TRANSCAER® Anhydrous Ammonia Training
Anhydrous Ammonia Properties

In this module, we will cover the properties of anhydrous ammonia and provide general understanding and guidance to emergency responders in addressing anhydrous ammonia incidents. Anhydrous ammonia is a liquefied compressed gas. You may have planning or response responsibilities to fixed facilities or a transportation incident and someone states "we have ammonia on site". Personnel may not distinguish between anhydrous ammonia and aqua ammonia – it is just ammonia to them since that is what they have on site or are transporting. Aqua ammonia is ammonia and water blended together – usually a 19% or 30% concentration. Anhydrous ammonia is pure 100% ammonia. It is important to know which product you are dealing with. Both are hazardous, but obviously anhydrous ammonia is more hazardous and response considerations will be different than with aqua ammonia. The type of storage or transport container will also be different.

Anhydrous Ammonia Uses

The main use of ammonia is fertilizer or in making fertilizer products. About 80% of anhydrous ammonia produced goes to agricultural purposes – could be direct injection into the ground pre or post planting or to make other products. What would happen if we put ammonia on live plants? It would burn them. Why? Because anhydrous ammonia is corrosive. Anhydrous ammonia is used because of its high nitrogen content. By molecular weight, ammonia is 82% nitrogen which is why it is such a good fertilizer. It is used in power plants for pollution control. Power plants that use coal or natural gas generate harmful Nitrogen Oxide and ammonia is a good scrubber for Nitrogen Oxide. In the presence of million dollar catalyst beds, ammonia vapor will convert Nitrogen Oxide to nitrogen and water – 2 inert products. Power plants could use either anhydrous ammonia or aqua ammonia (or other products such as urea). It is used in refrigeration. Why? Because ammonia has a low boiling point and has great capacity for absorption of heat – thus can keep food cold. Heat treat operations will use ammonia – usually they dissociate the ammonia back to nitrogen and hydrogen. What is the chemical formula for ammonia? – NH_3. Ammonia is used to keep metals shiny, or to harden or treat in some other fashion. Some water treatment sites use ammonia (either aqua or anhydrous). Though used less often than in the past, you may still find some blueprint sites which use ammonia.

Then there is the illicit use to make methamphetamine. Meth makers need liquid phase ammonia (not vapor). The picture to the right is a meth lab in the woods. Ammonia cylinders typically discharge vapor from an upright position. This lab had the cylinder on a pulley, upside down to get the liquid phase out. The cylinder could weigh over 350 pounds. It is also a problem with meth makers putting ammonia in "non spec" containers – household propane tanks, Igloo coolers, etc.

Anhydrous Ammonia Properties

Ammonia visually looks like water – colorless. It has a pungent odor. Ammonia has a low odor threshold. The average person can smell ammonia at 2 to 5 ppm (compare to PEL/REL/STEL of 50/25/35 ppm). Thus, it has good warning properties. Responders most likely will be dealing with the vapor phase, although anhydrous ammonia can form liquid pools. When ammonia boils, it absorbs a tremendous amount of heat, which is why it is used as a refrigerant. Based on its low Boiling Point and this absorption of heat, there is potential for frost or freeze burns if the liquid phase gets on skin. When ammonia boils (or is being released from a liquid phase to vapor phase) you will see a white cloud.

Even though ammonia vapor density is lighter than air, it can exhibit heavier than air characteristics. Weather will have an impact. Wet weather (such as high humidity, foggy, misty morning, light rain, etc) as well as cold temperatures can keep an ammonia cloud on the ground. In the picture to the right, there is a light rain and the cloud is staying close to the ground. Note this picture shows live ammonia release training at Tanner Industries in Philadelphia. Since this is a controlled release, you see responders in a Level B ensemble. Real life uncontrolled releases will most likely require Level A.

In the picture to the right, you see a better weather day for an ammonia leak with the cloud going up. Notice the "V" pattern of the cloud. Ammonia will take this pattern whether it is going up and away or if hugging the ground. Thus, if you are downwind, you want to move laterally and upwind to get out of the "V" line. The "side line" of the V is very defined. This will happen with invisible vapor clouds and visible white clouds. Even in good weather if you have a "thick dense gas cloud", ammonia can bounce back down to the ground. You see this cloud hooking back over. Thus even in good weather conditions the cloud could bounce back to the ground if it is a significant release.

As a compressed gas, ammonia has a high volumetric expansion ratio of 850 to 1. A small amount of liquid released and boiling off gives you a large amount of vapor volume. In picture to the right, the responder on the left is a 6'4" individual – how many pounds or gallons is making the white cloud? Probably about 10 to 12 pounds or about two gallons of product. Ammonia also has a high coefficient of expansion – do not overfill containers and do not trap liquid without pressure relief. The fill limit for ammonia storage containers is 85%. This prevents a hydrostatic pressure situation which could lead to a BLEVE. Containers will always have a vapor space provided it is not overfilled. The fill limit allows for the expansion and contraction as temperature changes.

Pressure/Temperature Relationship

The picture to the right is an ammonia cartridge (small cylinder). These types of containers as well as more typical larger containers do not typically have pressure relief valves. This cartridge was slightly overfilled. When filled the temperature of the ammonia was low. It was shipped to a facility and stored in a 70 degree room. The liquid ammonia expanded and ruptured the cartridge.

With ammonia there is a direct pressure/ temperature relationship. As the temp of the material inside a container rises, the vapor pressure exerted on that container will also rise. It is important to note that this relationship is independent of the volume amount in a container. The amount of product in the container has no bearing on this relationship (sans a hydrostatic type fill). Thus if a container is showing 0 gauge pressure that container may not be empty. At times you may see a frost or sweat line which would be an indication that liquid ammonia is present in a container or line.

Ammonia is a very, very strong base. You can get a chemical caustic/alkaline burn if it gets on your skin. Protect drains from runoff, even if using water downwind to knock down an ammonia cloud, since a little ammonia will drastically raise the pH of water. Ammonia is corrosive to copper and brass alloys. Refer to a Material Safety Data Sheet for full incompatibilities. If ammonia contacts a metal that it is incompatible with, you may see a greenish corrosion color on affected metals.

Ammonia does not have a flash point, but does have a LEL/UEL range. You will typically see 16-25% as this range; NIOSH lists at 15 – 28%. Even though this is a relatively high LEL and narrow range, indoor releases should be treated with caution in regards to flammability, especially with industrial refrigeration where you are likely to have other contaminants in the mix affecting the LEL/UEL range. Control ignition sources, and ventilate before entry. Ensure ventilation used is not exposed to flammable concentrations or a source of ignition. Stay out of areas with visible clouds. With outdoor releases, the chance of flammability is lessened.

A liquid phase exposure on skin can cause both thermal burns (frost bite) and chemical burns (caustic/alkaline). First aid for skin is copious amounts of water. If there is a liquid phase exposure, it can freeze clothing to skin. Decontaminate with water first prior to removing contaminated clothing. Keep in mind that duration of exposure and a person's physical makeup can also impact severity of symptoms if there are any pre existing conditions. The greater the concentrations the worse the symptoms may be, including potentially fatal doses. The Federal OSHA Permissible Exposure Limit is 50 ppm. The NIOSH Recommended Exposure Limit is 25 ppm and the IDLH (Immediately Dangerous to Life and Health) value is 300 ppm. The greater the concentration of ammonia the worse the effects will be. Health effects can range from irritation to fatal doses. Ammonia is moisture seeking. You will feel it in mucus membranes like the eyes, nose and throat. Moist areas of the skin will sting. Higher doses can lead to bronchial spasm and

even pulmonary edema. Ammonia has good early warning characteristics as it can be detected at low levels thus warning those in the area to evacuate the area. First aid for inhalation is move to fresh air, laterally and upwind. O_2 can be administered if needed.

Even though ammonia's textbook LEL/UEL is relatively high and a narrow range, indoor releases can pose a flammability risk, especially in industrial refrigeration where the ammonia is also contaminated with water and oil. Use ventilation and control ignition sources. Do not enter a visible clouded atmosphere. Ensure ventilation used is not exposed to flammable concentrations or a source of ignition.

Release Discussion

With outdoor release exposures, keep in mind the type of release phase (release phases will be covered in the response training block) and the weather impact. Remember the "V" pattern and that moist and cold weather conditions can keep the ammonia cloud close to the ground. Use water downwind to knock down vapors, not on leaking containers or the release point unless there is heat impingement on the container.

In the picture to the right, you see an outdoor ammonia release. Notice the "V" pattern. You can see the aerosol liquid droplets in the air near the release point and then the white dense gas cloud downwind. The "bottom" cloud is from the aerosol droplets. Determine the best spot for using water to protect downwind concerns in the area to the left of the picture – not in the aerosol cloud. The next concern would be containing the runoff since ammonia is a very strong base and a little ammonia can drastically change the pH of water.

There is a tarp and cover control/containment method for some ammonia release incidents. The release point is covered with a tarp (basic tarp you can buy at a local hardware supply made from polyethylene/polypropylene). The tarp covers the release point and the escaping dense gas cloud will condense to liquid phase product which will then cool the container/release point. We learned that there is a direct pressure/temperature relationship with ammonia and if the temperature drops, the pressure drops. Your downwind concerns are also minimized in that the release is controlled or contained to the local release area. This is not a cure all tactic. You would just have it controlled or contained at this point. You may then start to get liquid pooling of ammonia under and near the tarp. Do not walk through liquid pools. Do not work underneath the tarp. This procedure will be discussed further in the Response module.

Remember ammonia is a strong base. Even though its published vapor density is lighter than air, certain weather conditions or release phases can keep it close to the ground. Use water appropriately. Contain any run off since a little ammonia can drastically change the pH of water. Understand some basic pressure/temperature relationships with ammonia and do not trap ammonia without pressure relief.

TRANSCAER® Anhydrous Ammonia Training
Cargo Trailers, Nurse Tanks and Straight Trucks

This module will primarily focus on cargo trailers and nurse tanks. Straight trucks (bobtails) will be briefly reviewed. This session is primarily intended to be a hands-on review.

Cargo Tank

Nurse Tank

Cargo Tanks

MC-331 (or you could still see some MC-330 units) are the only DOT spec containers suitable for anhydrous ammonia. They are pressure coded vessels – built to a working pressure rating of 265 psig.

Bobtail

Bobtails are equipped with hoses for intercity delivery purposes. Straight trucks/bobtails are usually less than 3,500 e.g. capacity. Usually deliveries would be made using 1" hose connections.

Transports are limited by weight restrictions on the highway. Typically 80,000 lbs is the maximum weight. Water gallon capacity ranges from 3,500 gallons to up to 15,000 gallons. Typically units range in the 8,000–12,000 gallon capacity. Units can be unloaded from the center belly or the rear of the trailers. Not all trailers have unloading capabilities from both locations. When a trailer is loaded or unloaded, there is a strong possibility the trailer will "sweat" and drop moisture to the ground. This is common when the product on the inside is colder than the outside temperature. It works on the same principle as moisture collecting on the outside of a glass with ice and a drink in it. This trailer is not leaking. It collects and drops moisture just like the air conditioning in a car.

To get material loaded onto the truck or to unload material from the truck, the internal valve(s) have to be opened. The driver or operator would handle this function. These valves are referred to as the internal/excess flow valve. It is designed to close in the event of a leak through the delivery hose.

Emergency Controls

There are remote shut-offs for the internal valve. These are located at the driver front and passenger rear of the trailer. If something happened during the delivery, the driver or operator could engage these valves on their way when evacuating the area. Responders coming to the scene may also be able to engage these remote shut offs – and since they are at opposite ends one may be available from an upwind location. These are also actuated with fusible links. In the event of a fire, the fusible link would melt and activate either a spring that would "expand" and engage the lever or it would release air, actuating the shut-off.

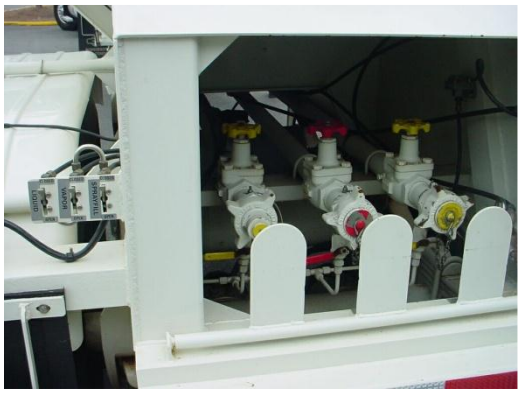
Cable Operated Rear Remote Shutoff

Cable Operated Remote Shutoff

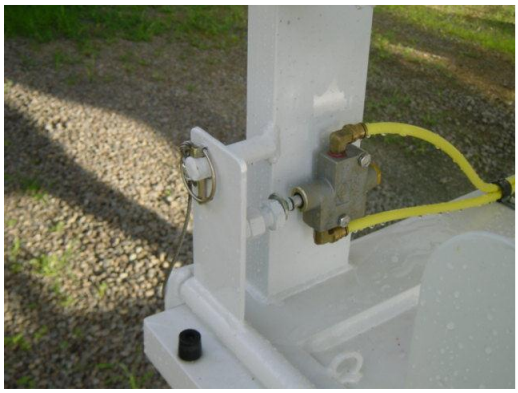
Air Activated Rear Remote Shutoff

Fusible Links

Some trailers are equipped with gates (referred to as loading gates or Dixie gates) that prevent hoses from being hooked to the inlet lines. The gate is attached to an air brake valve that locks the brakes on the trailer. This will prevent the trailer from being moved when the gate is in the down position.



Dixie Gate



Air Brake Valve

Loading and Unloading Operations

During an unloading operation you may see 2 hoses connected to the trailer: one for liquid transfer and one for vapor transfer. There are a couple of unloading methods – pump, compressor or a combination of both. With a pump unload there would typically be a 2" (or could be a 1") liquid line connection. The vapor line connection would then equalize pressures for the pump unload. Vapor lines are usually 1" or less in diameter. With a compressor delivery, there would also be a liquid line connection and a vapor line connection. Vapors from the receiving tank would be compressed and pressure added to the trailer to create a pressure differential to move product from the trailer to the receiving tank.

The pressure gauge will show the pressure of the NH_3 on the inside of the trailer. The volume gauge will show the liquid level in the trailer. You need to know the overall size of the trailer (water gallon capacity) in order to determine the quantity in the unit, for example, the gauge reading 50% equals 50% of 9,000 gallon capacity unit.

Since the trailer is a pressure coded vessel, there are safety relief valves that sit in the vapor space of the trailer at the top. There are usually two valves. One at the front end and back end or there could be 2 (side by side) in the middle. They are indented into the trailer in wells. This is in case the trailer rolls over – the safety relief valves will not get ripped off. Relief valves may be covered with a metal flap or a rubber insert, to prevent contamination from allowing the relief valve to operate properly. If you think a relief valve has been opened, looking to see position of the flap or insert may help you decide which relief valve has operated.

Other Safety Systems

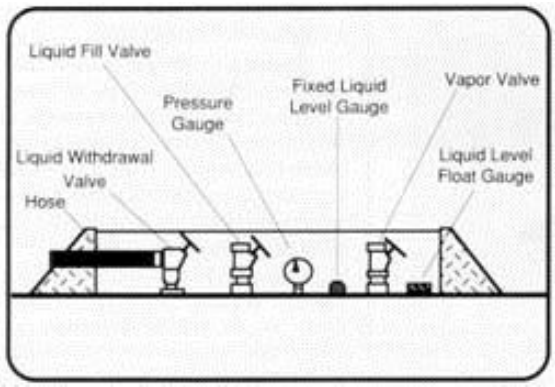
Cargo tanks are designed to withstand impacts. Plumbing is made to break away in the event of an accident. The internal/excess flow valve is designed to break at shear points to prevent leakage from the trailer. Passive mitigation is required by DOT. This is separate from the remote emergency shut off valves on a trailer. For 1" type transfers it is common to see either a "base" system which operates off a pressure drop detection (if a pressure drop is detected from a leak the delivery operation will shut down) or the mechanism such as a garage door type opener whereby the driver/operator attending the delivery must demonstrate that he/she is present at a periodic interval or the delivery operation will shut down.

For 2" type transfers it is common to see a Smart Hose type set up. The Smart Hose has a cable inside the hose and if the hose completely separates, the cable stretches and the hose ends will close at each end. It is imperative that the correct type of hose is used for off load. Trying to use LPG hoses for NH_3 offload can lead to leaks.

Nurse Tanks

Nurse tanks come in various configurations for agricultural applications in various parts of the country. Differences in tank size and mounting apparatus may be dictated by the local terrain on which these are used. Some tanks may have dual tank setups for capacities of 2000 gallons. Nurse tanks are generally parked together when sitting at the dealer location. It makes it hard to determine which tank is leaking in the event of a spill. There may be multiple warning signs and a placard on nurse tanks.

There are several valves and gauges on the nurse tank. There is a liquid withdrawal valve with a hose connection, a liquid fill valve, and a pressure gauge. In addition there is a fixed liquid level gauge, a vapor return valve and a liquid level float gauge.



Inside the tank there is a dip tube and excess flow valve. It is a spring loaded valve and designed to close based on flow rate. This is an added safety feature if a valve is sheared off. All liquid and vapor valves are protected by excess flow valves – this would hold true for cargo trailers, nurse tanks, rail cars, and above ground stationary tanks.

Case Study: Nurse Tank Rupture

A 1,000 gallon tank ruptured due to an internal non-code weld that weakened the shell of the tank. After the tank ruptured, it left its running gear and crossed the yard, splitting a tractor in half and came to rest 250 feet away. Fortunately it missed other tanks and a building. It rapidly released all of its contents and the vapor cloud moved across the property.

Tank ruptured and left its running gear

Tank split a tractor in half before coming to rest

TRANSCAER® Anhydrous Ammonia Training
Transporting Anhydrous Ammonia by Rail

The U.S. Department of Transportation (DOT) tracks transportation statistics and reports this information annually. 1.7 million bulk rail shipments move in the United States each year. Over 99.6 percent arrive at their destination without incident. This module will discuss contacting the railroad in an emergency, railroad resources, scene size up, reading shipping papers, placards for anhydrous ammonia rail shipments, tank cars for transporting anhydrous ammonia including service equipment and markings, and damage assessment.

Contacting the Railroad

When a rail emergency does occur, emergency response personnel must immediately contact the railroad upon notification of the emergency. The call may have been received through 911, but the call may have originated from a private citizen. The call will insure that the railroad knows there is an emergency and that you are responding.

When emergency response personnel arrive on the scene at a rail/highway crossing, they should:

a. Contact the emergency number for the railroad (look for the 24 hour emergency number on the signal bungalows or signs at the crossing
b. Give the location noted on the sign (look for railroad locations printed on signal bungalows or signs at the crossing; also look for US DOT crossing numbers as a means of telling the railroad where you are)
c. Give a summary of the situation.
d. Stay in contact with the railroad – emergency responders will be the eyes and ears of the railroad until railroad responders arrive.

When emergency response personnel arrive on the scene between rail crossings in a rural area, look for the railroad mileposts. Contact the railroad emergency number and give them the closest rail milepost number you see (check in both directions) as well as any other location information. If you have GPS capability, give these coordinates to the railroad emergency center. Again, be sure to stay in contact with the railroad emergency center. The center is staffed 24 hours a day and is usually located with the primary dispatching center for controlling trains and operations for the railroad. The center notifies, and makes continuing reports to, Chemtrec and the National Response Center, and will contact the chemical shippers whose cars are involved in the incident. The railroad emergency center will also make mandatory notifications to state and federal agencies and maintain communication with these agencies throughout the incident.

Railroad Resources

Railroad emergency centers have detailed Geographic Information System capabilities. Within minutes of a call the railroad emergency center can make available detailed maps and information of your location including utilities, roads and infrastructure, soil types, streams, waterways, environmentally sensitive areas, schools, hospitals, etc. The railroad emergency center can assist with plume modeling of suspected or verified hazmat releases.

Railroads work with the local Incident Commander and responders. The railroad will share information of what is involved and what resources are enroute to help deal with the incident. The railroad can provide on-scene personnel to assist with the emergency including:

a. Management personnel from the transportation, mechanical and engineering departments
b. Hazardous materials response personnel
c. Railroad police
d. Environmental assistance

The railroad may hire re-railing and environmental contractors as well. Remember the members of the railroad response team and their contractors are not far away. One of the key resources for railroad responses is the numerous response contractors. The Center for Toxicology & Environmental Health is one such resource and for large incidents with a vapor release or other issues they will be on scene for long-term air monitoring and reporting. This information will be made available to you by whatever means is quickest for your use.

Scene Size Up

Do a good scene size up. As with any emergency know what you are dealing with:

a. Determine if hazardous materials are present from the shipping papers or placards and markings on the cars using binoculars or other vision aids
b. Identify the rail cars/equipment involved and their contents from markings on the cars or the shipping papers
c. Identify the surroundings and weather conditions (current and how they may change)

The key to dealing with a rail hazmat emergency is obtaining and understanding the shipping papers.

a. Find the train crew. The conductor will have the most complete train list immediately available to you.
b. Ask the train crew to share the shipping papers and then ask them to help you read and understand them.
c. If the train crew is not available, contact the railroad emergency center and request a copy of the shipping papers be faxed or emailed to the scene. Railroad emergency centers can read shipping descriptions to you over the phone or radio.

Reading Shipping Papers

Rail shipping papers (train list, train consist, wheel report, etc – different names used by different railroads) provide the following information for each hazardous material in the train:

a. Description of the contents
b. Emergency response information
c. Position of each hazardous material shipment in the train (typically, railroads designate the rail car's position, or line number, from the front of the train – one railroad designates that line number starting from the rear of the train, and this will be noted on the document).

For each line number involving a hazardous material, the following information is provided:

a. A box of asterisks - hazardous materials shipments are quickly identified on the shipping papers by a box of asterisks or stars. This box of asterisks may contain wording or not. Typically, for anhydrous ammonia shipments, you will see the contraction HAZMAT or the word DANGEROUS. For other hazardous material shipments, you may see these words or other words such as EXPLOSIVE, POISON GAS, RADIOACTIVE.

b. Reporting mark (initials) and number - Every rail car has a unique identification marking called a reporting mark and number, or simply, initials and number. This alpha – numeric stencil is the positive ID for this rail car. No other rail car in North America will have these initials and numbers. They are like a license plate number. Spot them with your binoculars and match the initials and number on the car to the entries on the shipping papers.

c. Emergency response telephone number

d. Shipping description entries

   i. Total quantity of product

   ii. Identification number (may be in one of two places – either before the proper shipping or after the hazard class) – for anhydrous ammonia the number is **UN1005**

   iii. Proper shipping name – ANHYDROUS AMMONIA

   iv. Hazard class (with the prefix UN or NA as appropriate) – **2.2** (US) or **2.3** (Canada)

   v. Packing group notation I, II, III (not required for anhydrous ammonia)

   vi. Reportable Quantity notation – **RQ**

   vii. Packing group notation A, B, C, D (not required for anhydrous ammonia)

   viii. **INHALATION HAZARD** notation (US) or **POISON** (or **TOXIC**)-**INHALATION HAZARD** (Canada)

   ix. Trade name notation (not required for anhydrous ammonia)

   x. Shipper contact

   xi. Hazardous Materials Response Code (HazMat STCC) – for anhydrous ammonia **4904210**

   xii. Shipper (shipper of car) /Consignee (receiver of shipment) information

   xiii. For Canadian shipments, hazardous material response plan information

Shipping Description Entries - US Shipment

```
  19 UTLX  95248 LT19 NFGAS  HO754 ICG       PUEB   AMOS     IN ZAP COOL
                 60-MPH 126-TONS  51-FT  1-P    1.00-BRK 1585-ATONS 1068-AFT
                 RAIL SECURITY SENSITIVE MATERIAL
                 FLAT YARD - DO NOT KICK
                                          1/TC, 150000/LB
************************                  UN1005
*       DANGEROUS      *                  AMMONIA, ANHYDROUS
************************                  2.2
EMERGENCY CONTACT:                        RQ (AMMONIA)
  1-800-424-9300                          INHALATION HAZARD
                                          TN=(ANHYDROUS AMMONIA)
                                          SHIPPER CONTACT
                                            CHEMTREC
                                          HAZMAT STCC = 4904210
```

Note that the tank car in the example below is a residue shipment. Tank cars that have been unloaded typically have small amounts of residue in them. Therefore, regulations require the normal shipping description entries be displayed with the phrase RESIDUE: LAST CONTAINED in front of the proper shipping name. The shipment will remain placarded as if it were loaded to indicate the presence of the hazardous material.

Shipping Description Entries - Residue Shipments

```
**************************
*       DANGEROUS        *
**************************
EMERGENCY CONTACT:
  1-800-424-9300
```

```
1/TC
UN1005
RESIDUE: LAST CONTAINED
AMMONIA, ANHYDROUS
2.2
RQ (AMMONIA)
INHALATION HAZARD
TN=(ANHYDROUS AMMONIA)
SHIPPER CONTACT
  CHEMTREC
HAZMAT STCC = 4904210
```

Many U.S. Railroads include emergency response information in or with their documents. The emergency response information is more product specific than the Emergency Response Guidebook.

This information is pulled from an Association of American Railroads data file. The information is presented in clear, easy to read language.

Placards

Anhydrous ammonia shipments in the US will display the green Non-Flammable Gas 2.2 placard on both sides and both ends of the tank car. Anhydrous ammonia shipments in Canada will display the white Canadian anhydrous ammonia placard. Reciprocity between Transport Canada and US DOT allow for the Canadian anhydrous ammonia placard to be displayed in the US for shipments to and from Canada only.

Tank Cars for Transporting Anhydrous Ammonia

About 70% of hazmat moving by rail moves in tank cars. Tank cars transporting anhydrous ammonia are pressure tank cars, typically DOT Class 105 and 112. The minimum steel thickness for the tanks is $11/16^{th}$ inch. Typically, these tanks are covered with a $1/8^{th}$ inch jacket. The jacket is recognized by the following characteristics – flashing over the body bolster, rough weld seams from lap welds, a horizontal weld seam on the head, or patches welded onto the jacket. The fittings for these tanks cars are top mounted inside a protective housing. The capacity of these cars is 34,500 gallons but due to outage requirements, they will contain less than 30,000 gallons.

Tank Car Safety Systems

Tank car safety systems for tank cars transporting anhydrous ammonia, as well as other tank cars transporting hazardous materials, include:

a. Double shelf couplers (coupler vertical restraint systems) that are designed to keep the tank car coupled to the adjacent cars and avoid punctures in a derailment
b. Head shields (tank head puncture-resistance systems) – either full or half head shields which may or may not be visible to protect the head of the tank
c. Thermal protection, typically held in place with a jacket protects the tank metal under fire conditions to provide time for setting up defensive operations.

Tank Car Service Equipment (Valves and Fittings)

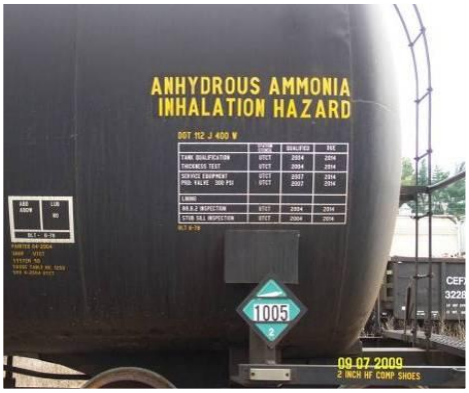
For tank cars transporting anhydrous ammonia, the service equipment (valves and fittings) for loading and unloading, pressure relief, gauging, and other functions are found on the top of the car inside a protective housing. The service equipment includes the following valves and fittings:

a. Two liquid eduction lines pointed toward the ends of the tank – with either ball type or plug type control valves for loading and unloading product
b. One vapor eduction lines pointing to the side of the tank – with either ball type or plug type control valves for handling vapor
c. One pressure relief valve (spring loaded) – to relieve excess pressure in the tank
d. One gauging device (closed type) – to determine the outage in the tank
e. One sample line with valve – for take a sample of the contents
f. One thermometer well – to allow the use of a thermometer to take the temperature of the contents (bring your own thermometer and string)

On some tank cars transporting anhydrous ammonia, the gauging device, sample line, and thermometer well are not present.

Tank Car Markings

In additional to placards, tank cars transporting hazardous materials are required to have certain markings/stencils to communicate the presence of hazardous materials. These placards, markings and stencils that help identify what materials may be loaded in the cars. The markings and stencils typically found on tank cars transporting hazardous material (particularly anhydrous ammonia) include:



a. Placard (previously noted)
b. Identification number – should match the four digit number on the shipping paper without the prefix UN or NA
c. Specification mark – provides information on the standard to which the tank car was built
d. Test date qualification stencil – indicates the required dates for testing the tank
e. Commodity name stencil – typically indicates the proper shipping name of the commodity being transported (required for many hazardous materials; match to shipping paper entries)
f. INHALATION HAZARD stencil

Damage Assessment

When it comes to determining and assessing the damage to tank cars, especially those transporting hazardous materials, emergency response personnel should utilize railroad response teams. Railroad response personnel are trained for this type work. These highly trained, specialized responders need access to the incident scene as quickly as safety allows. Based on what they find, the railroad responders will make decisions on the appropriate steps for dealing with the cars involved.

Remember that the large majority of tank cars utilized in North America have a jacket over the tank to hold the insulation and thermal blanketing in place, not hold the contents. The visible surface of the tank car may appear to be damaged, but that damage may be to the jacket not the actual tank. Look closely from a distance to spot the features that indicate a jacketed car.

Always remember, when dealing with a railroad emergency, you are not out there alone. Many resources are available and are on their way to assist in dealing with the emergency. It is important to contact the railroad and be prepared to coordinate the response with their responders.

TRANSCAER® Anhydrous Ammonia Training
Ammonia Emergency Response

This module will review the following:

a. Review the potential release phases that can be encountered when dealing with an anhydrous ammonia release
b. Real life plume modeling and weather impacts on ammonia releases and release phases
c. Life safety (how to determine and protect downwind threats), environmental Impacts and jargon/communication issues
d. Control and containment options for anhydrous ammonia releases

There are different approaches (defensive vs. offensive) based on the responder's training level. In this training session there will be some issues that are applicable to both training levels such as recognition/identification, types of releases, consideration of life safety and environmental impact. We will also discuss control and containment, and some methods, such as using water downwind to knock down a cloud can be accomplished by both Ops level and Tech level response personnel. Tarp & Cover would be an offensive method and only permitted to be performed by properly trained personnel.

Release Phases

There are four basic types of release to consider when ammonia escapes a vessel. Pressure within the vessel holds ammonia as a liquid. Ammonia exists naturally as an invisible vapor. When contained in a vessel the pressure and temperature of the ammonia determines the strength of the release. The liquid escapes as an aerosol and then mixes in the atmosphere to create a dense gas cloud (which mostly is condensation of humidity in the air – the white cloud), and then escapes to the atmosphere as an invisible vapor. At times the escaping aerosol is contained with a tarp or other cover and the aerosol will condense into a liquid. Liquid will also exist when large volumes of liquid are suddenly released from the vessel (such as a tank rupture). Once the pressure is released the liquid will flash off until a puddle of liquid settles and slowly evaporates to the atmosphere.

The cloud dispersion is highly dependent on wind, weather (humidity and upper air temperature inversions) and terrain on the downwind direction so please remember:

a. Ammonia loves water and will become a heavier than air gas cloud when mixed with water vapor
b. Cold temperatures slow the cloud dispersion while warm air adds energy to the ammonia molecule, thus spreading it faster
c. Wind is the most powerful mover of ammonia. High wind will stream out the release, and moderate wind will maximize dispersion, especially if the upper air is warm
d. Ammonia is a cold gas. The thermodynamic rule says warm always moves to cool NOT vice versa; ammonia clouds will hang in lower, cooler and more moist areas

Ammonia escapes the aerosol and dense gas as the heated air moves to warm the release. The time for vaporization is dependent upon the temperature of the air and the humidity. Dry and warm days provide the quickest dissipation of ammonia aerosol and dense gas to vapor. Ammonia liquid occurs when the surrounding atmosphere and containment area are cooled to at least -28°F. Ammonia liquid is fairly stable when left to slowly boil off. Add water, heat, or spread the liquid on the ground to produce a boiling vaporization.

Three basic risk factors: Life (yours and others), Environment (especially downstream pollution), and Product/Facility (inventory and equipment exposure/corrosion). Wet weather or cold weather or water/moisture source can keep the cloud close to the ground.

Release Characteristics

The chemical and physical characteristics of an outside release are dependent on volume, pressure, temperature, weather, environment and terrain. Basic rules of engagement: higher temperatures; higher/more active pressure and vapor movement; humidity and extremely cold temperatures slow vaporization. Ammonia is a cool gas and will track along low valleys where temperatures are cooler. Plant life, ponds, rivers, etc. will draw the ammonia but clearly, wind has the power of movement and dilution of the ammonia vapor.

This photo shows the movement of ammonia in a cone shaped v-pattern. Note how wind conditions may affect the movement of the dense gas cloud, and how the cloud widens as the ground temperatures cool, allowing the ammonia cloud to dissipate. This is important to consider when establishing the Hot Zone and Protective Action Zone.

Low pressure liquid is relatively safe if contained. After vaporizing and absorbing the heat, the liquid settles into a "sleeping" state. When the liquid is allowed to escape and react with the heat and moisture of the surroundings it will vaporize and boil off again. Ammonia loves water and will search it out in the environment. Ammonia's attraction to water is stronger than the attraction to air. One volume of water will absorb 1300 volumes of ammonia vapor. The expansion ratio of ammonia is 840 to 1.

When released from containment, ammonia boils and makes a "frying egg" sound; the same is true when ammonia suddenly escapes and gets on your skin. Those who have experienced this have said that it sounded and felt like frying eggs on their face! There is certainly a need for proper personal protective clothing.

Even though ammonia vapor density is lighter than air, it can exhibit heavier than air characteristics. Weather will have an impact. Wet weather (such as high humidity, foggy, misty morning, light rain, etc) as well as cold temperatures can keep an ammonia cloud on the ground. In this picture to the left, there is a light rain and the cloud is staying close to the ground. Note that this picture is a live release drill but since the exercise is outside with control ability, you see responders in a Level B ensemble. Real life uncontrolled releases will most likely require Level A.

In the picture to the left, you see the cloud going more up and away due to favorable weather conditions, however you see the hook at the top and since there is an aerosol and dense gas phase it actually hooks back down to the ground. This is similar to a "horseshoe effect". The height of the release plume will play into how the dense gas and vapor trail will disperse. In this case you can see the dense gas forming approximately 20 to 30 feet in the air. Those located in front of the release will not be exposed to as much ammonia as those further downwind when that dense gas cloud settles to the ground before dispersing into a vapor and heading off to the upper atmosphere. Always be cautious about the downwind drop of the ammonia plume; sometime it's several hundred feet (small release) and other times it may be hundreds of yards before the release plume drops and then moves up to disperse atmospherically. Once again, the shape of the cloud and the dispersing of the vapor are very dependent on the amount of release, distance of the aerosol stream, and the wind and weather conditions.

Response Considerations

Use extreme caution for environmental impacts of an unmitigated solution of aqua ammonia or pure anhydrous ammonia; the solution must be contained in a safe location so that the ammonia can evaporate (aeration of the solution will allow the ammonia pH to drop to possibly acceptable levels). Do not allow the ammonia solution to travel into live bodies of water… the solution is extremely dangerous to fish and wildlife that live in the water. Later we are going to discuss using water downwind to knockdown an ammonia vapor cloud. A little ammonia will drastically affect the pH of water (ammonia is a strong base) and this run off should also be contained to prevent harm.

Communication is the key in dealing with an incident, especially when different sites, organizations, and companies are working together. Ensure there is clear and accurate communication. Stay away from company/industry jargon. Some industry personnel will talk ammonia quantities in pounds. First responders probably have a better understanding of gallons. Rather than state the "recip blew a seal" – state "our compressor blew a seal". Instead of "we are stretching out an inch and a quarter" – state "we are stretching out a water line". It is a key to have a good site liaison with knowledge of system, product, and containers. In some circumstances that could be a contractor.

The hazards are always higher when the extreme conditions exist, i.e. high pressure, high volume, and high density clouds. Always assess the hazards before entering. The Incident Commander must assess risk and determine if the level of personal protective equipment is appropriate for the objective and tasks to be completed; this is communicated in an Incident Action Plan and safety plan. Always use caution for flammability of ammonia when working in and around an aerosol cloud of ammonia; it is very cold (as low as -80 to -100 degrees F).

The picture to the left shows a level A neoprene glove that froze while working on shutting a valve when inside a dense gas cloud and very near the aerosol stream. Deciding when to move forward and make a rescue and when to back off and use defensive strategies is difficult. Use a risk/benefit analysis before putting responders in harm's way. The key is:

a. Can you clearly see your exit pathway
b. Are you feeling any discomfort (groin, armpits, neck and head will feel the ammonia first – it will burn/sting).

Calculate your risk based on what you are able to save!

When it comes to evacuation, the first effort should be to define the hot zone and protective action zone. Those most at risk will be within the downwind pattern. Shelter-in-Place works very well for the downwind exposures. Evacuate if it's safe to enter the outside environment, otherwise stay inside and follow the shelter-in-place readiness protocols. To evacuate – move laterally and upwind (get outside of the "V" since the sideline of the V is very well defined with concentrations of ammonia).

CTEH (Center for Toxicology and Environmental Health) lab tested the value of turning on a shower and/or using a wet washcloth to protect those sheltered in place from any residual ammonia buildup.

In Minot, North Dakota a rail car accident resulted in 9 ammonia railcars releasing their contents. A cloud of dense gas ammonia floated over the community of Minot. The 9-1-1 center advised residents to shelter-in-place and to move to the bathroom and turn on the shower if ammonia odor became strong in their home. Levels of approximately 200 PPM were reported. CTEH replicated the shower and wet wash cloth protection and found that both were effective in reducing the level of ammonia to below 50 PPM. Note: the military has been professing the use of a wet cloth or shower option for water soluble gas protection for many decades, as a last resort personal protection option.

Domestic shipments within the US, ammonia can be classified and shipped as a DOT hazard class 2.2, non flammable gas. The green/white non flammable gas placard is used. Internationally, ammonia is classified as a 2.3 hazard class, poison gas, with a subsidiary warning of corrosive. You would see 2 placards or labels. The UN number is same for domestic and international shipments – UN 1005. Note that there are Canadian rail cars entering the US with a special permit placard, which looks like the 2.2 hazard class, but is white/black in color.

National Fire Protection Association Standard 704 provides the label standard for hazardous materials stored on site. The system has a 0-4 warning described as follows; 0 being not hazard and 4 the highest hazard:

Fire – red – top

Reactivity – yellow – right

Health – blue – left

Special information – white – bottom – special/other hazards

3-1-0- rating for ammonia; 3 for health, 1 for fire, 0 for reactivity.

3-3-0-possible to see this for indoor operations under certain building codes. Could also see "ALK" or "COR" in the white section since ammonia is a strong base. Most appropriate is blank, but "ALK" or "COR" is also seen.

Trapping liquid is dangerous. Do not be valve turners unless you know there is pressure relief protection where the ammonia may be trapped or contained. Ammonia has a high coefficient of expansion.

With outdoor releases there is not a high risk of flammability with ammonia. LEL/UEL is 16% to 25% or using NIOSH data is 15% to 28%. The most likely flame spread will occur while the flame is directed to a dense gas aerosol stream; the ammonia vapor will burn much like when the smoke from a hot campfire flash burns above the burning wood.

With indoor ammonia releases or within a confined area, there is a greater chance of flammability. A LEL/UEL mix could form and typically indoor releases happen at industrial refrigeration processes. In these closed loop ammonia processes, contaminants such as oil, can mix with the ammonia and affect the "textbook" flammability data. Indoor releases can pose potential flammability concerns. Ventilate the building and control all ignition sources prior to entering any building. Ensure ventilation used is not exposed to flammable concentrations or a source of ignition. The picture to the right is an example of a release that sparked a fire.

Ammonia loves water: one volume of water will absorb 1300 volumes of ammonia vapor. When ammonia moves to water located in an enclosed environment, like a tank or vessel, that movement of ammonia will cause a vacuum. Ammonia quickly mixes with water to form aqueous ammonia, or ammonium hydroxide, which is heavier than air and causes higher pH values (up to 13.2 from 11.6). When ammonia and water mix, an exothermic reaction occurs giving off heat. The molecular heat of the reaction raises the water temperature. This can be seen by measuring the increase in temperature of water used to "blow down" or remove ammonia from a system.

Ammonia loves water, but if you put water on ammonia it will become "spitting mad." On the other hand, if ammonia is introduced into water purposefully, the reaction isn't as bad, especially if the amount of water is adequate. The absorption of ammonia to water is about 1 volume of ammonia to 10 volumes of water when the solution is mixed completely at about 70°F. Aqueous ammonia vaporization is dependent upon the temperature of the water, the amount of wind, and the amount of surface area exposed. Usually, the volume of ammonia will reduce faster as temperature, surface area, and the amount of warm air is increased. Remember that one volume of water will absorb 1300 volumes of ammonia vapor. Ammonia joins with the water vapor and lays low until vaporized by surrounding air. Its pH value also increases and it can become much more irritating to the skin. The temperature of tepid water from a hose will be about 55 to 65°F. What would that do to the ammonia temperature and pressure within a vessel? When is it a good idea to put water on a vessel?

The main message is to avoid using water on liquid, aerosol or dense gas ammonia releases. Water is effective in reducing downwind vapor release, but the need for containing runoff is critical. Do not allow ammonia mixed with water find its way to a live body of water unless the pH is below local environmental standards (usually to under pH 8 or pH 9).

A complete size-up is critical in ammonia events. We should understand what happened, the type of release, nature of the event, status of the release (contained, still growing, out of control, peaked, reducing in impact)? What are the life safety and environmental threats downwind, especially in the protective action zone? What's happening now? Is there a growing, downwind threat? Is there a growing downstream threat? What do you recommend next? Do we have personnel accountability, environmental damage, facility product or equipment at risk? If you don't know don't go!

Tarp and Cover Control/Containment Method

This is a tarp and cover control/containment method for some ammonia release incidents. The release point is covered with a tarp (basic tarp you can buy at a local hardware supply – polyethylene/polypropylene). The tarp covers the release point and the escaping dense gas cloud will condense to liquid phase product which will then cool the container/release point. We learned that there is a direct pressure/temperature relationship with ammonia and if the temperature drops, the pressure drops. Your downwind concerns are also minimized in that the release is controlled and contained to the local release area. This is not a cure-all tactic. At this point you just have it controlled and contained. You may then start to get liquid pooling of ammonia under and near the tarp. Do not walk through liquid pools.

What is occurring under the tarp while the dense gas flows around the vessel? The cold gas will lower the pressure in the vessel and the condensation of the aerosol stream will result in liquid ammonia saturating the ground rather than to go downwind to threaten life hazard… if there is no life or environmental hazard on the downwind then allowing the ammonia to escape to atmosphere might be the best solution. In the picture to the right, notice how the dense gas cloud stays low as the gas begins to vaporize to atmosphere on the downwind direction. On a dry day the dense gas cloud is not as evident although the vapor risk may still be very high on the downwind direction.

You can see in the picture to the left that the tarp has minimized the exposure area. The leak point or leaking container will be cooled from the ammonia if we drop temperature the pressure in the container will also drop. Fully contained with the first tarp; secondary tarps may be helpful; now we can find the source of the release and control the flow and shut it down! A positive pressure ventilation fan is helpful in directing the dense gas away from the responders as they place the tarp and work on controlling the release… it's also a good first step to getting fresh air to a victim that may be down in the downwind direction.

In the picture to the right, notice the containment of an aerosol in a relatively low humidity circumstance: working in dense gas and aerosol requires Level A PPE. Placing the tarp from a distance, outside the dense gas cloud, can be accomplished with level A or even level B PPE. A fan used to support the responders is very valuable. Responders must be trained in this procedure before attempting it.

Rail tank cars typically have a capacity of 34,500 gallons, but due to outage requirements, they will contain less than 30,000 gallons. Capping kits may or may not work on the tank cars. It depends if there is enough spacing around the valve flanges. There will always be 2 liquid valves running the length of the car. A single vapor valve will be perpendicular to the liquid valves. Tanks will also have a pressure relief valve and may have other valves such as gauging device, thermometer well and sample tube line.

Cargo trailers (tractor trailer versions) could range in size from 3.500 gallon to almost 12,000 gallon. Nurse tanks range in size from 500 gallon to over 1,000 gallon.

In summary don't be valve turners since we do not want to trap liquid ammonia without being able to relieve pressure. Ensure use of proper personal protective equipment. Review where and when to use water. Be sure to contain any run off. Evaluate tarp and cover as a control/containment method for the incident. And finally, if you don't know, then don't go!

EMERGENCY RESPONSE CONTACT NUMBERS

Burlington Northern Santa Fe	**800-832-5452**
Canadian National	**800-465-9239**
Canadian Pacific	**800-716-9132**
CSX Transportation	**800-232-0144**
Kansas City Southern	**877-527-9464**
Norfolk Southern	**800-453-2530**
Union Pacific	**888-877-7267**
CHEMTREC®	**800-424-9300**
CANUTEC	**613-996-6666 (call collect)**

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The materials developed for the Anhydrous Ammonia Training Tour 2011 are intended to provide general understanding and guidance to emergency responders in addressing anhydrous ammonia incidents. They include information about the chemical and helpful considerations that the emergency responder can employ when faced with such an incident. The materials are in no way intended to be prescriptive or otherwise recommend specific procedures on how to respond. Emergency responders are encouraged to consult with the product manufacturer, carrier and other experts when assessing and managing any incident involving anhydrous ammonia.