APPENDIX C. AMMONIA QUICK RESPONSE GUIDE

C.1 Overview of Spill Characteristics, Properties, Behaviors, and Hazards

Table C-1, Table C-2, and Table C-3 provide a high-level overview of ammonia spill characteristics, properties, behaviors, and hazards.

Table C-1. Ammonia spill characteristics (Kass et al., 2021).

Behavior when Spilled	Dissipation or Degradation Rate	Ecological impacts	Flammable /Explosion Risk	Toxicity	Air Displacement and Suffocation Risk to Crew	Spill Cleanup
Will partition into water forming a heated surface layer of ammonium hydroxide	Fast	No long term impacts, but marine life near the spill zone may be chemically burned and poisoned	Low	High	High	Will dissipate before cleanup can begin

Table C-2. Summary of key ammonia properties and behaviors (ITOPF, 2024a).

	Properties	Behavior
Boiling Point	-33.3 °C	At ambient conditions, ammonia is a gas.
Liquid Specific Gravity (@ -33 °C)	0.682	Ammonia is less dense than water; therefore, as a liquid, ammonia will float if spilled on water.
Vapor Specific Gravity (@ -33 °C)	>1.0	When ammonia initially vaporizes in the presence of water vapor, it will form a whiteish cloud denser than air above the ground/sea surface.
Vapor Specific Gravity (@ 20 °C)	0.597	Vapors of ammonia at ambient conditions are lighter than air (buoyant) and will easily disperse in open or well-ventilated areas.
Solubility (@ 20 °C)	529 kg/m^3	Ammonia is highly soluble in water.
Flammability Range	15.5 – 27.0 (v/v) %	Outside of this range, the ammonia/air vapor mixture is not flammable.

Table C-3. High-level overview of hazards associated with ammonia (ITOPF, 2024g).

State		Longevity in the Environment	Toxicity to Humans	Health & Safety: Main Concerns	Protracted Response to Recover Pollutant
Under Ambient Conditions	During Transport				
Gas	Liquid (pressurized and refrigerated)	Hours to days	Acutely toxic (vapors and upon direct contact)	Immediate risk in vicinity of substance, high toxicity with particular risk from vapors	Unlikely

C.2 Responder Safety Considerations

Ammonia poses a unique set of hazards due to its toxicity, corrosiveness, and ability to form hazardous vapor clouds. Unlike cryogenic fuels such as LNG or flammable liquids like methanol, ammonia is a toxic inhalation hazard and must be treated primarily as a chemical spill with both environmental and public safety implications.

Response teams should approach from upwind and remain outside the vapor cloud.

Visual indicators such as white vapor clouds and the pungent odor can assist in identifying affected areas, though odor is not a reliable exposure limit indicator.

Principal hazards include:

- Toxicity: Ammonia is highly toxic via inhalation, skin contact, and eye exposure. It can cause respiratory distress, burns, and in high concentrations, fatal pulmonary edema.
- Corrosiveness: Ammonia reacts with moisture to form ammonium hydroxide, a corrosive substance due to its basic (alkaline) nature that damages tissue and materials.
- Flammability: While less readily flammable than other fuels, ammonia can ignite in the 15.5 - 27% concentration range under specific conditions.
- Vapor hazard: Ammonia vapor is initially heavier than air but becomes buoyant with warming, spreading quickly in confined or poorly ventilated areas.

Personal Protective Equipment (PPE):

- Chemical-resistant suits and self-contained breathing apparatus (SCBA).
- Ammonia-resistant gloves.
- Mandatory use of intrinsically safe equipment.

Decontamination and medical support must be on standby due to the potential for chemical burns and respiratory injury. Response operations should prioritize evacuation, exposure limitation, and containment of further release.

C.3 Detection and Monitoring

Table C-4 shows how effective existing detection methodologies are for identifying ammonia.

Table C-4. Summary of detection methodologies for ammonia (Kass et al., 2021).

Visible	Radar	Infrared	Fluorescence	Chemical Analysis
Yes, will form a cold cloud on the water surface that will quickly dissipate	No	Potentially yes, depends on temperature reduction of ship and water surface	Unknown	Yes

Ammonia detection requires chemical-specific sensors capable of real-time air monitoring. Electrochemical detectors, portable gas monitors, and fixed sensor arrays are commonly used to identify hazardous concentrations. In the marine environment, detection efforts must be supplemented with visual observation of white clouds and deployment of personal monitors for all entry personnel.

Multi-gas meters may provide general atmospheric data but must include sensors calibrated specifically for ammonia. Photoionization detectors (PIDs) are not effective for detecting ammonia due to ammonia's high ionization potential and inorganic structure. They should not be relied upon for ammonia-specific response.

Uncrewed aircraft systems (UAS) equipped with gas detection or imaging sensors may support perimeter mapping and exclusion zone management, particularly in large or inaccessible areas.

Water monitoring is necessary in cases of aqueous release. Ammonia is highly soluble and reacts immediately with water to form a toxic, alkaline solution. pH sensors and ammonia-specific test kits can help determine concentration and spread in marine environments.

In confined areas such as storage tanks or port infrastructure, continuous monitoring and remote telemetry may be needed. All data collected should inform the establishment of hazard zones, responder positioning, and ventilation strategies.

C.4 Fire Fighting

While ammonia is not easily ignited, it can burn under specific conditions if concentrations are within the 15.5 - 27% flammable range. If a fire involving ammonia occurs, it is typically due to secondary ignition following release, as in the case of a pool fire or jet flame.

- Small ammonia fires – use dry chemical extinguishers.
- Large ammonia fires – Apply water spray to cool surrounding equipment/structures and suppress surrounding vapors.

Concerns/considerations:

- Foam is not effective.
- Water should not be applied directly to liquid ammonia spills due to increased vapor generation.
- Implement ventilation to disperse vapors in enclosed spaces. Coordination with facility operators is critical to shut down supply systems and prevent further leakage or escalation.

C.5 Spill Response

Spill response operations for ammonia focus on public safety, vapor suppression, and environmental protection. Because ammonia is highly soluble in water and toxic to aquatic organisms, immediate action is required to minimize spread and impact.

Traditional mechanical recovery methods such as absorbents, booms, and skimmers are ineffective. Instead, responders should isolate the source, implement exclusion zones, and use water spray to dilute and knock down vapors. Fixed or mobile water deluge systems can assist in vapor suppression during large-scale incidents.

In confined areas, positive-pressure ventilation may be required to maintain breathable conditions. Surface runoff must be controlled to avoid discharge into sensitive habitats, and any ammonia-contaminated water should be collected and neutralized where feasible.

Responders should notify appropriate environmental authorities and initiate water sampling protocols. Coordination with hazmat teams, port authorities, and public safety officials is necessary for effective containment and recovery planning.

C.6 Environmental Impacts

Ammonia spills in the marine environment can cause acute toxicity in aquatic life and damage to infrastructure. When released, ammonia dissolves readily in water, increasing pH and forming ammonium hydroxide, which is highly corrosive and toxic to gill-breathing organisms and plankton.

Localized fish kills and disruption of benthic ecosystems are possible in low-energy environments such as harbors and estuaries. In open water, ammonia dilutes more quickly, reducing its long-term persistence. However, the severity of immediate ecological effects depends on the volume released, metocean conditions, and temperature.

Ammonia does not bioaccumulate and is eventually assimilated into natural nitrogen cycles. Unlike oil or other hydrocarbons, it does not form persistent surface slicks or tar balls. However, infrastructure exposed to liquid ammonia or high vapor concentrations may experience material degradation due to corrosion or cryogenic damage.

Environmental monitoring should continue following containment to assess ammonia concentration, pH variation, and biological recovery. Post-spill assessments can inform future risk reduction strategies, emergency planning, and restoration activities where needed.