Agent Characteristics

Agent Classification: Choking/pulmonary, lung damaging agent and Toxic Industrial Chemical
NOTE: For this QRG, ammonia refers to anhydrous ammonia gas, unless otherwise specified.

Chemical	CAS	Formula	Molecular Weight	Physical Description	Synonyms and Trade Names (examples)
Anhydrous Ammonia	7664-41-7	NH_3	17.03 g/mol	Clear colorless gas with a strong odor Clear colorless liquid under pressure	• Nitro-Sil • Refrigerant R717 • AM-Fol
Ammonium Hydroxide	1336-21-6	NH_4OH	35.04 g/mol	Colorless aqueous solution; NH_3 vapors can arise from the solution	• Aqueous ammonia (30% or less NH_3) • Ammonia water

Description: Clear, colorless gas with a pungent suffocating odor, or a clear, colorless liquid under pressure. Ammonia is a toxic gas or liquid that, when concentrated (~ 99%), is corrosive to tissues upon contact (e.g., eyes, skin, mouth, throat, lungs). Contact with unconfined ammonia liquid can cause frostbite. Exposure to ammonia in sufficient quantities can be fatal. One of the highest production-volume chemicals in the U.S., concentrated ammonia is used in manufacturing, refrigeration, and agriculture (as a fertilizer). Household ammonia solutions are much less concentrated (~ 5-10%) and rarely cause burns, but can cause irritation. The lowest level at which humans can detect the odor of ammonia is ~ 5-10 ppm v/v, (odor threshold) and this generally provides sufficient warning of exposure; however, persons with prolonged exposure to ammonia will lose their ability to detect the odor (olfactory fatigue). Liquified anhydrous ammonia is stored and shipped in pressurized containers (e.g., tanks, cylinders). Although the DOT requires liquefied anhydrous ammonia (UN1005) to be transported with a non-flammable gas placard, autoignition may occur at high temperatures (>1204°F, >650°C). When ammonia mixes with organic vapors and/or air it forms an explosive mixture. Pressurized containers may explode when heated. Ruptured containers or cylinders may rocket. Ammonia-air explosions have occurred from leaks in anhydrous ammonia refrigeration system equipment, especially in inadequately ventilated confined spaces, where an accumulating ammonia-air mixture (LEL=15%) was then ignited explosively by an ignition source. Ammonia reacts violently with strong oxidants, acids, halogens, and many heavy metals.

Persistence: Ammonia is considered "non-persistent." Vapor: minutes to hours; liquid: rapidly evaporates at ambient temperatures and pressures. Persistence will depend upon amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted.

Note: At most environmentally significant pHs, ammonia partially ionizes; therefore, many physical and chemical properties will be a function of pH. The amount of ammonia gas released from aqueous solution will increase with increasing pH, and the amount remaining in solution will increase at lower pHs.

Anhydrous Ammonia

(**CAUTION:** The NFPA diamond for anhydrous ammonia has a NOTE that the flammability hazard (red quadrant) may rise from 1 to 3 in a confined space)

Physical Properties

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m^3 x 0.7; mg/m^3 = ppm x 1.43.

Vapor Density: 0.5967 (air = 1)	**Boiling Point:** -28°F (-33.35°C)	**Specific Gravity:** 0.7710 at 760 mm Hg
Vapor Pressure: 6460 mm Hg	**Melting/Freezing Point:** -108°F (-77.7°C)	**Aqueous Solubility:** soluble in water
Volatility: Not established (high, is a gas)	**Explosive Range:** LEL = 15%; UEL= 28%	**Non-aqueous Solubility:** chloroform, ether

Release Scenarios

RELEASE OF GASEOUS AMMONIA (NH_3) IS ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.

Open Areas: NH_3 is a gas and is relatively easy to disperse, due to its volatility, and the primary release/attack scenario is an airborne release. Dispersed NH_3 gas is expected to dissipate, hastened because ammonia gas is lighter than air. However, dissipation may take minutes to hours, and dangerous concentrations can be present at the site of release or in the path of an NH_3 plume. Under certain conditions, such as when compressed liquefied ammonia gas initially escapes a cylinder or vessel and comes into contact with moisture in the air, it may form an "ammonia fog." This fog is likely to remain low to the ground and could prevent ammonia gas from rising in the air, mixing and dissipating more easily. Ammonia gas can react with moisture in the air to form aerosols of ammonium hydroxide (NH_4OH), a corrosive, alkaline compound, which can cause inhalation, dermal, and ocular hazards.

Water/Water Systems: After gaseous release, ammonia can dissolve into bodies of water, forming ammonium hydroxide (NH_4OH), a corrosive, alkaline solution, which may exert toxic effects if present in high concentration. If a large plume of NH_3 gas or vapors is released, not all NH_3 may dissolve before the NH_3 plume leaves the vicinity of the water. Excess ammonia may also be present in chlorinated drinking water systems as a result of equipment failure.

Indoor Facility: NH_3 leaks in indoor facilities have occurred due to failure of refrigeration systems that utilize anhydrous ammonia (e.g., ice rinks, industrial freezers, meat plants). Dangerous concentrations of ammonia gas can occur quickly in enclosed or poorly ventilated spaces, such as lower levels or utility corridors inside the building. Due to ammonia's volatility, HVAC systems could be impacted. Corrosive vapors, including ammonium hydroxide (NH_4OH), can be formed in the presence of moisture.

Combustion: Ammonia is flammable, and fire will produce irritating, corrosive, and/or toxic gases. When ammonia is heated to decomposition, it emits toxic fumes and nitrogen oxides. During firefighting, never direct the jet of water spray directly at liquid ammonia.

Other: Ammonia is a commonly used fertilizer in agriculture, however, not on edible products. Ammonia released to an edible product may impart unpalatable qualities to food when the gas reacts with moisture in the food.

Health Effects

Onset: Onset of symptoms is dose and route dependent. Following short-term exposure to high concentrations of NH_3 gas or vapors, effects occur rapidly although some respiratory symptoms may be delayed in onset. The full extent of eye damage may not be evident for up to one week after exposure. NH_3 is a severe irritant of the eyes, respiratory tract, gastrointestinal tract, and skin (frostbite and severe burns). It reacts with moisture in mucous membranes to produce ammonium hydroxide (NH_4OH), a corrosive, alkaline compound. Effects from NH_3 exposure depend on duration of exposure and concentration of gas or liquid. (see Signs/ Symptoms below).

Signs/Symptoms: Appearance and severity of symptoms will vary depending upon exposure route, concentration and duration. However, the following is a general list of possible symptoms.

Mild to Moderate: Rapid eye irritation and burning sensation. Nausea, emesis (vomiting), abdominal pain, and burns of mouth, pharynx (throat), esophagus, and stomach. Inhalation can cause irritation and burns of the nose, trachea (windpipe), lungs, shortness of breath, and chest pain.

Severe: Severe corrosive eye injury, eye redness and swelling, tearing, and temporary or permanent blindness. Swelling of lips, mouth, and larynx (voice box), and severe burns of mouth, pharynx (throat), esophagus, and stomach. Pulmonary edema (accumulated fluid in lungs) and pneumonia may also result from inhalation. Skin inflammation, blistering, necrosis (tissue death), and deep penetrating burns, especially on moist skin areas. Exposure to NH_3 in sufficient quantities can be fatal.

Health Effects (continued)

Exposure Routes:
Inhalation: The primary route of NH_3 exposure is in gaseous form. Vapor exposure is absorbed in mucous membranes, including the nose, pharynx (throat), nasopharynx (upper part of throat behind the nose), trachea (windpipe), and lungs, causing bronchiolar and alveolar edema, and airway destruction.
Skin: Direct contact with moist skin may cause irritation and redness. High concentrations can cause blistering and severe skin burns, especially on most skin. Contact with NH_3 as liquefied compressed gas can cause frostbite and severe skin burns.
Eyes: High concentrations can cause inflammation, tearing, and severe corrosive injury to surface and membranes of eye (e.g., corneal erosion). In cases of eye contact, ulceration (tissue damage) may result in late perforation of cornea after weeks or months. Blindness may ensue.
Ingestion: Ingestion is an uncommon route of exposure. Vapor exposure is absorbed in mucous membranes (e.g., esophagus, stomach).

Effect Levels

Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios for NH_3 (complete definitions are available at: https://www.epa.gov/aegl).

AEGL Level in ppm, at various exposure durations	**10 min.**	**30 min.**	**1 hr.**	**4 hr.**	**8 hr.**
AEGL 1: Threshold mild effects	30	30	30	30	30
AEGL 2: Potentially irreversible effects or impaired ability to escape	220	220	160	110	110
AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	2,700	1,600	1,100	550	390

Air: American Industrial Hygiene Association (AIHA) Emergency Response Planning Guidelines (ERPG^{TM}) for general population short-term (1 hour) single exposures to airborne concentrations of NH_3.

AIHA ERPG Level in ppm	**1 hr.**
ERPG-1: Mild, transient effects	≤ 25
ERPG-2: Serious, irreversible effects	≤ 150
ERPG-3: Life-threatening effects	≤ 1500

Note: ERPGs may be used during emergency response to evaluate potential health effects to the public or emergency response personnel; however, AIHA ERPG 2019 Handbook states "The levels are not to be used to determine safe limits for routine operations, as definitive delineators between safe and unsafe exposure conditions, or as a basis for quantitative risk assessment."

Exposure Guidelines

Note: (NA = not available)

Occupational		
NIOSH IDLH = 300 ppm	**NIOSH REL-STEL** = 35 ppm (27 mg/m^3) [15-min TWA]	**ACGIH TLV-TWA** = 25 ppm [8-hr TWA]
NIOSH REL-TWA = 25 ppm (18 mg/m^3) [10-hr TWA]	**OSHA PEL** = 50 ppm (35 mg/m^3) [8-hr TWA]	**ACGIH TLV-STEL** = 35 ppm [15-min TWA]
Population		
RSL Industrial Soil = NA	**RSL Residential Soil** = NA	**Drinking Water**: for 1 day (child) = NA; 10 days (child) = NA; Lifetime = 30 mg/L

Personnel Safety

Note: Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and the release scenario. Additional information on personnel safety and PPE selection criteria can be found at www.cdc.gov/niosh/ershdb. We also recommend that responders check their own internal procedures (i.e., SOPs), if applicable.

Medical: **Pre-incident:** Annual physical and respiratory function exam. **During Incident:** Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.

First Aid: Immediately remove person from affected area and remove contaminated clothing and articles. Keep the affected person warm and at rest.
Compressed liquid: Observe and treat for frostbite and chemical burns. Contaminated clothing could possibly be frozen to skin. Thaw frozen clothing from skin before removing. Wash bare skin immediately before removing clothes, with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for minimum of 20 minutes, ensure thorough soaking. For liquid ammonia contact, seek immediate medical attention. Rinse eyes exposed to liquid agent with potable water for minimum of 20 minutes. Hold eyelids apart and away from eyeball for thorough rinsing. **Gas**: Observe and treat for respiratory distress and maintain clear airway. Administer oxygen if respiratory distress develops. **Antidote: THERE IS NO ANTIDOTE.** In cases of ingestion, rinse mouth and do not induce vomiting. If conscious, give large amounts of water to drink. If unconscious, do not give anything by mouth. Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.
Post Incident: Post-incident medical surveillance is highly recommended.

Personal Protective Equipment (PPE): Note: the recommendations below apply to both Anhydrous Ammonia (NH_3) and ammonium hydroxide (NH_4OH), which is solution of ammonia in water up to 30% concentration.

WARNING: Exposure to liquid or rapidly expanding gases may cause severe chemical burns and frostbite to the eyes, lungs and skin.
CAUTION: Adding water directly to liquid spills will increase volatilization of ammonia, thus increasing the possibility of exposure. Contain spill and runoff from entering drains, sewers, streams, lakes, and water systems by utilizing methods such as diking, containment, and absorption.
GENERAL INFORMATION: NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA), NIOSH-approved Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, and chemical-resistant protective clothing (such as neoprene, polytetrafluoroethylene. and butyl rubber) should be used. Pre-incident training and exercises on the proper use of PPE are recommended. Per NIOSH guidance –
LEVEL A: Recommended for the initial response to an NH_3 incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), and eye protection when the contaminant identity or concentration is unknown. Select Level A when the NH_3 concentration is unknown or above the IDLH or AEGL-2, and when there is a potential of ocular or dermal exposure.
LEVEL B: Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the NH_3 concentration is unknown or above the IDLH or AEGL-2 and dermal exposure is less of a risk. Level B differs from Level A in that it typically incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not vapor tight.
LEVEL C: Select Level C when the contaminant identity and concentration are known and the respiratory protection criteria factors for the use of APR or PAPR (i.e., < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. **Note:** NH_3 may have limited inhalation warning properties due to olfactory fatigue. **Use APR/PAPR with caution.**

Personnel Safety (continued)

LEVEL D: Select Level D when the contaminant is known, and the concentration is below the appropriate occupational exposure limits for the stated duration times.

Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and risks of dermal exposure are known, and must be accompanied by on-site monitoring.

Field Detection

Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive and false negatives may occur in the presence of interferents common in the environment. The following is a summary of minimum screening concentration ranges or levels for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams and other agencies and responders, some with similar capabilities and limitations. **CAUTION: NH_3 reacts with water and moisture in air to form ammonium hydroxide (NH_4OH); monitoring for NH_4OH and changes in pH, as well as NH_3, is therefore recommended.**

Minimum Screening Ranges/ Levels for Air	Drager Tubes (ammonia 2/a)	Drager Sensors XS/XXS-NH_3	MultiRAE (NH_3 sensor)	MultiRAE (PID) IP = 10.18 eV
ppm	2.0	3.0 / 4.0	1.0	1.0
mg/m^3	1.4	2.1 / 2.8	0.7	0.7

	Orion Ion-specific electrode (ISE)	HACH colorimetric kits (various)	pH numerous meters and kits
Screening Levels for Water as NH_3-N (mg/L)	0.01	0.01	0.1 pH unit

Environmental Sampling

Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan.

Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. **Because NH_3 is reactive and volatile, field detection instead of laboratory analysis of samples may suffice and sometimes be necessary to achieve many goals of sampling.** The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for toxic organic compounds and chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). For sampling questions, call EPA/HQ-EOC at 202-564-3850.

Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is an NH_3 plume that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots," potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released.

Note: NH_3 is highly reactive, especially to moisture, so reaction by-products, mainly ammonium hydroxide (NH_4OH, a strong base) may be formed, causing high pHs, which may be detected in the field by monitoring for changes in pH. Changes in pH can be used as markers to determine the extent of contamination of the parent NH_3. Laboratory analysis will be necessary for other NH_3 reaction by-products. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes.

Types of Samples:

Air: On-site NH_3 monitors may provide sufficiently accurate real-time results. For lab analysis, samples are collected using appropriate solid phase absorbent or other media, at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces.

Water: Dissolved NH_3 forms NH_4OH, which may change the pH of the water. Measuring the pH of the water may be sufficient. Concurrent air monitoring for ammonia is recommended.

Soil: For localized "hot spot" areas where soil deposition may occur, surface soil samples may be analyzed for pH, and should be taken from a non-vegetated area to a depth of less than one inch. Measuring the pH of the soils may be sufficient. Concurrent air monitoring for ammonia is recommended.

Surface Wipes: Wipe samples may not be of concern due to ammonia's volatility. If wipe samples are desired to indicate the presence of NH_4OH on non-porous surfaces, measuring the pH of collected wipes may be sufficient. Concurrent air monitoring for ammonia is recommended.

Bulk: Bulk samples may not be of concern due to ammonia's volatility. If bulk samples are desired to indicate the presence of NH_4OH on non-porous surfaces, measuring the pH of the bulk sample may be sufficient. Concurrent air monitoring for ammonia is recommended.

Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.

Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.

Analysis

CAUTION: Many labs may not be able to perform analysis on all matrices. Ammonia analysis methods can be found in the EPA Selected Analytical Methods for Environmental Remediation and Recovery (SAM) (https://www.epa.gov/homeland-security-research/sam). Additional analytical methods for ammonia in air include NIOSH 6016 and OSHA ID-164. Reactive compounds such as ammonia gas (NH_3) and ammonium hydroxide (NH_4OH) may be accurately determined in the field using available meters and field kits. For access to the nearest ERLN laboratory specially trained and equipped for analysis of ammonia and its reaction by-products, contact the EPA/HQ-EOC at 202-564-3850. The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network).

Environmental Decontamination/Cleanup

DO NOT USE WATER DIRECTLY ON LIQUID ANHYDROUS AMMONIA. Use water spray to knock down vapors or to divert vapor plume drift. If using water spray, plan for ammonia hydroxide (NH_4OH) formation, an alkaline and corrosive liquid. pH adjustment of spillages and decontamination runoff may be necessary before discharge to receiving waters and wastewater systems. Avoid allowing water spray or runoff to contact liquid anhydrous ammonia.

The amount of ammonia gas released from an aqueous ammonia solution increases with pH. Anhydrous ammonia is so volatile that it will predominantly dissipate into the atmosphere and would not require decontamination by degradation. Anhydrous ammonia reacts violently with strong oxidants, acids, halogens and heavy metals. Hence, most decontamination or cleanup will not necessarily be for the anhydrous ammonia itself, but for reaction by-products, including ammonium hydroxide. Separate, long-term decontamination strategies will need to be developed if those by-products are of concern in a particular situation.

Environmental Decontamination/Cleanup (continued)

This decontamination/cleanup section refers to the anhydrous ammonia itself.

Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/cleanup plan. Decontamination may require a "tiered approach" using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information.

General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see WASTE MANAGEMENT section below).

Disposal Option: The urgency to restore a facility as quickly as possible may result in the outright and timely removal and disposal of contaminated materials. Certain materials may be damaged by exposure to ammonia and may be cheaper to discard and replace rather than to restore.

Monitored Natural Attenuation: Anhydrous ammonia dissipates via natural processes. Environmental monitoring must be maintained during decontamination and recovery phases. Monitored natural attenuation may require institutional controls (e.g., access restriction and contaminant containment measures). The time to achieve clearance must be considered in the overall cost/benefit evaluation. This option is more passive than other options but is non-destructive to materials. Aqueous ammonia solutions will also dissipate, yet slower than anhydrous ammonia, resulting in more concentrated solutions.

Fix-in-Place Option: Anhydrous ammonia dissipates rapidly via natural processes, as such a "Fix-in-Place Option" may not be required or feasible. Physical barriers can be used to separate and immobilize the agent contamination from coming into contact with the environment or the public. This can be a temporary or permanent solution. Solid or liquid anhydrous ammonia decomposition residues or wastes may require a separate decontamination evaluation process.

Decontamination Strategy: A decontamination strategy can be developed by designating contaminated areas based on presence of: 1) liquid anhydrous ammonia, 2) gaseous anhydrous ammonia, or 3) ammonia containing solutions.

Strategy for Liquid Anhydrous Ammonia: Do not allow direct contact with water. Actions that promote safe volatilization of liquid anhydrous ammonia may be useful since anhydrous ammonia in gaseous form is easier to decontaminate or allow to dissipate; volatilization may be a slow process depending on site conditions.

Strategy for Gaseous Anhydrous Ammonia: Ventilate spaces where gaseous anhydrous ammonia may be present. Impact on materials should be assessed for mitigation efforts, especially when in contact with liquid anhydrous ammonia. Mechanical, electrolytic, or chemical cleaning of corroded products may be needed. Forced or Hot Air ventilation methods are recommended for gaseous anhydrous ammonia contamination in large volumetric spaces or open areas.

Strategy for Aqueous Ammonia Solutions or Ammonium Hydroxide Solutions: Contain liquid or transfer liquid to appropriate containers and dispose according to WASTE MANAGEMENT section below.

Sensitive Equipment and Items: For difficult-to-clean equipment thought to be contaminated with small amounts of anhydrous ammonia, additional options for consideration include dissipation via monitored natural attenuation or flushing with water.

Verification of Decontamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.

Waste Management

Transportation: Federal requirements for transporting hazardous materials and procedures for exemptions are specified in www.fmcsa.dot.gov/safety-security/hazmat/complyhmregs.htm#hmp. Anhydrous ammonia (UN1005) and ammonia solutions >50% (UN3118) are considered Division 2.2 (non-flammable, non-poisonous gas) and Class 8 (corrosive) for transportation purposes. Ammonia hydroxide (UN2672) is considered Class 8 (corrosive) for transportation purposes. Current resources on packaging, labeling and shipping are available at www.phmsa.dot.gov/hazmat. Detailed state regulations can be found at www.envcap.org/.

Waste Management:
Under the Resource Conservation and Recovery Act (RCRA), waste is classified as hazardous waste (subtitle C) or solid waste (subtitle D). The RCRA regulations generally define a waste to be hazardous if it is: (1) a listed waste (40 CFR §261.31-§261.32); (2) exhibits specific characteristics (40 CFR §261.21-§261.24); or (3) is a discarded commercial chemical product, off specification species, container residue, or spill residue listed in 40 CFR §261.33. Concentrated ammonia waste may be corrosive hazardous waste, chemical code D002, if it is aqueous with a pH greater than or equal to 12.5 or it corrodes steel (§261.22). Listed or characteristic waste may be land disposed only if the waste meets the applicable treatment standards (40 CFR §268.40). Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), ammonia and anhydrous ammonia have a reportable quantity threshold (RQ) of 100 lbs and ammonium hydroxide has a RQ of 1,000 lbs (40 CFR §302.4).

The states (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the federal program, so it is critical to open a dialogue with state regulators as early as possible. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered.

EPA has developed **I-WASTE**, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contamination. Access to the EPA's web-based disposal tool requires pre-registration (http://www2.ergweb.com/bdrtool/login.asp).

EPA also recommends the creation of pre-incident waste management plans as a preparedness measure for chemical agent releases, and has created an **All-Hazards Waste Management Planning Tool** to help state, local, territorial, and tribal waste management officials coordinate and prepare these plans. Access to the All-Hazards Waste Management Planning Tool requires pre-registration (https://wasteplan.epa.gov/).