation at Break** | | |
| | Tube | 150% min. | ASTM D380 |
| | Cover | 200% min. | ASTM D380 |
| 5.1.5 | **Adhesion** | | |
| | Tube | 10 Pounds (1.75 kN/m) at all Interfaces | ASTM D380 for textile reinforcement. Appendix A-1 for wire reinforcement. |
| | Fly | 8 Pounds (1.4 kN/m) at all Interfaces | ASTM D380 |
| | Cover | 10 Pounds (1.75 kN/m) at all Interfaces | ASTM D380 |
| 5.1.6 | **Air Oven Aging** | | |
| | Cover Only | | ASTM D573 & ASTM D380 |
| | Tensile Strength | 80% Retention | 70 ± ½ hrs. at 212 ± 3.6°F (100 ± 2°C) |
| | Elongation | 50% Retention | |
| 5.1.7 | **Ozone Resistance** | | ASTM D1149 |
| | Cover Only | No cracking under 7X magnification | Longitudinal samples approximately 1 inch (25.4 mm) wide from cover shall be mounted in accordance with ASTM D518 procedure B. Conditioned for 24 hours and exposed for 70 hours in ozone—100 pphm at 104°F (40°C). |

### 5.2 Qualification Tests

The qualification tests are intended to establish that the hose is properly designed and constructed to give satisfactory service life. These tests shall be conducted by a qualified laboratory. The qualification tests shall consist of all the tests specified herein, including the ammonia performance test. Hose approved to the procedure specified in paragraph 5.2 of the 1978 edition of RMA IP-14, ANHYDROUS AMMONIA HOSE does not require reapproval. New hose designs/changes must be approved to the 1986 edition of RMA IP-14.

Two 12-foot (3.6 m) lengths shall be selected for the ammonia performance test. Each new hose design shall be subjected to a qualification test, and again whenever there has been a design change.

#### 5.2.1 Ammonia Performance Test

Hose to be tested shall be conditioned as follows:

NOTE: The operator in charge of the installation and inspection shall ensure compliance with all safety precautions concerning the handling of ammonia.

Total amount of hose conditioned must be sufficient to run burst, adhesion and flex tests. 24 inches (610 mm) is required for burst. 36 inches (910 mm) is required for the feeder hose (hose I) when specified. The length needed for flex test (hose II) will depend on flex unit design and hose size cut could range from 3 feet (0.91 meters) *to* 12 feet (3.66 meters).

Fill a length or lengths of hose with liquid anhydrous ammonia by connecting them to a tank and flushing out with ammonia to remove all the air. Seal one end of each length and leave the other end connected to the liquid space of a tank of anhydrous ammonia. Condition the hose for 30 days at standard laboratory temperature. Any valve between the ammonia tank and the hose may be closed, providing it is opened completely at least once each day to fill the hose with liquid anhydrous ammonia. If the hose is closed off by means of stop valves at each end when full of liquid, a hydrostatic relief valve should be provided between the stop valves. Examine the hose each day for visible defects. There shall be no evidence of blistering of the cover or perceptible leakage.

Upon completion of the 30 day test, there shall be no evidence of blistering or cracking of the inside bore.

Upon completion of the 30 day test, adhesion values between all components of textile reinforced hose shall be a minimum of 8 lbs./in. (1.4 kN/m).

##### 5.2.1.1 Conditioned Hose Burst Test

Subject a 24 inch (610 mm) length of conditioned hose to the hydrostatic burst test specified in section 5.1.1. The sample shall have a minimum bursting pressure as specified in section 5.1.1.

##### 5.2.1.2 Conditioned Hose Flexing Test

5.2.1.2.1 Place a length of conditioned hose in a flexing test machine (see figure 1—Hose "II"). Connect one end of the hose to the traveling block (see figure 2) and pass the free end around two pulleys of the diameters shown in table III. Then attach a weight to the free end of just sufficient mass to cause the hose to conform to the circumference of the pulleys. This hose must be long enough to prevent the free end from contacting the pulley when hose is pressurized and travel block is in up position.

5.2.1.2.2 Place a 36 inch (910 mm) length of conditioned hose in the feeder line of the flexing test machine (see figure 1—Hose "I"). Connect one end to

### 5.3 Table III

| Nominal I.D. | | Pulley Diameter | | Pulley Diameter Tolerance ± | | Feeder Hose Length | |
|---|---|---|---|---|---|---|---|
| Inch | mm | Inch | mm | Inch | mm | Inch | mm |
| ½ (0.500) | 12.7 | 14 | 355 | 0.250 | 6.4 | 36 | 915 |
| ¾ (0.750) | 19.1 | 14 | 355 | 0.250 | 6.4 | 36 | 915 |
| 1 (1.000) | 25.4 | 14 | 355 | 0.250 | 6.4 | 36 | 915 |
| 1¼ (1.250) | 31.8 | 15 | 380 | 0.250 | 6.4 | | |
| 1½ (1.500) | 38.0 | 18 | 460 | 0.250 | 6.4 | | |
| 2 (2.000) | 51.0 | 24 | 610 | 0.250 | 6.4 | | |
| 2½ (2.500) | 64.0 | 30 | 762 | 0.250 | 6.4 | | |
| 3 (3.000) | 76.0 | 36 | 915 | 0.250 | 6.4 | | |

the vertical traveling block as shown in figure 1 and connect the other end to a water source with pressure of 375 psi (2.4 MPa).

NOTES:

1. The test on the feeder hose does not apply to sizes over 1 inch (25.4 mm).

2. To conduct the flex test on the larger sizes, any convenient hose may be used as a feeder hose.

3. The flex testing shall begin within 6-8 hours of completion of the 30 day conditioning period.

5.2.1.2.3 Carry out the flexing for 72 hours at a rate of approx. 8 CPM (0.13 Hz) within a vertical movement of the traveling block of 3 feet (0.91 meters). Examine the hose each day for visible defects. There shall be no evidence of blistering or cracking of the cover or bore or leakage.

5.2.1.2.4 At the conclusion of the flexing period, cut a 24 inch (610 mm) sample from the middle of hose "I" and from the middle of hose "II" and subject each sample to the hydrostatic burst test specified in 5.1.1. Both samples shall have a minimum bursting pressure of 97.5% of the value specified in section 2 (pressure rating).

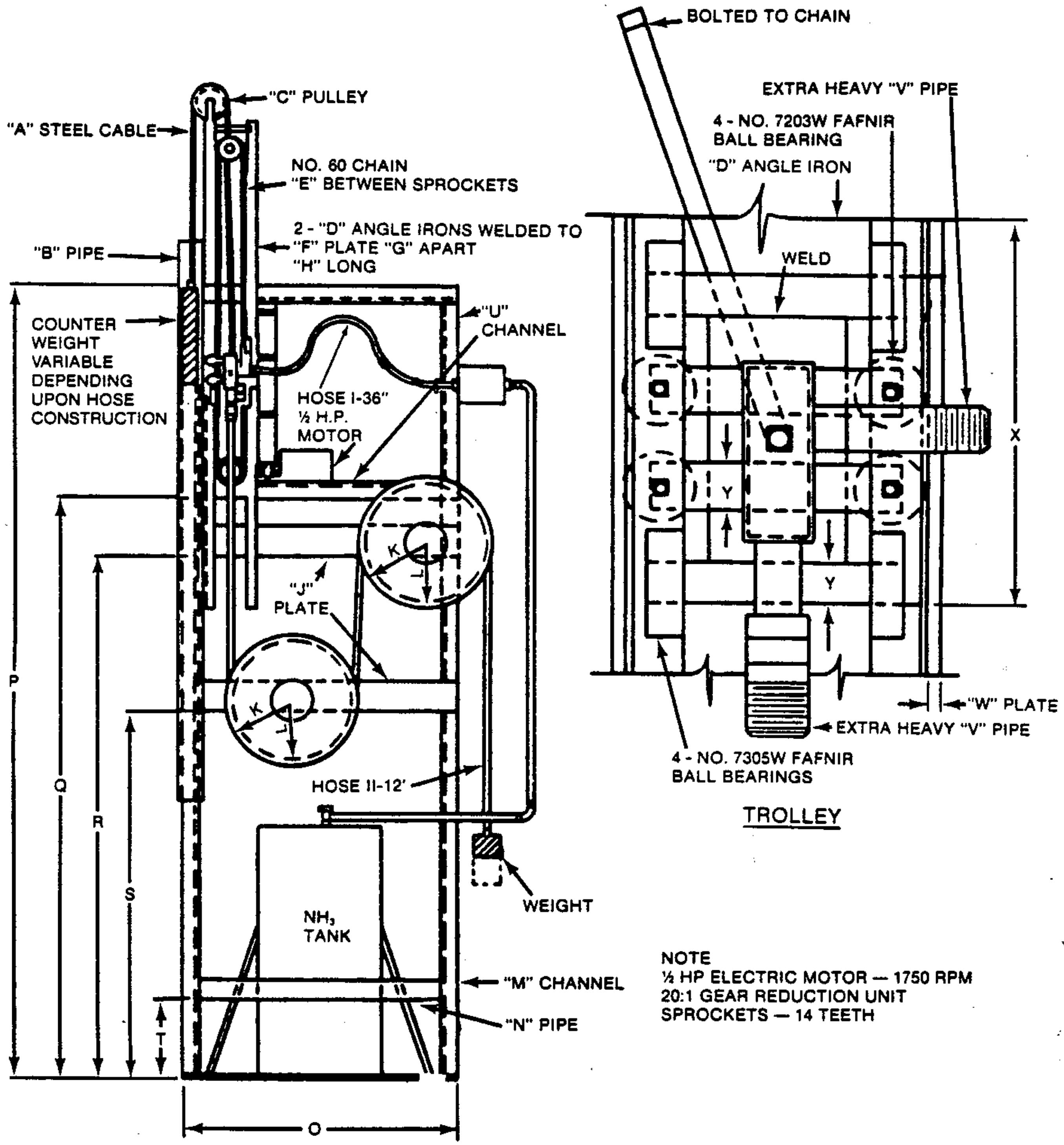
## 6. MARKINGS

Hose shall be clearly marked at least once every five feet with manufacturer's name or trademark, "Anhydrous Ammonia," the maximum working pressure in psig, and year of manufacture. As indicated in the scope, the maximum working pressure must not be less than 350 psig (2.4 MPa).

## FIGURE I — DIMENSIONS

| Dimensions | Inch or Feet | Metric |
|---|---|---|
| A | ¼″ | 6.4 mm |
| B | 3″ x 5′0″ | 76 mm x 1.52 m |
| C | 4½″ | 114 mm |
| D | 1″ | 25.4 mm |
| E | 42″ | 1.07 m |
| F | ½″ | 12.7 mm |
| G | 2½″ | 64 mm |
| H | 63″ | 1.60 m |
| J | 4″ x ⅜″ | 106 mm x 9.5 mm |
| K | Dimension "L" plus 1 inch | Dimension "L" plus 25.4 mm |
| L | See Table IV | — |
| M | 5″ | 127 mm |
| N | 2½″ | 64 mm |
| O | 35″ | 889 mm |
| P | 99″ | 2.55 m |
| Q | 69″ | 1.75 m |
| R | 62½″ | 1.59 m |
| S | 47″ | 1.20 m |
| T | 10″ | 254 mm |
| U | 5″ | 127 mm |
| V | ¾″ | 19.1 mm |
| W | ½″ | 12.7 mm |
| X | 7½″ | 191 mm |
| Y | 1″ | 25.4 mm |

## FIGURE 1 — TYPICAL HOSE FLEXING MACHINE




NOTE
½ HP ELECTRIC MOTOR — 1750 RPM
20:1 GEAR REDUCTION UNIT
SPROCKETS — 14 TEETH

## APPENDIX A-1

For wire reinforced hose having an inside diameter under 19 mm (3/4 in.), the hose may be tested for value of tube adhesion by use of the ball-vacuum method as follows: lay sections of hose in a straight line on an inclined surface. Pass a steel ball, 3.18 mm (1/8 in.) less in diameter than the nominal inside diameter of the hose, through the hose while under a vacuum of 50 to 69 kPa (15 to 20 in. Hg).

For wire reinforced hose having an inside diameter of 19 mm (3/4 in.) or larger, test a strip specimen in accordance with the static-mass method or machine method of ASTM D-413, except prepare the specimen as follows:

1. Split 12.2 mm (6") of hose lengthwise into two equal halves (band saw with Carborundum blade is a satisfactory method.) Care must be taken not to distort the wire braid pattern nor generate excessive heat in the area of the test width.

2. On one half-section, draw two parallel lines 25 mm (1 in.)* apart along the tube and cut through to the reinforcement. Remove a strip of the tube outside of each edge of the test width to avoid constriction during separation.

*This distance is to be measured on the surface of exiting curvature.

NOTE: A strip other than 25 mm (1 in.) wide can be used if necessary and adhesion calculated per ASTM D413, Section 12.

## APPENDIX B
## MINIMUM REQUIRED FLOW RATE OF PRESSURE RELIEF DEVICES

Minimum required rate of discharge in cubic feet per minute of air at 120 per cent of the maximum permitted start to discharge pressure for pressure relief valves to be used on containers other than those constructed in accordance with United States Department of Transportation cylinder specifications.

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

Surface Area = Total Outside Surface Area of Container in Square Feet. When the Surface Area is not stamped on the name plate 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.

Flow Rate—CFM Air = cubic feet per minute of air required at standard conditions, 60°F and atmospheric pressure (14.7 psia).

The rate of discharge may be interpolated for intermediate values of surface area. For containers with total outside surface area greater than 2,500 sq. ft., the required flow rate can be calculated using the formula, Flow Rate CFM Air = $22.11\ A^{0.82}$ where A = outside surface area of the container in square feet.

### CONVERSION FACTORS:

$ft^2$ × 0. 092 903 = $m^2$
CFM × 0. 028 317 = $m^3$/min
ft × 0. 304 8 = m

# PUBLICATIONS OF THE COMPRESSED GAS ASSOCIATION

| Pamphlet No. | Title |
|---|---|
| C-1 | Methods for Hydrostatic Testing of Compressed Gas Cylinders |
| C-2 | Recommendations for the Disposition of Unserviceable Compressed Gas Cylinders with Known Contents |
| C-3 | Standards for Welding on Thin Walled Steel Cylinders |
| C-4 | American National Standard Method of Marking Portable Compressed Gas Containers to Identify the Material Contained |
| C-5 | Cylinder Service Life—Seamless. Steel. High Pressure Cylinders |
| C-6 | Standards for Visual Inspection of Steel Compressed Gas Cylinders |
| C-6.1 | Standards for Visual Inspection of High Pressure Aluminum Compressed Gas Cylinders |
| C-6.2 | Guidelines for Visual Inspection and Requalification of Composite High Pressure Cylinders |
| C-7 | Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers |
| C-8 | Standard for Requalification of DOT-3HT Seamless Steel Cylinders |
| C-9 | Standard Color-Marking of Compressed Gas Containers Intended for Medical Use |
| C-10 | Recommended Procedures for Changes of Gas Service for Compressed Gas Cylinders |
| C-11 | Recommended Practices for Inspection of Compressed Gas Cylinders at Time of Manufacture |
| C-12 | Qualification Procedure for Acetylene Cylinder Design |
| C-13 | Guidelines for Periodic Visual Inspection and Requalification of Acetylene Cylinders |
| C-14 | Procedures for Fire Testing DOT Cylinder Safety Relief Device Systems |
| C-15 | Procedures for Cylinder Design Proof and Service Performance Tests |
| C-16 | Registration Program for Cylinder Owner Symbols |
| E-1 | Standard Connections for Regulator Outlets, Torches and Fitted Hose for Welding and Cutting Equipment |
| E-2 | Hose Line Check Valve Standards for Welding and Cutting |
| E-3 | Pipeline Regulator Inlet Connection Standards |
| E-4 | Standard for Gas Regulators for Welding and Cutting |
| E-5 | Torch Standard for Welding and Cutting |
| E-6 | Standard for Hydraulic Type Pipeline Protective Devices |
| E-7 | Standard for Flowmeters, Pressure Reducing Regulators, Regulator/Flowmeter and Regulator/Flowgauge Combinations for the Administration of Medical Gases |
| G-1 | Acetylene |
| G-1.1 | Commodity Specification for Acetylene |
| G-1.2 | Recommendations for Chemical Acetylene Metering |
| G-1.3 | Acetylene Transmission for Chemical Synthesis |
| G-1.5 | Carbide Lime—Its Value and Its Uses |
| G-1.6 | Recommended Practices for Mobile Acetylene Trailer Systems |
| G-2 | Anhydrous Ammonia |
| G-2.1 | American National Standard Safety Requirements for the Storage and Handling of Anhydrous Ammonia; ANSI K61.1 |
| G-2.2 | Guideline Method for Determining Minimum of 0.2% Water in Anhydrous Ammonia |
| G-3 | Sulfur Dioxide |
| G-4 | Oxygen |
| G-4.1 | Cleaning Equipment for Oxygen Service |
| G-4.3 | Commodity Specification for Oxygen |
| G-4.4 | Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems |
| G-4.5 | Commodity Specification for Oxygen Produced by Chemical Reaction |
| G-5 | Hydrogen |
| G-5.3 | Commodity Specification for Hydrogen |
| G-6 | Carbon Dioxide |
| G-6.1 | Standard for Low Pressure Carbon Dioxide Systems at Consumer Sites |
| G-6.2 | Commodity Specification for Carbon Dioxide |
| G-6.3 | Carbon Dioxide Cylinder Filling and Handling Procedures for Beverage Plants; NSDA TD01 |
| G-7 | Compressed Air for Human Respiration |
| G-7.1 | Commodity Specification for Air; ANSI Z86.1 |
| G-8.1 | Standard for Nitrous Oxide Systems at Consumer Sites |
| G-8.2 | Commodity Specification for Nitrous Oxide |
| G-9.1 | Commodity Specification for Helium |
| G-10.1 | Commodity Specification for Nitrogen |
| G-11.1 | Commodity Specification for Argon |
| G-12 | Hydrogen Sulfide |
| P-1 | Safe Handling of Compressed Gases in Containers |
| P-2 | Characteristics and Safe Handling of Medical Gases |
| P-2.1 | Recommendations for Medical-Surgical Vacuum Systems in Health Care Facilities |
| P-2.5 | Transfilling of High Pressure Gaseous Oxygen to be Used for Respiration |
| P-2.6 | Transfilling of Liquid Oxygen to be Used for Respiration |
| P-5 | Suggestions for the Care of High Pressure Air Cylinders for Underwater Breathing |
| P-6 | Standard Density Data, Atmospheric Gases and Hydrogen |
| P-7 | Standard for Requalification of Cargo Tank Hose Used in the Transfer of Compressed Gases |
| P-8 | Safe Practices Guide for Air Separation Plants |
| P-9 | The Inert Gases—Argon, Nitrogen and Helium |
| P-10 | Standard for Vinyl Chloride Monomer Tank Car Manway Cover and Protective Housing Arrangement and Emergency Safety Kit |
| P-11 | Metric Practice Guide for the Compressed Gas Industry |
| P-12 | Safe Handling of Cryogenic Liquids |
| P-13 | Safe Handling of Liquid Carbon Monoxide |
| P-14 | Accident Prevention in Oxygen-Rich and Oxygen-Deficient Atmospheres |
| P-15 | Filling of Industrial and Medical Nonflammable Compressed Gas Cylinders |
| S-1.1 | Pressure Relief Device Standards—Part 1—Cylinders for Compressed Gases |
| S-1.2 | Pressure Relief Device Standards—Part 2—Cargo and Portable Tanks for Compressed Gases |
| S-1.3 | Pressure Relief Device Standards—Part 3—Compressed Gas Storage Containers |
| V-1 | American National, Canadian, and Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections |
| V-5 | Diameter-Index Safety System (Non Interchangeable Low Pressure Connections for Medical Gas Applications) |
| V-6 | Standard Cryogenic Liquid Transfer Connections |
| V-6.1 | Standard Carbon Dioxide Transfer Connections |
| V-7 | Standard Method of Determining Cylinder Valve Outlet Connections for Industrial Gas Mixtures |
| CGA-341 | Standard for Insulated Cargo Tank Specification for Cryogenic Liquids |
| SB-1 | Hazards of Refilling Compressed Refrigerant (Halogenated Hydrocarbons) Gas Cylinders |
| SB-2 | Oxygen-Deficient Atmospheres |
| SB-3 | Evidence of Ownership of Compressed Gas Cylinders |
| SB-4 | Handling Acetylene Cylinders in Fire Situations |
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| SB-10 | Correct Labeling and Proper Fittings on Cylinders/Containers |
| SB-11 | Use of Rubber Welding Hose |
| TB-2 | Guidelines for Inspection and Repair of MC-330 and MC-331 Anhydrous Ammonia Cargo Tanks |
| TB-3 | Hose Line Flashback Arrestors |
| TB-4 | Product Certification: Health Care Industry Application |
| HB-2 | Handbook of Compressed Gases—2nd Edition |

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# EXHIBIT 5.1-C

## AMMONIA DILUTION AIR FAN
## TECHNICAL INFORMATION

Inquiry No. SCR – 702
SCS/DOE ICCT
Selective Catalytic Reduction (SCR) Project
Fan Data Sheet

In addition to the fan design requirements listed in the Supplemental Specification the following information is specific to each fan in this inquiry:

## 1.0 General

| | | |
|---|---|---|
| 1.1 | Application: | Ammonia Dilution Air Fan |
| 1.2 | Location: | Suction From Atmosphere |
| 1.3 | Number of Fans: | One (1) |
| 1.4 | Fan Control: | Inlet damper or inlet vane |

## 2.0 Performance

2.1 Air Analysis at MCR (at fan inlet):

| Air Component | Mass (lb/hr) |
|---|---|
| O2 | 128.32 |
| N2 | 422.24 |
| TOTAL | 550.56 |

2.2 Expected Conditions

| Load | Flow/Fan (acfm) | Ps @ Inlet ("wg) | Ps @ Outlet ("wg) | Ps Rise ("wg) | Density (lb/cuft) | Temp. (deg. F) |
|---|---|---|---|---|---|---|
| Test Block | 150 | 0.00 | 40.00 | 40.00 | 0.074 | 100 |
| Design | 124 | 0.00 | 30.00 | 30.00 | 0.074 | 100 |

## 3.0 Construction

3.1 Peak Design Temperature: 150 deg. F

6.6.4.5 **Bearings**
- a. Diameter (in.) ______
- b. Type ______
- c. Manufacturer ______
- d. Lubrication ______
- e. Reservoir capacity (gal.) ______
- f. Cooling water per fan (gpm) ______

6.6.4.6 Fan to motor connection
- a. Type (flexible, belt, etc.) ______
- b. Manufacturer ______
- c. Size ______

6.6.5 Additional proposal data

6.6.5.1 Dimension sheet ______

6.6.5.2 Performance curve ______

6.7 Ammonia Dilution Air Fan

6.7.1 General ______

6.7.1.1 Fan type (model/series): 2924, SWSI, Arr. #8

6.7.1.2 Type control: Outlet Damper

6.7.1.3 Drive arrangement: Direct connected

6.7.1.4 Number of fans: 1

6.7.2 Performance

6.7.2.1 Performance data for each fan at:

| | Test Block (guaranteed) | Maximum |
|---|---|---|
| a. Speed – rpm | 3500 | 3500 |
| b. Capacity – acfm | 150 | 124 |
| c. Density – lb/cuft | 074 | .074 |
| d. Temperature – deg F | 100 | 100 |
| e. Pressures – "wg | | |
| 1. Inlet static | -1.0 | -.8 |
| 2. Discharge static | 40 | 30 |
| 3. Fan static pressure | 41.0 | 30.8 |
| f. Static efficiency – % | 22 | 15 |
| g. Power input to fan – bhp | 4.5 | 4.2 |
| h. Compressibility | .983 | .985 |

6.7.2.2 General performance data

| | |
|---|---|
| a. Peak horsepower (@ TB density) | 14.0 |
| b. Maximum torque expected (ft-lb) | 12 |
| c. Starting torque (ft-lb) | 12 |

6.7.3 Sound data

6.7.3.1 Sound level data for fan at noisest conditions through casing @ one meter

| octave band center frequency (Hz) | Est. Lw dB (re 10^-12 watt) |
|---|---|
| 63 | 84 |
| 125 | 86 |
| 250 | 82 |
| 500 | 80 |
| 1000 | 80 |
| 2000 | 83 |
| 4000 | 80 |
| 8000 | 72 |

| | Est. Lp dB (re 20 mPa) |
|---|---|
| 6.7.3.2 Sound pressure level at one meter outside housing | 85 dba |

6.7.3.3 Above estimate includes/does not include:

| | |
|---|---|
| a. Inlet silencer | Does |
| b. Outlet silencer | Does not |
| c. Casing insulation | Does not |

6.7.4 Constructional data

6.7.4.1 Impeller general information

| | |
|---|---|
| a. Diameter at tip of blade (in.) | 24 |
| b. Width of wheel at tip of blade (in.) | 1 |
| c. Type of blade (backward inclined, radial, etc.) | Backward inclined |
| d. Number of blades | 10 |
| e. Tip speed at test block (fpm) | 22000 |
| f. Flywheel effect (lb-ft2) | 10 |
| g. Shaft dia. at hub (in.) | 1.44 |
| h. Shaft dia. at bearing (in.) | 1.44 |

6.7.4.2 Material type

| | |
|---|---|
| a. Shaft | Bar stock |
| b. Wheel | Aluminum |
| c. Liner | N/A |
| d. Housing | Carbon steel |
| e. Base | Carbon steel |
| f. Damper or Vane | Carbon steel |

| | | |
|---|---|---|
| 6.7.4.3 | Material thickness (in.) | |
| | a. Blades | Later |
| | b. Liner | N/A |
| | c. Center, side or back plates | Later |
| | d. Housing | 7 and 10 GA |
| | e. Base | .25 |
| | f. Damper or vane (blade) | Later |
| 6.7.4.4 | Weights (lbs.) | |
| | a. Fan | |
| | b. Motor | |
| | c. Pedestal | |
| | d. Damper of vane | [illegible] |
| | e. Weight of complete assembly | 1250 |
| 6.7.4.5 | Bearings | |
| | a. Diameter (in.) | 1.44 |
| | b. Type | Anti-friction |
| | c. Manufacturer | Later |
| | d. Lubrication | Grease |
| | e. Reservoir capacity (gal.) | Later |
| | f. Cooling water per fan (gpm) | None |
| 6.7.4.6 | Fan to motor connection | |
| | a. Type (flexible, belt, etc.) | Flexible |
| | b. Manufacturer | Falk or Equal |
| | c. Size | Later |
| 6.7.5 | Additional proposal data | |
| 6.7.5.1 | Dimension sheet | Attached |
| 6.7.5.2 | Performance curve | Attached |

## 7.0 EXCEPTIONS

7.1 We have reviewed your specifications and all related attachments. Unless specific exceptions are listed below (or included in our proposal and referenced below), it is understood that all of the provisions contained therein are acceptable to us.

Without exceptions: ______________________

With exceptions as follows: See attached comments and exceptions

AMERICAN DAVIDSON Sturtevant Division

SUPERSEDES

NEW ISSUE

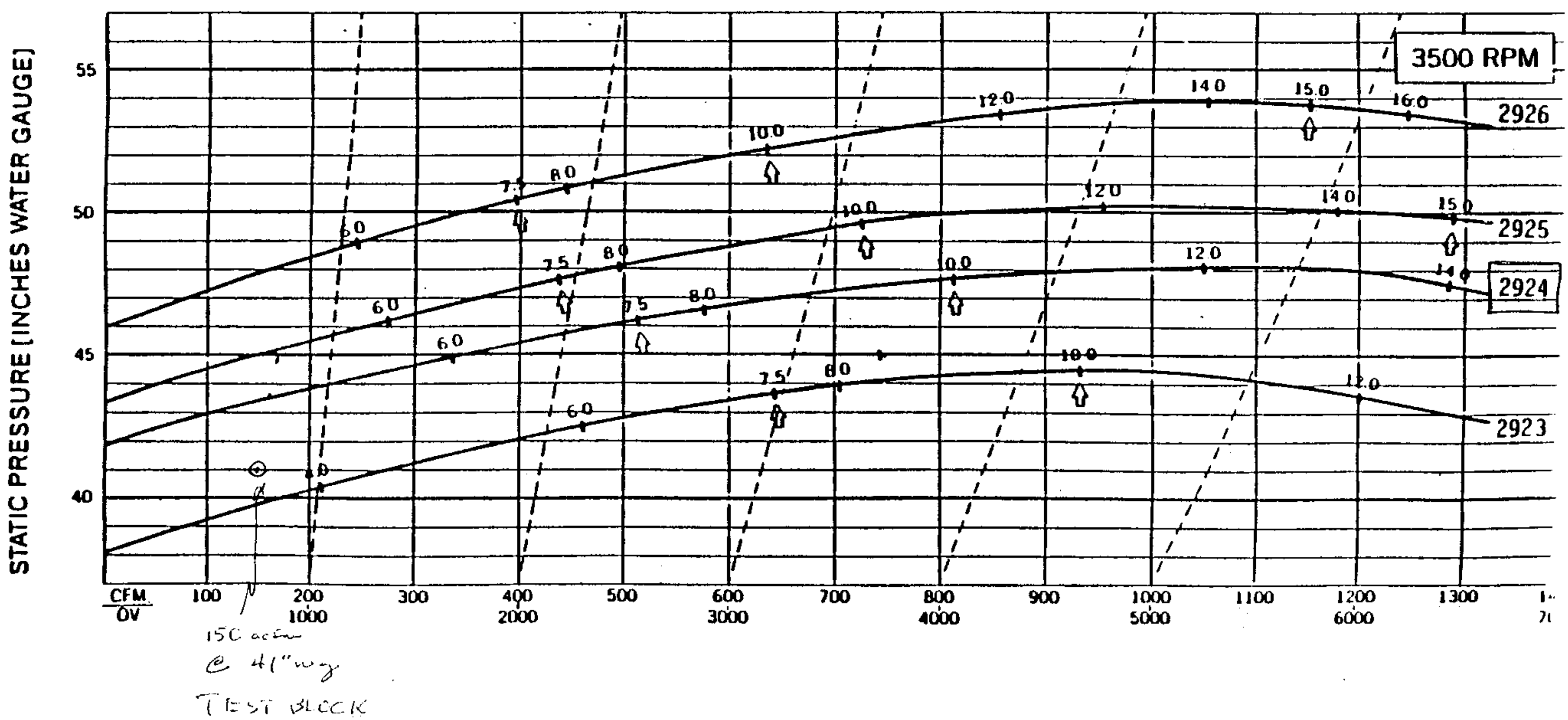
PERFORMANCE CURVE
SERIES 2900

PERFORMANCE CURVE
IF2900-PD
PAGE 5
EFFECTIVE
3/27/86

# 06 OUTLET SIZE

Performance shown is for Pressure Blowers with outlet duct and with or without inlet duct.

Outlet area: .20 sq. ft.



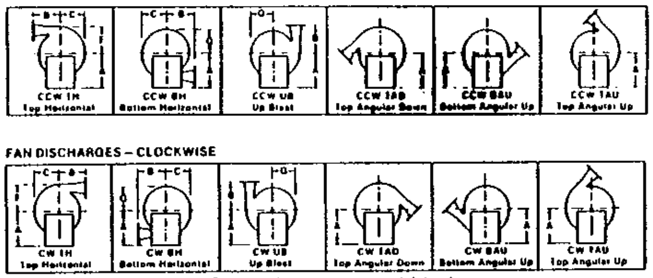
Ammonia Dilution Fan

Turbine Lube Oil Vapor Extractor





## FAN DISCHARGES — VIEWED FROM DRIVE SIDE




Down Blast and Bottom Angular Down discharges require special drawings.

ANGULAR DISCHARGES at 45 DEGREES

| MOTOR FRAME NO. | COUPLING | | | |
|---|---|---|---|---|
| | BORE | | KEYWAY | |
| | FAN | MOTOR | FAN | MOTOR |
| 143T & 145T | 7/8 | 7/8 | 3/16 x 3/32 | 3/16 x 3/32 |
| 182T & 184T | 1 1/8 | 1 1/8 | 1/4 x 1/8 | 1/4 x 1/8 |
| 213T & 215T | 1 7/16 | 1 3/8 | 3/8 x 3/16 | 5/16 x 5/32 |
| 254T & 256T | 1 7/16 | 1 5/8 | 3/8 x 3/16 | 3/8 x 3/16 |
| 284TS & 286TS | 1 7/16 | 1 5/8 | 3/8 x 3/16 | 3/8 x 3/16 |
| 324TS & 326TS | 1 7/16 | 1 7/8 | 3/8 x 3/16 | 1/2 x 1/4 |

| FLANGE DIMENSIONS (OUTLET-INLET) | | | |
|---|---|---|---|
| ID | BC | OD | HOLES† NO. & SIZE |
| 4 | 7 1/2 | 9 | 8 – 3/4" |
| 6 | 9 1/2 | 11 | 8 – 7/8" |
| 8 | 11 3/4 | 13 1/2 | 8 – 7/8" |
| 10 | 14 1/4 | 16 | 12 – 1" |
| 12 | 17 | 19 | 12 – 1" |

† Holes straddle the centerlines.

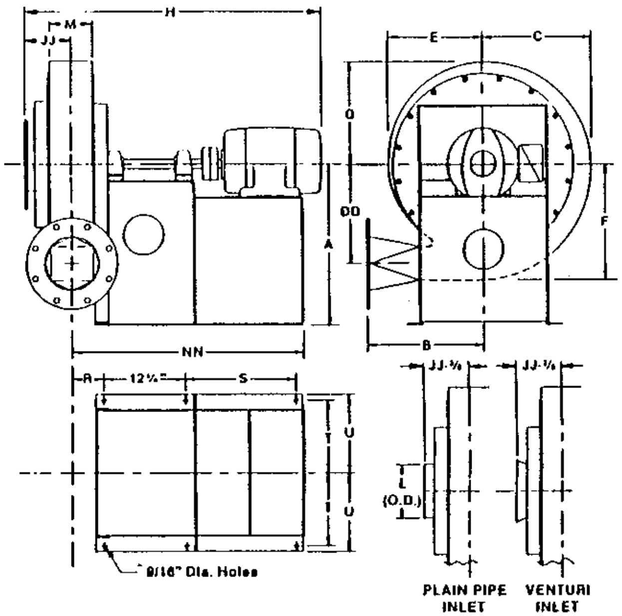
## DIMENSIONS (INCHES)

| WHEEL DIAMETER | A | C | DD | E | F | G | T | U | SHAFT DIA. | SQ. KEY |
|---|---|---|---|---|---|---|---|---|---|---|
| 14 THRU 18 | 19 1/2 | 13 5/8 | 11 3/4 | 12 | 14 3/4 | 12 3/4 | 9 1/8 | 10 | 1 7/16 | 3/8 |
| 19 THRU 22 | 23 5/8 | 16 1/2 | 14 7/8 | 14 1/2 | 17 1/2 | 15 1/2 | 10 7/8 | 13 3/4 | 1 7/16 | 3/8 |
| 23 THRU 26 | 26 5/8 | 19 1/2 | 17 5/8 | 17 1/8 | 20 5/8 | 18 1/4 | 10 7/8 | 13 3/4 | 1 7/16 | 3/8 |

| WHEEL DIA | OUTLET DIA | MOTOR FRAME | B | H | JJ | L | M | NN | R | S | FLANGED (OD) OUTLET | FLANGED (OD) INLET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 THRU 18 | 4 | 143 145 | 18 1/4 | 39 1/2 | 5 5/8 | 8 5/8 | 3 7/8 | 31 7/8 | 3 3/8 | 15 | 4 | 6 |
| | | 182 184 | 18 1/4 | 41 | 5 5/8 | 8 5/8 | 3 7/8 | 33 3/8 | 3 3/8 | 16 1/2 | 4 | 6 |
| 19 THRU 22 | | 143 145 | 17 3/4 | 39 1/2 | 6 1/8 | 8 5/8 | 3 7/8 | 31 7/8 | 3 3/4 | 15 | 4 | 6 |
| | | 182 184 | 17 3/4 | 42 1/2 | 6 1/8 | 8 5/8 | 3 7/8 | 33 3/8 | 3 3/8 | 16 1/2 | 4 | 6 |
| 14 THRU 18 | 6 | 143 145 | 18 1/4 | 41 7/8 | 6 3/4 | 8 5/8 | 5 1/4 | 33 | 4 1/2 | 15 | 6 | 8 |
| | | 182 184 | 18 1/4 | 44 3/8 | 6 3/4 | 8 5/8 | 5 1/4 | 34 1/2 | 4 1/2 | 16 1/2 | 6 | 8 |
| 19 THRU 22 | | 182 184 | 17 3/4 | 42 1/2 | 6 1/8 | 8 5/8 | 3 7/8 | 33 3/8 | 3 3/8 | 16 1/2 | 6 | 6 |
| | | 213 215 | 17 3/4 | 44 1/8 | 6 1/8 | 8 5/8 | 3 7/8 | 35 5/8 | 3 3/8 | 18 3/4 | 6 | 6 |
| 23 THRU 26 | | 182 184 | 19 | 43 5/8 | 7 | 8 5/8 | 5 | 34 3/8 | 3 7/8 | 17 | 6 | 8 |
| | | 213 215 | 19 | 47 5/8 | 7 | 8 5/8 | 5 | 36 5/8 | 3 7/8 | 19 1/4 | 6 | 8 |
| | | 254 256 | 19 | 50 1/8 | 7 | 8 5/8 | 5 | 42 | 3 7/8 | 24 5/8 | 6 | 8 |
| 14 THRU 18 | 8 | 182 184 | 18 1/4 | 44 3/8 | 6 3/4 | 8 5/8 | 6 1/4 | 34 1/2 | 4 1/2 | 16 1/2 | 8 | 8 |
| | | 213 215 | 18 1/4 | 47 1/2 | 6 3/4 | 8 5/8 | 6 1/4 | 36 3/4 | 4 1/2 | 18 3/4 | 8 | 8 |
| 19 THRU 22 | | 182 184 | 17 3/4 | 43 1/2 | 6 3/4 | 8 5/8 | 6 1/4 | 34 1/2 | 4 1/2 | 16 1/2 | 8 | 8 |
| | | 213 215 | 17 3/4 | 47 1/2 | 6 3/4 | 8 5/8 | 6 1/4 | 36 3/4 | 4 1/2 | 18 3/4 | 8 | 8 |
| | | 254 256 | 17 3/4 | 50 | 6 3/4 | 8 5/8 | 6 1/4 | 42 1/8 | 4 1/2 | 24 1/8 | 8 | 8 |
| 23 THRU 26 | | 213 215 | 19 | 45 3/4 | 7 | 8 5/8 | 5 | 36 5/8 | 3 7/8 | 19 1/4 | 8 | 8 |
| | | 254 256 | 19 | 51 7/8 | 7 | 8 5/8 | 5 | 42 | 3 7/8 | 24 5/8 | 8 | 8 |
| 19 THRU 22 | 10 | 213 215 | 21 3/4 | 45 5/8 | 6 3/4 | 8 5/8 | 6 1/4 | 36 3/4 | 4 1/2 | 18 3/4 | 10 | 10 |
| | | 254 256 | 21 3/4 | 51 3/4 | 6 3/4 | 8 5/8 | 6 1/4 | 42 1/8 | 4 1/2 | 24 1/4 | 10 | 10 |
| | | 284 286 | 21 3/4 | 52 7/8 | 6 3/4 | 8 5/8 | 6 1/4 | 42 7/8 | 4 1/2 | 24 7/8 | 10 | 10 |
| 23 THRU 26 | | 254 256 | 23 | 53 1/4 | 7 1/4 | 10 3/4 | 7 1/4 | 43 1/8 | 5 | 24 5/8 | 10 | 10 |
| | | 284 286 | 23 | 54 3/8 | 7 1/4 | 10 3/4 | 7 1/4 | 43 7/8 | 5 | 25 3/8 | 10 | 10 |
| 23 THRU 26 | 12 | 284 286 | 23 | 53 1/4 | 7 1/4 | 10 3/4 | 7 1/4 | 43 7/8 | 5 | 25 3/8 | 12 | 12 |
| | | 324 326 | 23 | 56 7/8 | 7 1/4 | 10 3/4 | 7 1/4 | 46 3/8 | 5 | 27 7/8 | 12 | 12 |

Dimension H varies slightly with motors of different manufacture

Tolerance: ± 1/8"




Pressure Blowers are rotatable in the field. Furnished with flanged outlet which fits ANSI 150 pipe flanges.
Maximum Temperature:
Alum. Wheel (std.) – 200°F
Steel Wheel – 300°F
Heat Fan – 800°F

## ACCESSORIES

Items checked are to be furnished.

- ____ Flanged Inlet. Fits ANSI 150 pipe flanges.
- ____ Venturi Inlet, with guard.
- ____ Plain Pipe Inlet.
- ____ Steel Wheel.
- ____ Drain, 1" tank flange (less plug).
- ____ Wafer Type Outlet Damper, Type AW/BW. Per drawing ________.
- ____ Wafer Type Outlet Damper, Type AL/BL. Per drawing ________.
- ____ Flexible Connector. Per drawing ________.
- ____ Inlet Filter. Per drawing ________.
- ____ Isolation. Per drawing ________.
- ____ ________ Type Spark Resistant Construction.
- ____ Shaft Seal-Ceramic Felt.
- ____ 301°F. thru 800°F. Heat Fan (steel wheel, shaft cooler and guard).
- ____ Nominally air tight Construction (solid drive side, shaft seal, neoprene inlet plate gasket). Blower not rotatable in the field.
- ____ Shaft Guard.
- ____ Coupling Guard.



NEW ISSUE
EFFECTIVE FEBRUARY, 1987
PRINTED IN U.S.A.

# EXHIBIT 5.1-D

## DYNAGEN'S WORK ON
## NOZZLE NUMBERS VERSUS DISTANCE
## REQUIRED FOR ADEQUATE MIXING

DynaGen, Inc.

January 23, 1991
Project No. SCS-2
SCR Pilot Plant Design
Contract No. 195-89-044

Mr. Doug Maxwell
Technology Assessment Department
Southern Company Services, Inc.
P.O. Box 2625
Birmingham, Alabama 35202

Dear Mr. Maxwell:

I will cover a number of unrelated topics in this letter under separate headings.

Ammonia Injection

We have been conducting some preliminary calculations to evaluate the uniformity of ammonia concentration downstream of the injection cross-section using our three-dimensional fluid dynamics computer program. Our initial calculations have been carried out for injection parallel with the axis of a 2' diameter straight pipe with flow conditions equal to your pilot plant pipe flow approaching one large reactor. We have done a series of calculations for a single nozzle on the centerline of the pipe, varying injection temperature and velocity. We have also done calculations at one temperature and velocity for multiple nozzle arrays.

Figure 1 presents the single nozzle results for two injection temperatures (60°F and 700°F) and three velocities (31.7, 63.4, and 253.6 fps). The results are presented as the ratio of minimum to maximum ammonia concentration in the same cross-section versus axial distance from the injection point. A plus or minus 5% ammonia concentration spread would give a ratio of 0.905. The results on Figure 1 show that injection temperature relative to a 700°F mainstream gas temperature has no effect on the results. The effect of injection velocity relative to about a 64 fps mainstream velocity does have a significant effect with injection velocities close to the mainstream velocity giving the shortest mixing distances.

Figure 2 presents the concentration ratio results for 1, 4, and 9 nozzles symmetrically arranged in a 2' diameter pipe. The number of nozzles makes a significant

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difference in the axial distance needed to achieve the $\pm 5\%$ concentration spread. The results from Figure 2 are as follows:

| Number of Nozzles | Axial Distance | Distance/ Diameter |
|---|---|---|
| 1 | 56' | 28 |
| 4 | 41' | 20.5 |
| 9 | 17' | 8.5 |

The closer the injection cross-section is to the inlet plane of the dummy reactor core, the more nozzles that will be needed to reach the concentration uniformity criteria.

Selection of Injection Locations

Although there will be differences in the required axial length due to the diffusers, turns, and vanes of the final duct system, the results presented on Figure 2 can be used to select the combinations of location and number of nozzles that could be used to achieve the concentration uniformity criteria. On Figure 2A (from 12/20/90 letter and attached here), several locations have been numbered at several distances from the dummy reactor core inlet. The approximate number of nozzles needed at each location are listed below:

| Location | Approximate Axial Distance Along Centerline | Approximate Number of Nozzles Needed |
|---|---|---|
| 1 | 9' | 15 |
| 2 | 12'-14' | 12 |
| 3 | 22' | 9 |
| 4 | 29'-31' | 7 |
| 5 | 37'-39' | 5 |
| 6 | 44'-45' | 3 |

Based on these approximate numbers, please review the locations identified on Figure 2A and the corresponding number of nozzles above and specify to me which locations you want us to consider for future calculations of ammonia concentration. After one of the three duct geometries on Figure 2A is selected for the field geometry, based on the experimental model tests, we will conduct some ammonia concentration calculations for the selected duct geometry to optimize the ammonia injection system.

Please respond to me by February 4th if possible.

Thermal Mixing Due to Hot Gas Injection Near Take Off Scoop

At our meeting in Birmingham on December 4, 1990, it was mentioned that under some low flow conditions, some hot gas flow may be injected in the pilot plant pipe near the scoop discharge to heat the main scoop flow up to 680°F. The distance from where the hot injection could be introduced to the take off locations for the small reactors is not very far. If you plan to do this hot gas injection, then care should be taken to achieve a uniform temperature quickly before reaching the first take off pipes to the small reactors.

We can evaluate the thermal mixing using the same computer program we have been using for ammonia concentration calculations. If you want us to do any work on this, please let me know and send the geometry and flow conditions we would need to make the calculations.

Reactor Inlet Duct Tests

As I mentioned on the telephone, the reactor core material did arrive last week. We will have this assembled into the model by the end of this week and will start testing next week. I will send you results as they are ready. When the testing is complete, you can decide whether you want to visit or just look at a video. We should be finished by mid to late February.

Yours truly,

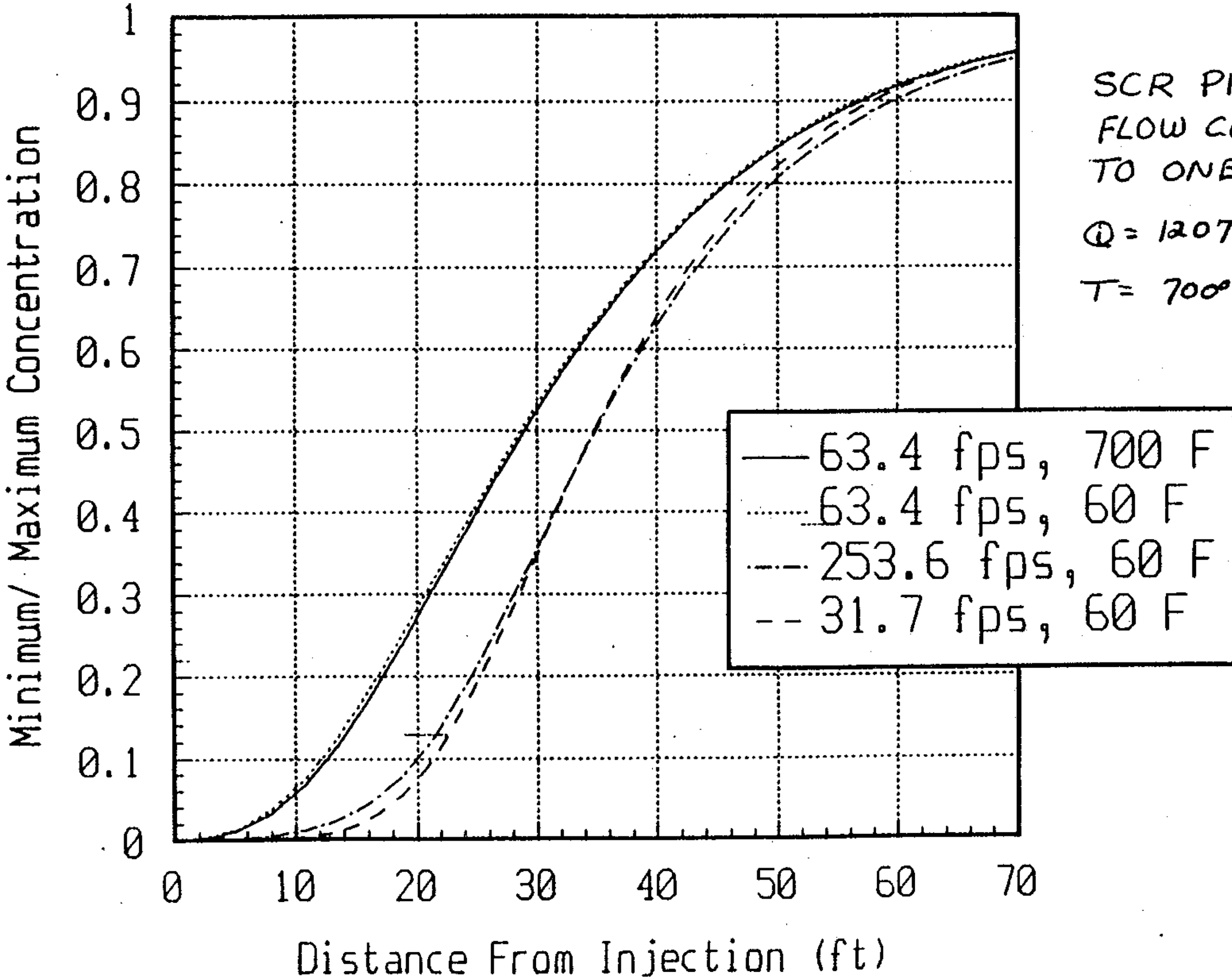
Gerald B. Gilbert

Gerald B. Gilbert
Manager,
Fluid Systems Division

GBG/cak

FIGURE 1 AMMONIA INJECTION IN A STRAIGHT PIPE (2'Φ)

Vary One Nozzle Injection Temperature and Velocity



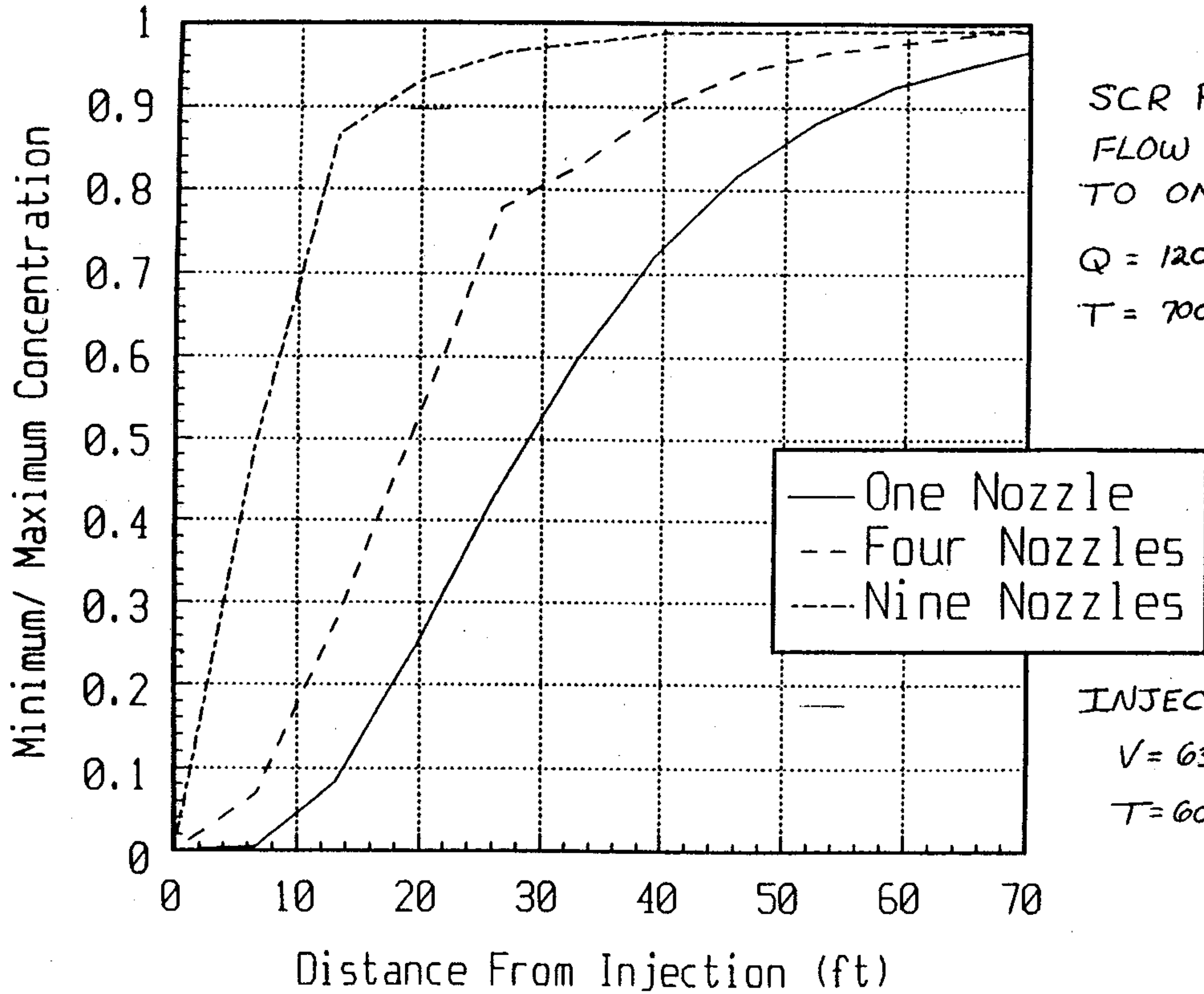

SCR PILOT PLANT FLOW CONDITIONS TO ONE REACTOR

Q = 12074 ACFM

T = 700° F

FIGURE 2 AMMONIA INJECTION IN A STRAIGHT PIPE (2'$\phi$)

One, Four, Nine Nozzles




SCR PILOT PLANT
FLOW CONDITIONS
TO ONE REACTOR

Q = 12074 ACFM

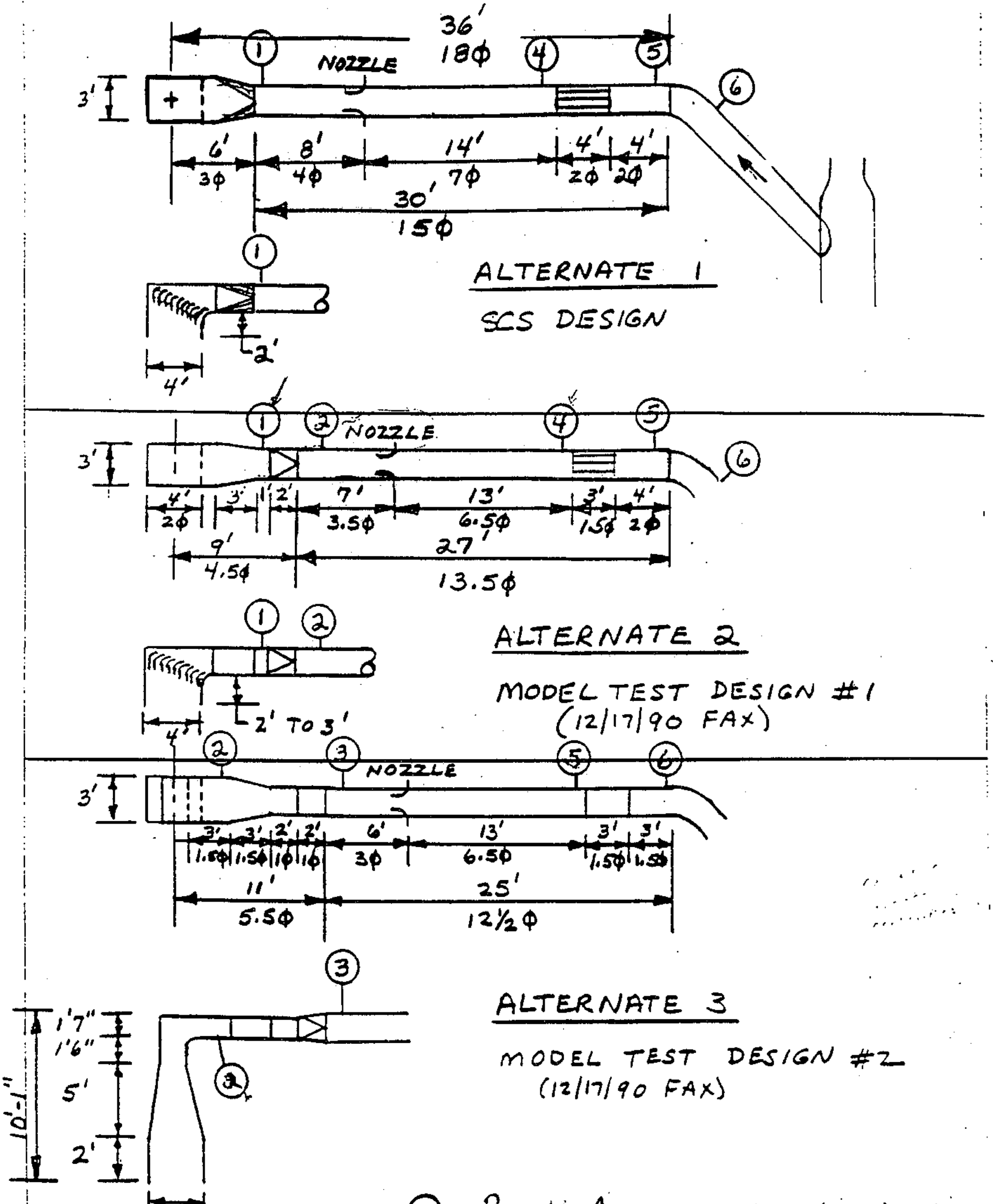
T = 700 °F

INJECTION CONDITION

V = 63.4 fps

T = 60 °F

# FIGURE 2A- ALTERNATE REACTOR INLET DUCT ARRANGEMENTS




○ = Possible Ammonia Injection Locations
See Letter Dated 1/23/91

## 5.2 MAJOR EQUIPMENT

Table 5.2-1
Listing of Major Equipment in Area 300

| Area | Description | Equipmnet No. |
|---|---|---|
| 300 | Ammonia storage tank | TNK-301 |
| 300 | Ammonia storage tank heater/vaporizer | HTR-301 |
| 300 | Ammonia accumulator tank | TNK-302 |
| 300 | Reactor train A ammonia flow control valve | FCV-301A |
| 300 | Reactor train B ammonia flow control valve | FCV-301B |
| 300 | Reactor train C ammonia flow control valve | FCV-301C |
| 300 | Reactor train D ammonia flow control valve | FCV-301D |
| 300 | Reactor train E ammonia flow control valve | FCV-301E |
| 300 | Reactor train F ammonia flow control valve | FCV-301F |
| 300 | Reactor train G ammonia flow control valve | FCV-301G |
| 300 | Reactor train H ammonia flow control valve | FCV-301H |
| 300 | Reactor train J ammonia flow control valve | FCV-301J |
| 300 | Ammonia dilution air fan | F-301 |
| 300 | Ammonia dilution air fan motor | MXR-301 |
| 300 | Reactor train A air/ammonia mixer | MXR-301A |
| 300 | Reactor train B air/ammonia mixer | MXR-301B |
| 300 | Reactor train C air/ammonia mixer | MXR-301C |
| 300 | Reactor train D air/ammonia mixer | MXR-301D |
| 300 | Reactor train E air/ammonia mixer | MXR-301E |
| 300 | Reactor train F air/ammonia mixer | MXR-301F |
| 300 | Reactor train G air/ammonia mixer | MXR-301G |
| 300 | Reactor train H air/ammonia mixer | MXR-301H |
| 300 | Reactor train J air/ammonia mixer | MXR-301J |
| 300 | Reactor train A air/ammonia injection grid | AIG-301A |
| 300 | Reactor train B air/ammonia injection grid | AIG-301B |
| 300 | Reactor train C air/ammonia injection grid | AIG-301C |
| 300 | Reactor train D air/ammonia injection grid | AIG-301D |
| 300 | Reactor train E air/ammonia injection grid | AIG-301E |
| 300 | Reactor train F air/ammonia injection grid | AIG-301F |
| 300 | Reactor train G air/ammonia injection grid | AIG-301G |
| 300 | Reactor train H air/ammonia injection grid | AIG-301H |
| 300 | Reactor train J air/ammonia injection grid | AIG-301J |
| 300 | Ammonia dilution air electric heater | HTR-302 |
| 300 | Reactor train A dilution air damper | DMP-301A |
| 300 | Reactor train B dilution air damper | DMP-301B |
| 300 | Reactor train C dilution air damper | DMP-301C |
| 300 | Reactor train D dilution air damper | DMP-301D |
| 300 | Reactor train E dilution air damper | DMP-301E |
| 300 | Reactor train F dilution air damper | DMP-301F |
| 300 | Reactor train G dilution air damper | DMP-301G |
| 300 | Reactor train H dilution air damper | DMP-301H |
| 300 | Reactor train J dilution air damper | DMP-301J |