

Refrigerating Engineers & Technicians Association



CARO STUDY GUIDE

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Introduction to the CARO Study Guide

This CARO Examination Study Guide is designed to help you prepare to demonstrate your mastery of the content covered in this RETA certification test. You will be tested on concepts addressed in IR-1 and IR-4 (safety section only).

You will improve your chances of earning your CARO credential by treating this CARO Study Guide as you would the technical manuals in a refrigeration facility where you work. Your chances of earning the CARO credential improve if you are familiar with the details in the CARO Study Guide. Just as your job requires that you know what is in operating manuals and when to refer to them to understand or resolve a problem, the CARO test requires that you know what is in the References document and when to use it. ***You will not be told when to use the references for this test.***

Calculators

All calculations for the CARO examination can be completed with a simple calculator. Candidates should bring a simple, non-printing calculator. A scientific calculator is ***NOT*** required to perform well on this examination. You are permitted to bring a simple non-printing calculator to the test, but you will be required to clear the calculator memory before you may take any calculator into the testing room. Test centers are not required to provide a calculator to candidates during this test.

CARO Examination Content

CARO consists of 110 questions in English. Candidates have three hours to complete the test. The minimum passing score is 70. CARO also includes 10 questions that are being evaluated for use in future exams. Candidate scores are for just the 100 active questions in the test. These pilot questions are not counted in the candidate's test score.

The following content areas are in the CARO examination.

| | |
|---|--------------|
| Refrigeration fundamentals | 9 questions |
| Refrigeration cycle | 8 questions |
| Properties of refrigerants and refrigerant tables | 7 questions |
| Types of refrigerant compressors | 6 questions |
| Operation and maintenance of compressors | 14 questions |
| Lubrication | 10 questions |
| Evaporators and cooling units | 9 questions |
| Condensers and high-pressure receivers | 12 questions |
| Purging | 5 questions |
| Safety, hazards, and prevention | 20 questions |

The remaining pages in this Study Guide will appear on-screen during the test. The first two pages illustrate how to navigate these references. The remaining pages provide the content that is included in these References during the test.

Using Onscreen References during the CARO Examination

CARO examinations taken in a proctored test center display onscreen references that appear in a PDF next to test questions. This section provides a sample question and two sample screens to illustrate the tools available to find information in the onscreen references for the CARO examination.

The first screen a candidate sees at the start of a test is illustrated below. The CIRO EXAM REFERENCES Table of Contents appears on the right side of the sample screen below. CARO examinations use similar reference documents. The CARO Study Guide includes all of the references that appear onscreen during the full examination and in the CARO practice test.

The screenshot displays the CARO examination interface. On the left side, there is a question: "1 of 1. Which of these becomes a risk from trying to control an ammonia fire with a CO₂ extinguisher?" with four multiple-choice options (A, B, C, D). Below the question is a checkbox labeled "Mark this item for later review." and three buttons: "Next >", "Review All", and "Submit Exam". At the top left, a timer shows "Time Remaining : 02:59:47". On the right side, there is a "CIRO EXAM REFERENCES Table of Contents" section. It features the RETA logo at the top, followed by the title "CIRO EXAM REFERENCES Table of Contents". Below the title is a table of contents listing various reference materials and their page numbers. At the bottom of the right side, there is a copyright notice: "© November 2020 REFRIGERATING ENGINEERS & TECHNICIANS ASSOCIATION (RETA)" and the page number "Page 1 of 53".

| Reference | Page |
|--|------|
| Using RETA References On-Screen | 2 |
| Formulas | 4 |
| Theoretical Discharge Chart – PSIG Scale | 5 |
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The following tools can help you use information in the CARO References file.

- Questions appear on the left side of the vertical line in the center of the screen.
- Time remaining appears in a countdown timer above the question.
- “Mark this item for later review” below the question lets the candidate flag the question to review later.
- Three buttons also appear below the question near the centerline:
 - Use the **Next** button to record the answer to a question and move to the next question on the test.
 - Use the **Review All** button to move to a screen that shows which questions the candidate has answered and identifies questions the candidate has marked for later review.
 - Use the **Submit Exam** button as the first of three steps required to end the test.

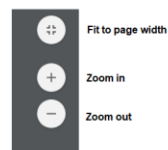
Candidates can move to each page in the onscreen references document by using one of these tools.

- Place the cursor on the icon in far right column at the top of the screen, then drag it to move to the page with the desired information. **OR**
- Use the mouse scroll wheel to move to the page with the desired information.

Candidates can expand the right side of the screen by moving the centerline to the left. This sample screen also shows the Fire Fighting Measures section of the Ammonia Safety Data Sheet (SDS) where the answer to the sample question appears. “Carbon dioxide can displace oxygen” parallels answer A in the sample question.

The screenshot shows an exam interface. On the left, there is a question: "1 of 1. Which of these becomes a risk from trying to control an ammonia fire with a CO₂ extinguisher?" with four multiple-choice options: A. Carbon dioxide may displace oxygen, B. Ammonia becomes more explosive in confined spaces, C. Water spray increases the risk of injury from ammonia gas, and D. Ammonia gas usually ignites at vapor concentrations above 60%. Below the question are three buttons: "Next >", "Review All", and "Submit Exam". On the right, a reference document titled "5. Fire Fighting Measures" is displayed. It contains two sections: "Extinguishing" with the text "Use Water Spray or Water Fog, Carbon Dioxide, Polar or Alcohol Foam, Dry Chemical, Halon may decompose into toxic materials. Carbon dioxide can displace oxygen. Use caution when applying halon or carbon dioxide in confined spaces." and "Special Exposure Hazards" with the text "Gas may ignite at vapor concentrations between 16% and 25% in air. However, ammonia-air mixtures are difficult to ignite and burn with little vigor. In the absence of oxygen enrichment, the risk of initiating an accidental fire or explosion is low. Do not allow ammonia vapors to accumulate in confined areas where ignition may occur. Intense heating particularly in contact with hot metallic surfaces may cause decomposition of ammonia generating hydrogen, a flammable gas."

Three navigation buttons appear on the far right side of the screen. The top button fits the image to the width of the window on the right side of the screen. The + and – icons zoom in or out. The CTRL key + Mouse scroll wheel also can be used to zoom in or out.



The CTRL key + Mouse scroll wheel can also be used to zoom in or out.

Formulas

Area of a rectangle: $A = side1 \cdot side2$

Area of a circle: $A = Radius \cdot Radius \cdot 3.1416$

Volume of a room $V = side1 \cdot side2 \cdot side3$

Volume of a cylinder $V = Length \cdot radius \cdot radius \cdot 3.1416$

One Horsepower (HP or BHP) = 2545 BTU / HR

To find kiloWatts of power (3 phase)

$$kW = \frac{Amps \cdot Volts \cdot PowerFactor \cdot 1.73}{1000}$$

To find Brake Horsepower used by a driven device (3 phase motor)

$$bhp = \frac{Amps \cdot Volts \cdot PowerFactor \cdot Efficiency \cdot 1.73}{746}$$

To find Power Cost in Dollars per Hour:

$$Cost(\$ / Hr) = (kiloWatt\ hour\ price \cdot kiloWatt\ hours) \div Hours$$

To find Power Cost in Dollars:

$$Cost(\$) = (kiloWatt\ hour\ price \cdot kiloWatt\ hours)$$

To find Brake Horsepower (used by a driven device) per TR (Ton of Refrigeration)

$$bhp\ per\ Ton = \frac{bhp}{TR}$$

To find kiloWatts per Ton of Refrigeration (TR)

$$kiloWatts\ per\ Ton = \frac{kW}{TR}$$

Heat Transfer Equations Where:

M = Mass or weight of object

C_p = Specific Heat of object

$(T_1 - T_2)$ = Difference in temperature before and after process

hL = Latent Heat quantity in a pound of the object

Sensible Heat Transfer: $Q_{sensible} = M \cdot C_p \cdot (T_1 - T_2)$

Latent Heat Transfer: $Q_{latent} = M \cdot hL$

Compression Ratio Equation:

Ratio = Absolute Discharge Pressure / Absolute Suction Pressure

Vacuum Conversion: Use Saturation Tables

| Refrigerant Characteristics | | | | | | | |
|--|----------------------------|----------------------------|--|--------------------------------|------------------------------|-------------------------------------|---------|
| 10 °F Evaporator Temperature, 95 °F Condensing Temperature | | | | | | | |
| Refrigerant | Evaporator Pressure (psig) | Condensing Pressure (psig) | Theoretical Discharge Temperature (°F) | Refrigerating Effect (BTU/lb.) | Mass Flow Rate (lb./min/ton) | Specific volume Vapor (Cu. ft./lb.) | CFM/ton |
| R-507 | 46.2 | 226.4 | 107 | 45 | 4.44 | .74 | 3.29 |
| R-134-a | 12 | 113.9 | 115 | 60 | 3.33 | 1.736 | 5.78 |
| HCFC-22 | 32.8 | 181.8 | 145 | 67.74 | 2.9 | 1.129 | 3.33 |
| R-404A | 59.17 | 234.92 | 105 | 52 | 3.85 | .7999 | 3.08 |
| HCFC-502 | 41.1 | 199.7 | 100 | 43.51 | 4.60 | .751 | 3.46 |
| R-717 | 23.8 | 181.1 | 221 | 465.50 | .43 | 7.304 | 3.14 |

| A Comparison of Theoretical Discharge Temperatures of Reciprocating Compressors at Various Evaporator Temperatures | | | | | |
|--|-----------------------------|---|---------------------------|----------------------------|--------------------------|
| Evaporator Temperature in °F | Condensing Temperature 95°F | Temperature Difference in °F (ΔT) | R-134a Discharge Temp. °F | HCFC-22 Discharge Temp. °F | R-717 Discharge Temp. °F |
| 30 | 95 | 65 | 100 | 133 | 190 |
| 20 | 95 | 75 | 105 | 141 | 207 |
| 10 | 95 | 85 | 110 | 145 | 221 |
| 0 | 95 | 95 | 112 | 155 | 257 |

| Theoretical Discharge temperatures (°F) for Ammonia at various operating pressures | | | | | | | | | | | | | | | | |
|--|---------|---|------------|----------|------------|----------|--------------|---------|-------------|-----------|-------------|------------|------------|------------|--------------|------------|
| Condensing Press./Temp | Psig °F | Suction Pressures and Corresponding Saturation Temperatures | | | | | | | | | | | | | | |
| | | 0 -28 | 2.5 -22 | 5 -17 | 7.5 -12 | 10 -8 | 12.5 -4.6 | 15 0 | 17.5 2.4 | 20 5.5 | 22.5 8.5 | 25 11.3 | 27.5 14 | 30 16.6 | 32.5 21.4 | 35 25.8 |
| 105 psig / 65.9°F | | 240 | 225 | 210 | 200 | 189 | 183 | 172 | 167 | 160 | 154 | 149 | 142 | 138 | 131 | 123 |
| 115 psig / 70.4°F | | 253 | 238 | 223 | 213 | 202 | 195 | 184 | 179 | 172 | 165 | 160 | 154 | 149 | 141 | 132 |
| 125 psig / 74.7°F | | 265 | 251 | 234 | 225 | 214 | 206 | 195 | 190 | 183 | 176 | 171 | 165 | 160 | 151 | 142 |
| 135 psig / 78.7°F | | 277 | 262 | 246 | 236 | 225 | 217 | 205 | 200 | 193 | 186 | 181 | 175 | 170 | 161 | 152 |
| 145 psig / 82.6°F | | 288 | 273 | 256 | 246 | 235 | 227 | 214 | 209 | 203 | 196 | 191 | 184 | 179 | 170 | 161 |
| 155 psig / 86.2°F | | 298 | 283 | 266 | 256 | 245 | 237 | 224 | 219 | 212 | 205 | 200 | 193 | 188 | 179 | 170 |
| 165 psig / 89.7°F | | 308 | 293 | 276 | 266 | 254 | 246 | 233 | 228 | 221 | 214 | 209 | 202 | 197 | 188 | 179 |
| 175 psig / 93.1°F | | 318 | 303 | 286 | 275 | 263 | 255 | 242 | 237 | 230 | 223 | 217 | 210 | 205 | 196 | 187 |
| 185 psig / 96.2°F | | 328 | 312 | 295 | 284 | 272 | 264 | 251 | 246 | 238 | 231 | 225 | 218 | 213 | 204 | 195 |
| 195 psig / 99.4°F | | 336 | 321 | 304 | 292 | 280 | 272 | 259 | 254 | 246 | 239 | 233 | 226 | 221 | 212 | 203 |
| 205 psig / 102.3°F | | 345 | 329 | 312 | 300 | 288 | 280 | 267 | 262 | 254 | 247 | 241 | 234 | 228 | 219 | 210 |
| 215 psig / 105.2°F | | 354 | 337 | 320 | 308 | 295 | 288 | 274 | 269 | 261 | 254 | 248 | 241 | 235 | 226 | 217 |
| 225 psig / 108 0°F | | 361 | 345 | 328 | 316 | 303 | 295 | 281 | 276 | 268 | 261 | 255 | 247 | 242 | 233 | 224 |



Safety Data Sheet

1. Product Identifier and Company Identification

| | | |
|---------------------------------------|--|--|
| Product name | : Anhydrous Ammonia | |
| HBCC SDS number | : CA10000 | |
| Synonym | : Ammonia; NH ₃ | |
| Product use and Restrictions | : Refer to label or call | |
| Manufacturer | : Corporate Headquarters | Corporate Safety & Compliance |
| Contact Address | Hill Brothers Chemical Company 1675 North Main Street Orange, California 92867 714-998-8800 800-821-7234 | Hill Brothers Chemical Company 7121 West Bell Road, Suite 250 Glendale, Arizona 85308 623-535-9955 - Office 623-535-9944 - Fax |
| Emergency telephone Number (Chemtrec) | : 800-424-9300 | |
| Website | : http://hillbrothers.com | |

2. Hazard Identification

Classification : Flammable Gases – Category 2
Gases Under Pressure – Compressed Gas
Acute Toxicity: Inhalation – Category 3
Skin Corrosion/Irritation – Category 1B
Serious Eye Damage/Eye Irritation – Category 1
Aquatic Toxicity (Chronic) – Category 1

Signal Word : DANGER

Pictogram(s) :



Hazard Statements : Flammable Gas.
Contains gas under pressure; may explode if heated. Toxic if inhaled.
Causes severe skin burns and eye damage.
Very toxic to aquatic life with long lasting effects.

Precautionary Statements

- Response** : IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a POISON CENTER or doctor.
IF SWALLOWED: Rinse mouth. Immediately call a POISON CENTER of physician. Do NOT induce vomiting.
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower. Wash contaminated clothing before reuse. Immediately call a POISON CENTER or doctor.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or doctor.
- Prevention** : Wear protective gloves, protective clothing, eye protection and face protection.
Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. – No Smoking.
Use only outdoors or in a well-ventilated area.
Avoid release to the environment.
Do NOT breathe gas or vapors.
Wash hands thoroughly after handling. Collect spillage.
Leaking gas fire: Do not extinguish, unless can leak be stopped safely.
In case of leakage, eliminate all ignition sources.
- Storage** : Store locked up.
Protect from sunlight.
Store in a well-ventilated place. Keep container tightly closed.
- Disposal** : Dispose of contents and container in accordance with all local, regional, national and international regulations.

3. Composition/Information on Ingredients

| CAS Number | Ingredient Name | Weight % |
|------------|--------------------------------------|--------------------|
| 7664-41-7 | Anhydrous Ammonia (NH ₃) | 99.8 – 99.999% wt. |
| 7732-18-5 | Water | 0.2% -.001% wt. |

4. First Aid Measures

- Ingestion** : If this gas is swallowed in liquid form, keep victim warm and OBTAIN IMMEDIATE MEDICAL ATTENTION. If signs of respiratory obstruction develop, immediately transport to medical facility. Do not induce vomiting. Never give fluids or induce vomiting if patient is unconscious or having convulsions.
- Inhalation** : Remove victim to fresh air. Give oxygen if breathing is difficult. If breathing has stopped, start artificial respiration. OBTAIN IMMEDIATE MEDICAL ATTENTION.
- Skin** : Apply water immediately to exposed areas of skin and continue for at least 30 minutes. Remove contaminated clothing, shoes, and constrictive clothing while continuing to apply water, being careful not to tear the skin. If skin surface is damaged, apply a clean dressing. If skin surface is not damaged, cleanse the affected area(s) thoroughly with mild soap and water. Do not apply salves or ointments to affected areas. OBTAIN IMMEDIATE MEDICAL ATTENTION.
- Eyes** : Remove victim to fresh air. Immediately flush with plenty of water for at least 30 minutes with the eyelids held apart. OBTAIN IMMEDIATE MEDICAL ATTENTION.
- Medical Conditions** : Ammonia is a respiratory irritant. Persons with impaired pulmonary function may be at an increased risk from exposure. Also pre-existing skin disorders may be aggravated by exposure.
- Effects of Overexposure** : N/A
- Summary of Acute Health Hazards** : N/A
- Ingestion** : This material is a gas under normal atmospheric conditions and ingestion is unlikely. Ingestion of liquid ammonia may result in severe irritation or ulceration of the mouth, throat and digestive tract which may be displayed by nausea, vomiting, diarrhea and, in severe cases, collapse, shock and death.

- [Inhalation](#) : Irritation to the mucous membranes of the nose, throat and lungs is noticeable at 100 ppm. Concentrations above 400 ppm will cause throat irritation and may destroy mucous surfaces upon prolonged contact. High concentrations can cause pulmonary edema. Breathing air containing concentrations greater than 5,000 ppm may cause sudden death from spasm or inflammation of the larynx.
- [Skin](#) : Liquid Ammonia produces severe skin burns on contact. Ammonia gas may cause skin irritation, especially if skin is moist. The liquid can cause skin damage resulting from combined freezing and corrosive action on the skin. Atmospheric concentrations above 30,000 ppm will burn and blister skin after a few seconds of exposure.
- [Eyes](#) : Exposure to high gas concentrations may cause temporary blindness and severe eye damage. Direct contact of the eyes with liquid ammonia will produce serious eye burns.
- [Note to Physicians](#) : N/A
- [Summary of Chronic Health](#) : N/A

5. Fire Fighting Measures

- Extinguishing** : Use Water Spray or Water Fog, Carbon Dioxide, Polar or Alcohol Foam, Dry Chemical. Halon may decompose into toxic materials. Carbon dioxide can displace oxygen. Use caution when applying halon or carbon dioxide in confined spaces.
- Special Exposure Hazards** : Gas may ignite at vapor concentrations between 16% and 25% in air. However, ammonia-air mixtures are difficult to ignite and burn with little vigor. In the absence of oxygen enrichment, the risk of initiating an accidental fire or explosion is low. Do not allow ammonia vapors to accumulate in confined areas where ignition may occur. Intense heating particularly in contact with hot metallic surfaces may cause decomposition of ammonia generating hydrogen, a flammable gas.
- Special Protective to Firefighters Equipment** : Stop flow of gas. Use water fog to keep fire-exposed containers cool and protect personnel effecting the shut-off. Wear self-contained breathing apparatus (SCBA) and encapsulating chemical protective clothing. Approach fire upwind and evacuate area downwind. Emergency responders in the danger area should wear bunker gear and self-contained breathing apparatus for fires beyond the incipient stage (29CFR 1910.156). In addition, wear other appropriate protective equipment as conditions warrant (See Section VIII). Isolate damage area, keep unauthorized personnel out. Stop spill/release if it can be done with minimal risk. If this cannot be done, allow fire to burn. Move undamaged containers from danger area if it can be done with minimal risk. Stay away from ends of container. Water spray may be useful in minimizing or dispersing vapors. Cool equipment exposed to fire with water, if it can be done with minimal risk.
- Fire Fighting Procedures** : Dry Chemical or carbon dioxide are recommended extinguishing media. Stop flow of gas before extinguishing fire. Use water spray to keep fire exposed containers cool. Extinguish fire using agent suitable for surrounding fire.
- Combustible. Wear goggles, self-contained breathing apparatus, and rubber over clothing (including gloves). Stop flow of gas, or liquid if possible. Let fire burn.
- If material involved in fire: Cool all affected containers with flooding quantities of water. Apply water from as far distance as possible. Use water spray to knock-down vapors. Solid streams of water may spread fire. Do not use water on material itself. Do not apply water to point of leak in tank car or container.

NFPA Rating : Health - 3
Flammability - 1
Instability - 0



0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme

Uniform Fire Code Rating : According to the (UFC) Uniform Fire Code Standard 79-3 (2000), the degree of Hazard is 3-3-0 in a confined space.

Additional Description Requirement : Inhalation Hazard

6. Accidental Release Measures

Personal Precautions : Note that although ammonia gas is lighter than air, sudden release may generate an aerosol of liquefied ammonia which may cling to the ground for long distances. May ignite in the presence of open flames and sparks. Narrow lower to upper combustion range (16-25%) makes ignition difficult. Keep all sources of ignition away from spill/release. Do not apply water onto leaking tank. Stop the flow of gas or liquid. Use water to protect personnel effecting the shut-off. Approach from upwind. Evacuate the area immediately. Eliminate all open flames in vicinity of indoor spills or released vapor. Water fog can be used to cleanse atmosphere of ammonia vapor. Downwind areas can be protected by water fog nozzles positioned downwind.

Emergency Procedures : Do not enter a visible cloud of ammonia. Isolate and evacuate the leak or spill area immediately for at least 150 feet in all directions. For larger spills, isolate at least 300 feet in all directions and then evacuate area downwind at least 0.4 miles in width and at least 0.8 miles in length. Keep area isolated until gas has dispersed.

Methods of Containment And Clean-Up : Dike liquid spills to contain liquid.

7. Handling and Storage

- Safe Handling** : Contents are under pressure. The use of explosion-proof equipment is recommended and may be required (see appropriate fire codes). Do not enter confined spaces such as tanks or pits without following proper entry procedures such as ASTM D-4276. Protect against physical damage.
- Storage** : Outside shaded area or detached storage is preferred. Inside storage should be in a cool, dry, well ventilated, noncombustible location, away from all possible sources of ignition.
- Work/Hygienic Practices** : Avoid contact with skin and avoid breathing vapors. Do not eat, drink, or smoke in work area. Wash hands before eating, drinking, or using restroom. Do NOT place food, coffee or other drinks in the area where dusting or splashing of solutions is possible.
- Ventilation** : Local exhaust is essential. Spark-proof fans desirable with mechanical ventilation. Ducts should be located at ceiling level and lead upwards to the outside. Eyewash and safety shower should be available in work area.

8. Exposure Controls/Personal Protection

Occupational Exposure Limits : CAL-OSHA: 25 ppm, 18 mg/m³ Oregon-OSHA: 25 ppm, 18 mg/m³; STEL: 35 ppm, 27 mg/m³

| Chemical Name: Anhydrous Ammonia | | | | |
|----------------------------------|---------|------------------------------|------------------------------|------------------------------|
| Exposure Limits (TWAs) in Air | | | | |
| CAS Number | IDLH | ACGIH TLV | OSHA PEL | STEL |
| 7664-41-7 | 300 ppm | 25 ppm, 18 mg/m ³ | 50 ppm, 35 mg/m ³ | 35 ppm, 27 mg/m ³ |

Protective Equipment : Rubber or synthetic chemical gloves and boots should be worn as well as cotton clothing and underwear. Rubber or synthetic chemical coats or aprons should be available, an encapsulating chemical protective clothing garment is desirable for heavy exposures. The use of long sleeved clothing closed at the neck is advised. Change if clothing becomes contaminated.

Eye Protection : Chemical splash goggles should be worn when handling Anhydrous Ammonia to protect from liquids or mists.

A face shield can be worn over chemical splash goggles as additional protection. Do not wear contact lenses when handling Anhydrous Ammonia.

A full-face air-purifying respirator (APR) or supplied-air respirator (SAR) should be worn to protect from chemical vapors.

Respiratory Protection : Unless ventilation is adequate to keep concentration below permissible exposure limit (PEL), wear NIOSH approved ammonia chemical cartridge or canister full facepiece chin-style respirators with an air-purification factor (APF=50). In emergency or planned entry into unknown concentrations, use self-contained breathing apparatus (SCBA) or any supplied-air full facepiece chin-style respirators.

9. Physical and Chemical Properties

| | |
|--|---|
| Appearance: Compressed Liquid Gas, clear, colorless | Odor: Sharp, penetrating |
| Odor Threshold: 5 ppm | pH: 11.6 for 1% NH ₃ solution |
| Melting Point/Freezing Point: -107.9°F; -78°C | Initial Boiling Point/Range: -28°F; -33.4°C |
| Flash Point: N/A | Evaporation Rate (BuAc=1): N/A |
| Flammability: 16 – 25% in air | Lower/Upper Explosive Limit: 25% by Volume/16% by Volume |
| Vapor Pressure (mmHg): 110 PSIG at 68°F (20°C) | Vapor Density (Air=1): 0.0549 lb./ft ³ at -28°F at 1 atm |
| Relative Density: 42.57 lbs./cu.ft @ -28°F and 1 atm | Solubility in Water: 33.10% |
| Partition Coefficient: N/A | Autoignition Temperature: 650°C; 1204°F |
| Decomposition Temperature: N/A | Viscosity: N/A |
| % Volatiles: 100% | Specific Gravity (Water=1): 0.6189 of liquid at -28°F and 1 atm |
| Molecular Weight: 17.032 | VOC: N/A |

10. Stability and Reactivity

- Reactivity** : Reacts violently and explosively with oxidizing gases such as chlorine, bromine, and other halogens. Reacts explosively with hypochlorites such as bleach. Reacts vigorously with acids. Highly reactive with reducing agents. Hazardous polymerization will not occur.
- Chemical Stability** : Stable
- Possibility of Hazardous Reactions or Polymerizations** : Avoid contact with oxidizing gases, chlorine, bromine, mineral hypochlorite, iodine, halogens, calcium, and strong acids. Avoid contact with copper, silver, zinc, and alloys of same. Mercury, silver oxide can form explosive compounds.
- Conditions to Avoid** : Avoid all possible sources of ignition. Heat will increase pressure in the storage tank.
- Incompatible Materials** : Avoid contact with strong acids, use of metals containing copper or zinc.
- Hazardous Decomposition Products** : Combustion will generate oxides of nitrogen. Intense heating of the gas, particularly in contact with hot metallic surfaces, may cause decomposition of ammonia to hydrogen and nitrogen.

11. Toxicological Information

Acute and Chronic Effects : Can cause irritation and burns of the skin and mucous membranes, and headache, salivation, nausea, and vomiting. Difficult or labored breathing and cough with bloody mucous discharge. Can cause bronchitis, laryngitis, hemoptysis, and pulmonary edema or pneumonitis. Death may result. Can cause ulceration of the conjunctiva and cornea, and corneal and lenticular opacities. Damage to the eyes may be permanent.

Routes of Exposure

Ingestion : Yes
 Inhalation : Yes
 Skin : Yes
 Eyes : Yes

Symptoms related to Physical, Chemical & Toxicological Characteristics : Can cause burning of the eyes, conjunctivitis, skin irritation, swelling of the eyelids and lips, dry red mouth and tongue, burning in the throat, and coughing, and in more severe cases of exposure, difficulty in breathing, signs and symptoms of lung congestion, and, ultimately, death from respiratory failure due to pulmonary edema may occur.

Numerical Measures of Toxicity :

| | | | |
|-----------------|------------|-------|------------|
| Oral LD50 | 350 mg/kg | Rat | ATSDR 1991 |
| | 96 mg/kg | Mouse | EPA 1989 |
| Inhalation LC50 | 19,770 ppm | F Rat | EPA 1989 |
| | 14,140 ppm | M Rat | EPA 1989 |
| | 17,401 ppm | Rat | ATSDR 1991 |

Chronic Toxicity : N/A

Carcinogenicity :

| Product Name: Anhydrous Ammonia | | | | | |
|---------------------------------|------|-----|-------|-----|------|
| ACGIH | IARC | EPA | NIOSH | NTP | OSHA |
| No | No | No | No | No | No |

Target Organs : N/A

12. Ecological Information

Ecotoxicity : Even at extremely low concentrations aquatic life will be harmed by liquid ammonia.

Persistence and Degradability : N/A

Bioaccumulative Potential :

| Product/Ingredient | Log _{Pow} | BCF | Potential |
|--------------------|--------------------|-----|-----------|
| - | - | - | - |

Mobility in Soil : When anhydrous ammonia is applied in the soil, ammonia reacts with organic matter, and it dissolves in water. Anhydrous Ammonia reacts with water to form ammonium. The initial reactions with water, organic matter and clays limit the mobility of ammonia.

13. Disposal Considerations

Disposal of Container : Because of the toxicity of ammonia to aquatic organisms, NEVER dispose of or allow any ammonia or ammonia contaminated water to flow into any surface water bodies. Surface water bodies include drainage ditches, storm water and sanitary sewers, wetlands, ponds, lakes and streams. Diking will contain the liquid and allow it to stabilize. Keep unprotected personnel away from area until it is free of ammonia. Do not apply water directly to ammonia liquid as this will cause boiling and splattering. Soil contaminated with ammonia or aqua ammonia may need to be excavated and properly disposed of according to local and state regulations.

Consult Federal, State, or Local Authorities for additional proper disposal procedures.

14. Transport Information

UN# : UN1005
 Proper Shipping Name : Anhydrous Ammonia
 Hazard Class/Division : 2.2 [Domestic]; 2.3, (8) [International]
 Packing Group : N/A
 Marine Pollutant : Yes
 Special Provisions : 13, T50
 Emergency Response : 2012 ERG, Guide 125, pages 188-189

Guidebook

Placard Advisory :



15. Regulatory Information

SARA 302 Extremely Hazardous Substances (EHS) : This product contains the following Extremely Hazardous Substance(s) (EHS) under Section 302 of EPCRA, subject to the reporting requirements of Sections 311 and 312 (Tier I/Tier II reporting) at quantities greater than or equal to 500 pounds or in excess of the substance's EHS Threshold Planning Quantity (TPQ), whichever is lower. A Safety Data Sheet (SDS) must be provided to the SERC, LEPC, and local fire department.
 Ammonia, CAS #7664-41-7 Sec. 302 EHS TPQ = 500 lbs. (226.8 kg.)

SARA 304 Extremely Hazardous Substances (EHS) Release Notification : EPCRA Section 304 requires a facility to notify the SERC and LEPC in the event of a release an EHS at or exceeding the substance's RQ under Section 302 of EPCRA, or its CERCLA RQ, if applicable, whichever is lower. This product contains the following Extremely Hazardous Substance(s) (EHS) subject to the reporting requirements of Section 304.
 Ammonia, CAS #7664-41-7 Sec. 304 RQ = 100 lbs. (45.4 kg.)

SARA 311/312 Hazards :

| SARA 311/312 Hazards | | | | |
|----------------------|---------|--------------|----------|------------|
| Acute | Chronic | Flammability | Pressure | Reactivity |
| Yes | No | Yes | Yes | No |

- SARA 313 Reportable Chemicals** : This product contains the following chemical(s) subject to annual emissions, transfers, and/or waste management reporting under the Community-Right-to-Know provisions of EPCRA Section 313, also known as the Toxic Release Inventory (TRI) Report or Form R: Ammonia, CAS #7664-41-7
- CERCLA Hazardous Substances** : This product contains the following CERCLA hazardous substance(s) subject to the National Response Center (NRC) reporting requirements if released to the environment in quantities greater than or equal to the substance's CERCLA Reportable Quantity (RQ).
Ammonia, CAS #7664-41-7 CERCLA RQ = 100 lbs. (45.4 kg.)
- Clean Air Act (CAA) Section 112(r) Air Pollutants** : This product contains the following air pollutant(s) under the U.S. Clean Air Act (CAA), Section 112(r) [40 CFR 61], which, if accidentally released to the atmosphere in quantities at or above the CAA 112(r) Threshold Quantity (TQ), is reportable.
Ammonia, CAS #7664-41-7 CAA 112(r) TQ = 10,000 lbs. (4436 kg.)
- California Prop 65 Chemicals** : This product does not contain any chemicals known to the state of California to cause cancer, birth defects or other reproductive harm.
- Hazard Label Warning** : This product requires the following hazard label warning:
Domestic: Non-Flammable Gas (Class 2.2)
International: Poisonous Gas Inhalation (Class 2.3); Corrosive (Class 8)

ACRONYMS:

- CAS # – Chemical Abstract Services Registry Number
 CFR – Code of Federal Regulations
 CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
 EPCRA – Emergency Planning and Community Right-to-Know Act
 LEPC – Local Emergency Planning Committee
 SERC – State Emergency Response Commission



Maximum use level for Anhydrous Ammonia under NSF/ANSI Standard 60
 Maximum Use 5 mg/l

| | |
|-----|-------------------|
| 16. | Other Information |
|-----|-------------------|

Revision date :05/14/2015
Supersedes :05/20/2014
First Issue :12/01/1985

Chemical Family/Type :Hydride, (Alkaline Gas), InorganicBase

Section(s) changed since last revision :MSDS to First Issue SDS Conversion

IMPORTANT! Read this SDS before use or disposal of this product. Pass along the information to employees and any other persons who could be exposed to the product to be sure that they are aware of the information before use or other exposure. This SDS has been prepared in accordance with the Globally Harmonized System of Chemical and Labeling of Chemicals (GHS) Fifth Edition and the OSHA Hazard Communication Standard [29 CFR 1910.1200]. The SDS information is based on sources believed to be reliable. Available data, safety standards, and government regulations are subject to change and the conditions of handling and use, or misuse are beyond our control; Hill Brothers Chemical Company makes no warranty, either expressed or implied, with respect to the completeness or continuing accuracy of the information contained herein and disclaims all liability for reliance thereon. Additional information may be necessary or helpful for specific conditions and circumstances of use. It is the user's responsibility to determine the suitability of this product and to evaluate risks and exercise appropriate precautions for protection of employees and others prior to use.

| Refrigerant R717 (Ammonia) | | | | | | |
|--|---------------------------------|----------------------------------|--|---|--|---|
| Temp in Degrees Fahrenheit (°f) | Gauge Pressure psig * | Absolute Pressure psia | Specific Volume liquid ft ³ /lb. | Specific Volume Vapor ft ³ /lb. | Density Liquid lbs./ ft ³ | Density Vapor lbs./ ft ³ |
| -65 | 20.4" hg | 4.69 | 0.0227 | 52.5619 | 44.15 | 0.0190 |
| -64 | 20.0" hg | 4.84 | 0.0227 | 50.8815 | 44.11 | 0.0197 |
| -63 | 19.7" hg | 5.02 | 0.0227 | 49.3229 | 44.07 | 0.0203 |
| -62 | 19.4" hg | 5.18 | 0.0227 | 47.7644 | 44.03 | 0.0209 |
| -61 | 19.0" hg | 5.37 | 0.0227 | 46.3175 | 43.99 | 0.0216 |
| -60 | 18.6" hg | 5.53 | 0.0228 | 44.8709 | 43.95 | 0.0223 |
| -59 | 18.2" hg | 5.72 | 0.0228 | 43.5023 | 43.90 | 0.0230 |
| -58 | 17.8" hg | 5.91 | 0.0228 | 42.1830 | 43.86 | 0.0237 |
| -57 | 17.4" hg | 6.11 | 0.0228 | 40.9108 | 43.82 | 0.0244 |
| -56 | 17.0" hg | 6.31 | 0.0228 | 39.6840 | 43.78 | 0.0252 |
| -55 | 16.6" hg | 6.52 | 0.0229 | 38.5006 | 43.74 | 0.0260 |
| -54 | 16.2" hg | 6.73 | 0.0229 | 37.3589 | 43.69 | 0.0268 |
| -53 | 15.7" hg | 6.95 | 0.0229 | 36.2572 | 43.65 | 0.0276 |
| -52 | 15.3" hg | 7.18 | 0.0229 | 35.1939 | 43.61 | 0.0284 |
| -51 | 14.8" hg | 7.41 | 0.0230 | 34.1675 | 43.57 | 0.0293 |
| -50 | 14.3" hg | 7.64 | 0.0230 | 33.1765 | 43.53 | 0.0301 |
| -49 | 13.8" hg | 7.89 | 0.0230 | 32.2196 | 43.48 | 0.0310 |
| -48 | 13.3" hg | 8.14 | 0.0230 | 31.2953 | 43.44 | 0.0320 |
| -47 | 12.8" hg | 8.39 | 0.0230 | 30.4025 | 43.40 | 0.0329 |
| -46 | 12.2" hg | 8.66 | 0.0230 | 29.5398 | 43.46 | 0.0339 |
| -45 | 11.7" hg | 8.92 | 0.0231 | 28.7062 | 43.32 | 0.0348 |
| -44 | 11.1" hg | 9.20 | 0.0231 | 27.9004 | 43.27 | 0.0358 |
| -43 | 10.6" hg | 9.48 | 0.0231 | 27.1216 | 43.23 | 0.0369 |
| -42 | 10.0" hg | 9.77 | 0.0232 | 26.3685 | 43.19 | 0.0379 |
| -41 | 9.3" hg | 10.07 | 0.0232 | 25.6402 | 43.15 | 0.0390 |
| -40 | 8.7" hg | 10.38 | 0.0232 | 24.9359 | 43.10 | 0.0401 |
| -39 | 8.1" hg | 10.69 | 0.0232 | 24.2545 | 43.06 | 0.0412 |
| -38 | 7.4" hg | 11.01 | 0.0232 | 23.5953 | 43.02 | 0.0424 |
| -37 | 6.8" hg | 11.34 | 0.0233 | 22.9574 | 42.97 | 0.0436 |
| -36 | 6.1" hg | 11.67 | 0.0233 | 22.3400 | 42.93 | 0.0448 |
| -35 | 5.4" hg | 12.01 | 0.0233 | 21.7423 | 42.89 | 0.0460 |
| -34 | 4.7" hg | 12.37 | 0.0233 | 21.1637 | 42.85 | 0.0473 |
| -33 | 3.9" hg | 12.73 | 0.0234 | 20.6035 | 42.80 | 0.0485 |
| -32 | 3.2" hg | 13.10 | 0.0234 | 20.0609 | 42.76 | 0.0498 |

| Refrigerant R717 (Ammonia) | | | | | | |
|--|-----------------------------|------------------------------|--|---|--|---|
| Temp in Degrees Fahrenheit (°f) | Gauge Pressure psig * | Absolute Pressure psia | Specific Volume liquid ft ³ /lb. | Specific Volume Vapor ft ³ /lb. | Density Liquid lbs./ ft ³ | Density Vapor lbs./ ft ³ |
| -31 | 2.4" hg | 13.47 | 0.0234 | 19.5353 | 42.72 | 0.0512 |
| -30 | 1.6" hg | 13.86 | 0.0234 | 19.0262 | 42.67 | 0.0526 |
| -29 | .8" hg | 14.25 | 0.0235 | 18.5328 | 42.63 | 0.0540 |
| -28 | 0 psig | 14.66 | 0.0235 | 18.0548 | 42.59 | 0.0554 |
| -27 | 0.37 | 15.07 | 0.0235 | 17.5914 | 42.55 | 0.0568 |
| -26 | 0.79 | 15.49 | 0.0235 | 17.1422 | 42.50 | 0.0583 |
| -25 | 1.23 | 15.93 | 0.0236 | 16.7068 | 42.46 | 0.0599 |
| -24 | 1.67 | 16.37 | 0.0236 | 16.2845 | 42.42 | 0.0614 |
| -23 | 2.12 | 16.82 | 0.0236 | 15.8750 | 42.37 | 0.0630 |
| -22 | 2.58 | 17.28 | 0.0236 | 15.4778 | 42.33 | 0.0646 |
| -21 | 3.05 | 17.75 | 0.0236 | 15.0925 | 42.29 | 0.0663 |
| -20 | 3.54 | 18.24 | 0.0237 | 14.7187 | 42.24 | 0.0679 |
| -19 | 4.03 | 18.73 | 0.0237 | 14.3559 | 42.20 | 0.0697 |
| -18 | 4.53 | 19.23 | 0.0237 | 14.0038 | 42.16 | 0.0714 |
| -17 | 5.05 | 19.75 | 0.0237 | 13.6621 | 42.11 | 0.0732 |
| -16 | 5.57 | 20.27 | 0.0238 | 13.3303 | 42.07 | 0.0750 |

| Refrigerant R717 (Ammonia) | | | | | | |
|--|-----------------------------|------------------------------|--|---|--|---|
| Temp in Degrees Fahrenheit (°f) | Gauge Pressure psig * | Absolute Pressure psia | Specific Volume liquid ft ³ /lb. | Specific Volume Vapor ft ³ /lb. | Density Liquid lbs./ ft ³ | Density Vapor lbs./ ft ³ |
| -15 | 6.11 | 20.81 | 0.0238 | 13.0082 | 42.02 | 0.0769 |
| -14 | 6.66 | 21.36 | 0.0238 | 12.6954 | 41.98 | 0.0788 |
| -13 | 7.22 | 21.92 | 0.0238 | 12.3917 | 41.94 | 0.0807 |
| -12 | 7.79 | 22.49 | 0.0239 | 12.0966 | 41.89 | 0.0827 |
| -11 | 8.37 | 23.07 | 0.0239 | 11.8100 | 41.85 | 0.0847 |
| -10 | 8.96 | 23.66 | 0.0239 | 11.5315 | 41.81 | 0.0867 |
| -9 | 9.57 | 24.27 | 0.0239 | 11.2608 | 41.76 | 0.0888 |
| -8 | 10.19 | 24.89 | 0.0240 | 10.9978 | 41.72 | 0.0909 |
| -7 | 10.82 | 25.52 | 0.0240 | 10.7422 | 41.67 | 0.0931 |
| -6 | 11.47 | 26.17 | 0.0240 | 10.4937 | 41.63 | 0.0953 |
| -5 | 12.13 | 26.83 | 0.0240 | 10.2521 | 41.59 | 0.0975 |
| -4 | 12.80 | 27.50 | 0.0241 | 10.0172 | 41.54 | 0.0998 |
| -3 | 13.48 | 28.18 | 0.0241 | 9.7887 | 41.50 | 0.1022 |
| -2 | 14.18 | 28.88 | 0.0241 | 9.5665 | 41.45 | 0.1045 |
| -1 | 14.89 | 29.59 | 0.0241 | 9.3503 | 41.41 | 0.1069 |
| 0 | 15.62 | 30.32 | 0.0242 | 9.1401 | 41.36 | 0.1094 |
| 1 | 16.36 | 31.06 | 0.0242 | 8.9355 | 41.32 | 0.1119 |
| 2 | 17.11 | 31.81 | 0.0242 | 8.7364 | 41.27 | 0.1145 |
| 3 | 17.88 | 32.58 | 0.0243 | 8.5426 | 41.23 | 0.1171 |
| 4 | 18.66 | 33.36 | 0.0243 | 8.3540 | 41.19 | 0.1197 |
| 5 | 19.46 | 34.16 | 0.0243 | 8.1704 | 41.14 | 0.1224 |
| 6 | 20.28 | 34.98 | 0.0243 | 7.9917 | 41.10 | 0.1251 |
| 7 | 21.10 | 35.80 | 0.0244 | 7.8177 | 41.05 | 0.1279 |
| 8 | 21.95 | 36.65 | 0.0244 | 7.6482 | 41.01 | 0.1307 |
| 9 | 22.81 | 37.51 | 0.0244 | 7.4831 | 40.96 | 0.1336 |
| 10 | 23.68 | 38.38 | 0.0244 | 7.3224 | 40.92 | 0.1366 |

| Refrigerant R717 (Ammonia) | | | | | | |
|--|---------------------------------|----------------------------------|--|---|--|---|
| Temp in Degrees Fahrenheit (°f) | Gauge Pressure psig * | Absolute Pressure psia | Specific Volume liquid ft ³ /lb. | Specific Volume Vapor ft ³ /lb. | Density Liquid lbs./ ft ³ | Density Vapor lbs./ ft ³ |
| 11 | 24.58 | 39.28 | 0.0245 | 7.1657 | 40.87 | 0.1396 |
| 12 | 25.48 | 40.18 | 0.0245 | 7.0132 | 40.82 | 0.1426 |
| 13 | 26.41 | 41.11 | 0.0245 | 6.8645 | 40.78 | 0.1457 |
| 14 | 27.35 | 42.05 | 0.0246 | 6.7196 | 40.73 | 0.1488 |
| 15 | 28.31 | 43.01 | 0.0246 | 6.5784 | 40.69 | 0.1520 |
| 16 | 29.28 | 43.98 | 0.0246 | 6.4408 | 40.64 | 0.1553 |
| 17 | 30.28 | 44.98 | 0.0246 | 6.3066 | 40.60 | 0.1586 |
| 18 | 31.29 | 45.99 | 0.0247 | 6.1758 | 40.55 | 0.1619 |
| 19 | 32.32 | 47.02 | 0.0247 | 6.0483 | 40.51 | 0.1653 |
| 20 | 33.36 | 48.06 | 0.0247 | 5.9240 | 40.46 | 0.1688 |
| 21 | 34.43 | 49.13 | 0.0247 | 5.8027 | 40.41 | 0.1723 |
| 22 | 35.51 | 50.21 | 0.0248 | 5.6844 | 40.37 | 0.1759 |
| 23 | 36.61 | 51.31 | 0.0248 | 5.5690 | 40.32 | 0.1796 |
| 24 | 37.73 | 52.43 | 0.0248 | 5.4564 | 40.27 | 0.1833 |
| 25 | 38.87 | 53.57 | 0.0249 | 5.3466 | 40.23 | 0.1870 |
| 26 | 40.03 | 54.73 | 0.0249 | 5.2395 | 40.18 | 0.1909 |
| 27 | 41.21 | 55.91 | 0.0249 | 5.1349 | 40.14 | 0.1947 |
| 28 | 42.41 | 57.11 | 0.0249 | 5.0328 | 40.09 | 0.1987 |
| 29 | 43.62 | 58.32 | 0.0250 | 4.9332 | 40.04 | 0.2027 |
| 30 | 44.86 | 59.56 | 0.0250 | 4.8360 | 40.00 | 0.2068 |
| 31 | 46.12 | 60.82 | 0.0250 | 4.7410 | 39.95 | 0.2109 |
| 32 | 47.40 | 62.10 | 0.0251 | 4.6483 | 39.90 | 0.2151 |
| 33 | 48.70 | 63.40 | 0.0251 | 4.5678 | 39.85 | 0.2189 |
| 34 | 50.02 | 64.72 | 0.0251 | 4.4695 | 39.81 | 0.2237 |
| 35 | 51.37 | 66.07 | 0.0252 | 4.3831 | 39.76 | 0.2281 |

| Refrigerant R717 (Ammonia) | | | | | | |
|--|-----------------------------|------------------------------|--|---|--|---|
| Temp in Degrees Fahrenheit (°f) | Gauge Pressure psig * | Absolute Pressure psia | Specific Volume liquid ft ³ /lb. | Specific Volume Vapor ft ³ /lb. | Density Liquid lbs./ ft ³ | Density Vapor lbs./ ft ³ |
| 36 | 52.73 | 67.43 | 0.0252 | 4.2988 | 39.71 | 0.2326 |
| 37 | 54.12 | 68.82 | 0.0252 | 4.2165 | 39.67 | 0.2372 |
| 38 | 55.53 | 70.23 | 0.0252 | 4.1360 | 39.62 | 0.2418 |
| 39 | 56.96 | 71.66 | 0.0253 | 4.0574 | 39.57 | 0.2465 |
| 40 | 58.41 | 73.11 | 0.0253 | 3.9806 | 39.52 | 0.2512 |
| 41 | 59.89 | 74.59 | 0.0253 | 3.9055 | 39.47 | 0.2560 |
| 42 | 61.39 | 76.09 | 0.0254 | 3.8321 | 39.43 | 0.2610 |
| 43 | 62.91 | 77.61 | 0.0254 | 3.7604 | 39.38 | 0.2659 |
| 44 | 64.46 | 79.16 | 0.0254 | 3.6903 | 39.33 | 0.2710 |
| 45 | 67.03 | 81.73 | 0.0255 | 3.6218 | 39.28 | 0.2761 |
| 46 | 67.63 | 82.33 | 0.0255 | 3.5548 | 39.23 | 0.2813 |
| 47 | 69.25 | 83.95 | 0.0255 | 3.4893 | 39.18 | 0.2866 |
| 48 | 70.89 | 85.59 | 0.0255 | 3.4253 | 39.14 | 0.2919 |
| 49 | 72.56 | 87.26 | 0.0256 | 3.3626 | 39.09 | 0.2974 |
| 50 | 74.25 | 88.95 | 0.0256 | 3.3014 | 39.04 | 0.3029 |
| 51 | 75.97 | 90.67 | 0.0256 | 3.2415 | 38.99 | 0.3085 |
| 52 | 77.71 | 92.41 | 0.0257 | 3.1828 | 38.94 | 0.3142 |
| 53 | 79.48 | 94.18 | 0.0257 | 3.1255 | 38.89 | 0.3199 |
| 54 | 81.28 | 95.98 | 0.0257 | 3.0694 | 38.84 | 0.3258 |
| 55 | 83.10 | 97.80 | 0.0258 | 3.0145 | 38.79 | 0.3317 |
| 56 | 84.95 | 99.65 | 0.0258 | 2.9608 | 38.74 | 0.3377 |
| 57 | 86.83 | 101.53 | 0.0258 | 2.9082 | 38.69 | 0.3439 |
| 58 | 88.73 | 103.43 | 0.0259 | 2.8568 | 38.64 | 0.3500 |
| 59 | 90.66 | 105.36 | 0.0259 | 2.8064 | 38.59 | 0.3563 |
| 60 | 92.62 | 107.32 | 0.0259 | 2.7571 | 38.54 | 0.3627 |

| Refrigerant R717 (Ammonia) | | | | | | |
|--|-----------------------------|------------------------------|--|---|--|---|
| Temp in Degrees Fahrenheit (°f) | Gauge Pressure psig * | Absolute Pressure psia | Specific Volume liquid ft ³ /lb. | Specific Volume Vapor ft ³ /lb. | Density Liquid lbs./ ft ³ | Density Vapor lbs./ ft ³ |
| 61 | 94.60 | 109.30 | 0.0260 | 2.7089 | 38.49 | 0.3692 |
| 62 | 96.62 | 111.32 | 0.0260 | 2.6616 | 38.44 | 0.3757 |
| 63 | 98.66 | 113.36 | 0.0260 | 2.6154 | 38.39 | 0.3824 |
| 64 | 100.73 | 115.43 | 0.0261 | 2.5701 | 38.34 | 0.3891 |
| 65 | 102.83 | 117.53 | 0.0261 | 2.5257 | 38.29 | 0.3959 |
| 66 | 104.96 | 119.66 | 0.0262 | 2.4823 | 38.24 | 0.4029 |
| 67 | 107.12 | 121.82 | 0.0262 | 2.4397 | 38.19 | 0.4099 |
| 68 | 109.31 | 124.01 | 0.0262 | 2.3981 | 38.14 | 0.4170 |
| 69 | 111.53 | 126.23 | 0.0263 | 2.3572 | 38.09 | 0.4242 |
| 70 | 113.78 | 128.48 | 0.0263 | 2.3173 | 38.04 | 0.4315 |
| 71 | 116.06 | 130.76 | 0.0263 | 2.2781 | 37.99 | 0.4390 |
| 72 | 118.37 | 133.07 | 0.0264 | 2.2397 | 37.93 | 0.4465 |
| 73 | 120.71 | 135.41 | 0.0264 | 2.2021 | 37.88 | 0.4541 |
| 74 | 123.08 | 137.78 | 0.0264 | 2.1652 | 37.83 | 0.4619 |
| 75 | 125.48 | 140.18 | 0.0265 | 2.1291 | 37.78 | 0.4697 |
| 76 | 127.92 | 142.62 | 0.0265 | 2.0936 | 37.73 | 0.4776 |
| 77 | 130.39 | 145.09 | 0.0265 | 2.0589 | 37.67 | 0.4857 |
| 78 | 132.89 | 147.59 | 0.0266 | 2.0249 | 37.62 | 0.4939 |
| 79 | 135.42 | 150.12 | 0.0266 | 1.9915 | 37.57 | 0.5021 |
| 80 | 137.99 | 152.69 | 0.0267 | 1.9588 | 37.52 | 0.5105 |
| 81 | 140.59 | 155.29 | 0.0267 | 1.9268 | 37.46 | 0.5190 |
| 82 | 143.22 | 157.92 | 0.0267 | 1.8953 | 37.41 | 0.5276 |
| 83 | 145.89 | 160.59 | 0.0268 | 1.8645 | 37.36 | 0.5363 |
| 84 | 148.59 | 163.29 | 0.0268 | 1.8342 | 37.31 | 0.5452 |
| 85 | 151.33 | 166.03 | 0.0268 | 1.8046 | 37.25 | 0.5541 |

| Refrigerant R717 (Ammonia) | | | | | | |
|--|---------------------------------|----------------------------------|--|---|--|---|
| Temp in Degrees Fahrenheit (°f) | Gauge Pressure psig * | Absolute Pressure psia | Specific Volume liquid ft ³ /lb. | Specific Volume Vapor ft ³ /lb. | Density Liquid lbs./ ft ³ | Density Vapor lbs./ ft ³ |
| 86 | 154.10 | 168.80 | 0.0269 | 1.7755 | 37.20 | 0.5632 |
| 87 | 156.90 | 171.60 | 0.0269 | 1.7470 | 37.14 | 0.5724 |
| 88 | 159.75 | 174.45 | 0.0270 | 1.7190 | 37.09 | 0.5817 |
| 89 | 162.62 | 177.32 | 0.0270 | 1.6915 | 37.04 | 0.5912 |
| 90 | 165.54 | 180.24 | 0.0270 | 1.6646 | 36.98 | 0.6007 |
| | | | | | | |
| 91 | 168.48 | 183.18 | 0.0271 | 1.6381 | 36.93 | 0.6105 |
| 92 | 171.47 | 186.17 | 0.0271 | 1.6122 | 36.87 | 0.6203 |
| 93 | 174.49 | 189.19 | 0.0272 | 1.5867 | 36.82 | 0.6302 |
| 94 | 177.55 | 192.25 | 0.0272 | 1.5617 | 36.77 | 0.6403 |
| 95 | 180.65 | 195.35 | 0.0272 | 1.5372 | 36.71 | 0.6505 |
| | | | | | | |
| 96 | 183.78 | 198.48 | 0.0273 | 1.5131 | 36.66 | 0.6609 |
| 97 | 186.95 | 201.65 | 0.0273 | 1.4895 | 36.60 | 0.6714 |
| 98 | 190.16 | 204.86 | 0.0274 | 1.4663 | 36.55 | 0.6820 |
| 99 | 193.41 | 208.11 | 0.0274 | 1.4436 | 36.49 | 0.6927 |
| 100 | 196.70 | 211.40 | 0.0274 | 1.4212 | 36.43 | 0.7036 |
| | | | | | | |
| 101 | 200.02 | 214.72 | 0.0275 | 1.3993 | 36.38 | 0.7146 |
| 102 | 203.39 | 218.09 | 0.0275 | 1.3777 | 36.32 | 0.7258 |
| 103 | 206.80 | 221.50 | 0.0276 | 1.3565 | 36.27 | 0.7372 |
| 104 | 210.24 | 224.94 | 0.0276 | 1.3358 | 36.21 | 0.7486 |
| 105 | 213.73 | 228.43 | 0.0277 | 1.3153 | 36.15 | 0.7603 |
| | | | | | | |
| 106 | 217.25 | 231.95 | 0.0277 | 1.2953 | 36.10 | 0.7720 |
| 107 | 220.82 | 235.52 | 0.0277 | 1.2756 | 36.04 | 0.7839 |
| 108 | 224.43 | 239.13 | 0.0278 | 1.2563 | 35.98 | 0.7960 |
| 109 | 228.08 | 242.78 | 0.0278 | 1.2373 | 35.93 | 0.8082 |
| 110 | 231.77 | 246.47 | 0.0279 | 1.2186 | 35.87 | 0.8206 |
| | | | | | | |

| Refrigerant R717 (Ammonia) | | | | | | |
|--|-----------------------------|------------------------------|--|---|--|---|
| Temp in Degrees Fahrenheit (°f) | Gauge Pressure psig * | Absolute Pressure psia | Specific Volume liquid ft ³ /lb. | Specific Volume Vapor ft ³ /lb. | Density Liquid lbs./ ft ³ | Density Vapor lbs./ ft ³ |
| 111 | 235.50 | 250.20 | 0.0279 | 1.2003 | 35.81 | 0.8331 |
| 112 | 239.28 | 253.98 | 0.0280 | 1.1822 | 35.75 | 0.8459 |
| 113 | 243.10 | 257.80 | 0.0280 | 1.1645 | 35.70 | 0.8587 |
| 114 | 246.96 | 261.66 | 0.0281 | 1.1471 | 35.64 | 0.8718 |
| 115 | 250.87 | 265.57 | 0.0281 | 1.1300 | 35.58 | 0.8850 |
| | | | | | | |
| 116 | 255.40 | 269.52 | 0.0282 | 1.1132 | 35.52 | 0.8983 |
| 117 | 259.40 | 273.51 | 0.0282 | 1.0967 | 35.46 | 0.9118 |
| 118 | 263.50 | 277.55 | 0.0282 | 1.0805 | 35.41 | 0.9255 |
| 119 | 267.60 | 281.63 | 0.0283 | 1.0645 | 35.35 | 0.9394 |
| 120 | 271.70 | 285.76 | 0.0283 | 1.0488 | 35.29 | 0.9535 |
| | | | | | | |
| 121 | 275.90 | 289.93 | 0.0284 | 1.0334 | 35.23 | 0.9677 |
| 122 | 280.10 | 294.15 | 0.0284 | 1.0183 | 35.17 | 0.9820 |
| 123 | 284.40 | 298.41 | 0.0285 | 1.0033 | 35.11 | 0.9967 |
| 124 | 288.70 | 302.72 | 0.0285 | 0.9887 | 35.05 | 1.0114 |
| 125 | 293.10 | 307.08 | 0.0286 | 0.9743 | 34.99 | 1.0264 |