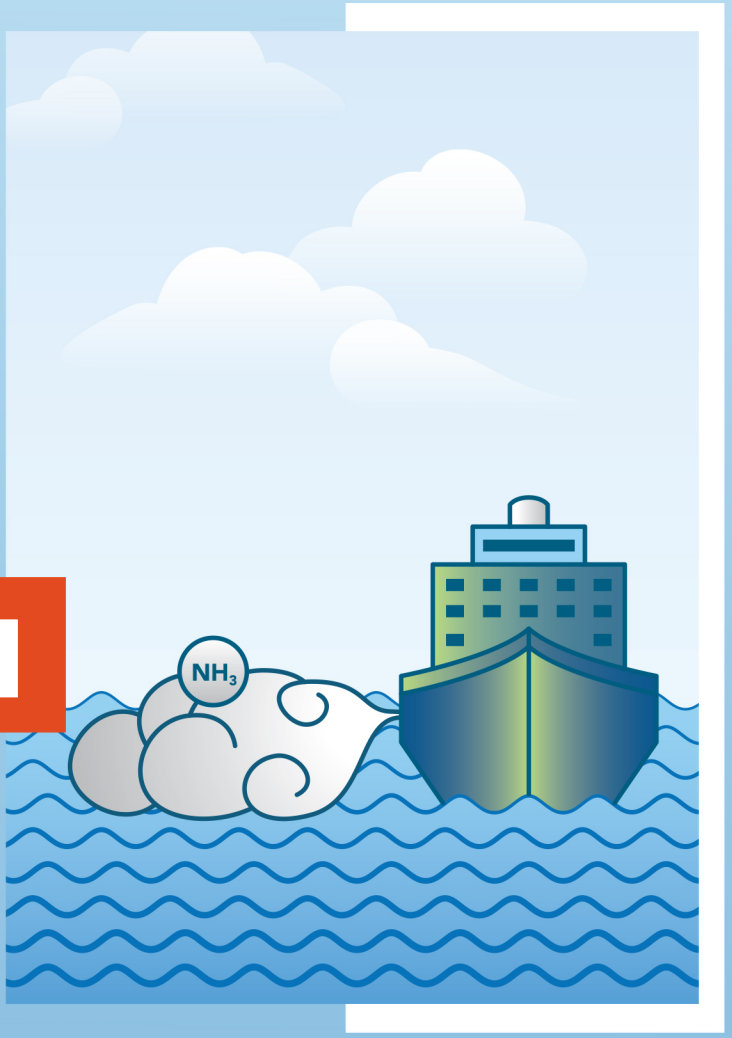
GCMD | updates

Global Centre for MARITIME DECARBONISATION

How do we respond to an ammonia release at sea?

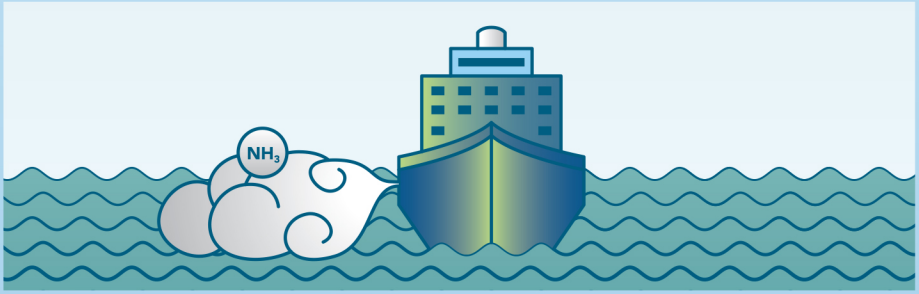


Accidental release of ammonia into the sea and air can be harmful to humans at high concentrations, and fatal in severe cases.

Can we adopt existing chemical spill emergency response plans (ERPs) to respond to these incidents?

The answer is **yes**, but with crucial modifications.

What happens when liquefied ammonia comes into contact with air?



Release of liquefied ammonia (-33°C) causes rapid expansion into gas, creating a cooling effect in the surrounding area.

This cooling effect condenses moisture in air, forming a dense, visible ammonia cloud. Some of the ammonia reacts with atmospheric moisture to form ammonium hydroxide (NH_4OH).

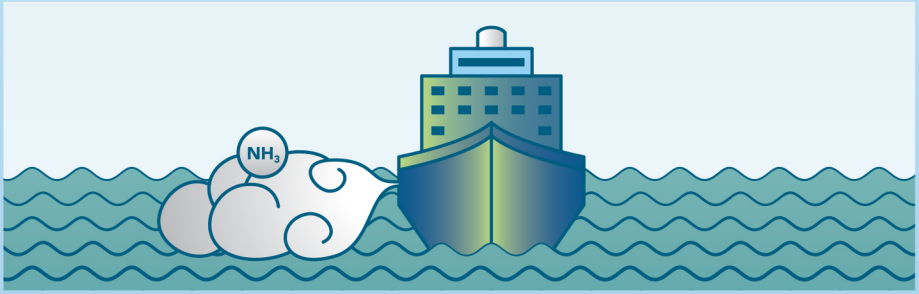
Weather conditions affecting dispersion:

Temperature:
- Ammonia boils at -33°C at atmospheric pressure. Temperatures greater than the boiling point of ammonia will cause it to vaporise.
- Cold ammonia vapour tends to stay close to the release level, which can increase the risk of exposure to humans.
- Ammonia is more volatile at yet warmer temperatures, leading to quicker dispersion in the atmosphere. This dispersion can increase the propensity of ammonia vapour reacting with other atmospheric pollutants, forming secondary pollutants, like PM2.5.

Humidity:
- In dry conditions, ammonia remains in its gaseous form, potentially increasing the risk of respiratory problems for exposed individuals.
- High humidity facilitates the formation of ammonium aerosols, contributing to air pollution.

Wind speed:
- In calm conditions, ammonia can accumulate in the release area, increasing local exposure risk.
- Strong winds can disperse ammonia quickly over a large area, reducing local concentrations but potentially affecting a wider region.

What happens when liquefied ammonia comes into contact with water?



Release of liquefied ammonia (-33°C) below the waterline forms ammonium hydroxide (NH_4OH).

Ammonium hydroxide solutions are lighter than water, floating on top and slowly diffusing into the water column. As aqueous ammonium hydroxide is colourless up to 30% concentration in water, visual observations of floating or dissolved plumes during spills are difficult.

Factors affecting ammonia dissolution in water:

- Rate and extent of ammonia vaporisation
- Heat generated from ammonia dissolving in seawater
- Reactions of ammonium hydroxide with seawater impurities
- Solubility of ammonium hydroxide at the specific sea temperature

Previous tests of ammonia release into water have shown that 55-60% of the ammonia dissolved in water. Therefore, the vapour above remains pungent, stinging, and irritating. A dissolved ammonia plume in seawater can continuously release ammonia vapour depending on current and wind conditions.

Safety levels of Ammonia Exposure

Ammonia poses significant health risks at different Acute Exposure Guideline Levels (AEGLs), as defined by the US Environmental Protection Agency.

These levels can guide the development of appropriate zones of concern and exclusion zones for spill sites.

Ammonia (CAS: 7664-41-7) expressed in parts per million (ppm)							
Exposure	**Health risks**		**10 min**	**30 min**	**60 min**	**4 hr**	**8 hr**
AEGL 1	Transient	Notable discomfort, irritation, or specific asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible	30	30	30	30	30
AEGL 2	Irreversible	Irreversible or severe, long-lasting adverse health effects or an impaired ability to escape	220	220	160	110	110
AEGL 3	Potentially life-threatening or fatal	Life-threatening health effects or death	2,700	1,600	1,100	550	390

Leveraging existing ERPs for ammonia release scenarios

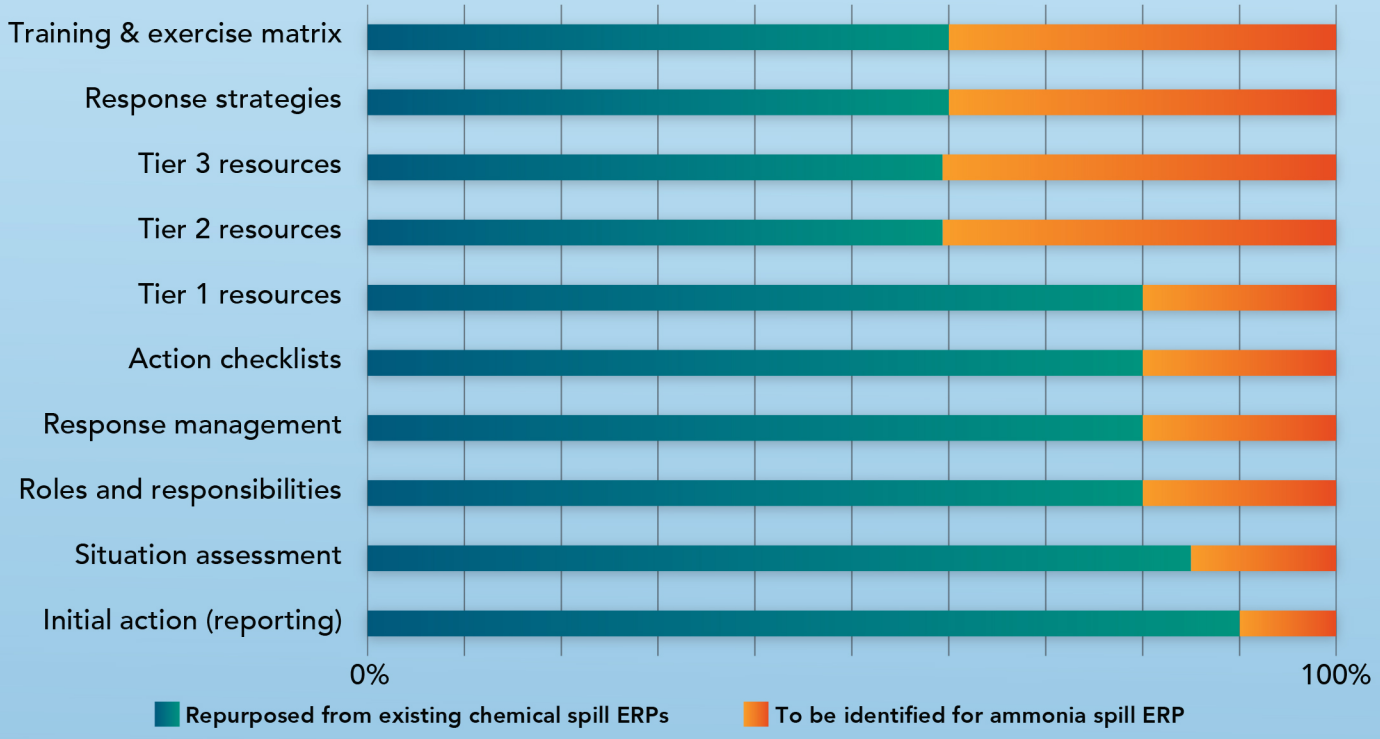
While existing ERPs for oil and chemical spills provide a strong knowledge base, they need to be adapted to address the specific properties of ammonia.

For example, a fire onboard an ammonia carrier can cause direct injuries and damage; heat from the fire can also vaporise ammonia, causing a build-up of vapour, leading to an unintended release.

GCMD is working with industry parties to develop a draft ERP for ammonia STS operations, with the aim of adapting it for bunkering.

Existing ERPs		+ Ongoing gap analyses	= Outcome
			
Shipboard Marine Pollution Emergency Plan (SMPEP)	**Shipboard Oil Pollution Emergency Plan (SOPEP)**	**Ammonia release gap analyses**	**Draft ERP for accidental ammonia release during bunkering**
Covers mitigation and response strategies for chemical spills incidents	Covers mitigation and response strategies for oil spill incidents	Ongoing work to identify and close gaps particular to ammonia release	

Repurposing existing ERPs for ammonia release



Identifying the gaps for an ammonia release ERP

The graph illustrates the extent to which existing ERPs for chemical spills can be repurposed for ammonia release ERPs.

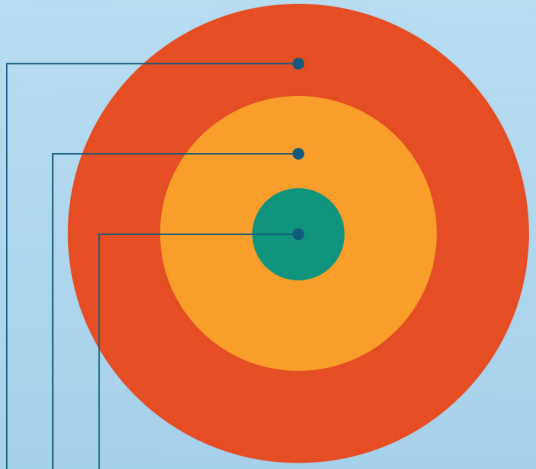
What can be repurposed?

Procedures for initial actions, like reporting, situation assessment, resources for multiple spill tiers and the responsibility matrix can be repurposed.

What are the gaps that need to be addressed?

Response strategies and training requirements specific to handling ammonia release need to be defined.

Responding to ammonia accidental release



Tier 1: Can be sufficiently handled by crew onboard; no external support is required

Tier 2: Requires potential external assistance from local authorities

Tier 3: Requires potential external assistance from global salvage companies or response organisations

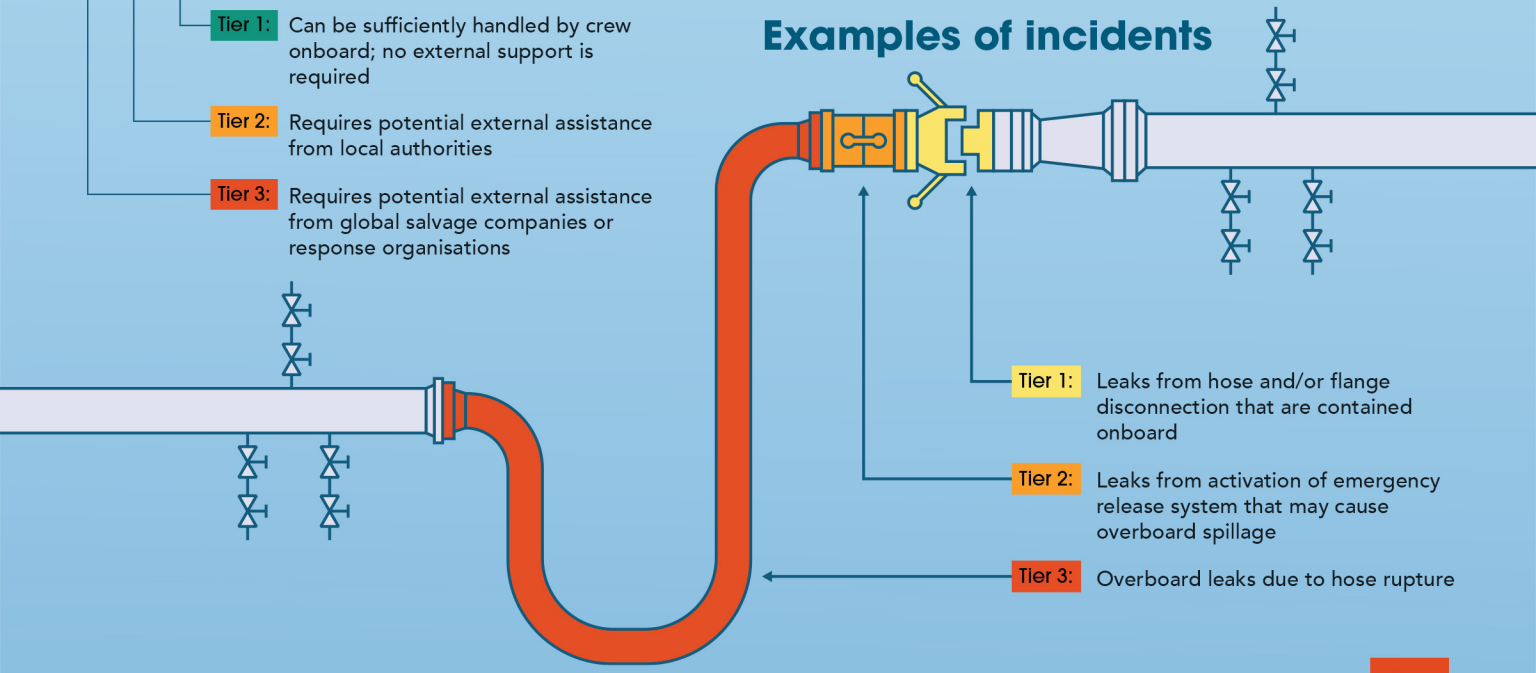
Responses are typically categorised into **three escalating levels** based on severity.

Determining tier levels helps prioritise and allocate resources based on magnitude, impact and consequences.

As ammonia disperses rapidly, Tier 1 response from vessel crew is critical.

Fire management within the vicinity of ammonia is also critical as ammonia can vaporise in the presence of heat, resulting in secondary release.

Examples of incidents

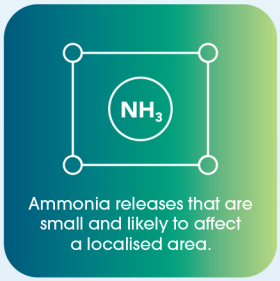
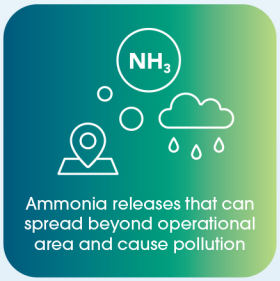
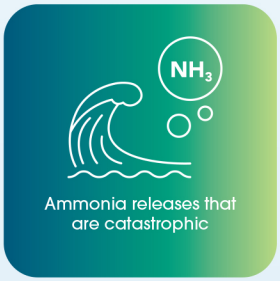


Tier 1: Leaks from hose and/or flange disconnection that are contained onboard

Tier 2: Leaks from activation of emergency release system that may cause overboard spillage

Tier 3: Overboard leaks due to hose rupture

Determining tier scenarios in the event of an ammonia release

	Tier 1	Tier 2	Tier 3
Examples of release scenarios	 Ammonia releases that are small and likely to affect a localised area.	 Ammonia releases that can spread beyond operational area and cause pollution	 Ammonia releases that are catastrophic
Mobilisation levels	**Onboard Crew**	**Incident Commander appointed by the vessel owner** Government authorities may take charge based on initial reporting and subsequent communication	**Government authorities** With Incident Management Team and Crisis Management Team
Characteristics of release and response	+ Release is contained onboard and toxicity risks are minimal + Fire that is localised and can be readily handled with onboard firefighting equipment + Resources can be easily managed using response resources available on the vessel + Minor environmental impact and likely to dissipate naturally	+ Possible continuous release with moderate toxicity risks + Fire that has spread to other areas, such as cargo or superstructure, that may not be readily handled with onboard firefighting equipment + Tier 1 resources and shipboard response team are overwhelmed, needs external response resources, agencies and/ or authorities + Potential environmental impact to sensitive areas and/ or local communities	+ Release has gone offboard with elevated toxicity risks + Fire that has spread extensively across multiple areas and cannot be handled with onboard firefighting equipment + Tiers 1 and 2 resources overwhelmed, requiring global salvage, international response resources, agencies and/ or authorities + Significant environmental impact to local communities, surrounding vessels, coastline or inland waterway

Upcoming provisional ERP report

Global Centre for MARITIME DECARBONISATION

Oil Spill Response

BlueTack.

SMT Stream Marine Technical

GCMD and partners are jointly developing an ammonia release draft ERP.

Keep a watch for the provisional ERP report scheduled to be released in 4Q2024.