8 FACT SHEETS

List of fact sheets

GESAMP hazard profiles

The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) is an advisory body, established in 1969, that advises United Nations (UN) bodies on the scientific aspects of marine environmental protect.

GESAMP evaluates Environmental Hazards of Harmful Substances (EHS) and aims to:

- provide human health and safety criteria to assist in the assignment of transport requirements for each substance, in accordance with the IBC Code;
- contribute to protecting the marine environment from the impacts of operational discharges or accidental spills from ships;
- establish hazard end-points which assist IMO in regulating the transport of bulk chemical cargoes.

To achieve this, each substance listed in the IBC Code has a “Hazard Profile” addressing 14 human health or environmental effects (Table 10). The GESAMP hazard evaluation procedure was specifically developed for the maritime transport of bulk liquid chemicals, but it is in line with the Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

	Hazard criterion	Comment
A- Bioaccumulation and Biodegradation		
A1	Bioaccumulation	Measures the tendency of a substance to bioaccumulate in aquatic organisms.
A2	Biodegradation	Used to identify substances with biodegradation characteristics (readily biodegradable (“RN”) and not readily biodegradable (“NR”))
B- Aquatic toxicity		
B1	Acute aquatic toxicity	Toxicity to fish, crustaceans and microalgae, generally measured in appropriate laboratory tests.
B2	Chronic aquatic toxicity	Reliable data on chronic aquatic toxicity, based on fish, crustaceans and microalgae.
C- Acute mammalian toxicity		
Distinguishes lethal toxicity as a result of exposure through the following routes:		
C1	Oral toxicity	Measured in appropriate tests with laboratory animals, based on human experience or on other reliable evidence.
C2	Dermal toxicity (skin contact)	
C3	Inhalation toxicity	
D- Irritation, corrosion and long-term mammalian health effects		
Distinguishes toxicity as a result of the following:		
D1	Skin irritation/corrosion	Measured in appropriate tests with laboratory animals, based on human experience or on other reliable evidence
D2	Eye irritation	
D3	Long-term health effects	Carcinogenicity (C), Mutagenicity (M), Reprotoxicity (R), Skin Sensitization to skin (Ss)/Rrespiratory Sensitization system (Sr) , Aspiration hazard (A), Specific Target Organ Toxicity (T), Neurotoxicity (N) and Immunotoxicity (I).

E– Interference with other uses of the sea		
E1	Flammability	Rated according to a measured flash point with subsequent risk of flammability.
E2	Behaviour of chemicals in the marine environment and physical effects on wildlife and on benthic habitats	Behaviour in seawater, i.e. the tendency to form slicks or blanket the seabed, evaluated on the basis of solubility, melting point, vapour pressure, specific gravity and viscosity.

Table 10: Hazard criteria/End-points used in the GESAMP Hazard Evaluation Procedure (Source: IMO, 2020)

Each substance's properties are listed on quantitative rating scales per category and often displayed in a single figure. The scales range from 0 ("practically non-hazardous" or "negligible hazard") to a maximum of 3 to 6, indicating an increasingly severe hazard.

The "GESAMP Composite List" (GESAMP, 2019) is issued annually. All substances are listed alphabetically by their assigned EHS name (and number) in concordance with the IBC Code. A Transport Reference Name and Number (TRN) are also given, as well as a CAS Number, if available. Details on rating criteria and information required to decipher abbreviations found in the GESAMP Composite List can be found in the "GESAMP Hazard Evaluation Procedure for Chemicals carried by Ships" (GESAMP, 2020).

EHS Name TRN Name	EHS TRN	A1a	A1b	A1	A2	B1	B2	C1	C2	C3	D1	D2	D3	E1	E2	E3
Hydrochloric acid	864	Inorg	0	0	Inorg	1	NI	1	1	3	3C	3			DE	3

A1	A2	B1	B2	C1	C2	C3	D1	D2	D3	E1	E2	E3
0	N	0	0	0	0	0	0	0	C	0	Fp	0
1	NR	1	1	1	1	1	1	1	M	1	Fp	1
2	inorganic	2	2	2	2	2	2	2	R	2	S	2
3		3	3	3	3	3	3	3	Ss	3	G	3
4		4	4	4	4	4			Sr	4	E	
5		5							A		D	
		6							T			
									N			

Figure 39: Illustration of a GESAMP hazard profile for hydrochloric acid (CAS Number 7647-01-0)

Hydrochloric acid (CAS Number 7647-01-0) is an inorganic substance (A2), which is likely to dissolve and evaporate in seawater (E2 = D and E). It does not bioaccumulate (A1 = 0) and has "practically no acute aquatic toxicity" (B1 = 1), therefore there is no information listed on chronic aquatic toxicity (B2 = NI). Hydrochloric acid has slight oral (C1 = 1) and dermal (C2 = 1) toxicity but moderately high inhalation toxicity (C3 =3). It causes skin corrosion (D1 = 3C ("full-thickness skin necrosis following exposure up to 3 min")) and is severely irritating to the eyes with irreversible corneal injury (D2 = 3). Hydrochloric acid has a high potential to interfere with coastal amenities (E3 = 3).

Safety data sheet content

BACK

A Safety Data Sheet (SDS) is a compulsory document issued by the chemical supplier which provides information on chemical products that ensure their safe supply, handling and use. SDS is required to follow a 16-section format and includes information such as the properties of each chemical; the physical toxicity and ecotoxicity, hazards; protective measures; and safety precautions for handling, storing, and transporting the chemical.

This document facilitates the risk assessment for the use of the substance.

Section	Title	Description
Section 1	Identification of the subs-tance/mixture and of the company/ undertaking	1. GHS Product Identifier 2. Other means of identification 3. Recommended use of the chemical and restrictions on use 4. Supplier's details (name, address, phone number, etc.) 5. Emergency phone number
Section 2	Hazard identification	1. GHS classification of the substance/mixture and any national or regional information 2. GHS label elements, including precautionary statements. Hazard sym-bols may be provided as a graphical reproduction of the symbols in black and white or the name of the symbol (e.g. "flame", "skull and crossbones") 3. Other hazards which do not result in classification (e.g. "dust explosion hazard") or are not covered by the GHS
Section 3	Composition/ information on ingredients	1. Substance 2. Chemical identity 3. Common name, synonyms, etc. 4. CAS number, EC number, and other unique identifiers 5. Impurities and stabilising additives which are themselves classified and which contribute to the classification of a substance 6. Mixture 7. The chemical identity and concentration or concentration ranges of all ingredients which are hazardous within the meaning of the GHS and are present above their cut-off levels. 8. Cut-off level for reproductive toxicity, carcinogenicity, and category 1 mutagenicity is ≥ 0.1% 9. Cut-off level for all other hazard classes is ≥ 1%
Section 4	First aid measures	1. Description of necessary measures, subdivided according to the diffe-rent routes of exposure (i.e. inhalation, skin and eye contact, and inges-tion) 2. Most important symptoms/effects, acute and delayed 3. Indication of immediate medical attention and special treatment nee-ded, if necessary
Section 5	Fire fighting measures	1. Suitable (and unsuitable) extinguishing media 2. Specific hazards arising from the chemical (e.g. nature of any hazardous combustion products) 3. Special protective equipment and precautions for fire-fighters
Section 6	Accident Release measures	1. Personal precautions, protective equipment, and emergency procedures 2. Environmental precautions 3. Methods and materials for containment and cleaning up

Section 7	Handling and storage	1. Precautions for safe handling 2. Conditions for safe storage, including any incompatibilities
Section 8	Exposure controls/ personal protection	1. Control parameters (e.g. occupational exposure limit values or biological limit values) 2. Appropriate engineering controls 3. Individual protection measures, such as personal protective equipment
Section 9	Physical and chemical properties	1. Appearance (physical state, color, etc) 2. Odor 3. Odor threshold 4. pH 5. Melting point/freezing point 6. Initial boiling point and boiling range 7. Flash point 8. Evaporation rate 9. Flammability (solid, gas) 10. Upper/lower flammability or explosive limits 11. Vapor pressure 12. Vapor density 13. Relative density 14. Solubility 15. Partition coefficient: n-octanol/water 16. Auto-ignition temperature 17. Decomposition temperature
Section 10	Stability and Reactivity	1. Chemical stability 2. Possibility of hazardous reactions 3. Conditions to avoid (e.g. static discharge, shock, or vibration) 4. Incompatible materials 5. Hazardous decomposition products
Section 11	Toxicological information	1. Chemical stability 2. Possibility of hazardous reactions 3. Conditions to avoid (e.g. static discharge, shock, or vibration) 4. Incompatible materials 5. Hazardous decomposition products
Section 12	Ecological information	1. Ecotoxicity (aquatic and terrestrial, where available) 2. Persistence and degradability 3. Bioaccumulative potential 4. Mobility in the soil 5. Other adverse effects
Section 13	Disposal considerations	Description of waste residues and information on their safe handling and methods of disposal, including the disposal of any contaminated packaging
Section 14	Transport Information	1. UN number 2. UN proper shipping name 3. Transport hazard class(es) 4. Packing group, if applicable 5. Environmental hazards (e.g. marine pollutant (yes/no)) 6. Transport in bulk 7. Special precautions which a user needs to be aware of, or needs to comply with, in connection with the transport or conveyance within or outside their premises
Section 15	Regulatory information	Safety, health, and environmental regulations specific for the product in question
Section 16	Other information	including information on preparation and revision of the SDS

Table 11: Risk assessment for the use of the substance

GHS vs UN TDG

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) and the UN Recommendations on the Transport of Dangerous Goods – Model Regulations (TDG) are the most important guidance documents on chemical hazard communication. Neither document is legally binding in any country.

Figure 40: GHS pictograms

The UN GHS Purple Book is a guidance document on the Globally Harmonized System of Classification and Labelling of Chemicals. It defines physical, health and environmental hazards of chemicals, harmonises classification criteria and standardises the content and format of chemical labels and Safety Data Sheets.

The UN Orange Book is the UN Recommendations on the Transport of Dangerous Goods – Model Regulations, a guidance document developed to standardise dangerous goods transport regulations. It forms the basis for most dangerous goods regulations such as the IMDG Code and IATA.

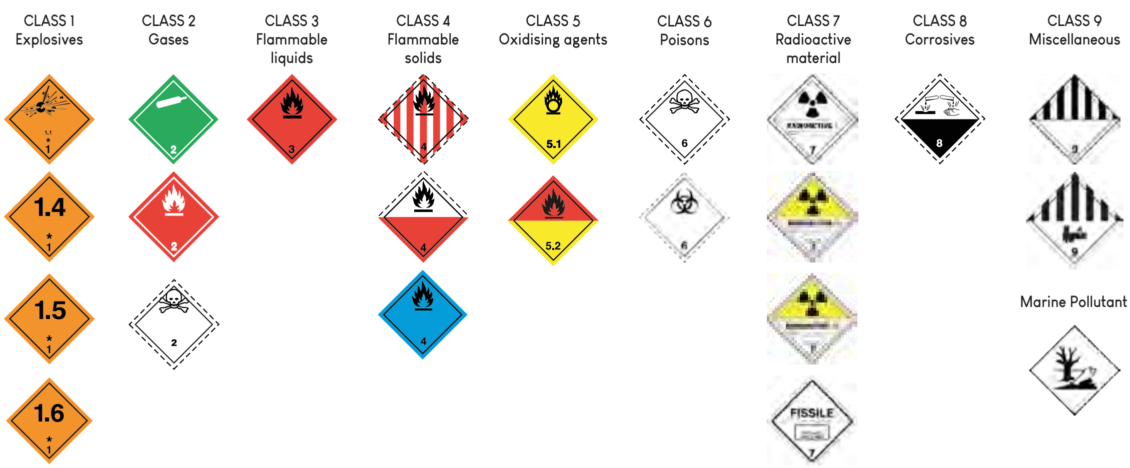

Figure 41: Classification of dangerous goods according to UN Recommendation

Hazardous chemicals vs dangerous goods

- **Hazardous chemicals** are chemicals meeting GHS classification criteria (GHS);
- **Dangerous goods** are chemicals and articles on the Dangerous Goods List or meeting dangerous goods classification criteria (TDG).

Most chemicals that are listed as dangerous goods are usually GHS-classified (and therefore hazardous chemicals) but not all dangerous goods are chemicals or GHS-classified (such as batteries or airbags).

	Transport of Dangerous Goods Model Regulation	**Globally Harmonized System of Classification and Labelling of Chemicals**
Alternative name	UN Orange Book	UN Purple Book
Purpose	Safe transport	Communicate chemical hazards to workers or recipients (occupational health and safety)
Scope	Dangerous, hazardous, and harmful substances, materials and articles	Chemical substances and mixtures
Classes	9 hazard classes	27 hazard classes
Hazard communication	• Hazard labels • Markings	• Pictograms • Signal words • Hazard and precautionary statements
Multi-layer packaging labelling placement	Outer package/ cargo transport unit	Inner package
Documentation	Dangerous Goods Manifest/ Declaration, Safety Data Sheet	Safety Data Sheet

Table 12: Hazardous chemicals vs dangerous goods

FACT SHEET 4.1

External communication

BACK

Information management is crucial to keep all external stakeholders and the general public informed and updated on the progress of the response and related matters. The communications team should be aware that different types of media will convey messages to different audiences. It is important to review the type of media utilised in order to ensure the best outreach for the target audience for every communication. This can include website updates, official press release statements and social media status updates, including photos.

Having an appropriate communication plan prior to an event improves the dissemination and quality of the response by the communication team. It is essential to have a set of engagement rules and pre-prepared statement templates. Therefore, the contingency plan should include a list of external outlets with which to communicate, such as local government, journalists, environmental groups, etc. This list should be kept updated by the communications team. Having a reliable online presence on social media prior to a crisis can help successfully share information during an event.

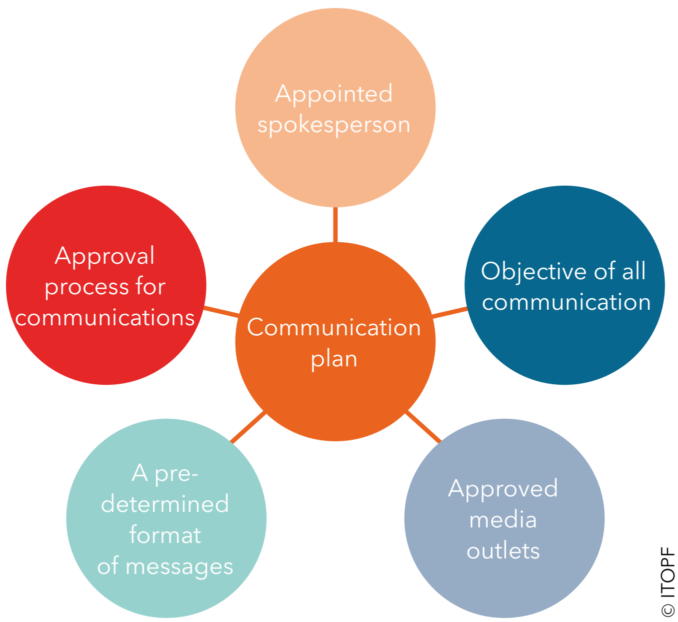

Figure 42: Communication plan

Important rules to note:

Appointspokesperson

A communication plan should appoint a single person to be the spokesperson during a response. This person should ideally undergo media training prior to an incident and be experienced in public speaking.

All official enquiries should be directed to the spokesperson.

Communicate early and often

Rumours or fake news can spread fast in the absence of readily available, accurate information. Therefore, communicating early on in a response can reduce the spread of false information. Keeping all external stakeholders and the general public updated on the progress of the response will affect how response efforts are perceived.

Keep it concise

Information must be concise. This is particularly important in the age of social media where short snapshots of information are favoured. Indeed, most social media platforms encourage succinctness, limiting the lengths of statements or allowing only short videos. The key points of the message should be conveyed in easy to understand, non-specialist language as efficiently as possible.

Stick to the facts

Only true and verified information should be shared. However, it is important to keep in mind that whenever limited information is available, communication might still be necessary, to inform the public of the actions taken so far. Partial or incomplete information from verified sources can sometimes be preferable to no information at all. However, unverified information should never be released.

Figure 43: Key issues relating to external communication - © ITOPF

▶ 4.2 Press conferences

The relationship between the media and the response effort

Different types of media, and their various sources, can influence numerous aspects of a response. Irrespective of whether a well-defined or poor media strategy was in place, media can have a huge impact throughout the incident, influencing many facets of a response. At the beginning of a response, the impact is more direct and immediate on strategy and operational aspects and the media has a duty to communicate facts and highlight societal issues. Furthermore, increased accountability of the stakeholders involved in the response will have a major positive impact on the effectiveness of the response. As the response moves into the project management phase, the media interest usually starts to decrease. However, reporting of the potentially negative impacts of a spill on human health, the environment and socio-economic resources means that it is often too late to counteract certain perceptions of damage which may lead to non-genuine claims.

This balance is difficult to achieve, and the communications team needs to be well trained to address these types of issues when they arise.

FACT SHEET 4.2

Press conferences

BACK

Drafting a press release and organising a press conference

Aim of organising a press conference: deliver a clear and managed message to a target audience.

Press statement

A press release statement is a tool that must be included in a contingency plan; it allows a pre-determined, concise message to be delivered to a wide range of media outlets to quickly and efficiently disseminate information. As with all external communication, any press statement should be approved by the On-Scene Commander (OSC) and the communications team.

▶ 4.1 External communication

Things to consider when drafting a press statement:

- answer the questions relating to the event: Who? What? Where? How?
- be concise, stick to the facts;
- use simple, straight-forward and non-specialist language;
- use a tone that reassures the end-user;
- provide contact details for all media and public enquires to allow your organisation to manage the incoming information efficiently.

Don't forget: the time, date and reference number of the statement release

Press conferences

Press conferences should be organised by the communications team with the approval of the OSC.

- Media outlets need to be invited and a presentation or statement should be prepared ahead of time to provide an update on the situation and as many facts as is appropriate to give a clear understanding of the situation.

- A spokesperson, who has adequate media training, should be appointed to deliver the press conference. However, questions may arise that are best answered by experts/specialists, who should therefore be part of the speaker panel. If this is the case, a moderator for the panel should be appointed.

- As with all external communication, all parties must be briefed on the key points and on the facts that have been checked to be released to external parties.

- Keep the communication channels open with the public and the media but direct them through your approved channels to ensure your organisation has as much control as possible to sort and prioritise queries.

- Try to provide regular press conferences to give updates throughout the response and provide a platform for the public and the media to ask questions.
▶ 4.1 External communication

Things to consider when planning a press conference:

- make a clear and planned opening statement summarising the key facts;
- be clear and concise;
- direct any questions requiring expert knowledge to the appropriate person on the panel;
- allow a fixed number of questions or set a specific time frame for questions (e.g. 5 questions/20 min);
- prepare for challenging questions from the media, and keep answers factual;
- anticipate questions and prepare answers;
- do not speculate, or answer questions outside your competence;
- limit the whole conference to an hour/hour and a half at the most to ensure key messages are not lost.

Questions to consider before the conference:

What happened?	Has anyone been injured?	What caused the incident?	Who is responsible for the incident?
What has been affected?	Who is going to pay for the response?	What is being done to solve the situation?	What are the risks for the local population?
What are the risks for the environment/ socio-economic factors?	What are the long-term risks of the substance spilled?	Could the accident have been avoided?	Who is involved?

Social media

Social media can intensify the pressure for official outlets to provide information and to keep up with information shared online. It is important to be proactive in the world of social media and act as a reliable and consistent source of information during an event. In relation to press conferences, the communications team should use social media to advertise the details of the press conference and distribute highlights from the press conference in a clear and concise manner. This will encourage the public to seek information from official rather than alternative sources.

FACT SHEET 4.3

Internal communication

BACK

During the emergency phase of a crisis, internal and external communication can be very challenging. Below are some common issues that arise, and ways to reduce their impacts on internal communication.

Lack of awareness of responsabilities

Having a developed and up-to-date communication plan prior to any crisis is essential to ensure roles and responsibilities are already defined. Each assigned team member should be aware of their role and have received adequate training prior to an event to allow them to fulfil the role competently.

Overwhelming incoming requests for information

Having a dedicated communication team is essential to prioritise key information received from various stakeholders. Information should be delivered to all parties simultaneously in a controlled manner, and not delivered piecemeal with each request.

Getting information to where it needs to go

A clear communication path is required to allow information to be delivered where needed across all internal teams efficiently.

The communication plan should outline how updates and essential information is delivered to different teams so that a clear path of internal information transfer is outlined.

Lack of meetings/openness with information

Regular and consistent updates across the internal team is crucial to ensure the response is well coordinated and informed. Meetings and briefings provide good opportunities for the communication team to deliver key messages which ensure a high level of understanding across the team. Liaison officers might ensure that rapidly changing developments are communicated effectively.

Figure 44: Main issues relating to internal communication

On-site communication

The transmission of information between responders and transmission to the On-Scene Commander (OSC) must be considered and prepared. Communication plays a key role in safety issues in the field throughout the various steps of the response.

Indeed, clear transmission of information is required, especially in the case of HNS for which a single letter in the name of a chemical can change everything. The use of the international alphabet for transmission of key words is recommended as well as asking the receptor to repeat information to ensure it has been received correctly.

During the response, responders should be able to communicate with team members. This might be possible for instance with type 1A suits equipped with bluetooth communication or by using agreed hand signals.

On site communication, SCOPE exercise 2017

Incident management team communication

The Incident Commander is responsible for implementing a communication plan that keeps all stakeholders informed. All information needs to be prioritised and filtered across the response team by a team dedicated to communication, ensuring that adapted, standardised and factual information is provided to all relevant parties in a timely and clearly transmitted manner. This communication can use a variety of means and tools including Very High Frequency (VHF) radios, emails, phone calls, text messages or any other applicable methods. It also includes Pollution Reports (POLREPs) to convey updates about the observed pollution.

▶ 5.1 Incident notification

These procedures need to be appropriate for team members in an office setting, as well as for those in the field on aircrafts, vessels or in remote locations. Therefore, suitable methods may be team-specific.

Internal communication will aim at:

- **informing** all stakeholders of the current situation and the process for communication channels;
- **outlining** the roles and responsibilities of each team within the response, and what is expected of them;
- **advising** by providing reliable advice on how to act in different situations regarding communications.

Communication plan

Information can be overwhelming for decision-makers during a crisis; a clear approach is required to allow information to be sifted through, organised and responded to in an appropriate and timely manner. For a communication plan to aid effective control of the information flow, it needs to include:

Waste management

BACK

Objective

The waste management strategy must be established at the start of the response. The key objectives of all provisions relating to hazardous waste management are the protection of human health and the environment against harmful effects throughout the different stages of waste management:

- recovery;
- storage;
- transport;
- treatment;
- upgrade or waste disposal.

Applicability

Waste can be generated during recovery, dredging or decontamination operations. The HNS spill itself can kill/contaminate flora and fauna and generate –sometimes huge– volumes of contaminated biological waste (animal carcasses, dead algae…).

Response strategy	Type of waste generated
Pumping, skimming and dynamic recovery	Recovered HNS Contaminated water Water-in-HNS or HNS-in-water emulsion Contaminated flotsam
Recovery with sorbents	Contaminated sorbents
Containment and recovery on the seabed	Recovered HNS Contaminated sediments
Decontamination of personnel and equipment	Contaminated water Contaminated material/PPEs Equipment that is difficult to decontaminate
Fire fighting	Fire-extinguishing water Cargo residues Burned-out containers
Recovery of damaged containers/tanks of HNS	Debris Hazardous and non-hazardous cargoes Improperly packaged HNS
Manual or mechanical recovery on the shoreline	Improperly packaged HNS Contaminated sediments Contaminated debris Contaminated sorbents Contaminated water Recovered HNS mixed with sediments

Table 13: Types of waste that may be generated in the case of a maritime HNS spill

Recovery/storage

Waste minimisation must be a permanent objective during response operations.

Waste segregation must also be emphasised as early as possible on the response sites. If waste is contaminated with one chemical/product, refer to Section 7 (Handling and storage) of the ▶ 3.1 Safety data sheet content. In the case of a mixture of chemicals, expertise from industrial hazardous waste specialists is required.

Contaminated materials may be sorted into the following categories:

- liquid;
- solid;
- non-biodegradable (contaminated plastics, contaminated clean-up equipment…);
- biodegradable (contaminated seaweed, fauna).

In terms of waste storage, different options can be used depending on the location, the volumes of waste to be recovered, the chemical properties, the state of the waste (liquid, solid) and the hazard level.

Storage capacities on the deck

When planning at-sea recovery, it is important to consider the waste storage capacity of the vessels used. If required, auxiliary tanks or containers can be installed on deck. In other cases, floating storage tanks can be towed.
▶ 4.5 Response vessels

Waste is then transferred to shore, to treatment units or to temporary land-based storage sites.

On the shoreline, temporary storage sites are also required in the vicinity of the clean-up worksites, for the immediate deposit of the generated/collected waste before their transfer to a treatment unit or an intermediate storage site. These sites should be equipped to contain leaks and rainwater.

Established at the start of the response, temporary storage sites should be accessible by road and should also be located as far as possible from homes, environmentally sensitive areas and watercourses.

Regardless of the type of storage considered, equipment should be:

- resistant;
- composed of materials compatible with the chemicals recovered;
- impermeable and equipped with a closing device;
- equipped with a level monitoring device (or sufficiently transparent to allow visual monitoring) in order to prevent overflow and anticipate the replacement of the container;
- equipped with a base valve for decanting;
- stowable, crane-liftable and transferable.

Transport

In terms of waste transport, it is necessary to:

- take into account the characteristics and hazard level of the waste;
- ensure compliance with transportation of hazardous goods and waste legislation (ADR by road, RID by train, etc.);
- award contracts to companies that are registered waste carriers and that have appropriate equipment and trained drivers.

Waste treatment and disposal

Treatment and disposal processes include methods by which chemicals and chemical-contaminated waste are valorised, eliminated or disposed of. Such methods are normally applied after the response phase. These techniques are performed at specifically licensed facilities after transportation of the hazardous materials.

The main waste treatment options are outlined below:

Industrial use:

- If the cargo recovered during response is unspoiled, it can be transported to the industrial firms concerned for normal use, after having undergone the relevant legal procedures.

Re-use/waste upgrading:

- The possibilities of upgrading waste will depend on three factors: the type of waste, the degree of pollution and the existence of suitable upgrading solutions. Several options exist, such as distillation and refining for solvents, energy production for certain flammable wastes and recovery for metals.

Biological treatment:

- It is possible to use micro-organisms that are able to break down certain chemical products such as chlorinated compounds or nitro compounds, alcohols or organic acids.

Thermal treatment:

- collected waste can be sent to special industrial waste incineration plants. In addition to energy recovery, this option has two further advantages: it decreases the volume of waste and reduces the hazardous nature of the substances involved;
- the atmospheric and aqueous discharges generated by this activity undergo different treatments and are strictly controlled before being released into the environment. Meanwhile, incineration residues, such as mud and clinker, are sent to specialised landfill sites.

Physico-chemical treatment:

- some waste is neutralised by stabilisation. An initial solution involves incorporating it with a mineral substance such as lime, cement, clay or activated carbon. Through this process, the waste forms clusters of varying sizes. This type of treatment is cost-effective but has the drawback of increasing the volume of waste;
- there exists an alternative, known as vitrification, whereby the waste is melted at a high temperature (between 1,200°C and 4,000°C according to the process) to form a glass matrix. It is then moulded into ingots or granules. This technique requires investments in substantial equipment and involves non-negligible energy consumption. It does however considerably reduce the volume of waste. Stabilised waste can in some cases be buried.

Burial:

- at appropriate storage centres (landfills). Waste burial is subject to increasingly tight regulations.

FACT SHEET 4.5

Response vessels

BACK

Objective

Advice on main capabilities and characteristics of response vessels to be sent to the incident area, taking into account the purposes they must fulfil in the area of the accident (monitoring, search and rescue, clean up).

Generality

The response vessel typology to use for responding to an HNS spill should be chosen carefully, and in accordance with the strategies detailed in the contingency plan; depending on political willingness, it is important to bear in mind that these dedicated vessel are quite expensive both in construction and maintenance but have high value in an HNS incident.

Many aspects need to be considered, including:

- sea state in which the vessel can navigate; therefore, if use is foreseen in open sea or in harbours;
- minimum depth for navigation (draught) (shallow or deep waters);
- minimum crew required;
- width of freeboard where required to work;
- mobilisation time and availability of vessel to arrive in involved area;
- response activities that the vessel must carry out, especially:
  - search and rescue,
  - detection & monitoring,
  - towage,
  - containment & recovery;
- consequently, equipment needed on board.

Due to the high costs of HNS response vessels, they are generally multipurpose.

Characteristics of a response vessel

If a vessel is to navigate in areas with a potentially toxic and dangerous atmosphere, its superstructure must be air-tight and at positive pressure and, most of all, clean air must be provided with filtering systems to accommodate the ship's crew during operations.

Different kinds of vessel with different designs could be used:

- **tug boats**: bollard pull is the most important measure; size and power must be sufficient for towage. There are harbour and ocean-going tugs, respectively used to tow a vessel out of a harbour or to tow it to a sheltered area ▶ 5.30 Places of refuge. A specific example of a tug boat is the Emergency Tow Vessel (ETV), a multi-purpose boat used by state authorities to tow disabled vessels on high seas;
  ▶ 5.29 Emergency towing
- **purpose built at-sea response vessels** (with sweeping arms, dispersant spray arms, skimmers, pumps, storage tanks, etc.): some such vessels have a substantial towing capacity;
- **offshore supply vessels**: a ship specially designed to supply offshore activities (mainly oil and gas platforms);
- **vessels of opportunity (VOO)**: boats usually used for other purposes (fishing, charter, etc.) utilised during an oil or HNS emergency. In general terms VOOs are defined as "Any vessel in the vicinity of the casualty vessel which may be able to provide assistance but is not formally part of the responsible authorities official response plan".

Purpose built at-sea response vessels with oil and HNS response capabilities

Oil tanker equipped by EMSA with oil response equipment

The characteristics of a HNS response vessel will depend on the activities that it must carry out. Vessels might need to be equipped to:

- provide medical care;
- detect and monitor pollutants, see Chapter 5.6.2;
- fight various types of fires (water/mist/foam);
  ▶ 5.34 Using water curtain
  ▶ 5.35 Using Foam
- contain and recover floating pollutants using booms and skimmers and suitable storage tanks, possibly with a heating (or cooling) system;
  ▶ 5.42 Containment techniques: Booms
  ▶ 5.43 Recovery techniques: Pumps and skimmers
  ▶ 5.37 Using sorbents

- recover containers and other goods lost at sea (using cranes, cradles, etc.) and provide sufficient deck storage capacity for such debris.
  ▶ 5.41 Packaged goods response
- perform underwater operations using divers or ROV in case of sunken chemicals or containers
  ▶ 5.39 HNS response on the seabed
- decontaminate personnel and equipment at the end of operations
  ▶ 5.21 Decontamination
- store large amounts of solid/liquid waste from clean-up operations and decontamination
  ▶ 4.4 Waste management
- launch small craft to transfer personnel from/to the casualty

EMSA (European Maritime Safety Agency) conducted a study aimed to propose vessel design and equipment requirements to operate in a range of scenarios in order to provide a safe platform for responders and any crew from the vessel involved in an HNS incident. Study proposes criteria for adaptation of different ship typologies in case of an HNS incident.

The level of design requirements needed for the vessels responding to HNS incidents in a safe manner is established on the basis of the potential hazards of the chemical substances and the consequent scenario as well as safety zones in which vessel is to navigate (H= High risk; M= Medium risk; L= Low risk) ▶ 5.19 Safety zones. The hazards taken into consideration are:

- flammable/explosive leak;
- fire;
- health hazard/toxic;
- cryogenic/gas under pressure;
- corrosive

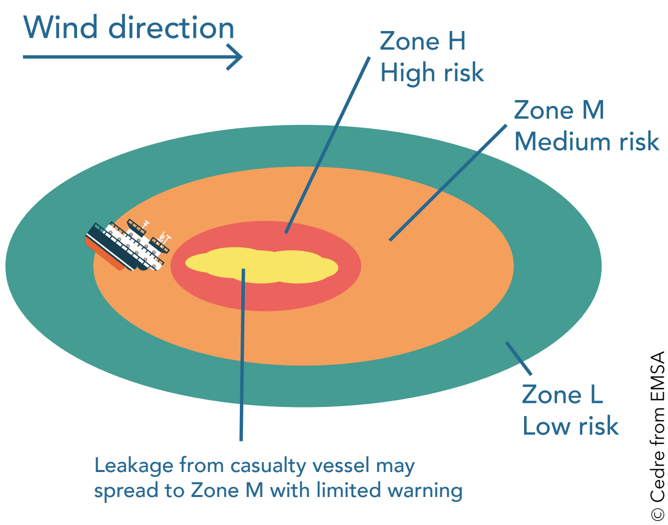

Figure 45: Zoning of incident area

Vessel response			**Zone applicability**
Type	Description	Requirements	
1	Vessel to approach (not to enter zone M or H). Main functions are: monitoring of situation and on-site control	Vessel will not require protective or specialist equipment, remaining at a safe distance from the hazards	L (low risk)
2	Vessel to approach (not to enter zone H) and deliver and recover response teams and rescue crew members by deployment of boats into zone M	Vessel will need to have some level of decontamination and medical facilities	L&M (low/medium risk)
3	Vessel to enter in hazardous environments, deliver response teams and rescue crew members	Vessel will have limited additional protection to allow it to operate in zone M and in exceptional circumstances also in zone H	M & limited H (Medium/high risk)
4	Vessel to enter in hazardous environment, deliver response teams and rescue crew members and recover hazardous substances	Vessel will have highest level of protection to operate for long periods in the high risk zone H. It should be specifically designed for this role	H (high risk)

Table 14: Vessel response according to zone mapping (source EMSA, 2012)

Acquisition and maintenance

BACK

Objective

To provide guidance on the acquisition and maintenance of pollution response equipment

Determining the risks for which equipment is purchased

Any procurement process for pollution control equipment must begin with the identification of the specific pollution risks: what type of pollution is likely to occur? Where are the potential pollution hotspots and what circumstances might lead to such pollution incidents? This type of risk assessment forms the basis of an HNS contingency plan. The pollution response equipment purchased should be part of the mitigation measures addressing the identified risk.

When choosing pollution response equipment, it is important to ensure that the equipment is suitable for the anticipated environmental conditions, meets chemical compatibility criteria and fulfils the specific conditions of use (for instance explosive atmosphere). It is interesting to look into past experience on the use of specific equipment intended to be purchased and to check whether tests conducted by the manufacturer were performed under near-real conditions.

Conditions of use

When choosing equipment, in general terms, it must be suitable for use in the specific conditions reported in the contingency plan. It is then important to evaluate where the equipment could be employed:

- **exposed areas** (open ocean): heavy-duty equipment suitable for rough weather conditions (swell, wind) and capable of collecting and storing large quantities of pollutant;
- **sheltered areas** (coastal, harbour): intermediate-sized equipment;
- **shoreline**: portable equipment.

Adaptation to the type of pollution

- **fire/explosion hazard**: if the flash point of the product is close to ambient temperature, it is advisable to use equipment that does not cause the substance to ignite (ATEX or Ex-proof certification);
- **compatibility of materials**: the pollution response equipment must be compatible with the spilled/recovered substances;
- **behaviour of the pollutant**: the equipment must be suited to the expected behaviour of the pollutant:
    - gas or evaporator: vapour reduction equipment;
        ▶ 5.34 Using water curtains
        ▶ 5.35 Using foam

- floater: containment, skimming, transfer, storage equipment;
  - ▶ 5.37 Using sorbents
  - ▶ 5.42 Containment techniques: Booms
  - ▶ 5.43 Recovery techniques: Pumps and skimmers
- dissolver: pumping of the water body and in situ treatment unit or equipment (in very confined environment);
  - ▶ 5.38 HNS response in the water column
- sinker: containment on the bottom, pumping on the bottom;
  - ▶ 5.31 Cargo transfer
  - ▶ 5.33 Wreck response
  - ▶ 5.39 HNS response on the seabed

- **sampling and detectors**: choose on the basis of chemical and physical properties of pollutants and depending on environmental matrices to be collected.
  - ▶ 5.25 Portable gas detectors for first response
  - ▶ 5.26 Sampling techniques and protocols

Indirect costs

In addition to the purchase cost of equipment, the following indirect costs must be considered:

- use of the equipment: complete list of all the necessary tools (e.g. crane to place it in the water; system for its towage, etc.);
- training of personnel to ensure the safe and effective use of the equipment;
- regular operational maintenance (qualified personnel, consumable and replacement parts, preventive/corrective maintenance, etc.);
- appropriate storage facility;
- shipment to and deployment of the equipment on site (during an incident or for exercises);
- disposal of contaminated materials ▶ 4.4 Waste management.

Sharing of equipment

Given the high direct and indirect costs of pollution response equipment, sharing of assets might be considered via an agreement for rapid provision of all or part of the necessary equipment by a storage cooperative, response company or equipment storage centre.

When stockpiles are placed in strategic locations accessible by multiple regions/countries it is important to ensure, for their common use, that:

- regional/bilateral/multilateral agreements are in place;
- transfer/shipping of equipment is pre-arranged (customs clearance, etc.);
- equipment is maintained and personnel are trained.

Equipment maintenance

Equipment to respond to an HNS spill is very delicate and expensive and, when required, it must be ready for use. Equipment maintenance is often overlooked but plays a fundamental role for two reasons:

- it guarantees operational readiness for the rare occasions on which it is required;
- it ensures economic savings by extending the lifetime of expensive equipment.

The use of such equipment can be sporadic and it can remain stored in the warehouse for long periods of time. Therefore, it is recommended to plan regular operational maintenance, conducted by qualified personnel, which also includes the implementation of tests. Equipment should be stored in suitable places, in accordance with the manufacturer's recommendations.

It is important to keep the response equipment maintenance log up-to-date. This log should include information on the use of the equipment (reason, dates, number of hours of use, etc.), and its maintenance (dates of maintenance actions, references of parts replaced, etc.).

Incident notification

BACK

Ship reporting systems and requirements (vessel to nearest coastal state)

Under MARPOL 73/78 as amended, it is the master's (or shipowner's) duty to report incidents involving a discharge or probable discharge of oil and/or HNS to the nearest coastal state. Incident reports can also be produced by responding or passing vessels. The standard reporting format is described in IMO Resolution A.851(20) (1997), as amended by Resolution MEPC.138(53) (2005), which differentiates between:

- Harmful Substances report (HS) for spills of oil and noxious liquid substances in bulk
- Packaged dangerous goods report (DG)
- Marine Pollutants report (MP)

Such reports should include information about the vessel (name, location, etc.) but also the type of oil or correct technical name of HNS on board/discharged/lost, UN number/IMO hazard classes, pollution category, type of packages, names of manufacturers where known, quantity on board/lost, whether substances are floating or have sunk, cause of loss, estimation of the surface area of the spill, name and number of the ship's owner and representative, measures taken so far.

International reporting between coastal states

Pre-agreed emergency communication channels (such as SafeSeaNet and CECIS Marine Pollution in Europe) might be used between Contracting Parties to alert –and request assistance from– other countries when a maritime pollution incident has occurred or when a threat of such is present (also see REMPEC (2018)). The standard POLREP used for this purpose is divided into three parts:

- **Part I or POLWARN** (POLlution WARNing): gives first information or warning of the pollution or the threat;
- **Part II or POLINF** (POLlution INFormation): gives detailed supplementary information as well as situation reports;
- **Part III or POLFAC** (POLlution FACilities): is used for requesting assistance from other Contracting Parties and for defining operational matters related to the assistance.

Pollution observation report

If a pollution report does not originate from the polluting vessel, but for instance from a surveillance aircraft, the message format will comply with the country's national or regional reporting standard for aerial surveillance (such as Bonn Agreement (2017) for oil). Such observation reports are unlikely to include exact information on the type and volume of the substance(s) spilled (e.g. UN number) and/or the vessel/cargo owner. Further investigation is therefore required to complete a ▶ 5.5 Situation assessment. Pollution observation reports play an important role in gathering photographic evidence (if possible) of the pollution and obtaining a better understanding of the fate/behaviour, extent and trajectory of a pollutant; therefore, it is crucial that aerial surveillance is conducted by trained and experienced observers.

Incident data gathering

It is essential that the following information be obtained as soon as possible in order to assess the situation.

	Information	Source
	BASIC INFORMATION	
✓	Name of vessel, IMO Number, MMSI (Maritime Mobile Service Identity), GT (Gross Tonnage), DWT (Dead Weight Tonnage), vessel owner	Ship Captain, Coast Guard, Maritime Rescue Coordination Centre (MRCC), Navy, Salvors, Harbour master's office
✓	Date and time of incident (LT/UTC)	
✓	Position (latitude/longitude)	
✓	Number of crew (including health status)	
✓	Cause of the incident (e.g. collisions, grounding, explosion, fire, etc.)	
✓	Nature of damage	
✓	Status of vessel and response operations as well as actions taken so far	
✓	Cargo on board and description of pollution or dangerous cargo lost overboard/spilled	
	CARGO - HNS	
✓	Cargo Certificate/Shipper's Declaration/Dangerous Goods Declaration, SDS ▶ 3.1 Safety data sheet content	Ship owner, cargo owner, P&I Club and correspondents, manufacturer, port authorities from last port of call
✓	UN or CAS number, state of chemicals: solid, liquid, gas, bulk, packaged	
	BUNKERS	
✓	Bunkering Certificate	Ship owner, cargo owner, P&I Club and correspondents, manufacturer
✓	Main characteristics: density, viscosity, pour point, distillation characteristics, wax & asphaltene content and volume	
✓	Distribution of cargo/bunkers/location relative to damage using the ship's General Arrangement Plan	
	POLLUTION OBSERVATION REPORT	
✓	Pollution observation: pollution incident report by the vessel, pollution observation report by authorities/general public	▶ 5.1 Incident notification

Table 15: Information gathering

During an HNS incident it is crucial to obtain verified details about the spilled substance's correct name and its properties. Shipping documents such as Cargo Certificate/ Shipper's Declaration/Bill of Lading/Dangerous Goods Declaration and the appropriate SDS are the best initial sources of information for substance-specific information. However, other resources might be needed to supplement the official documents available ▶ 5.3 Information resources. This type of documents is available from the ship/ship owner/cargo vary and might be dependent on the legal documentation requirements associated with the cargo itself and its mode of transport.

One crucial piece of information to find is the manufacturer's contact details, which might be needed to obtain the most recent and up-to-date SDS (or other substance-specific information).

The information available for a cargo is dependent on the type of vessel they are transported in (Chapter 2). Figure 46 below specifically highlights the sources for each key piece of information for each vessel type.

Key information	Containerised Cargo	Tanker	Bulk Carrier	Source
Exact Cargo Name	Bill of Lading	Bill of Lading	Bill of Lading	Shipper/Consignee
Exact Cargo Properties	Safety Data Sheet	Safety Data Sheet	Safety Data Sheet	Manufacturer
Summary	Dangerous Goods Declaration/ Cargo Manifest	Cargo Certificate/ Certificate of Origin	Shipper's Declaration	Shipper/Consignee
Location on board	Stowage Plan	Tank Arrangement Plan	Cargo Stowage Plan	Ship

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Figure 46: Summary of applicable sources of information available by cargo type

The **Bill of Lading** is a legal document acting as proof of receipt for the cargo on board, proof of transport agreement and title of ownership. It is issued by the carrier to the shipper and specifies the **original and specific cargo name**, type, quantity, and destination of the goods being transported.

Information resources

Shipping documents such as the Cargo Certificate/Shipper's Declaration/Dangerous Goods Declaration and the appropriate SDS and IMO code are the best initial sources to obtain substance-specific information. However, other resources might be needed to supplement the official documents available. Some information resources are listed below.

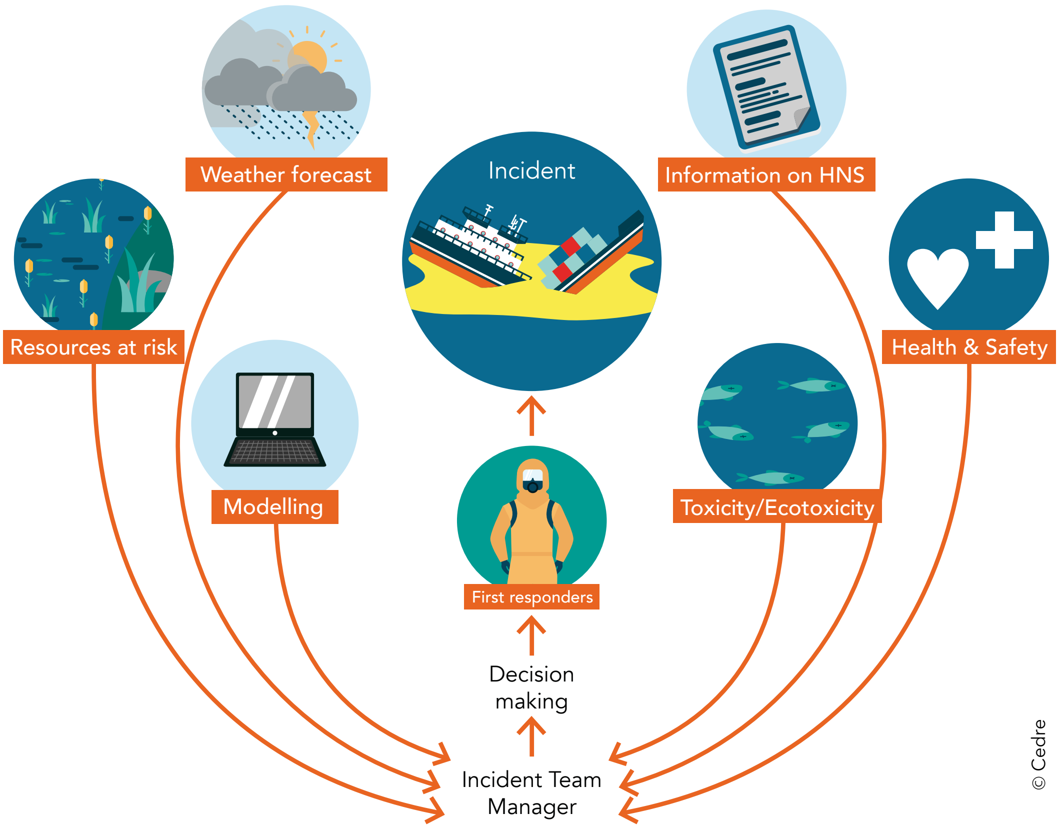


Figure 47: Information resources

Detailed information on HNS

- eChemPortal provides information on the properties of chemicals, biocides and pesticides including links to information prepared for government chemical programmes at national, regional, and international levels (including ECHA, 2020) (OECD, 2020);
- HNS-MS is a web-based decision support tool, composed of an HNS database, vulnerability maps and a 3D model to forecast the drift, fate and behaviour of acute marine pollution by HNS (DG ECHO, 2017);
- MARine Chemical Information Sheets (MAR-CIS) provide substance-specific and maritime-relevant information on chemicals, aimed at assisting the competent authorities during the initial stage of the response to maritime incidents involving such substances. They are available to EU Member States via log-in;

- Chemical Reactivity Worksheet (CRW) is software by EPA and NOAA that indicates the possible hazards due to mixtures of chemicals (CCPS, 2019).

Web-based response guides

- MIDSIS TROCS developed by REMPEC (2020);
- CAMEO Chemicals developed by NOAA (2018).

Modelling ▶ 5.11 HNS spill modelling

- CHEMMAP: fate and behaviour modelling (aquatic and atmospheric) (RPS, 2020);
- ALOHA: atmospheric dispersion model by NOAA (2020).

Occupational health and safety ▶ 5.20 Personal protective equipment

- International Chemical Safety Cards (ICSCs) provide essential safety and health information on chemicals (ILO, 2020);
- GESTIS is the Information system on hazardous substances of the German Social Accident Insurance with a strong focus on Personal protective equipment (IFA, 2020).

Toxicity/ecotoxicology ▶ 5.7 Response considerations: Toxic substances

- GESAMP provides a composite list of hazard profiles for substances transported in bulk by sea in accordance with MARPOL Annex II;
- PubChem is a large collection of freely accessible chemical information including chemical and physical properties, toxicity and ecotoxicity, health and safety, patents and further literature citations (NIH, 2020);
- CAFE (the Chemical Aquatic Fate and Effects database) summarises information on the fate and effects of chemicals, oils, and dispersants and aims to assist in assessing environmental impacts on aquatic species (developed by NOAA);
- Cedre Chemical Response Guides (Cedre, 2020).

First responders

- Fire brigade, Civil Protection;
- The CEFIC Emergency Response Intervention Cards (ERICards or ERIC's) provide guidance on initial actions for fire crews when they first arrive at the scene of a chemical transport accident without having appropriate and reliable product-specific emergency information at hand (CEFIC, 2020);
- PHMSA's Emergency Response Guidebook (ERG) provides first responders with a go-to manual to help deal with hazmat transportation accidents during the critical first 30 minutes (USDOT, 2020).

Resources at risk

- Contingency plans, ESI maps;
- Environmental resources:
  - Conservation tools such as:
    - Protected Planet, an up-to-date and complete source of information on protected areas, updated monthly. It is managed by the United Nations Environment World Conservation Monitoring Centre with support from IUCN and its World Commission on Protected Areas (Protected Planet, 2020).
    - IUCN Red List of Threatened Species (IUCN Red List, 2020a)
    - IUCN Red List of Ecosystems (IUCN Red List of Ecosystems, 2020b)
  - Digital Observatory for Protected Areas, which can be used to assess, monitor, report and possibly forecast the state of and the pressure on protected areas at multiple scales (Joint Research Center, 2020);
- Socio-economic resources (aquaculture, amenities, etc.).

Weather forecast

- National meteorological services, national hydrographic office;
- Current and predicted weather and sea conditions, wind speed and direction, water and air temperature.

International assistance

- Requests for assistance via HELCOM, REMPEC, Bonn Agreement and CECIS Marine Pollution;
- EMSA (activated by member state's maritime administrations)
  - MAR-ICE Network (providing remote as well as on-site advice for member states in case of a chemical spill);
- IMO "Guidelines on International Offers of Assistance in Response to a Marine Oil Pollution Incident". Developed for incidents that exceed a country's capacity for oil spill response and may be used as a non-binding supplement to existing bilateral and multilateral agreements for support (IMO, 2016);
- Mediterranean Guide on Cooperation and Mutual Assistance in Responding to Marine Pollution Incidents (REMPEC, 2018);

Packaged goods identification

Dangerous goods containers washed up on the shore following a shipping incident

Packaged goods may be accidentally lost overboard, jettisoned in an emergency situation or contained in sunken or grounded vessels. They may be carried over considerable distances by the effects of currents, wind, or tides.

To aid the identification of hazards, all dangerous goods packages and their cargo transport unit must be appropriately marked (Proper Shipping Name, UN number and MP mark) and labelled (primary and secondary hazard labels) before transport (as per IMDG Code (Chapter 2). However, when packages remain in the marine environment for a certain time, their markings and labels may no longer be legible (e.g. covered by marine flora and fauna, partial destruction of label, ink washed off).

Dangerous goods containers on board

Freight container identification

While the most common types of freight containers are 20-foot or 40-foot dry storage containers, there are also flat rack (open sides and top), open top, refrigerated, tank and many other types of containers. As per the IMDG Code, all containers carrying dangerous goods must display the following (see example in Figure 48):

- main and subsidiary hazard placards (250 x 250 mm) of all dangerous goods inside the container;
- UN number if the DG are in excess of 4,000 kg gross mass (either separate placard of 300 x 120 mm or jointly with the main hazard placard).

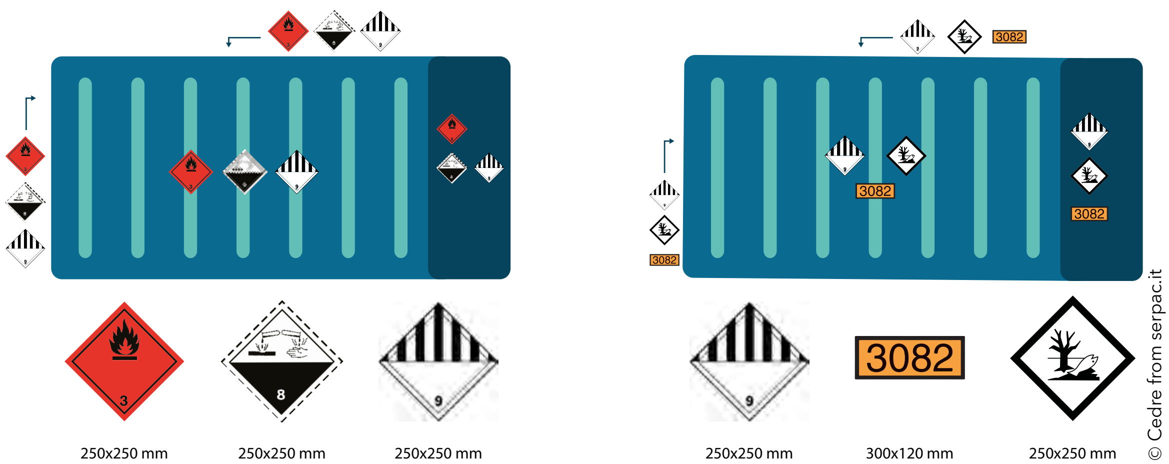


Figure 48: Container carrying DG of different UN numbers or one DG with a subsidiary risk (left); Container carrying DG of UN3082 in excess of 4,000 kg gross mass (right)

Package identification

Inside a container, the cargo may be shipped "loose" (such as fish, paper rolls, cars, etc.) or in various receptacles (Table 16).

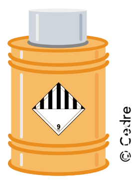
Type	Material	Picture
Drums	Steel, aluminium, plywood, fibre, plastics, other metal	
Jerricans	Steel, aluminium, plastics	
Boxes	Steel, aluminium, natural wood, plywood, reconstituted wood, fibreboard, plastics, other metal	
Bags	Woven plastics, plastic film, textile, paper	
Composite packaging	Plastic/glass/porcelain/stoneware receptacle in drum/box/other packaging	
Intermediate Bulk Containers (IBC)	Metal (steel, aluminium, other), flexible material (plastics, textile, paper, rigid plastics, composite, fibreboard), wooden (natural, plywood, reconstituted wood)	

Table 16: Packaging types and materials as per IMDG Code Chapter 6

All packages or outer packages (if composite packaging) should display the following (Figure 49):

- Main and subsidiary hazard label (Chapter 2.3.4);
- PSN and UN number (Chapter 2);
- UN packing markings (see below);
- Orientational label (optional).

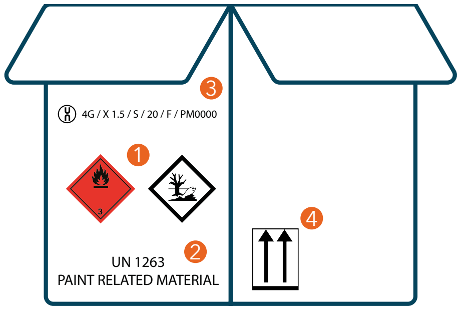


Figure 49: Example of box identification

Content: UN 1263, Paint; Hazards: Flammable liquid, marine pollutant; Packaging: UN certified fibreboard box, tested for PG X, maximum gross weight 15 kg, manufactured by PM0000 in the Netherlands in 2020

All package markings should be readily visible and legible, displayed on a background of contrasting colour on the external surface of the package and should not be located with other package markings that could substantially reduce their effectiveness. Also, the information should be identifiable on packages surviving at least three months' immersion in the sea.

UN packaging markings

The packing specifications of the outer package are standardised (included in the IMDG code, Vol. 1 Chapter: Construction and testing of packagings). Package markings only describe the specifications of the package itself, rather than what it carries; therefore, a package certified to carry dangerous goods of the highest degree of hazard might be carrying innocuous substances.

1. The **United Nations symbol** indicates that the packaging has been tested and certified according to the UN standard.
2. The **Packing Identification Code** specifies the type of container, the material used and packaging head or material wall type.
3. The **letters X** (Packing Group I – highest degree of danger), **Y** (Packing Group II – medium degree of danger) or **Z** (Packing Group III – lowest degree of danger) indicate for which packing group the package was tested.
4. The **gross mass for solids** indicates the maximum gross mass in kg that the package is allowed to carry (packing including content). The **specific gravity for liquids** indicates the maximum specific gravity allowable for that package.
5. **For solids "S"**; for liquids the marking indicates the **maximum hydrostatic pressure** the container was tested at in kPa.
6. Two last digits of the **year of manufacture**.
7. **Abbreviation of the manufacturing country**.
8. **Code, name and address or symbol** identifying the approval agency or the manufacturer.

However, operationally, during the response, seeing the parcel/package/box is often more useful than knowing what all the codes stand for.

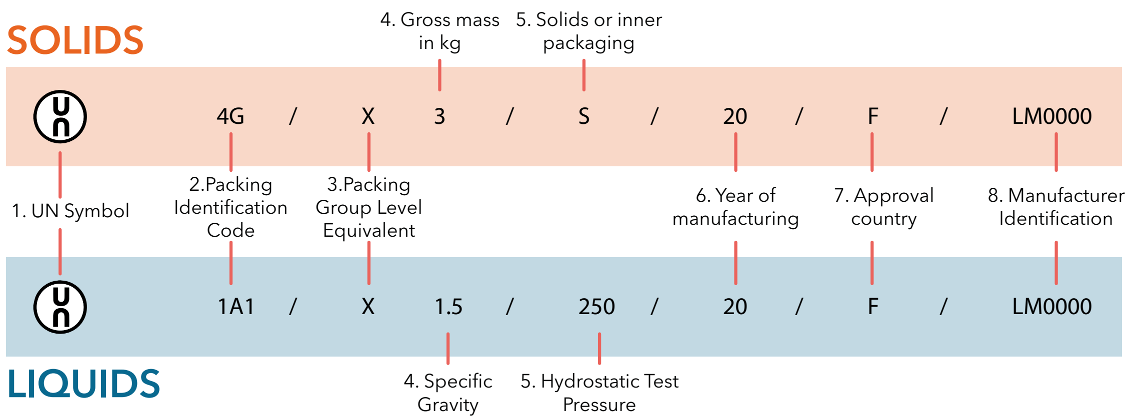


Figure 50: UN package identification for liquids and solids

Example for solids: UN certified fibreboard box capable of carrying solid goods of Packing Group I (highest degree of danger) with a gross mass maximum weight of 3 kg. The box was manufactured by LM0000 in France in 2020.

Example for liquids: UN certified steel drum with non-removable head capable of carrying liquids of Packing Group I (highest degree of danger) with a maximum specific gravity of 1.5. The maximum hydrostatic pressure the drum was tested at is 250 kPa. The drum was manufactured by LM0000 in France in 2020.

Situation assessment

Objective

Following the reporting of an incident, situation assessment is the starting point of the decision-making process and should help to define the strategy for protecting the population, environment and/or amenities. Therefore, the situation assessment should take into account existing or potential risks, directly related to the conditions of the accident. When the strategy is defined, it can be translated into tactics and techniques to be deployed in the field. This is an on-going process that should be regularly updated.

Applicability

Situation assessment is required for any intervention. Depending on the size and conditions of the incident, the risk assessment may be different and the risk assessment procedures should be detailed in the contingency plan (see Chapter 4):

- for a small leakage, proficient personnel trained in chemical hazards can assess the situation and, on the basis of procedures indicated in the emergency plan, can implement first measures to stop or mitigate the HNS release.
- for more complex situations involving HNS, such as a large spill, a high potential impact, a high level of hazard, difficult salvage or response operations, a more robust assessment of the situation is required before response implementation. In this case, the situation assessment is performed according to the planning section of the structural organisation.

Method description

The situation assessment process uses information gathered on the incident ▶ 5.2 Incident data gathering, especially to identify hazards related to the HNS involved. Thanks to information included in the contingency plan (see Chapter 4), collected during the preparatory phase, it can be cross-linked with identified hazards to estimate risk and vulnerability.

Risk can be estimated by combining the probability of a hazard occurrence and the potential scale of consequences such as injury, damage or loss (socio-economic, environmental, etc.).

The risk assessment approach in case of an incident is different from that during the preparatory phase to develop contingency planning. In the first case, specific information related to hazards should be collected (▶ 5.2 Incident data gathering) on the HNS involved and the exact conditions of the incident. The risks and their probability of occurrence are assessed to anticipate the potential worsening of the situation. In the second case, risks and their probabilities are based on statistics for vessel traffic, HNS transported, as well as frequency and type of past incidents in the area considered.

From the probability of risk occurrence, potential **consequences can be evaluated** and will correspond to worsening conditions. For example in the case of an explosive or flammable chemical, the risk of the vapour cloud igniting should be assessed.

Figure 51: The 3 main steps in the situation assessment

Possible impact on:	**Hazard identification**	**Estimation of risk and vulnerability. Need to refer to similar past incidents (similar conditions or hazards)**	**Evaluation of consequences**
Humans	- Physical hazards of HNS: danger class(es), sub class(es) of danger - Toxicological levels - Hazards related to the vessel - Environmental conditions	Probability of population being exposed to HNS	- Number of proven or potentially injured people - Health impact on population, responders
Environment	- Consider hazards of HNS on for the environment - Ecotoxicological effects - Environmental conditions	Probability of the pollutant reaching environmentally sensitive areas identified in the contingency plan	Proven or potential impacts on the environment (value, structure, function or ecosystem)
Socio-economic activities and amenities	Hazards for areas or entities, for instance: aquaculture, water intakes, tourism, etc.	Probability of the pollutant to reaching socio-economically sensitive areas identified in the contingency plan	Losses: proven or potential costs, loss of activity, etc.

Table 17: Description of the three main steps of situation assessment

As far as possible, relevant data to assess hazards, risk/vulnerability, as well as consequences, should be quantitative. All these data can subsequently be gathered in a table, dated and recorded for further archiving.

To anticipate possible changes in the situation, some input data should be considered as they worsen or become increasingly favourable. These can be for instance:

- environmental conditions (change of weather, tide, etc.);
- sensitive period (forthcoming peak period, for instance during holidays, political elections, etc.) or location (remote area, difficult access, etc.).

Special care for incidents involving containers

Searching for information in cargo manifest is drastically time-consuming when faced with several hundreds or even thousands of containers. This task should be performed through a collaborative effort and by people familiar with (or at least with sufficient knowledge of) the use of the IMDG Ccode and information resources related to containers.

Tips: use a spread sheet obtained from an expert organisation to identify containers, danger classes, UN number, etc. It is useful to rank and highlight more problematic containers. If the situation were to evolve, this would allow the response team to modify the ranking (for instance initial ranking for a vessel on fire will be modified in case of shipwreck).

Required personnel/equipment

Personnel involved in the Incident Team should include:

- experts in different fields involved: naval officer, chemical engineer, environmental engineer (biologist, ecologist, etc.);
- local experts on potentially impacted sensitive areas.

Considerations

- A situation assessment may be time-consuming due to a lack of available data (on HNS, vessel, contingency plan).
- In case of a mixture of chemicals: possible hazards due to the mixing of chemicals should be considered and a medical expert should be consulted to assess the possible effects of combined exposure to multiple chemicals.
- The reliability level of the situation assessment is directly correlated to the quantity and reliability of information gathered from the incident.

▶ 5.2 Incident data gathering

FACT SHEET 5.6

Response
BACK

Response considerations: Flammable and explosive

Related GHS pictograms and UN Regulation

Examples of related case studies:

- ***Cason*, 1987**, Cape Finisterre, Galicia, Spain; Sodium (1,400 barrels) and other hazardous chemicals (flammable/toxic/corrosive products in 5,000 different package forms; 1100 tonnes transported and spilled). Cause of spill: fire on board (reaction of sodium with seawater) and subsequent grounding.
- ***Val Rosandra*, 1990**, Port of Brindisi, Italy; Propylene (1,800 tonnes in bulk, controlled burning, quantity spilled: 0). Cause: fire.
- ***Alessandro Primo*, 1991**, 30 km off Molfetta, Adriatic Sea, Italy. Acrylonitrile (549 tonnes in 594 barrels) and of Dichloroethane (3, 013 tonnes); recovery from sunken wreck. Cause: structural damage subsequent due to a storm.
- ***Igloo Moon*, 1996**, outside Key Biscayne in South, Florida; Butadiene (6,589 tonnes, recovery of the cargo, quantity spilled: 0). Cause: grounding.
- ***MF Ytterøyningen*, 2019**, Norwegian; Ethylene Glycol leak (coolant components). Cause: fire and subsequent explosion (failure communication failure between the EMX –Energy management system– and the battery packs).

Alert and notification in case of a potential leak:

Depending on the location of the incident, the MRCC, site emergency services and public emergency services must be alerted. Ships (crew) and the population downwind (vapour cloud) and downstream (spill) must also be warned in order to prevent complications arising.

Applicability and main risks:

For more information and a description of the flammability and explosivity of substances, refer to Chapter 3 on hazardous substances.

Applicability[1]	Risks for humans/ responders	Risks for the environment	Risks for amenities
- Leakage of gas from a sealine (subsea pipeline) - Leakage of liquefied gas - Mixing of reactive chemicals forming gas - Evaporation from slicks - Gas cloud formed after reaction of chemicals	- Direct injuries due to fire or explosion - Anoxia, asphyxia, especially in confined space - Depending on chemicals: toxicity or corrosivity	- No major expected chronic impact expected - Possible indirect impact (e.g. fire residues)	- Window-shattering explosion, - Building destruction

Table 18: Flammable and explosive substances: applicability and main risks

[1] Events leading to a flammable/explosive situation

Risk assessment

- Risks of flammability or explosion must be assessed by monitoring the LEL/LFL and UEL/UFL values and the evolution of concentrations over time.
  ▶ 5.25 Portable gas detectors for first responders
  ▶ 5.26 Sampling techniques and protocols
- Forecast of the gas cloud drift must be requested from experts.
- If applicable (regarding the characteristics of the chemical and the situation), the toxicity risk should be assessed, as well as corrosivity.
  ▶ 5.7 Response considerations: Toxic substances
  ▶ 5.8 Response considerations: Corrosive substances

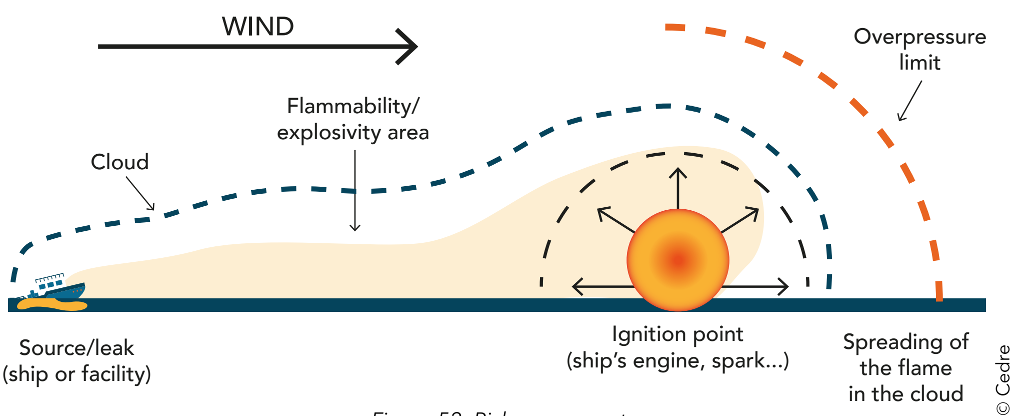


Figure 52: Risk assessment

- Areas to consider for intervention:
- Consider (and control) aggravating factors:
  - in the event of fire, prevent the risk of BLEVE by cooling tanks in direct contact with heat radiation; risk of toxic gas production.

Protective measures (human health, environment and amenities)

- Evacuation:
  - the distressed vessel's crew: the helicopter/rescue ship must approach from downwind;
  - the population: modelling should be carried out to determine the specific area to evacuate or the containment measures to be implemented.
- Protection:
  - ventilation of the explosive atmosphere in order to lower the LEL/LFL;
  - activation of the existing firefighting systems;
  - gas or vapour cloud should be prevented from entering confined or closed areas and obstacles must be removed (if possible) to reduce turbulence;
  - protection of responders against inhalation of vapours or mist.
    ▶ 5.20 Personal protective equipment

Reminder: a flammable cloud may **become explosive** when the speed of the front flame exceeds several meters per second (due to HNS nature, atmosphere turbulence and obstacles) or in a confined space. Continue to monitor the LEL/LFL throughout the response.

Response measures

- Stopping the leakage;
  ▶ 5.32 Sealing and plugging
- Elimination of sources of ignition.
  - Behaviour:
    ▶ 5.13 Response considerations: Gases and evaporators
    ▶ 5.14 Response considerations: Floaters
  - Techniques:
    ▶ 5.19 Safety zones
    ▶ 5.34 Using water curtains
    ▶ 5.35 Using foam
    ▶ 5.36 Natural attenuation and monitoring

FACT SHEET 5.7

Response considerations: Toxic substances

BACK

Related GHS pictograms and UN Regulation

Examples of related case studies:

- ***Cavtat*, 1974**, southern Italy, Tetraethyl lead and tetramethyl lead;
- ***Burgenstein*,1977**, port of Bremerhaven, Germany, Sodium Cyanide, Potassium Cyanide;
- ***Sindbad*, 1979**, North Sea, Chlorine;
- ***Testbank*, 1980**, Louisiana, USA, Hydrogen Bromide
- ***Rio Neuquen*, 1984**, Port of Houston, USA, Aluminium Phosphide;
- ***Santa Claira*, 1991**, New Jersey, USA, Arsenic Trioxide

Alert and notification in case of a potential leak:

Depending on the location of the accident, the Munster Regional Communications Centre (MRCC), site emergency services and public emergency services must be alerted. Ships (crew) and the population downwind (vapour cloud) and downstream (spill) must also be warned in order to prevent complications arising.

Applicability and main risks:

For more information and description of toxic substances, refer to Chapter 3 on hazardous substances.

Applicability[1]	Risks for humans/responders	Risks for the environment
- Leakage of toxic gas from drum or tank - Leakage of toxic chemicals - Mixing of reactive chemicals forming gas - Evaporation from slicks - Gas cloud formed after reaction of chemicals	- Injuries due to direct contact with substance (skin/mucosa contact, ingestion, inhalation) - Carcinogenetic issues	- Direct impact on animals and the environment - Chronic impact - Possible indirect impact (e.g. extinguishing water, dissolver in water curtain)

[1] Events that may lead to a toxic atmosphere

Table 19: Toxic substances: applicability and main risks

Risk assessment

- Assess the risks of atmospheric and marine toxicity by gathering data on the substances.
- Consider toxic exposure limits (see Chapter 3) to assess the risk for the population;
- Model the behaviour and movements of the toxic cloud;
- Evaluate the environmental compartment(s) (atmosphere, water column…) liable to be impacted by the toxic substance or any by-products that may be formed in the scenarios;
- Assess route of entry of the toxic substances (dermal contact, ingestion, inhalation…);
- Consider (and control) aggravating factors:
    - weather conditions: wind, current, temperature, rain and fog, atmospheric stability, etc.
    - reactions between chemicals, reactions due to the increase in temperature, time of exposure…

Protective measures (human health, environment and amenities)

Protective measures must be tailored to the penetration process of the substance involved and its characteristics. Toxicity is not only related to airborne substances; the population and responders can also be affected through contact, ingestion, etc.

▶ 5.20 Personal protective equipment (e.g. Self-Contained Breathing Apparatus -SBCA for toxic gas, specific protective clothing for dermal risks…)

▶ 5.25 Portable gas detectors for first responders

- Evacuation:
    - the distressed vessel's crew: the helicopter/rescue ship must approach from downwind in case of a toxic cloud;
    - the population: modelling should be used to determine specific areas to evacuate or shelter-in-place measures to implement (in case of a toxic cloud).
- Protection:
    - in the case of marine toxic substances, resources (e.g. fisheries, water intakes…) liable to be impacted should be assessed along with measures to protect them if required;

    ▶ 5.40 HNS response on the shore

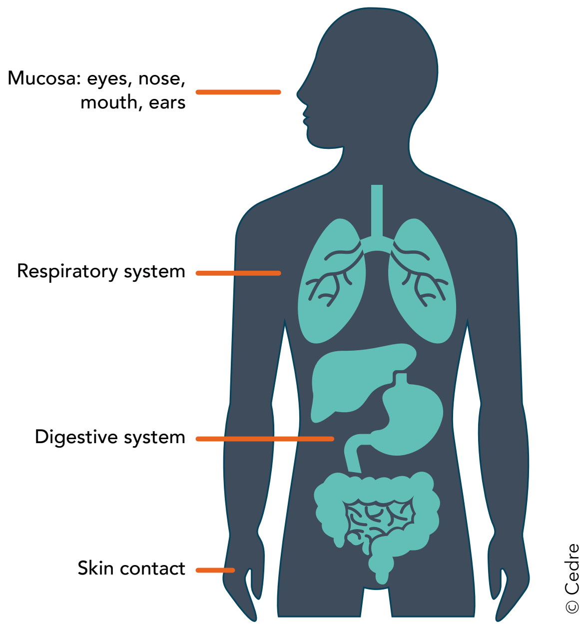


Figure 53: Toxicity to human health

- additional contamination due to by-products resulting from the response to the incident must be avoided by containing and recovering these substances (residual water from water curtain techniques, extinguishing water…).

Response measures

- The source of the leakage must be isolated if possible (tank or drum storage) to facilitate the response;
- Protective Action Criteria (PACs, see dedicated part in Chapter 3) should be used for intervention and to select proper PPE;
- Depending on the substances:
  - behaviour:

▶ 5.13 Response considerations: Gases and evaporators
▶ 5.14 Response considerations: Floaters
▶ 5.15 Response considerations: Dissolvers
▶ 5.16 Response considerations: Sinkers

  - techniques:

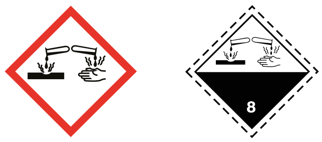
▶ 5.34 Using water curtains
▶ 5.35 Using foam
▶ 5.36 Natural attenuation and monitoring

FACT SHEET 5.8

Response
BACK

Response considerations: Corrosive substances

Related hazard pictograms



Examples of related case studies:

- **Unknown lost packages, 1975**, Swedish West Coast about 100 km north of Gothenburg, Sweden. Propionic Acid (approximately 30 drums lost at sea). Cause: probably lost deck cargo.
- ***Puerto Rican*, 1984**, 8 miles west of Golden Gate Bridge, San Francisco Bay, California, USA. Caustic soda solution, 50% (quantity spilled 400-500 m^3). Cause of spill: explosion (reaction of caustic soda with the epoxy coating).
- ***Julie A*, 1989**, Port of Aarhus, Denmark. Hydrochloric Acid (quantity spilled: 1 to 5 tonnes of HCl 31%; quantity transported: 300 tonnes). Cause of spill: structural damage to internal tank coating (reaction of hydrochloric acid with sheet iron, with formation of hydrogen gas).
- ***Kenos Athena*, 2012**, in water adjacent to Zheland Island, southern Guangdong Province, China. Sulphuric Acid (ship loaded with 7,000 tonnes and 140 tonnes of residual fuel oil; chemical and bunker-oil removal from sunken ship). Cause: shipwreck, sunk after about a month.

Alert and notification in case of a potential leak:

Depending on the location of the accident, the Munster Regional Communications Centre (MRCC), site emergency services and public emergency services must be alerted. Ships (crew) and the population downwind (corrosive gases) and downstream (spill) must also be warned in order to prevent complications arising.

Applicability and main risks:

For more information and a description of corrosive substances, refer to Chapter 3 on hazardous substances.

Applicability[1]	Risks for humans/ responders	Risks for the environment	Risks for amenities
- Leakage of corrosive liquid or gas from drum or tank - Mixing of reactive chemicals forming corrosive gas or compound - Evaporation from slicks	- Injuries due to direct contact with substance (dermal necrosis, inhalation, ingestion)	- Direct impact on animals and the environment - Acute and chronic impact - Possible indirect impact (e.g. extinguishing water, dissolver in water curtain)	- Chemical corroding drums or tanks, leading to a pollutionspill - Corrosion of metals (ship's deck, crane, etc.) (limitation/interference to with the legitimate uses of the sea/amenities)

[1] Events that may lead to a toxic atmosphere

Table 20: Corrosive substances: applicability and main risks

Risk assessment

For the general consideration of corrosive substances, responders should focus on:

- assessing the risks of atmospheric and marine toxicity by gathering data on the substances;
- assessing the risks of exposure to corrosive substances on the basis of its physical state and behaviour, monitoring pH if applicable;
- assessing associated hazards if present and evaluate the priority for response; corrosive substances are often associated with other hazards such as flammability and/or explosivity and/or toxicity;
  ▶ 5.6 Response considerations: Flammable and explosive substances
  ▶ 5.7 Response considerations: Toxic substances
  ▶ 5.9 Response considerations: Reactive substances
- analysing weather data and detector measurements;
- modelling the behaviour and movements of the corrosive gas/vapours/fume clouds, if applicable. Consider modelling corrosive floater/dissolver/sinker if spilled in water column, if applicable;
- assessing measures to protect sensitive areas (environmental, ecological, social, industrial sites) and facilities, including through preventive shutdown, determining the hazards posed by any products that may be formed in the scenarios and assessing the associated hazard levels (smoke from fire, reaction with the environment, etc.);
  ▶ 5.2 Incident data gathering
- avaluating the location of facilities and equipment for quick response.

Areas to consider for intervention:

- evaluate/model the extent of the area affected by dangerous concentrations of corrosive substances in the water column and/or in the atmosphere to limit legitimate uses of the sea and amenities.
  ▶ 5.19 Safety zones

Consider (and control) aggravating factors:

- Reactions between acids and bases, reactions due to the increase in temperature, time of exposure;
- Possible highly exothermic reaction when certain acids or bases are spilled in water;
- Maximum precautionary measures must be taken especially in the case of in situ response on the vessel (confined space);
- High viscosity values slow down dilution and dispersion processes at sea.

Protective measures (human health, environment & amenities)

As corrosive substances gather a large group of chemicals, protective measure must comply with the conclusions of the risk assessment:

- corrosive liquids (mineral acids, alkali solutions and some oxidisers): eyes and skin are particularly vulnerable due to splashes of the substance and effects on tissues are generally very fast;
- corrosive gases and vapours: effect is generally related to the solubility of the substances in the body fluids. Highly soluble gases like ammonia or hydrogen chloride cause severe nose and throat irritation, whereas lower solubility vapours (phosgene, sulphur dioxide, etc.) penetrate deep into the lungs;
- corrosive solids: direct contact can cause burns to the skin (phenol, sodium hydroxide…) and dust affects the respiratory system. Many corrosive solids may produce highly exothermic reactions when dissolved in water;
- in case of a water-reactive product, the substance must be prevented from reaching the water surface and the spill must be contained (construct berms, sand dikes…).

▶ 5.20 Personal protective equipment
▶ 5.25 Portable gas detectors for first responders

On board:

- Attention should be paid to avoiding direct contact with the skin and protecting against inhalation of vapours or mists. Check atmosphere before entering a confined space; do not operate without self-contained breathing apparatus;

▶ 5.20 Personal protective equipment
▶ 5.25 Portable gas detectors for first responders

- evacuation must be implemented immediately downwind (gas/evaporator/fumes);
- attention should be paid to decontaminating protective clothing: wash down with water and then remove.

Population and amenities:

- Modelling will need to be conducted to determine the specific area to decide on the implementation of evacuation or shelter-in-place measures (in case of a corrosive cloud or marine environment contamination);
- evacuation must be implemented in downwind impacted areas (in case of hazardous vapours, gas clouds, fumes);
- zoning: downstream area of the spill (targets of polluted runoff, liquid and solid spills) and evaluate any limitations on the use of the sea and amenities.

Response measures

On board:

- If possible, other chemicals or organic products must be isolated from the leaking substances until its reactive potential has been assessed;
- if the substance is not water-reactive, acids and bases may be neutralised by a dilution process in order to reduce the concentration (overboard washing with indirect water jets if possible). pH should be measured before discharging the diluted mixture in the environment;
  ▶ 5.34 Using water curtains
  ▶ 5.36 Natural attenuation and monitoring
- water-reactive substances may be treated by compatible sorbent or inert materials;
  ▶ 5.37 Using sorbents
- in the case of an on board leak, appropriate containment and recovery methods and techniques according to the substances involved and scenarios should be used (Emergency Schedules (EmS), IMO, 2020).

In the environment:

Refer to the characteristics, behaviour and fate and of the spilled (or leaked) substances, using specific precautions for the risk of corrosivity.

Behaviour:
▶ 5.13 Response considerations: Gases and evaporators
▶ 5.14 Response considerations: Floaters
▶ 5.15 Response considerations: Dissolvers
▶ 5.16 Response considerations: Sinkers
▶ 5.41 Packaged goods response

Techniques:
See Chapter 5.6.3

FACT SHEET 5.9

Response
BACK

Response considerations: Reactive substances

Related hazard pictograms (direct and indirect hazards)

Flammable/explosive:

GHS

GHS

Oxidising/peroxidising:

GHS

UN Regulation

Physical hazards not otherwise classified (refer to Safety Data Sheet)

Examples of related case studies:

Reactivity	Main Risks & Hazards - Related case studies	Examples of substances
With oxygen (air)	Ignition, explosion. ***Ocean Liberty*, 1947**, port of Brest, France; ammonium nitrate (3,160 tonnes) + oil (300 tonnes). **Cause of spill:** fire and subsequent explosion.	Some alkali metals (e.g. potassium, sodium, calcium), some metal hydrides (e.g. hydrides of sodium, hydrides of calcium), with phosphorus, some oxidants (e.g. acetaldehyde; diethyl ether, isopropyl ether), pyrophoric liquids (tributylphosphine, trimethyl aluminum)
With water ***(hydrolysis, hydration, oxidation; consider also possible reaction with moisture in the air)***	Explosion or formation of hazardous products (corrosive, toxic or flammable). ***Adamandas*, 2003**, Réunion Island; deoxidised iron of ore balls (21,000 tonnes) and diesel (470 tonnes). Risk of production of hydrogen gas. **Cause of spill:** structural damage	Some alkaline metals, sodium or potassium phosphide, alkali metal cyanide salts, aluminum chloride, calcium carbide, cyanide salts
Polymerisation	Highly exothermic reaction (with violent explosion in some cases) due to self-reaction of a monomer; ***Stolt Groenland*, 2019**, Ulsan, South Korea; Styrene monomer (5,200 tonnes). **Cause of spill:** explosion, fire due to over-pressurisation and ignition of styrene.	Acrylonitrile; cyclopentadiene, hydrocyanic acid; methacrylic acid; methyl acrylate; vinyl acetate
With other substances	Fire, explosion or release of toxic vapours depending on amounts, and surrounding conditions); ***Burgenstein*, 1977**, port of Bremerhaven, Germany; Sodium peroxide and other hazardous products including cyanide. **Cause of spill:** structural damage to a drum of sodium peroxide.	Some incompatible groups: flammable and toxic products; flammable products and oxidisers; acids and bases; oxidisers and reducers See The Chemical Reactivity Worksheet (CRW)

Self-reactive substances	A self-reactive substance means a thermally unstable liquid or solid substance liable to undergo strongly exothermic decomposition even without the participation of oxygen (air). This definition excludes substances or mixtures classified under the GHS as explosive, organic peroxides or as oxidising agents (GHS, 2019).		
	Light-induced Mechanical shock Inherently unstable	Explosive reactions ***M/V Sinbad*, 1979**, 20 nautical miles west of Ijmuiden, Netherlands, offshore of Amsterdam; Chlorine (51 steel cylinders/51 tonnes). Losst of deck cargo at depth of 30 m. **Cause of spill:** structural damage (adverse weather) Can detonate under certain pressure and temperature conditions.	Hydrogen and chlorine Acetylides, oxides, organic nitrates and many peroxides Acetylene

Table 21: Related case studies of incidents involving reactive substances

Alert and notification in case of a potential leak:

Depending on the location of the incident, the Munster Regional Communications Centre (MRCC), site emergency services and public emergency services must be alerted. Ships (crew) and the population downwind (vapour cloud) and downstream (spill) must also be warned in order to prevent complications arising.

Applicability and main risks:

Reactive substances include a wide range of potential consequences which depend heavily upon their chemical nature (see above table). For more information and a description of reactive substances, see 3.2.5 Hazard: reactivity.

Also note:

- In the case of a fire/spillage involving self-reactive substances, non-water-reactive but flammable substances, polymerising substances:
  ▶ 5.6 Response considerations: Flammable and explosive substances
- In the case of fire/spillage of chemicals which form toxic or corrosive products by reaction with other materials or other spills:
  ▶ 5.7 Response considerations: Toxic substances
  ▶ 5.8 Response considerations: Corrosive substances

Applicability[1]	Risks for humans/ responders	Risks for the environment	Risks for amenities
Leakage of reactive substances that cause ignition/ explosion	- Direct injuries due to fire or explosion or highly exothermic reactions (violent explosion) - Oxidising substances could ignite combustible material or destroy material (e.g. responder equipment) - Anoxia, asphyxia, especially in confined spaces	- No major expected chronic impact expected - Possible indirect impact (e.g. fire residues)	- Direct and indirect damages (or destructions) to vessels, buildings, other maritime infrastructures (in some scenarios, even at a considerable distance from the incident).
Leakage of reactive substances that form corrosive products	- Injuries due to direct contact with substance (dermal necrosis, inhalation, ingestion)	- Direct impact on animals and the environment - Chronic impact - Possible indirect impact (e.g. extinguishing water, dissolver in water curtain)	- Chemical corroding drums or tanks, leading to a pollution spill - Corrosion of metals (ship's deck, crane, etc.) (limitation/interference with the legitimate uses of the sea/amenities)
Leakage of reactive substances that form toxic products	- Injuries due to direct contact with substance (skin/mucosa contact, ingestion, inhalation) - Carcinogenetic issues	- Direct impact on animals and the environment - Acute and chronic impact - Possible indirect impact (e.g. extinguishing water, dissolver in water curtain)	Contamination of the marine environment by toxic-persistent product may lead to a closure/ limitation/interference to with the legitimate uses of the sea

[1] Events that may lead to a corrosive spill or atmosphere

Table 22: Reactive substances: applicability and main risks

Risk assessment

For the general consideration of corrosive substances, responders should focus on:

- assessing the risks of atmospheric and marine toxicity by gathering data on the substances;
- assessing the risks of exposure to corrosive substances on the basis of its physical state and behaviour, monitoring pH if applicable;
- assessing associated hazards if present and evaluate the priority for response; corrosive substances are often associated with other hazards such as flammability and/or explosivity and/or toxicity;
  ▶ 5.6 Response considerations: Flammable and explosive substances
  ▶ 5.7 Response considerations: Toxic substances
  ▶ 5.9 Response considerations: Reactive substances
- analysing weather data and detector measurements;
- modelling the behaviour and movements of the corrosive gas/vapours/fume clouds, if applicable. Consider modelling corrosive floater/dissolver/sinker if spilled in water column, if applicable;

- assessing measures to protect sensitive areas (environmental, ecological, social, industrial sites) and facilities, including through preventive shutdown, determining the hazards posed by any products that may be formed in the scenarios and assessing the associated hazard levels (smoke from fire, reaction with the environment, etc.);
  ▶ 5.2 Incident data gathering
- evaluating the location of facilities and equipment for quick response.

Areas to consider for intervention:
- evaluate/model the extent of the area affected by dangerous concentrations of corrosive substances in the water column and/or in the atmosphere to limit legitimate uses of the sea and amenities.
  ▶ 5.19 Safety zones

Consider (and control) aggravating factors:
- reactions between acids and bases, reactions due to the increase in temperature, time of exposure;
- possible highly exothermic reaction when certain acids or bases are spilled in water;
- maximum precautionary measures must be taken especially in the case of in situ response on the vessel (confined space);
- high viscosity values slow down dilution and dispersion processes at sea.

Protective measures (human health, environment & amenities)

As corrosive substances gather a large group of chemicals, protective measure must comply with the conclusions of the risk assessment:
- corrosive liquids (mineral acids, alkali solutions and some oxidisers): eyes and skin are particularly vulnerable due to splashes of the substance and effects on tissues are generally very fast;
- corrosive gases and vapours: effect is generally related to the solubility of the substances in the body fluids. Highly soluble gases like ammonia or hydrogen chloride cause severe nose and throat irritation, whereas lower solubility vapours (phosgene, sulphur dioxide, etc.) penetrate deep into the lungs;
- corrosive solids: direct contact can cause burns to the skin (phenol, sodium hydroxide…) and dust affects the respiratory system. Many corrosive solids may produce highly exothermic reactions when dissolved in water;
- in case of a water-reactive product, the substance must be prevented from reaching the water surface and the spill must be contained (construct berms, sand dikes…).
  ▶ 5.20 Personal protective equipment
  ▶ 5.25 Portable gas detectors for first responders

On board:

- attention should be paid to avoiding direct contact with the skin and protecting against inhalation of vapours or mists. Check atmosphere before entering a confined space; do not operate without self-contained breathing apparatus;
  ▶ 5.20 Personal protective equipment
  ▶ 5.25 Portable gas detectors for first responders
- evacuation must be implemented immediately downwind (gas/evaporator/fumes);
- attention should be paid to decontaminating protective clothing: wash down with water and then remove.

Population and amenities:

- modelling will need to be conducted to determine the specific area to decide on the implementation of evacuation or shelter-in-place measures (in case of a corrosive cloud or marine environment contamination);
- evacuation must be implemented in downwind impacted areas (in case of hazardous vapours, gas clouds, fumes);
- zoning: downstream area of the spill (targets of polluted runoff, liquid and solid spills) and evaluate any limitations on the use of the sea and amenities.

Response measures

On board:

- if possible, other chemicals or organic products must be isolated from the leaking substances until its reactive potential has been assessed;
- if the substance is not water-reactive, acids and bases may be neutralised by a dilution process in order to reduce the concentration (overboard washing with indirect water jets if possible). pH should be measured before discharging the diluted mixture in the environment;
  ▶ 5.34 Using water curtain
  ▶ 5.36 Natural attenuation and monitoring
- water-reactive substances may be treated by compatible sorbent or inert materials;
  ▶ 5.37 Using sorbents
- in the case of an on board leak, appropriate containment and recovery methods and techniques according to the substances involved and scenarios should be used (Emergency Schedules (EmS), IMO, 2020).

In the environment:

Refer to the characteristics, behaviour and fate and of the spilled (or leaked) substances, using specific precautions for the risk of corrosivity.

Behaviour:

- ▶ 5.13 Response considerations: Gases and evaporators
- ▶ 5.14 Response considerations: Floaters
- ▶ 5.15 Response considerations: Dissolvers
- ▶ 5.16 Response considerations: Sinkers
- ▶ 5.41 Packaged goods response

Techniques:

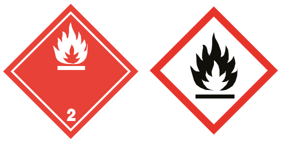
See Chapter 5.6.3

Hyundai Fortune *marine accident, March 2006, Gulf of Aden, at about 100 km south of Yemen; following an explosion and fire on board, 60 to 90 containers were lost at sea.*

LNG

Related GHS pictograms and UN Regulation

UN number: 1972
SEBC: G



Objective

To deliver characteristics on LNG, its properties and transport, and to provide information on potential risks in the event of a spill.

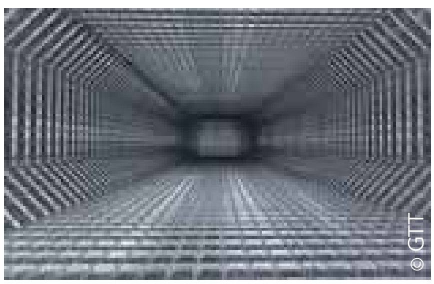
General features relating to LNG

LNG, or Liquefied Natural Gas, is increasingly used as a source of energy as its main advantages are to release significantly less carbon and lower pollutant emissions, including NOx, SOx and particulate matter. In the maritime shipping world, LNG can either be transported as cargo or used as bunkering fuel. For the latter, LNG can be used alone or with a dual fuel engine.

Type of LNG	Tank volume	Type of tank type
Cargo	10,000 - 45,000 m^3 per tank Maximum cargo 266,000 m^3 for Q-max vessel	
Bunker	20,000 m^3	Thermally insulated tank, pressure lower than 0.7 bar
	500 – 10,000 m^3	Type-C tank, pressure lower than 4 bars Temperature range: -162°C up to -121°C
	40 m^3	ISO tank (IMDG compliance), pressure lower than 10 bars

Table 23: Type of LNG

Cargo



Storage tank for seaborne transport of LNG

Jiyeh power plant after the Israeli bombing, 2006

ISO tank (IMDG compliance)

Physical and chemical properties

The main physical and chemical properties of LNG are summed up in the following table.

Boiling point	-162°C	LFL-UFL	5-15%
Flash point	-188°C	Density of LNG	0.4
Auto ignition temperature	595°C	Density of methane (20°C)	0.6

Table 24: Physical and chemical properties of LNG

Hazards and behaviour

LNG is mostly composed of methane (CH_4, CAS Number 74-82-8), representing about 90%, and a few other alkanes (such as ethane, propane and butane) with a total concentration of less than 10%. LNG is **odourless**, both in cargo or bunkers. No additive is present to detect a release by a characteristic odour. LNG is a **colourless** liquid when liquefied at -162°C. At this temperature **cryogenic effects** can be expected. Water in contact with LNG can form ice and block safety devices.

A 1 m^3 release of LNG will represent 600 m^3 after evaporation into the atmosphere. The **anoxia** or **asphyxia** hazard may also be high, especially in a confined area. When released into surface waters it can form a pool that will evaporate rapidly and create a **flammable** cloud when mixed with air with the subsequent formation of a white cloud due to the condensation of water humidity in the air. If the vapour ignites it can create a jet (pressurised gas release) or **pool fire**, a **flash fire** or even a **vapour cloud explosion** when the surrounding environment creates overpressure and blast damage. For pressurised tanks, **BLEVE** may also occur in case of fire. See Chapter 3.

Methane does not exhibit violent reactivity with products that are frequently used or transported on ships. However it reacts violently with liquid oxygen.

Possible impacts on people, environment and amenities are summarised in the following table.

	Effects on:		
Type of incident	**People**	**Environment**	**Amenities**
Release of cryogenic liquid	Serious injuries due to cold burn or due projections in case of Rapid Phase Transition	Can form ice in water. In absence of fire, no damage to aquatic life because LNG is not soluble in water and it will evaporate rapidly into the atmosphere.	Brittle fracture damage to steel structures
Evaporation of methane into the atmosphere	Anoxia/asphyxia	Extremely low solubility in water	-
Ignition of LNG slick	Injuries or death	No major damage expected	Fire, temperature

Inflammation of vapour cloud	Injuries or death	No major damage expected	Fire, temperature
Explosion of gas in confined space (for instance engine room)	Injuries or death	Extremely low solubility in water	- Glass explosion - Building destruction
BLEVE following fire of tank containing LNG under pressure	Injuries or death	Possible physical damage due to explosion	- Glass explosion - Building destruction

Table 25: Effects of an incident involving LNG on people, environment and amenities, depending on the origin of incident

Situation assessment

As with gaseous products, LNG has fast-moving kinetics. It is important to properly assess the situation using all the tools available to effectively protect the population and stakeholders but also to initiate a response on the ground:

- ▶ 5.5 Situation assessment
- ▶ 5.6 Response considerations: Flammable and explosive substances
- ▶ 5.11 HNS spill modelling
- ▶ 5.22 Remote sensing technologies
- ▶ 5.25 Portable gas detectors for first responders

Depending on the situation, especially the type of release and whether LNG is pressurised or only refrigerated, the following decision tree can support risk assessment.

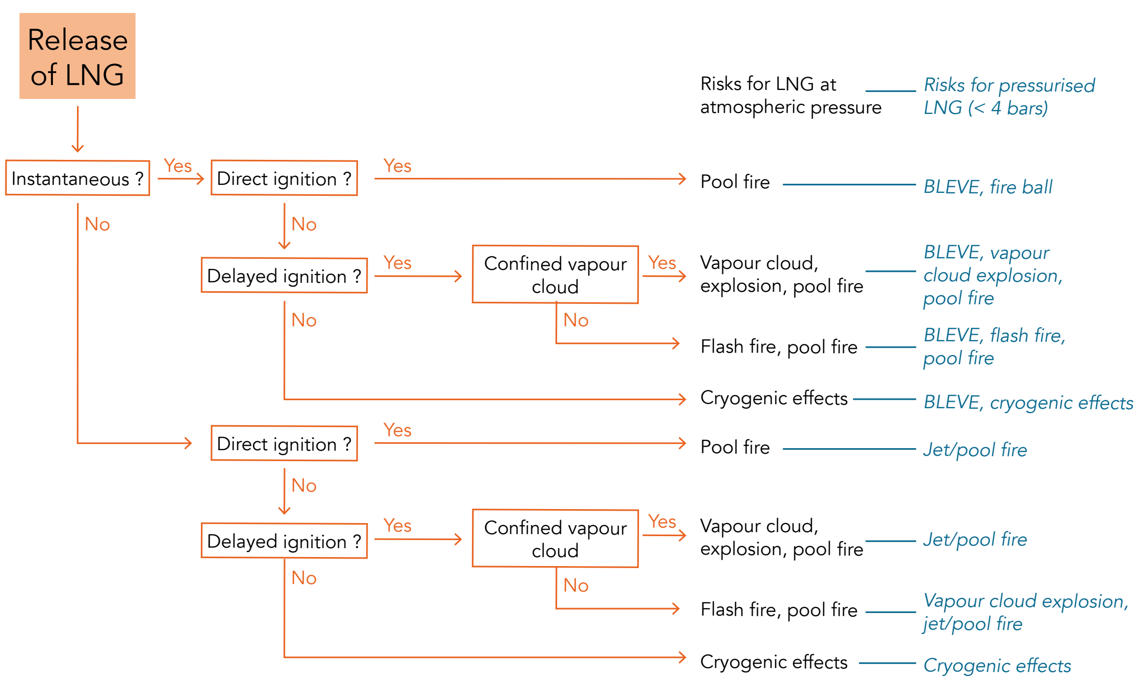


Figure 54: Decision tree regarding release of LNG

Operational features relating to LNG

Response

Protective measures (human health, environment and amenities):

- zoning should be established (▶ 5.19 Safety zones) and monitoring performed over time to assess the risk of flammability. In case of evacuation of the crew from a distressed vessel, the helicopter/rescue ship must approach from downwind;
  ▶ 5.20 Personal protective equipment
  ▶ 5.11 HNS detection and analysis methods
- flammable ignition sources should be removed. Before responders plan to enter in confined space, ventilation can be carried out to lower the concentration below the LEL.

Response following a leak of LNG:

- all sources of ignition should be eliminated;
- nobody should walk on or touch the spilled LNG;
- if the LNG is likely to leak, water can be sprayed on the vessel's hull to prevent brittle fracture on the steel structure due to cryogenic effect;
- water should not be sprayed directly onto LNG to avoid Rapid Phase Transition or RPT (no spray or run-off);
- water curtains should be used, especially to reduce the concentration below the LEL;
  ▶ 5.34 Using water curtains
- if leakage cannot be stopped, the substance should preferentially be released in gaseous state rather than as cryogenic liquid;
- water can form ice when in contact with LNG, which can represent an advantage to temporarily block a leak.

Response in case of fire:

- a leak of burning gas should never be extinguished, unless the source of the leak can be stopped;
- water curtains should be used, especially to reduce radiation effects;
- fire should be fought from a maximum distance or with use of water cannons;
- minor fire (bunker for instance): dry chemical powder or CO_2;
- major fire: water spray or fog;
- if possible, combustible products should be moved away from LNG on fire.

HNS spill modelling

A computer-based model can be an extremely useful tool during an HNS spill. Generally, these models are computer programmes that are designed to simulate what might (forecast) or what did happen (hindcast/backcast) in a situation. They can be created to simulate almost any scenario, however, to make a model from scratch will require expertise and a lot of testing to ensure the model is working. Many organisations and research institutes have developed models to simulate different aspects of HNS spills. Specific model capabilities include:

Predicting the fate of pollutants

Fate models predict how a pollutant changes both physically and chemically when released into the environment. Such models are used as a tool to help understand the expected characteristics and behaviour of a pollutant and prepare for an efficient response (Figure 55).

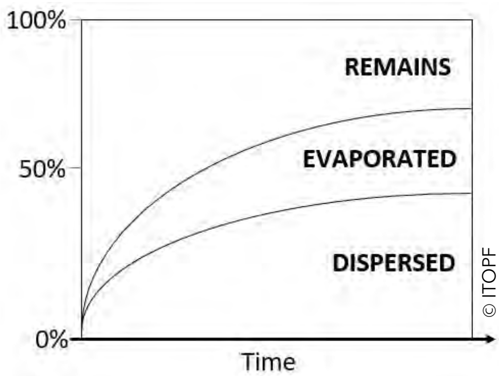


Figure 55: Fate model output

Although fate models can be stand-alone, they are usually built within a trajectory model, as physical and chemical changes can alter a pollutant's behaviour and subsequently, its trajectory.

Fate models require detailed specifications of the pollutant, such as physical and chemical properties, along with environmental data, such as temperature and wind speed.

Predicting a pollutant trajectory in water

Trajectory models can simulate the movement of a pollutant in water, using environmental data such as wind, currents, and wave information as well as the substance's physical characteristics. The simulation can be either forward-looking or backtracking. Forward modelling can help with predicting where the pollutant may strand along a shoreline or provide warning if it is heading towards a particularly sensitive area. Likewise, by using the model to backtrack a situation, it can be used to work out where the pollutant may have come from. These models can be either 2D (movement at the water surface only) or 3D (movement within the entire water column) (Figure 56).

Figure 56: Pollutant trajectory on sea surface

Predicting a pollutant trajectory in the air

Trajectories of hazardous gas clouds that are a result of an HNS incident can be modelled using an atmospheric dispersion model. Generally, these models can estimate how quickly the chemical will be released into the atmosphere and how it will travel downwind (Figure 57).

Along with the pollutants' physical and chemical properties, the models require environmental data, relating to wind and temperature.

The model results can then be used as an indication of where there may be significant threat to human life.

Figure 57: Air pollutant trajectory

Analysing response methods

Models can also be used to analyse different response methods. They are used only as a guide to help manage resources, which is particularly useful in the case of a large incident with limited resources (Figure 58).

Fate models are usually used in conjunction with response models as the pollutant may change physically and chemically over time, resulting in different possible recovery totals. However, they can also be combined with trajectory models, allowing for an overall prediction of how the incident will evolve and be managed.

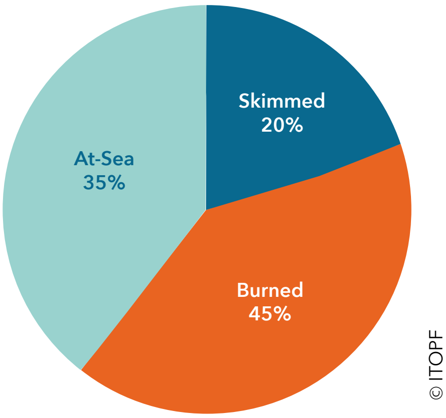


Figure 58: Response model output

Model limitations

To work, a model needs information regarding the incident, pollutant, and environmental conditions, for instance the incident time and location, pollutant properties, atmospheric and water temperatures, and wind speed and direction. However, for a model to produce reliable results, the input data needs to be as accurate as possible. Accurate data is not always feasibly obtainable for several reasons. Firstly, there may not be any **environmental data available** in the required area or timeframe, information may be missing regarding the incident, or the pollutant properties may be unknown.

Secondly, the **spatial and temporal resolution** in environmental datasets may be too large to represent certain physical processes. For example, turbulent eddies in water, prevalent around coastlines and in rivers, may be too small to be represented in current data. In addition to input data inaccuracies, during the construction of a model, approximations and assumptions are unavoidable, therefore no model will, unfortunately, ever be entirely exact. Also, models cannot take into consideration multiple substances and reactivity. With these points in mind, it is important that models should not be relied upon entirely but rather **used simply as a guide**, validating results through in situ observations where feasibly possible.

Models available

Specialist training to learn to use models for an HNS incident and understand their limitations is advised. Alternatively, many modelling providers or developers can carry out the modelling themselves and provide an explanation of the results, through contract-based work. Usually, modelling providers will also have access to the environmental data needed for the model, such as wind speed and direction, sea temperatures, wave heights, in addition to chemical and SDS databases. The table below lists some, but by no means all, models that have been created for use in an HNS incident. Oil spill models have been added since they might be suitable to predict the fate and behaviour of substances such as vegetable oils.

Model	Developer/provider	Capability
ADIOS (open source)	NOAA	Oil fate
AIRMAP	RPS ASA	Chemical air trajectory and fate
ALOHA (open source)	NOAA	Chemical air trajectory and fate
CALPUFF	TetraTech	Chemical fate
CHEMMAP	RPS ASA	Chemical air and sea trajectory and fate
GNOME (open source)	NOAA	2D at-sea oil trajectory and fate
MOHID Water	MOHID	3D at-sea and air chemical trajectory
MOTHY	Meteo-France	2D at-sea oil and floating objects (such as containers) trajectory
OILMAP	RPS ASA	3D at-sea oil trajectory, fate, and response analysis
OpenDrift/OpenOil (open source)	MET Norway	Chemical/objects at sea and air trajectory and fate
OSCAR	SINTEF	3D at-sea oil trajectory and fate
SPILLCALC	TetraTech	3D at-sea oil trajectory
ROC (open source)	NOAA	Oil response method analysis

Table 26: Models available

Non dangerous goods cargo

BACK

Objective

To draw the attention of decision-makers and operators to products not strictly classified as dangerous, as per international classification, but could present risks for responders or could be harmful for the environment. Some advice on approach or first elements of response are provided for some categories of products.

Applicability

All the fact sheets and the structure of this Manual are based on identified and classified hazards according to international regulations and consistent with the 2010 HNS Convention and corresponding codes (IGC, IBC, IMSBC, IMDG). Many non-dangerous products are also shipped and past incidents have shown that some non-dangerous products may be harmful and have considerable impacts on humans or the environment. The location of the incident is of high importance as it may amplify the risks for humans, or the environmental sensitivity may cause severe damages and alter or compromise the natural restoration of the environment.

Method description

Issues posed by non-dangerous goods may be related in some cases to the quantity released in the environment. A product introduced in relatively large quantities compared to the size of the area may cause issues, and possible impacts can differ depending on physical, chemical or biological effects. Physical damage can first occur through shading/smothering of the seabed and dust may impact turbidity. Additionally a change in the chemical composition of the water compartment may alter biological processes. For instance an unusual and important provision of organic products can lead to oxygen depletion, creating an anoxic medium with fish mortality. Decomposition of organic matter will result in an exothermic reaction, creating favourable conditions for the development of sulphate-reducing microflora. This microflora will degrade the organic matter on the site, with significant production of hydrogen sulphide (H_2S), a highly toxic gas for humans.

For these reasons, an effective post-incident monitoring programme should be set up to assess impacts, in particular on species/habitats of nature conservation importance (e.g. in relation to the EU Birds and Habitats Directives, OSPAR), commercial stocks of fish and shellfish, the wider ecosystem and its functionality, and the human food chain, as well as to support subsequent compensation claims.

The following table presents an overview of the main categories of products frequently transported in large quantities by sea and that may present issues when spilled at sea.

Nature of product	Transport mode	Examples	Potential impact	Response
Organic	**Liquid bulk** Packaged goods (e.g. drums, tank, flexitank)	Glucose solution, Lecithin, orange juice, vegetable protein solution	In low renewal shallow waters, risk of oxygen depletion (low Biochemical Oxygen Demand) leading to death of flora and fauna	Depending on exact conditions: oxygenation, thanks to mechanical stirring, or creation of a current to renew the water when quantity of substance is too high compared to the environment
	Incident: pipeline, 2013; Hawaii harbour, US. Cargo: molasses			
	Solid bulk Packaged goods (e.g. bags)	Grain (wheat, rapeseed…), Rice Seed cake (soya meal/pellet, oil by-products….).	Fermentation and production of gases and potentially harmful by-products **Sinker**: reduction of oxygen rate due to increase in bacteria; smothering	Removal of the substances (by ROV, dredging or divers) ▶ 5.39 HNS response on the seabed ▶ 5.24 Remotely operated vehicles
	Incident: Fénès*, 1996; Lavezzi islands off Corsica, France. Cargo: wheat*			
Plastic pellets	**Solid bulk** Packaged goods (e.g. bags)	Chopped rubber and plastic insulation, Granulated tyre rubber, Coarse chopped tyres, Recycled plastic resin/pellets, Nurdles	Depending on the size of pellet: - **Floater**: risk of ingestion for birds and fish; - **Suspended matter**: increase of turbidity, impact on species on respiratory/digestive system; - **Sinker**: smothering of life on the seabed.	Recovery at the surface/on the seabed/shoreline ▶ 5.43 Recovery techniques: Pumps and skimmers Removal of the substances (by ROV, dredging or divers) ▶ 5.39 HNS response on the seabed ▶ 5.24 Remotely operated vehicles Manual recovery of pellets on the shoreline ▶ 5.38 HNS response in the water column
	Incident: MSC Susanna*, 2018; South Africa. Cargo: plastic nurdles packaged in 25 kg bags.*			
Minerals and coal	**Solid bulk** Packaged goods (e.g. bags)	Chamotte, Chlorite, Limestone, Magnesite, Clay, Ores, Coal	Depending on the grain size: - Suspended matter: increase of turbidity, impact on species on respiratory/digestive system; - Smothering of life on the seabed (sinkers)	When possible and if quantity of spilled product is too high compared to the environment, the water should be renewed or polluted water pumped and filtered ▶ 5.38 HNS response in the water column Removal of the substances (divers, dredging) ▶ 5.39 HNS response on the seabed
	Incident: M/V Eurobilker IV*, 2001; Sardinia, Italy. Cargo: 17,000 tonnes of coal dispersed on seafloor causing suffucation of surrounding Posidonia oceanica meadows*			
Cement	**Solid bulk** Packaged goods (e.g. bags)	Cement, Cement clinkers	Suspended matter: increase of turbidity, impact on species on respiratory/digestive system; Sedimentation or solidification on the seabed	Dilution or filtration if quantity of substance is too high compared to the environment ▶ 5.38 HNS response in the water column Removal of sunken solidified part if necessary ▶ 5.39 HNS response on the seabed

Table 27: Examples of possible incidents, potential impacts and response option depending on the nature of product and type of transport

FACT SHEET 5.13

Response
BACK

Response considerations: Gases and evaporators

(applicable to all groups with "G" and "E" as SEBC behaviour)

Physical State	Gaseous		Liquid	
SEBC Code	G	GD	E	ED
Density at 20°C	-		< seawater density	
Vapour pressure (kPa) at 20°C	> 101.3		> 10	
Solubility (%)	< 10	> 10	< 1	1-5

Table 28: Behaviour of gases and evaporators

Note: for SEBC subgroups "GD" and "ED" see also ▶ 5.15 Response considerations: Dissolvers

Response strategies need to consider the factors affecting the behaviour and fate of the released substances, taking into account that gases and evaporators mainly undergo short-term processes when spilled at sea, due to their physic state (for G) or hight volatility (for E).

PROCESSES AND FACTORS AFFECTING BEHAVIOUR AND FATE OF GASES AND EVAPORATORS					
Physical state		Gaseous		Liquid	
SEBC Code		G	GD	E	ED
BEHAVIOUR and FATE	Processes when spilled at sea	Immediate evaporation/ atmospheric partitioning	Immediate evaporation/ atmospheric partitioning Dissolution	Rapid evaporation	Rapid evaporation Dissolution
	Environmental factors influencing intensity of process	Sea state /wind intensity/air and water temperature/humidity (when on board)/ solar irradiance/coastline morphology			
	Drift and spread of HNS	Atmospheric dispersion with potential production of dangerous air mixture. Potential violent reactions with smoke/gas/aerosol production, possibly toxic. Non-persistent.	Dispersion, diffusion, dilution in sea surface waters		Dispersion, diffusion, dilution in sea surface waters
	Other relevant HNS properties and hazards	Flash point, explosive range, reactivity, toxicity, corrosivity, gas/ vapour density			
	Impact on marine environment	Gas/evaporator substances tend to readily leave the water column by partitioning first in the sea surface layer and then in the atmosphere: time- and space-limited impact (generally low) on pelagic ecosystem; risks could be more significant for avifauna and more sensitive pleuston organisms.			
For hazards and risks see also 3.2 Hazards					

Table 29: Processes and factors affecting behaviour and fate of gases and evaporators

Considerations

- Main risks for safety and/or human health (crew; population if source and cloud near to the coast)
  ▶ 5.6 Response considerations: Flammable and explosive substances
  ▶ 5.7 Response considerations: Toxic substances
- Minor risks for the marine environment (non-persistent substances)
- Response actions are conducted on board the ship

Situation assessment and first actions

Information gathering:

- immediately refer to Safety Data Sheet or chemical databases. In the case of an unknown substance, act as in the case of maximum risk;

  ▶ 3.1 Safety data sheet content
- immediately refer to data related to the location of the incident and other relevant information;
- consider sea and weather forecast.

  ▶ 5.1 Incident notification
  ▶ 5.2 Incident data gathering
  ▶ 5.3 Information resources

Situation assessment:

- on the basis of the information gathered on the incident and the risks identified during contingency planning, consider conducting:
- hazard identification;

  ▶ 5.6 Response considerations: Flammable and explosive substances
  ▶ 5.7 Response considerations: Toxic substances
  ▶ 5.8 Response considerations: Corrosive substances
  ▶ 5.9 Response considerations: Reactive substances
- estimation of risk and vulnerability;
- evaluation of consequences.

  ▶ 5.5 Situation assessment

First actions:

- take into account the first actions to guarantee safe conditions for the responders by identifying and reducing the hazards of explosion, fire, exposure to toxic clouds, etc. and then stop or reduce the source of the HNS spill;

  ▶ 5.17 First actions (casualty)
  ▶ 5.18 First actions (responders)
- consider public safety;

  ▶ 5.19 Safety zones
- equipment/logistics;

  ▶ 5.20 Personal protective equipment
  ▶ 5.25 Portable gas detectors for first responders

Monitoring

Modelling:

- modelling of gas cloud in air; Input to be considered: chemical and physical parameters of the substance, weather condition and forecast, type of spill source.
  ▶ 5.11 HNS spill modelling

Monitoring using remote measuring instruments and search techniques:

- aerial surveillance: planes and helicopters (not in case of explosive or unknown gas); drones;
  ▶ 5.22 Remote sensing technologies
- use of markers (not in case of explosive or unknown gas) for safety and operational reasons.
  ▶ 5.23 Substance marking

Monitoring using in situ measuring instruments and search techniques:

Air sampling

- trace gas sensors: explosimeter and gas detection to detect explosion or fire risks; detectors for toxic substances (on board and in environment);
- oxygen deficiency: electrochemical oxygen sensor.
  ▶ 5.25 Portable gas detectors for first responders

Water sampling

- water sampling by "niskin" bottles and storage of samples for laboratory analysis (for not surface spill)/bottle sampling for surface water (for substances "DE" and "ED"). For GD substances (in particular with regard for VOC and semi-VOC).
  ▶ 5.26 Sampling techniques and protocols
  ▶ 5.27 HNS detection and analysis methods

Response options

Vessel-oriented actions: ▶ 5.28 Emergency boarding

- mark out the risk area on board;
- stop the release of substance from its source;
  ▶ 5.32 Sealing and plugging
- ventilate when possible (e.g. with ventilators) to reduce concentration but be careful if there is a very rich atmosphere (> UEL). In this case, ventilation could reduce the concentration below the UEL;
  ▶ 5.6 Response considerations: Flammable and explosive substances
- for small spills, consider using techniques to prevent/control ignition or evaporation of the chemicals;
  ▶ 5.35 Using foam

- recovery operation of the residual load;
  ▶ 5.31 Cargo transfer
- towing & boarding;
  ▶ 5.29 Emergency towing
  ▶ 5.30 Places of refuge

Pollutant-oriented actions:

- high pressure water spray jet;
  ▶ 5.34 Using water curtains
- re-condensation of spilled gas in liquid state: for small spillage;
- controlled release technique;
  ▶ 5.36 Natural attenuation and monitoring
- wildlife response focuses on toxic effects on avifauna or marine mammals (inhalation hazards).
  ▶ 5.44 Wildlife response

Containment and recovery: None. Monitoring only.

Natural attenuation and monitoring:

- evaluate the non-intervention strategy in the case of: high risks for human health; no risks of cloud advection towards the coast. Set up exclusion/ban areas, until natural processes have reduced pollutant concentrations.
  ▶ 5.36 Natural attenuation and monitoring

Post-Spill

Environmental investigation:

- generally UNNECESSARY in the case of gaseous and highly volatile substances. To be considered in the case of damages following a release of gas/evaporator (e.g. fire and/or explosion);
- for soluble substances (GD): detection of concentrations in water and evaluation of the effects on sensitive organisms;
- chemical and ecotoxicological analysis of samples of contaminated water;
- chemical analysis and studies on biomarkers of sedentary species;
- the same investigations must always be carried out in areas chosen as a reference. Not for explosive HNS.
  ▶ 5.27 HNS detection and analysis methods

See Chapter 6.2 Post-spill monitoring

  ▶ 6.2 Environmental restoration and recovery

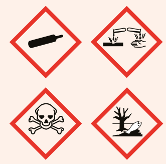
EXAMPLES OF GASEOUS/EVAPORATOR CHEMICALS OF MARINE ENVIRONMENTAL CONCERN		
SEBC group	Main characteristics and impact on the marine environment	GHS pictograms
Vinyl chloride (G)	Highly flammable, shows long-term toxicity (carcinogen), thermal degradation with the formation of toxic/corrosive fumes. Incident: *Brigitta Montanari*, 1984; off Croatian coast. Cargo: bulk (1,300 tonnes of vinyl chloride monomer) Incident: tanker-barge *Pampero*, 2020; at the locks in Sablons, Rhône France. Cargo: bulk (2,200 tonnes)	
Anhydrous ammonia (GD) shipped in liquid state	Corrosive, highly toxic to aquatic organisms due to formation of a highly corrosive solution with water. Incident: *René 16*, 1976; Port of Landskrona, Sweden. Cargo: bulk (533 tonnes of anhydrous ammonia)	
Benzene (E)	Toxic liquid for humans and the environment. Not persistent in the water column, tends to partition in the atmosphere. Depending on the release conditions, it could be toxic for marine organisms, in particular for pleuston due to the tendency of benzene to float. Dangerous for marine mammals and avifauna if inhaled. Vapours of benzene are heavier than air. Incident: Barge, 1997; Mississippi River, US. Cargo: bulk (pyrolysis gasoline contains 41.0% benzene)	
Methyl-t-butyl ether (ED)	It has low acute and chronic toxicity for marine species but acute effects were found at high concentrations for the grass shrimp and marine mussel. It poses limitations on uses of the sea. Vapours heavier than air. Incident: *Carla Maersk*, 2015; Houston Ship Channelgo, US. Cargo: bulk 5,600 tonnes of MTBE.	

Table 30: Examples of gaseous/evaporator chemicals of marine environmental concern

FACT SHEET 5.14

Response considerations: Floaters

BACK

(applicable to all groups with "F" as SEBC behaviour)

Physical state	Liquids				Solids	
SEBC Code	F	FD	FED	FE	F	FD
Density at 20°C	< seawater density					
Vapour pressure (kPa) at 20°C	<0.3		0.3 - 3		-	
Solubility at 20°C (%)	≤ 0.1	0.1-5		< 0.1	≤ 10	10-100

Table 31: Behaviour of floaters

Note: for SEBC subgroups "FD" and "FED" see also ▶ 5.16 Response considerations: Dissolvers
for SEBC subgroup "FED" ▶ 5.13 Response considerations: Gases and evaporators

Response strategies need to consider the factors affecting the behaviour and fate of the released substances as well as the short- and long-term processes when spilled at sea.

PROCESSES AND FACTORS AFFECTING BEHAVIOUR AND FATE OF FLOATERS IN A MARINE ACCIDENT INCIDENT

	Physical state	Liquids				Solids	
	SEBC Code	F	FD	FED	FE	F	FD
BEHAVIOUR and FATE	Processes when spilled at sea	Spreading					
				Evaporation			
			Dissolution				Dissolution
	Environmental factors influencing intensity of processes	Sea state, wind intensity, air and water temperature					
	Drift and spread of HNS	Drifting of the slick at sea surface (temporal continuity and persistence are variable). Possible impact on shoreline.				Drifting at sea surface	
		Possible emulsification, production of aggregates that could sink or affect shoreline (high viscosity substances)	Dispersion, dilution			Potential shoreline involvement	Dispersion, dilution
				Atmospheric dispersion with potential production of dangerous air mixture in case of hazardous chemicals			
		Evaluate potential violent reactions and aerosol production.					
	Other relevant HNS properties and behaviour	Viscosity		Vapour density		Buoyancy	Viscosity
		Persistence				Persistence	
	Impact on marine environment	Floaters mainly affect surface, pelagic and pleuston ecosystems, and their slicks (F-liquids) can alter atmospheric/sea-surface gas exchange, especially if the substance is persistent (F(p)). Shoreline ecosystems can also be affected by floating chemical spills. FE and FED substances can generate potentially dangerous vapours; the main social effects are related to navigational safety and strong limitations for legitimate uses of the sea.					
For hazards and risks see also 3.2 Hazards							

Table 32: Processes and factors affecting behaviour and fate of floaters in a marine incident

Considerations

- Oil spill response techniques could be used for floater spills.
- In the case of floater-dissolver substances, containment and recovery operations could be very limited. Usually, the only response option is to leave natural processes (e.g. dispersion, dilution) to deal with the spill, and, where possible, accelerate these processes.
- The selection of response techniques is strongly related to weather conditions

Situation assessment and first actions

Information gathering:

- immediately refer to SDS or chemical databases. In the case of an unknown substance, act as in the case of maximum risk;
  ▶ 3.1 Safety data sheet content
- immediately refer to data related to the location of the incident and other relevant information;
- consider sea and weather conditions;
  ▶ 5.1 Incident notification
  ▶ 5.2 Incident data gathering
  ▶ 5.3 Information resources

Situation assessment:

On the basis of the information gathered on the incident and the contingency planning risk, conduct:

- hazard identification;
  ▶ 5.6 Response considerations: Flammable and explosive substances
  ▶ 5.7 Response considerations: Toxic substances
  ▶ 5.8 Response considerations: Corrosive substances
  ▶ 5.9 Response considerations: Reactive substances
- estimation of risk and vulnerability;
- evaluation of consequences.
  ▶ 5.5 Situation assessment

First actions:

- take into account the first actions to guarantee safe conditions for the responders by identifying and reducing possible exposure to toxic vapours and/or hazards of explosion, fire, etc. and then stop or reduce the source of the HNS spill.
  ▶ 5.17 First actions (casualty)
  ▶ 5.18 First actions (responders)

- consider public safety
  ▶ 5.19 Safety zones
- equipment/logistics
  ▶ 5.20 Personal protective equipment
  ▶ 5.25 Portable gas detectors for first responders

Monitoring

Modelling:

- modelling of drifting floaters (solids and liquid slicks) at the sea surface. Input to be considered: chemical and physical parameters of the substance (e.g. viscosity), current sea and weather conditions and weather forecast, type of spill source;
  ▶ 5.11 HNS spill modelling
- modelling of gas cloud in air (for FE substances).
  ▶ 5.13 Response considerations: Gases and evaporators

Monitoring using remote measuring instruments and search techniques:

- aerial surveillance: planes and helicopters (not in case of dangerous situations), drones;
- use of markers to make the substance visually detectable at the sea surface: NOT applicable in the case of an explosion hazard or unknown substances.
  ▶ 5.23 Substance marking
  ▶ 5.24 Remote sensing technologies
  ▶ 5.26 Sampling techniques and protocols

In situ monitoring using measuring instruments and research techniques:

- trace gas sensors/explosimeter and gas detection (in case of explosion or fire risks or toxic vapours/aerosol formation or unknown substances);
- acquisition of physicochemical parameters of surface waters by multi-parametric probe (T, fluorescence, pH, conductibility, etc.); Specialised personnel could be required.
  ▶ 5.25 Portable gas detectors for first responders
  ▶ 5.26 Sampling techniques and protocols

Water sampling

- sampling of sea surface (surface waters and/or sea surface microlayer) using specific methods to obtain samples of spilled floating substance as free as possible of marine environmental matrices (e.g., polyethylene cornet, PFTE pad, BSH Helicopter sampling apparatus); in the field and/or laboratory: determination and/or analysis of physicochemical properties (e.g. GC-MS, GC-FID, GC-PD, IR, etc.). **Specialised personnel could be required, especially for high viscosity fluids**;

- water sampling by "niskin" bottles (or other methods) and storage of samples for laboratory analysis or field measurements. In the case of a deep or subsurface spill, consider the use of a multi-parametric probe to locate the substances in the water column (**specialised personnel could be required**);
- sampling of solid floaters in the surface and sub-surface layer of the water column (e.g. with specific nets, ROV, divers).

▶ 5.24 Remotely operated vehicles
▶ 5.26 Sampling techniques and protocols
▶ 5.27 HNS detection and analysis methods

Air sampling

- trace gas sensors: detectors for toxic substances (on board and in the environment); explosimeter and gas detection to detect explosion or fire risks;
- oxygen deficiency: electrochemical oxygen sensor

▶ 5.25 Portable gas detectors for first responders

Response options

Action on vessel: ▶ 5.28 Emergency boarding

- stop the release of substance from its source;

▶ 5.32 Sealing and plugging

- recovery operation of the residual load;

▶ 5.31 Cargo transfer

- on board: collect spillage, where practicable, using sorbent material for safe disposal if applicable;

▶ 5.37 Using sorbents

- towing & boarding;

▶ 5.29 Emergency towing
▶ 5.30 Places of refuge

- evacuate the downwind area and evaluate the need for a ban on navigation or other exploitation of marine resources (for FE, FED);
- prevent the formation of dangerous vapours (inject inert gas, ventilate and/or dehumidify the atmosphere).

▶ 5.6 Response considerations: Flammable and explosive substances
▶ 5.7 Response considerations: Toxic substances
▶ 5.8 Response considerations: Corrosive substances
▶ 5.9 Response considerations: Reactive substances

Action on pollutant:

- Containment techniques with a physical barrier (in particular for insoluble/low solubility liquids):

- using special barriers developed for solids and liquids, in shallow waters;
- oil spill booms; often in association with sorbents (slicks or floating solids);
  ▶ 5.42 Containment techniques: Booms
  ▶ 5.43 Recovery techniques: Pumps and skimmers
- contain by water barriers, in the presence of vapour or smoke; for FE/FED;
  ▶ 5.34 Using water curtain

- Recovery techniques:
  - sorbents (booms, sheets, pillows…);
  - by pumping operations with various types of skimming;
  - trawl nets or net bags towed by boats; for high viscosity chemicals or small floating solids.
    ▶ 5.42 Containment techniques: Booms
    ▶ 5.43 Recovery techniques: Pumps and skimmers
- Cleaning techniques:
  - chemical dispersant; only for "dispersible" F substances (evaluation based on the value of kinematic viscosity) and only in very limited scenarios.
    ▶ 5.38 HNS response in the water column
- Standard intervention techniques on wildlife (avifauna, marine mammals, marine reptiles) affected by oil spills could be applied in the case of some floater spills, on the basis of physico-chemical characteristics and behaviour.
  ▶ 5.44 Wildlife response

Controlled release technique:

- controlled release of substances still stored on board (not advisable – evaluate for offshore, only implement after a rigorous evaluation).

Natural attenuation and monitoring:

- evaluate the non-intervention strategy (not advisable – evaluate for offshore, only implement after a rigorous evaluation).
  ▶ 5.36 Natural attenuation and monitoring

Post-Spill

- Chemical and ecotoxicological analysis of the sea surface layer and/or undiluted substance;
- chemical analysis (e.g. bioaccumulation) and biological analysis (e.g. biomarkers) of involved fauna to evaluate toxic effects (even on the coast, if involved).
  ▶ 6.2 Environmental restoration and recovery

EXAMPLES OF FLOATERS THAT POSE HEALTH AND/OR MARINE ENVIRONMENTAL HAZARDS		
SEBC group	Main characteristics	GHS pictograms
Vegetable and animal derived oils (F(p) - liquid)	Formation of persistent biodegradable surface films, dissolved oxygen consumption and alteration of gas exchange. Some oils may polymerise. They undergo weathering processes (emulsification). Poses limitations on uses of the sea. Incident: *Kimya*, 1987; off coast of Anglesey, Wales. Cargo: bulk liquid Incident: *Allegra*, 1997; off the coast of Guernsey, English Channel. Cargo: 15,000 tonnes of palm oil (solid)	No classification: data conclusive but not sufficient for classification
Aniline oil (FD - liquid)	Very toxic liquid; when heated, vapours may form explosive mixtures with air; risk of hazardous polymerisation. Very harmful for aquatic life (high acute toxicity and long-lasting effects). Incident: *Herald of Free Enterprise*, 1987; Zeebrugge, Belgium. Cargo: package	
Butyl acrylate (FED - liquid)	Highly flammable and polymerisable; vapours (heavier than air) form explosive mixture with air. Slight acute toxic for aquatic organisms. It undergoes weathering processes (emulsification). Risks of impact on the coast. Incident: *Sam Houston*, 1982; off New Orleans, US. Cargo: package	
Xylene (FE - liquid)	Highly flammable liquid, explosive, not biodegradable. Toxic to aquatic organisms with moderate potential to bioaccumulate. Incident: *Ariadne*, 1985; Mogadishu, Somalia. Cargo: package	
Paraffin wax ($F_{(p)}$ - solid)	Appears as yellow-white aggregation on the sea surface. Very high risk of affecting the coast, also with effect on wildlife. Paraffins undergo weathering processes; in the case of sunken emulsified products benthonic habitats could also be affected (suffocation, inhibition of feeding and other non-specific toxic effects). Poses limitations on uses of the sea. Incident: unknown source, Tyrrhenian Sea, 2018.	No classification: data conclusive but not sufficient for classification

Table 33: Examples of floaters that pose health and/or marine environmental hazards

Response considerations: Dissolvers

solubility > 5% (applicable to all group with "D" as SEBC behaviour)

Physical state	Gas	Liquids				Solids	
		floaters		sinkers		floaters	sinkers
SEBC Code	GD	D	DE	DE	D	D	D
Density at 20°C	-	< seawater density		> seawater density		< seawater density	> seawater density
Vapour pressure at 20°C (kPa)	> 101.3	< 10	10		< 10	-	
Solubility at 20°C (%)	> 10	> 5				100	

Table 34: Behaviour of dissolvers

Note: for SEBC subgroup "GD", "DE", "ED" see also ▶ 5.13 Response considerations: Gases and evaporators. For floaters and sinkers see also respectively ▶ 5.14 Response considerations: Floaters ▶ 5.16 Response considerations: Sinkers

Response strategies need to consider the factors affecting the behaviour and fate of the released substances as well as the short- and long-term processes when spilled at sea.

PROCESSES AND FACTORS AFFECTING BEHAVIOUR AND FATE OF DISSOLVER IN A MARINE ACCIDENT INCIDENT								
Physical state		GAS	Liquids				Solids	
			floaters		sinkers		floaters	sinkers
SEBC Code		GD	D	DE	DE	D	D	D
BEHAVIOUR and FATE	Processes when spilled at sea	Dissolution, dispersion, diffusion dilution, potential violent reactions.						
		Immediately evaporation		Partial evaporation				
	Environmental factors influencing intensity of processes	Sea sate, air/water temperature, water-column turbulence/humidity (if on board)						
					Sea-bottom currents, bottom morphology, bathymetry			Sea-bottom currents, bottom morphology, bathymetry
	Drift and spread of HNS	Production of plumes in water column; dispersion, diffusion, dilution						
		Atmospheric dispersion	Floating slick until completely dissolved. Involves sea superficial layer.		Dissolving submerged floating plume. Residuals can accumulate on sea bottom.		Floating on sea surface until completely dissolved. Involves sea surface layer	Solids and their dissolving plume sink in water column. Sea bottom is potentially involved.
				Atmospheric dispersion				
		Evaluate risk of violent reactions with smoke/gas/aerosol production, possibly toxic (e.g. exothermic reaction from strong acids and bases). Evaluate risks of flammability/explosivity.						
	Other relevant HNS properties	Toxicity; reactivity; flammability; explosivity; pH						
			viscosity					
			Δd (d_{sw} – d_{liquid}): affects speed of sinking and buoyancy					
	Impact on marine environment	Main risks are primarily for pelagic ecosystem. In the case of dissolver and sinker substances, the benthic ecosystem could be also affected. Possible severe interference with and restrictions on coastal amenities.						
For hazards and risks see also 3.2 Hazards								

Table 35: Processes and factors affecting behaviour and fate of dissolvers in a marine incident

Considerations

- Very narrow time window for response at sea
- In case of dissolving substances, containment and recovery operations are very limited. Usually, the only response option is to leave natural processes like dispersion and dilution to deal with the spill, and, wherever possible, to accelerate these processes.

Situation assessment and first actions

Information gathering:

- immediately refer to Safety Data Sheet or chemical databases. In the case of an unknown substance, act as in the case of maximum risk;
  ▶ 3.1 Safety data sheet content
- immediately refer to data related to the location of the incident and other relevant information;
- consider sea and weather conditions.
  ▶ 5.1 Incident notification
  ▶ 5.2 Incident data gathering
  ▶ 5.3 Information resources

Situation assessment:

On the basis of the information gathered on the incident and the contingency planning risk, conduct:

- hazard identification;
  ▶ 5.6 Response considerations: Flammable and explosive substances
  ▶ 5.7 Response considerations: Toxic substances
  ▶ 5.8 Response considerations: Corrosive substances
  ▶ 5.9 Response considerations: Reactive substances
- estimation of risk and vulnerability;
- evaluation of consequences.
  ▶ 5.5 Situation assessment

First actions:

- take into account the first actions to guarantee safe conditions for the responders by identifying and reducing the hazards of explosion, fire, exposure to toxic vapours, etc. and then stop or reduce the source of the HNS spill.
  ▶ 5.17 First actions (casualty)
  ▶ 5.18 First actions (responders)

- identification of the main hazards
  - ▶ 5.6 Response considerations: Flammable and explosive substances
  - ▶ 5.7 Response considerations: Toxic substances
  - ▶ 5.8 Response considerations: Corrosive substances
  - ▶ 5.9 Response considerations: Reactive substances
- consider public safety
  - ▶ 5.19 Safety zones
- equipment/logistics
  - ▶ 5.20 Personal protective equipment
  - ▶ 5.25 Portable gas detectors for first responders

Monitoring

Modelling:

- modelling dissolved plume in water column. Input to be considered: chemical and physical parameters of the substance, weather condition and forecast, type of spill source
  - ▶ 5.11 HNS spill modelling

Monitoring using remote measuring instruments and search techniques:

- aerial surveillance: planes and helicopters (not in case of dangerous situations), drones
  - ▶ 5.22 Remote sensing technologies
- use of markers to make the substance visually detectable in water column with ROV or specific sensor (e.g. fluorimeter): NOT applicable in the case of an explosive or unknown dissolver.
  - ▶ 5.23 Substance marking
  - ▶ 5.24 Remotely operated vehicles
  - ▶ 5.26 Sampling techniques and protocols

Monitoring using in situ measuring instruments and search techniques:

- acquisition of chemical and physical parameters of the water column by multi-parametric probe and analytical determinations using field instruments (e.g. GC-MS, GC-FID, GC-PD, IR, etc.);
- trace gas sensors/explosimeter and gas detection (in case of explosion or fire risks or flammable/toxic vapours/aerosol formation or unknown substances.
  - ▶ 5.25 Portable gas detectors for first responders
  - ▶ 5.26 Sampling techniques and protocols

Water sampling:

- water sampling by "niskin" bottles (for deep or sub-surface sampling) or by manual sampling (e.g. with a glass bottle for floating substances) and storage of samples for laboratory analysis. Use of multi-parametric probe to locate the plume. Very narrow time window. Specialised personnel could be required;
- sampling solid substances (if not completely dissolved) in surface and sub-surface seawaters with specific nets, etc. Very narrow time window.
  ▶ 5.26 Sampling techniques and protocols
  ▶ 5.27 HNS detection and analysis methods

Air sampling:

- trace gas sensors: detectors for toxic substances (on board and in the environment); explosimeter and gas detection to detect explosion or fire risks;
- oxygen deficiency: electrochemical oxygen sensors.
  ▶ 5.25 Portable gas detectors for first responders

Response options

Vessel-oriented actions: ▶ 5.28 Emergency boarding

- stop the release of substance from its source;
  ▶ 5.32 Sealing and plugging
- recovery operation of the residual load;
  ▶ 5.31 Cargo transfer
- on board: collect spillage, where practicable, using sorbent material for safe disposal;
  ▶ 5.37 Using sorbents
- towing & boarding.
  ▶ 5.29 Emergency towing
  ▶ 5.30 Places of refuge

Pollutant-oriented actions: ▶ 5.38 HNS response in the water column

- neutralising agent: in the case of accidents involving substances that induce strong pH variations. Applicable only for small spills, restricted areas and no current, consider dissolution kinetics;
- suction of contaminated water and suitable purification treatment (e.g. adsorption on activated carbon; flocculating agents). Applicable only for shallow waters and calm waters;
- physical barrier to stop or slow down the spread of the pollutant. In the presence of vapour or smoke, contain using bubble barriers. Applicable for small spills and calm weather conditions;
- filtering flow to protect intakes;

- recovery of solids suspended in the water column;
  ▶ 5.38 HNS response in the water column
- wildlife response will focus on avifauna and marine mammals exposed to toxic or corrosive substances.
  ▶ 5.44 Wildlife response

Controlled release technique:
- controlled release of substance still stored on board (not advisable – evaluate for offshore, only implement after a rigorous evaluation).

Natural attenuation and monitoring:
- evaluate the non-intervention strategy (not advisable – evaluate for offshore only).
  ▶ 5.36 Natural attenuation and monitoring

Post-Spill

Environmental investigation:
- chemical and ecotoxicological analysis of contaminated seawater and/or undiluted substance.
- chemical and biological analysis of marine organisms (e.g. biomarkers) and involved wildlife
  ▶ 5.27 HNS detection and analysis methods
  ▶ 6.2 Environmental restoration and recovery

EXAMPLES OF DISSOLVERS THAT POSE HEALTH AND/OR MARINE ENVIRONMENTAL HAZARDS		
SEBC group	Main characteristics	GHS pictograms
Methyl amine solution in water <42% (DE) (L - liquid)	Irritating and toxic for humans. Slight acute toxicity for marine organisms. Poses limitations on the use of the sea.	
Sodium metal (D - solid)	Highly reactive metal. May ignite spontaneously in air. Reacts violently with water to give sodium hydroxide and hydrogen, which ignites spontaneously. Highly soluble salt production when in water. Time -and space- limited impact on the marine environment. Its high viscosity slows down dilution and dispersion. Incident: *Cason*, 1987; off North Spain; Cargo: package	
NaOH Caustic soda (D - solid)	Corrosive and irritating substance. Main risks for intervention team, on-board personnel; social and economic impact. Generally low acute toxicity for marine organisms but high risks due corrosive and irritating power. High viscosity slows down dilution and dispersion. For pH values > 8.5-9 or < 3-5 very high danger for aquatic life. Incident: *Puerto Rican*, 1984; San Francisco Bay, US; Cargo: bulk	

Table 36: Examples of dissolvers that pose health and/or marine environmental hazards

Response considerations: Sinkers

(applicable to all groups with "S" as SEBC behaviour)

Physical state	Liquids		Solids	
SEBC Code	S	SD	S	SD
Density at 20°C	> seawater density			
Vapour pressure at 20°C (kPa)	-			
Solubility at 20°C (%)	≤ 0.1	≤ 10	0.1-5	>10

Table 37: Behaviour of sinkers

Note: for SEBC subgroup "SD" see also ▶ 5.15 Response considerations: Dissolvers

Response strategies need to consider the factors affecting the behaviour and fate of the released substances as well as the short- and long-term processes when spilled at sea.

PROCESSES AND FACTORS AFFECTING BEHAVIOUR AND FATE OF SINKERS IN A MARINE ACCIDENT INCIDENT					
	Physical state	Liquids	Solids	Liquids	Solids
	SEBC Code	S		SD	
BEHAVIOUR and FATE	Environmental factors influencing intensity of processes	Water column/sea bottom currents, water temperature; bottom morphology, bathymetry			
	Drift and spread of HNS	Drift, dispersion, floating in water column before deposit; drift on sea bottom			
		Accumulation on sea bottom/ potential penetration into sediment		While sinking: dissolution, dilution and dispersion in water column (potential submerged floating plume). Residuals accumulate on sea bottom	
	Other relevant HNS properties	Δd (density) (d_{sw} - d_{solid}): affect sinking speed			
		logKow/log Koc		viscosity of the liquid or dissolved fraction	
		Reactivity, toxicity, persistency			
	Impact on marine environment	Impact on marine environment mainly related to benthic ecosystems; water column could be also affected. Microbial degradation of some sinkers may occur (e.g. decomposition of grain to form hydrogen sulphide). Some insoluble sinkers are persistent in marine environment.			

For hazards and risks see also 3.2 Hazards

Table 38: Processes and factors affecting behaviour and fate of sinkers in a marine incident

Considerations

- High cost for research and recovery activities;
- In case of emergency on board a ship it should be considered to avoid dangerous situation related to hazard of the substances involved.

Situation assessment and first actions

Information gathering:

- immediately refer to SDS or chemical databases. In the case of an unknown substance, act as in the case of maximum risk
  - ▶ 3.1 Safety data sheet content
- immediately refer to bathymetric and geomorphological data related to sea-bottom and to incident information.
- consider sea and weather conditions
  - ▶ 5.1 Incident notification
  - ▶ 5.2 Incident data gathering
  - ▶ 5.3 Information resources

Situation assessment:

On the basis of the information gathered on the incident and the contingency planning risk, consider conducting:

- hazard identification;
  - ▶ 5.6 Response considerations: Flammable and explosive substances
  - ▶ 5.7 Response considerations: Toxic substances
  - ▶ 5.8 Response considerations: Corrosive substances
  - ▶ 5.9 Response considerations: Reactive substances
- estimation of risk and vulnerability;
- evaluation of consequences.
  - ▶ 5.5 Situation assessment

First actions:

- take into account the first actions to guarantee safe conditions for the responders by identifying and reducing the hazards of explosion, fire, exposure to toxic clouds, etc. and then stop or reduce the source of the HS spill
  - ▶ 5.17 First actions (casualty)
  - ▶ 5.18 First actions (responders)
- consider public safety
  - ▶ 5.19 Safety zones
- equipment/logistics
  - ▶ 5.20 Personal protective equipment
  - ▶ 5.25 Portable gas detectors for first responders

Monitoring

Modelling:

- spill modelling: trajectories, drifting on seabed;
- for sinkers, to be considered: type of release, environmental conditions during the incident; evaluate prevailing weather and sea conditions to determine way and distribution of chemical on sea bottom.

▶ 5.11 HNS spill modelling

Monitoring using in situ measuring instruments and search techniques:

- towing dredge (for solid substances) or absorbent material (for some liquid substances) along sea bottom;
- sonar systems: side scan sonar (solids) and multibeam echosounder (seafloor depression or accumulation, bottom pool of sinking liquids), ROV investigations.

▶ 5.22 Remote sensing technologies
▶ 5.24 Remotely operated vehicles

Sediment sampling:

- sampling: box corer, grabs/videos using ROV and/or professional divers

Water sampling:

- acquisition of chemical-physical parameters in (deep) water column by multi-parametric probe and analytical determinations using field instruments (e.g. GC-MS, GC-FID, GC-PD, IR, etc.). Only for SD or dissolved reaction products.

3.2.5 Hazard: Reactivity

Air sampling on board:

- some sinkers, such as calcium carbide, can react violently with water and can be ignited under almost all ambient temperature conditions, while others, such as naphthalene, are reactive to air and flammable;
- trace gas sensors for explosion or fire risks: explosimeter and gas detection;
- oxygen deficiency: electrochemical oxygen sensor.

▶ 5.25 Portable gas detectors for first responders
▶ 5.26 Sampling techniques and protocols
▶ 5.27 HNS detection and analysis methods

Response options

Vessel-oriented actions: ▶ 5.28 Emergency boarding

- stop the release of substance from its source;

▶ 5.32 Sealing and plugging

- transfer cargo or tow the ship to a place of refuge;
  - ▶ 5.29 Emergency towing
  - ▶ 5.30 Places of refuge
  - ▶ 5.31 Cargo transfer
- retain all or part of the flow of the pollutant on board before it can reach marine environment.

Pollutant-oriented actions: ▶ 5.27 HNS response on the seabed
- containment and recovery: dredging (mechanical, pneumatic or hydraulic) for solid sinkers; pumping systems for liquid sinkers (also operated with ROV or with underwater operators, depending on how dangerous the substance is and the depth of the seabed);
- wildlife response focuses on the seafloor to minimise the impact on benthic ecosystems.
  - ▶ 5.44 Wildlife response

Controlled release technique:
- controlled release of a substance still stored on board (e.g. in the case of loss of ship stability due to heavy weather; not advisable – evaluate for offshore, only implement after a rigorous evaluation).

Natural attenuation and monitoring:
- evaluate the non-intervention strategy: recovery of sunken substance is often not possible.
  - ▶ 5.36 Natural attenuation and monitoring

Post-spill
- chemical and biological analysis (e.g. biomarkers) on pelagic and benthic organisms;
- chemical analysis on sea bottom and in water column (for persistent substances).
  - ▶ 5.27 HNS detection and analysis methods
    See Chapter 6.2 Post-spill monitoring
  - ▶ 6.2 Environmental restoration and recovery

EXAMPLE OF SINKER CHEMICALS THAT POSE HEALTH AND/OR MARINE ENVIRONMENTAL HAZARDS

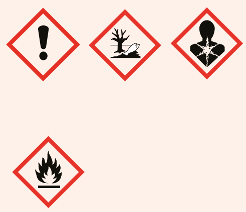
SEBC group	Main characteristics	GHS pictograms
Benzyl chloride (S - liquid)	Flammable and moderately explosive when exposed to heat or flame. When heated to decomposition, it emits toxic and corrosive fumes. Harmful for human health. Rapid reaction in water. Moderately acute aquatic toxicity. Interference with and restriction of legitimate uses of the sea and coastal structures (warning issued leading to the closure of amenities).	
Ethylene dichloride (SD - liquid)	Highly flammable liquid and vapour (poison). On combustion, forms toxic and corrosive fumes. Reacts with oxidisers. Slight acute toxicity for marine organisms. Effects on wildlife and bottom habitats (smothering of the seabed). Not readily biodegradable. Incident: *Alessandro I*, 1991; 30 km from Molfetta, Adriatic Sea, Italy; Cargo: bulk (ethylene dichloride and acrylonitrile)	
Calcium carbide (SD - solid)	Reacts violently with water forming highly flammable and explosive gas (acetylene) and can be ignited under almost all ambient temperature conditions. Harmful for humans. Low impact on marine environment. Incident: *Stanislaw Dubois*, 1981; Off Texel Island, Netherlands. Cargo: packages (857 tonnes of calcium carbide, 955 tonnes of caustic soda (solid sodium hydroxide), 5.4 tonnes of a flammable organic peroxide and 5.6 tonnes of explosives.	
Naphthalene (S - solid)	Harmful for human health. Presents hazards and risks for the marine environment: highly acutely toxicity, long-lasting effects, moderate bioaccumulation and bioconcentration. Persistent in the marine environment. Molten naphthalene is also flammable.	

Table 39: Example of sinker chemicals that pose health and/or marine environmental hazards

First actions (casualty)

BACK

Who's who?

A ship's crew can be grouped into four main departments: deck, engine, hospitality and others. The **Captain** or **Master** is the highest-ranking officer and the representative of the owner on board. On merchant vessels, the **Chief Mate** or **First Officer** is the "second in command" and responsible for all cargo operations, the vessel's safety and security and he/she leads the deck department. The **Chief Engineer** is the head of the engine department and responsible for all machinery (including engines, propulsion, electrical power supply, etc.).

The key contact person linking the vessel's crew on board and the owner/charterer on land is the **Designated Person Ashore** (DPA). The office-based DPA should have direct access to the highest management level.

Shipboard contingency plans

As per MARPOL Annex I, oil tankers ≥ 150 GT and all ships ≥ 400 GT need to carry an approved **Shipboard Oil Pollution Emergency Plan (SOPEP)** and, as per MARPOL Annex II, vessels ≥ 150 GT carrying noxious liquid substances in bulk need to carry a **Shipboard Marine Pollution Emergency Plan (SMPEP)**. Should a vessel be required to carry both plans, they are merged into a single SMPEP. Shipboard contingency plans are drawn up in accordance with specific MEPC guidelines (Resolutions MEPC. 54 (32) and MEPC.85 (44)).

These plans stipulate the actions to be taken by the captain and the vessel's crew during a marine pollution incident; they include reporting requirements, response protocols/procedures and national and local contact points.

In case of an incident involving dangerous goods, the **Emergency Response Procedures for Ships Carrying Dangerous Goods (EmS) Guide** and **Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG)** (both of which are part of the IMDG Code) are of particular importance to guide the crew's actions.

Equipment

Depending on their type, size and area of trading/operations, ships are equipped with various forms of lifesaving appliances and firefighting equipment corresponding to the provisions stated in the applicable IMO code and specific flag state requirements.

All equipment on board is indicated (type and location) in the **Fire Control and Safety Plan**. Copies of this plan are permanently located in conspicuous locations throughout the vessel. It should also be permanently kept in a weathertight container outside the superstructure for easy access for shore-side support when the vessel is in port.

Communication equipment

A vast mix of communication equipment is carried on board ships. Almost all vessels carry fixed and/or portable VHF radios for internal ship communication, ship-to-ship and ship-to-shore communication. Depending on a vessel's operational trading area, special emergency communication systems may need to be installed in line with the **Global Maritime Distress and Safety System (GMDSS)**. The GMDSS components are satellite telephony, high and medium frequency radiotelephony, digital selective calling, **NAVTEX** (automated system for the distribution of maritime safety information), **EPIRB** (Emergency Position Indicating Radio Beacon) and **SART** (Search and Rescue Radar Transponders).

Lifesaving appliances

To protect human life at sea, vessels are required to carry lifesaving appliances (as per SOLAS), which might include lifeboats, rescue boats, life rafts, various types of life buoys, immersion suits, life jackets, signalling equipment (flares and smoke signals), and line throwing apparatus. Technical specifications are listed in the International Life-Saving Appliance (LSA) Code.

Firefighting

Firefighting equipment requirements vary according to ship types/sizes. Specifications are laid out in the **Fire Safety Systems (FSS) Code**. In addition to structural fire preventive measures (fire retardant bulkheads, fire doors, dampers) and detection systems (heat/smoke detectors) most vessels will be equipped with portable and fixed firefighting systems such as:

- a series of hydrants (coupled with hoses and nozzles) placed throughout the ship (within the superstructure and on deck), which are loaded with sea water by designated fire pumps. If a fire breaks out on board a vessel whilst in port and the ship's fire pump system is not operational, the **International Shore Connection** can be used to connect shore water to the vessel's system;
- sprinkler/water mist extinguishing system;
- fixed CO_2 systems might be used to flood specific enclosed spaces of a vessel (engine room, cargo hold);
- various types of portable fire extinguishers (powder, CO_2, foam).

The ship's crew is equipped with at least two firefighters' outfits including self-contained breathing apparatus.

Unlike firefighting on land, an excess of water can be very dangerous inside a ship since it might cause the vessel to develop a severe list or trim, a reduction of freeboard or ultimately cause the vessel to sink. An additional consideration is reactivity, whereby the vessel's cargo might react with extinguishing water and release hazardous gasses or cause further fires and/or explosions.

▶ 5.9 Response considerations: Reactive substances

Oil spill response equipment

As per the specifications identified in the SOPEP, a vessel is likely to carry a SOPEP spill kit, which is likely to include oil absorbent pads/socks/cushions/booms, Personal protective equipments (coveralls, masks, goggles, gloves), a hand pump, buckets, non-spark shovels and disposable bags. These kits are designed to respond to minor spills of oil on deck only, but some of this equipment might be useful to limit the spread of an HNS spill.

First actions (responders)

BACK

Objective

To implement immediate actions in safe conditions for the responders, in order to mitigate potential spill impacts. The priority has to focus first on protecting people, the environment and finally amenities. These actions are carried out in complement or subsequent to those already initiated by the crew members or the master of the vessel.

▶ 5.17 First actions (casualty)

Who may implement first actions?

These actions must be carried out by trained and qualified responders identified in the emergency response plan, and who are familiar with the HNS involved, its behaviour and associated hazards.

▶ 5.6 Response considerations: Flammable and explosive substances
▶ 5.7 Response considerations: Toxic substances
▶ 5.8 Response considerations: Corrosive substances
▶ 5.9 Response considerations: Reactive substances

These personnel might be from the maritime or port authority and may be firefighters, coast guards, or port facility security officers.

Principle

First actions are taken to prevent the situation from worsening, especially to reduce the hazards of explosion, fire, reaction with other substances (e.g. water, air), release of a toxic cloud, etc., and to stop or reduce the source of the HNS spill.

All the initial actions described below must be performed in safe conditions for the responders, who must select proper Personal protective equipment and portable sensors according to the identified hazards.

Monitoring

Monitoring should be performed immediately at different levels in order to implement zoning, assess the situation and provide input to the information gathering process. External assistance must be requested at early stage to perform remote detection
See 5.6.2 Monitoring

Lifesaving

Consider Search and Rescue* (SAR) actions and the protection of the population
▶ 5.19 Safety zones.

*See Handbook for Maritime SAR in HNS Incidents

Immediate actions to respond to the substance

Action	Description
At the source	Isolate the source of the spill Assess interest/possibility of towing ▶ 5.29 Emergency towing ▶ 5.30 Places of refuge
On the flow	Mobilise and activate collective protective equipment. Mark the hazardous material in order to make its fumes and/or floating slicks visible, see sheets on behaviour and substance marking.
In the area surrounding incident location	Offshore or on the shoreline: - Warning to seafarers and possibly prohibit shipping in incident area as well as any legitimate uses of the sea; ▶ 5.19 Safety zones - Monitor wildlife; ▶ 5.44 Wildlife response On the shoreline or in a port: - Close water intakes; - Notify industries (nuclear power station, desalination plant), aquaculture activities (fish ponds, fish tanks, etc.) and socio-economic activities (thalassotherapy, recreational fishing, etc.) and possibly stop these activities; - Warn local authorities and population.

Table 40: Immediate actions to respond to the substance

Isolation of the source of the spill

Safety zones

Objective

Safety zones are established immediately after an incident involving dangerous goods to prevent any further damage. This approach is used even if no hazardous product has been released to give the response team time to assess the situation and respond in an organised and safe way. Each zone is defined with limits related to the hazard levels and type of operations that could be conducted, with access restricted to authorised and protected personnel. The end of the enforcement of safety zones should be announced only after a thorough situation assessment, including evaluation of residual risks based on advice from experts and thoroughly verified field measurements.

Three types of zones may be established, for which safe distances are defined considering the levels of hazards due to the presence of the chemical but also considering other potential hazards, especially the status of the distressed vessel.

Any entry point to one of the safety zones should be defined in order to:

- Stay upwind of the hazardous area;
- Consider the weather forecast;
- Ensure the response vessel or response team that has entered a high or medium risk zone can escape safely prior to immediate decontamination ▶ 5.21 Decontamination. Only vessels with the capacity to perform rescue operations in a hazardous atmosphere should enter the safety zone ▶ 4.5 Response vessels.

The following table presents the different types of zones, with the corresponding hazard level, potential effects and limits to consider for each type of hazard.

Type of zone	Definition	Potential effects and limits to consider based on hazards		
		Explosivity	Flammability	Toxicity
Exclusion/ high* risk zone	Area with highest risk	Highest injuring effect due to overpressure. No access except for SAR	Highest potential exposure for flammable vapours or fumes. No access except for SAR	Highest potential exposure for toxic vapours. No access except for SAR
Contamination reduction/ medium* risk zone	Transition area between high and low risk zones.	Entrance only by authorised responders equipped with appropriate PPE for the risk. Any entrance should be recorded.		
Support/low* risk zone	Used for workers supporting the response operations	Hazards related to normal working area. Entry point and perimeter under surveillance to prevent unauthorised access		

Table 41: Different types of zones and the potential effects and limits to consider based on hazards

*Other terminology can be found in some documents: hot/warm/cold or red/orange/green zones, with equivalent correspondence respectively to high/medium/low risk zone.

Defining safety zones

Safety zones may be hemispheres centered around the distressed vessel (DV) in case of an explosion risk.

Safety zones may be half-cones in case of possible atmospheric plumes: triangle of around 30° angle (high risk zone) and around 60° (medium risk zone) from the release or in case of fire or toxic cloud.

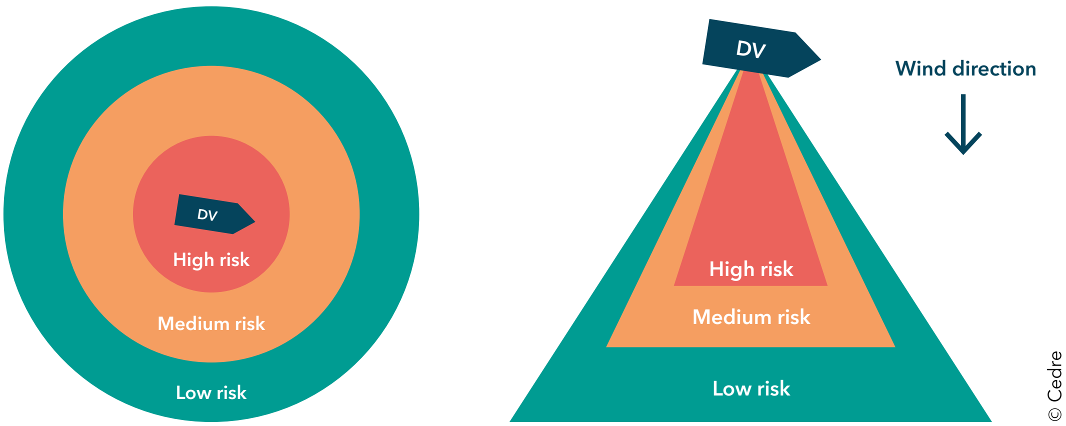


Figure 59: Safety zones

Procedure

Steps	Possible sources of information ▶ 5.3 Information resources See Chapter 5.3
1) Establishment of immediate danger zone, including for navigation (maritime and air) and possibly the population (evacuation or shelter-in-place)	- Immediate safe distance included in guides or Safety Data Sheet - No information: at least 2 NM radius from the DV
2) Definition of safety zones	- Experts - Monitoring - Forecast models - Databases - National and local warnings (contingency plan)
3) Implementation of safety zones	- High, medium, low risk zones - Entry points
4) Implementation of navigational warnings related to safety zones	
5) Monitoring and surveillance	

Table 42: Procedure to establish safety zones

Personal protective equipment (PPE)

BACK

Objective
To determine how to choose the protection level as well as how to wear PPE.

Introduction
PPE refers to the clothing and respiratory equipment that is necessary to protect a person from the hazardous properties of chemicals. Its selection should be appropriate to the particular hazards associated with the chemical(s) spilt. The following should be considered:

- Chemical spilt (concentration, exposure time);
- PPE material (durability, heat resistance);
- Level of respiratory protection required;
- Responder's ability to undertake specific work tasks.

General considerations to add: all PPE needs to be certified and may have an expiration date. Always follow the manufacturer's instructions, store appropriately, train personnel in donning and doffing.

In all cases, communication systems should be considered.

EU categories
In Europe, Regulation (EU) 2016/425 of 9 March 2016 on Personal protective equipment (the PPE Regulation) covers the design, manufacture and marketing of Personal protective equipment. It specifies three categories I, II and III, with category III addressing all risks that "may cause very serious consequences such as death or irreversible damage to health":

- **Category I**: products of simple structure, used in a low-risk environment. The user is able to independently assess the PPE protection effectiveness;
- **Category II**: products protecting against hazards which can cause injuries. The hazard for injury is determined as "not very low and not very high";
- **Category III**: products of complex structure, protecting in the situations of serious or permanent hazard which can affect the user's life and health.

Chemical protection suits are classified into six types (Table 43).

If the spilled chemical has not been identified, responders should assume a worst-case scenario and wear the highest level of protection. It is important that responders are thoroughly trained in the use of PPE to minimise the risk of harm.

US certification system

A number of government agencies, including the US Occupational Safety and Health Administration (OSHA) have devised four categories of PPE based on the level of protection required (Levels A, B, C and D). Generally, the number of chemicals and conditions for testing are higher compared to EU levels. These four levels are recognised by most response organisations:

- **Level A** offers the highest level of respiratory, skin, eye and mucous membrane protection;
- **Level B** protection should be selected when the highest level of respiratory protection is needed, but a lesser level of skin and eye protection is needed. Level B is considered the minimum level of protection when the nature of the product and the relative danger has not yet been defined and therefore before any monitoring, sampling and all the related analysis methods;
- **Level C** protection should be worn when the type of airborne substance is known, concentration measured, criteria for using air-purifying respirators met, and skin and eye exposure is unlikely. A full-face mask may be considered sufficient, with suitable filters;
- **Level D** is similar to a work uniform and should only be worn when it is certain that personnel will not be exposed to harmful levels of HNS.

Table 43 compares the two classification systems:

European level	Type 1 Category III	Type 2 Category III	Type 3 Category III	Type 4 Category III	Type 5 Category II	Type 6 Category I
Level of protection	Protects against liquid and gaseous chemicals (gas tight)	Protects against liquid and gaseous chemicals (non-gas tight)	Protects against liquid chemicals for a limited period (liquid tight)	Protects against aeroso chemicals (spray tight)	Protects against aerosol chemicals for a limited period	Protects parts of body against liquid chemicals
Respiratory equipment	Self-Contained Breathing Apparatus	Self-Contained Breathing Apparatus	Self-Contained Breathing Apparatus or air-purifying respirator	Air-purifying respirator	Air-purifying respirator	Air-purifying respirator
Approx. equivalent American level	level A	level B		level C		level D

Table 43: EU and US PPE classification systems

The flowchart below is designed to help in the selection of the most appropriate PPE in case of an HNS incident.

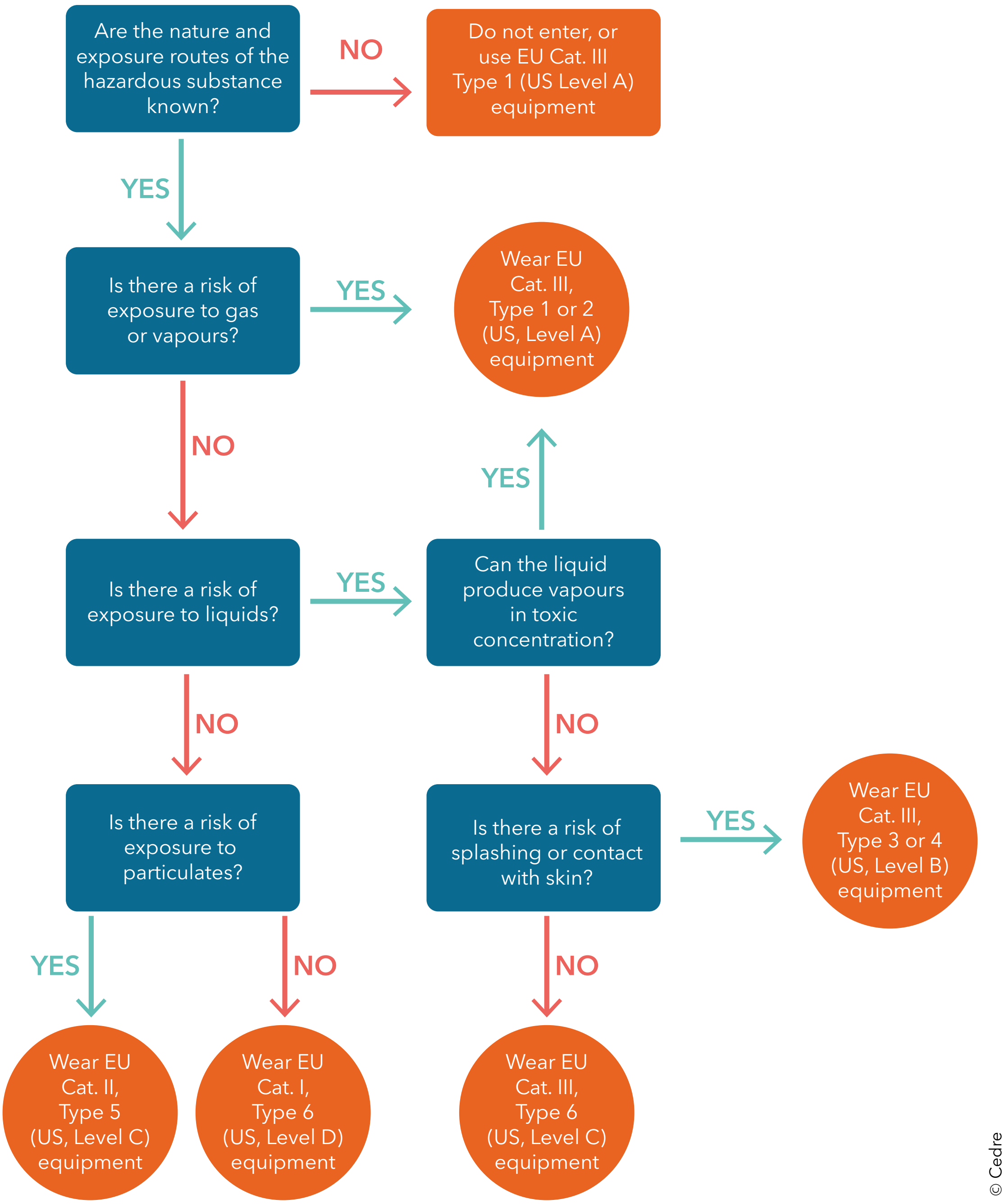


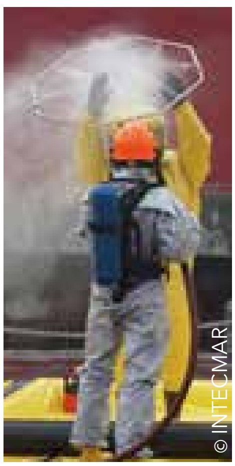
Figure 60: List of PPE with respect to protection level

Below is a list of PPE according to the level of protection required (European categories).

Type 1 Category III	Type 2 Category III
• SCBA (Self-Contained Breathing Apparatus); • Full coverage hazmat suit (gas-tight); • Inner chemical resistant gloves; • Outer chemical resistant gloves; • Chemical resistant boots with steel toe; • Long-sleeved cotton shirt (under suit); • Helmet (under suit); • Work overalls (under hazmat suit); • Radio communication system (under suit).	• SCBA (Self-Contained Breathing Apparatus); • Full coverage hazmat suit (non-gas-tight); • Inner chemical resistant gloves; • Outer chemical resistant gloves; • Chemical resistant boots with steel toe; • Disposable boot covers: • Radio communication system; • Helmet (optional); • External protective visor (optional).
Type 3 Category III	**Type 4 Category III**
• SCBA (Self-Contained Breathing Apparatus) or air-purifying respirator; • Full coverage temporarily hazmat suit (liquid-tight); • Inner chemical resistant gloves; • Outer chemical resistant gloves; • Chemical resistant boots with steel toe; • Disposable boot covers; • Work overalls (under disposable coveralls); • Radio communication system; • Helmet (optional); • External protective visor.	• Full coverage mask with filters; • Disposable chemical protective coveralls (spray-tight); • Inner chemical resistant gloves; • Outer chemical resistant gloves; • Chemical resistant boots with steel toe and leg; • Disposable boot covers; • Work overalls (under disposable coveralls); • Radio communication systems; • Helmet (optional); • External protective visor (optional); • Escape mask (optional).
Type 5 Category II	**Type 6 Category I**
• Air-purifying respirator; • Disposable chemical protective coveralls (spray-tight); • Chemical resistant gloves; • Chemical resistant boots with steel toe and leg; • Disposable boot covers; • Radio communication system; • Helmet (optional).	• Uniform for non-dangerous chemicals • Work overalls; • Safety shoes or boots. Other protective devices should be considered according to specific needs (e.g. air-purifying respirator). It is essential to have a certified absence of risks to the respiratory tract and of other possible potential risks.

Table 44: List of PPE according to the level of protection required (European categories)

Category III Type 1



Category III type 3 (foreground)

PPE for Category I Type 6

Increasing or decreasing the level of protection

Consideration criteria for increasing the level of protection:

- Confirmed or suspected presence of risk through skin contact;
- Potential or highly probable emission of gases or vapours;
- Change of tasks that increases level of (potential) contact with dangerous substances;
- Reporting from responders that describes a scenario worse than expected;
- Risk of encountering unknown substances.

Consideration criteria for decreasing the level of protection:

- Information indicating the presence of risk lower than originally expected;
- Decreased hazard due to effectiveness of intervention;
- Change of tasks that decreases the level of contact or potential contact with dangerous substances.

Donning of PPE

Donning:

Donning protective suits can be difficult. It is therefore advisable to be assisted by another person. Supervisors should oversee this task.

The order may differ depending on the PPE.

For a Category III suit:

- Remove jewellery and any potentially dangerous personal belongings: pen, cell phone, belt, etc.;
- Place suit on ground in a clean, flat location;
- Open the cylinder, check the volume of air available (regulator pressure) and put the equipment on your back.
- Open zipper completely;
- Put suit on;
- Carefully close the locking system of the suit;
- Put on gloves and boots and fasten closures;
- Check that the pressure relief valve is functional.

Doffing:

- Decontaminate before removing PPE suit; ▶ 5.21 Decontamination
- When removing the PPE suit, take care to avoid contact with any potential traces of the substance.

Personal protective equipment for divers

The main objectives of safety measures are to minimise the possibility of skin contact and the inhalation of pollutant that can penetrate both suit materials and the diver's skin. Therefore, equipping operators with a suitable diving support system (including both respiratory and physical protection) must be the primary concern.

The standby divers must be equipped with at least an equal level of protection.

Mask:

A full-face mask may reasonably protect mucous membranes of the eyes, nose, and mouth. Full-face masks can be configured to operate with compressed gas SCUBA tanks, a configuration that affords the diver freedom of movement and provides moderate protection. Most full-face masks can also be configured to operate with surface-supplied compressed gas which affords greater endurance but restricts mobility compared to SCUBA. Moreover, a full-face mask which incorporates a positive-pressure regulator will help eliminate water entering the mouth. Additionally, full-face masks offer no protection for the diver's head, neck, or ears, all potential sites exposed to waterborne hazards.

As regards the first stage of the breathing apparatus, the so-called "environmental kit" is often optional; it prevents water entrance and even if it is ideated for diving into icy water it seals the mechanism from polluted water.

A rigid helmet is coupled to a vulcanized dry suit; it isolates the diver in contaminated water. In this case the level of protection for divers is highest. Main problems with using helmets are linked to the amount of air consumed, which requires a supply boat with an air compressor on board and leads to limited mobility of operators. Moreover, in heavily contaminated water, some latex components of helmets are highly susceptible to degradation, requiring frequent replacement (US Navy, 2008).

Diver equipped with a rigid helmet and a vulcanised dry suit

Suits and gloves:
Wet suits offer little to no protection while diving in certain levels of contaminated water. The skin is directly exposed, while foam neoprene can absorb large amounts of contaminated water making decontamination difficult.

Vulcanised dry suits offer substantial protection in highly contaminated waters although a dry suit is subject to degradation.

Chemically resistant waterproof gloves should be used when diving in contaminated water. Gloves should be positioned over cuff rings on the sleeves of the dry suit. If the diver is liable to encounter bulky, adherent contaminants, a disposable oversuit (e.g., TYVEX®) may be used. Such disposable hazardous protective suits can be secured on a diver after he/she has been outfitted with the entire diving rig (U.S. Environmental Protection Agency, 2010).

Decontamination

Objective

Decontamination aims at removing or neutralising contaminants that have accumulated on personnel and equipment. It is critical to health and safety at hazardous waste sites. Different methods can be used depending on the nature and behaviour of the chemical; they can be physical, chemical or a combination of both. A decontamination plan, linked with waste management, is a necessary step and should be prepared before a response is set up.

Operator decontaminating responder (SCOPE 2017 exercise)

Applicability

Decontamination should be well organised and a team of trained operators, in charge of decontamination, should be led by a person in charge of conducting and supervising the decontamination process. Depending on the subjects to be decontaminated, some method(s) should be identified as well as procedures to implement them in a defined area of decontamination. The following figure highlights key points to be considered in order to establish a decontamination plan. The subjects to be decontaminated, as well as the method(s) and layout, are detailed below.

Subjects to decontaminate

Figure 61: Key points to establish a decontamination plan

Decontamination should be conducted on three possible subjects:

- Decontamination of accidentally exposed personnel: personnel may be exposed immediately after the spill or after cross-contamination. In these cases, refer to section 4 of the ▶ 3.1 Safety data sheet content and contact a doctor.
- Decontamination of responders after intervention: even if no exposure has been noticed, each responder should undergo a decontamination process. Surface contamination should be considered but also contamination due to permeation and influence of contact time, concentration, temperature and physical state.
- Decontamination of equipment (including response vessels) should also be thoroughly considered as, depending on the pollutant, it can be time-consuming and expensive.

Decontamination method(s) and layout

Suitable method(s) for decontamination should be selected regarding different criteria including hazards and properties of the chemical(s), and the level to be reached for decontamination. The main methods are presented in the following table.

Type of method	Name of method	Description	Constraints or limitations
Physical	Absorption	Wiping off equipment, including PPE, with sponges, sorbent pads, towels or disposable cloths	Absorbent materials should be inert or have no active properties
	Adsorption	Contaminant will preferably adhere to the surface of another material	In some cases, adsorption can produce heat and can cause spontaneous combustion
	Brushing or scraping	Used in presence or absence of liquid decontamination solutions	Chemical compatibility should be checked
	Dilution/ washing	Used to flush the hazardous materials from PPE and equipment. Proper chemical properties can improve efficiency: acid/base (weak acid, carbonates, very diluted caustic soda, weak base, etc.), surfactant (soap) or solvent	Chemical compatibility should be checked
	Freezing	Used to solidify runny or sticky liquids into a solid so that it can be scraped or flaked up	Limited use at emergency incidents
	Heating	High temperature steam is used in conjunction with high pressure water jets to heat up and blast away the contaminant	Application on equipment only. Heating techniques should never be used to decontaminate PPE
	Airing	May be used to blow dust and liquids from hard-to-reach places on equipment and structures	Airing techniques should never be used to decontaminate PPE. Risk of formation of aerosol of the chemical
	Vacuuming	Used to decontaminate structures and equipment	The washing agent should not react with the chemical. Physical washing should not be abrasive
Chemical	Chemical degradation	Alters the chemical structure of the pollutant through the use of a second chemical or material. For instance: calcium hypochlorite bleach, sodium hypochlorite bleach, sodium hydroxide (household drain cleaner), sodium carbonate slurry (washing soda), calcium oxide slurry (lime)	Sufficient quantity of chemical for neutralisation should be stored, transported and handled in the decontamination area
	Neutralisation	Used on corrosives to bring the pH of the final solution closer to neutrality, reasonably at some point between pH 5 to pH 9	May be expensive
	Solidification	Contaminant physically or chemically bonds to another object or is encapsulated by it	May produce large amount of waste

Table 45: Decontamination method(s) and layout

Rough decontamination of sticking or adhering chemicals can be removed by physical means while some physical or chemical methods can be used to achieve more complete decontamination. Testing for effectiveness, for instance with pH paper in the case of an acid or base, can confirm proper decontamination.

Different decontamination areas can be set depending on safety zones ▶ 5.19 Safety zones, for instance gross decontamination when leaving the high risk zone and complete decontamination when leaving the medium risk zone. The decontamination area should be close enough to the response site in order to allow sufficient time for responders to fulfil their mission (rescue, observation, sampling, action implementation), considering the limited time available due to go and return added to delay for decontamination.

Operational aspects

The decontamination area should always be divided into 'clean' and 'dirty' areas, with a "hot line" defined between them, in order to minimise cross-contamination. Additionally, disrobing and re-robing areas may be designated. The following figure gives an example of how to organise the layout of the decontamination area.

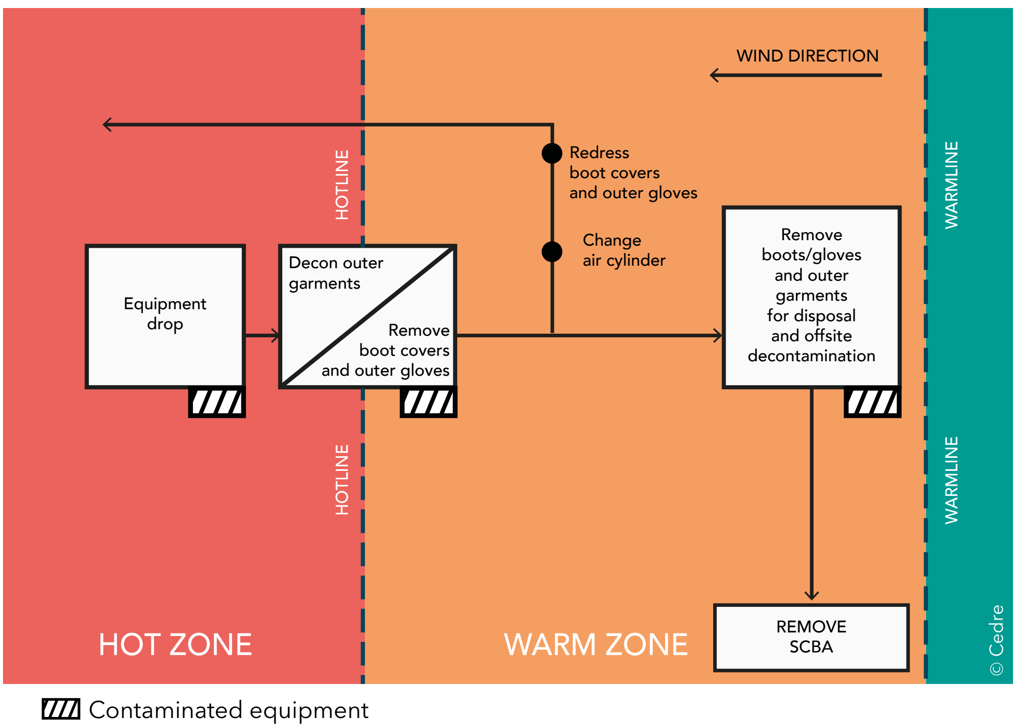


Figure 62: Decontamination area layout

Method description

Decontamination procedure:

- Position the decontamination area (see above for criteria to be considered). Movement within the incident zone must be organised based on a one-way system;
- Brief responders in the decontamination area: hazards, avoid contamination, safe path to decontamination area (at no time must a contaminated emergency responder cross paths with a non-contaminated emergency responder and vice versa), explain decontamination method;
- Set out the decontamination area;
- Drop tools: position a suitable sealable container or bag to collect tools;
- Remove or reduce contamination: before starting, check for breaches of Personal protective equipment and personal exposure. For multiple steps for decontamination, first removal of gross contamination, rinsing, washing, scrubbing, rinsing. Wiping of chemical protective clothing zips, Personal protective equipment joints and respiratory protective equipment seals. The operator should talk to responder during decontamination to check welfare;
- Check for exposure: check contamination using reactive agents/tools;
- Undress safely;
- Wash hands, face and any areas of exposure;
- Re-robe and ensure welfare (especially hydration);
- Record any exposure;
- Manage contaminated PPE and equipment;
- Conduct secondary decontamination;
- Consider waste disposal and treatment ▶ 4.4 Waste management.

Considerations

- During response, the decontamination process may seem long for responders wearing what may be heavy and cumbersome equipment. Physical fatigue may combine with mental fatigue due the pressure of the response. This fatigue may be accentuated by difficult conditions (fire, heat, movement, etc.).
- The best approach to avoid or mitigate the decontamination process is to keep contamination to a minimum:
  - Response operations should be performed upwind and upslope wherever possible;
  - Response is thirsty work: hygiene must be strictly controlled in relation to hydration;
  - Work practices or procedures minimising contact with hazardous materials should be prioritised;
  - Attention should be paid to not walking through contaminated areas;
  - Appropriate measures should be taken to prevent slips, trips and falls;

- Exposure times of protective equipment should be minimised as far as possible.
- Breathing/respiratory protective equipment should be worn for as long as possible during the decontamination process.

Decontamination of diver

Remote sensing technologies

Objective

Provide an overview of existing remote sensing technologies used for HNS detection.

Method description

Remote sensing is defined as the acquisition of information about an object (or incident in this case) without making physical contact with it. In the case of a pollution incident, remotely sensed data might be useful to estimate the spatial and temporal extent of a spill in near real-time. Remote sensing technology can be mounted on satellites, planes, helicopters and UAVs. The operational advantages and limitations of these platforms are compared in Table 46, while sensor limitations are summarised in Table 47.

Applicability

In contrast to most refined oil products, most chemicals are not readily detectable and identifiable using remote sensors. Of the five main HNS behaviour categories, only gases, evaporators and floaters might be detectable by remote sensors. The detection range will depend on a combination of factors, such as: chemical and physical properties of the substance spilt (visibility, thermal properties) and its concentration, sensor capability and specs (active/passive, type of carrier), environmental/atmospheric conditions.

Platform		ADVANTAGES	LIMITATIONS
SATELLITES using various sensors		Regular overpasses Large coverage area Multiple sensors	Overpasses are fixed in terms of frequency, coverage and trajectory Data processing and interpretation can be complex and time-consuming Spill detectability might be weather-dependent
Manned aircraft	**Planes** Using various sensors and trained observers	Multiple types of sensors can be used Can be deployed relatively quickly Human observation feasible Longer range than helicopter	Cannot operate in explosive atmospheres Cannot operate at minimum speed and altitude Cover smaller area than satellite
	Helicopters Using various sensors and trained observers	Human observation feasible Manoeuvrability Ability to perform stationary flight	Limited number of sensors (FLIR) Cannot operate in explosive atmospheres Limited number of observers Limited range
DRONES/UAV Using various sensors		Price range/low cost Remote piloting Can be adapted to operate in explosive atmospheres Integration of miniaturised sensors	Need for drone aircraft runway (for UAVs) Limited flight time Limited by weather conditions Limited to lightweight sensors Increasingly strict regulations for operating UAV
Autonomous ships			Limited navigating time Limited by sea surface state Limited to lightweight sensors
Vessels		Observation of benthos Platform to deploy drone or ROV	Delay to access remote area
ROV		▶ 5.24 Remotely operated vehicles	

Table 46: Operational advantages and limitations of platforms for remote sensing

	MAIN TYPES OF EXISTING DETECTORS AND KEY CHARACTERISTICS										
DETECTOR NAME	**Synthetic Aperture Radar (SAR)**	**Side-Looking Airborne Radar (SLAR)**	**Microwave Radiometer (MWR)**	**Laser Fluorosensor (LFS)**	**Sonar, single or multibeam**	**(Visible + infrared)**	**Multispectral optical and thermal (Visible and infrared)**	**Raman spectroscopy**	**Ultraviolet (UV)**	**Video and photography**	**Human observer**
	USAGE CHARACTERISTICS										
Detection method	Backscatter	Backscatter	Microwave emission	UV-induced fluorescence	Echo sounder	-	Reflectance	-	Reflectance	Reflectance	Reflectance
Sensor type	Active	Active	Passive	Active	Active	-	Passive	Active	Passive	Passive	Passive
Satellite/Aircraft/ RPAS/vessel	Satellite	Aircraft	Aircraft/RPAS	Aircraft/RPAS	Vessel/ROV	-	Aircraft/RPAS/ vessel	RPAS	Aircraft/RPAS	Satellite/Aircraft/ RPAS	Aircraft
	ENVIRONMENTAL CONDITIONS										
Time of day	All	All	All	All	All	IR: 24h	Vis: Daylight only TIR: 24h	All	Daylight only	Daylight only	Daylight only
Atmospheric limitations	None	None	Clear skies only	Clear skies only	None	-	Clear skies only	Clear skies only	None	Clear skies only	Clear skies only
Sea surface (in Beaufort - Bft)	1 < Bft < 6	1 < Bbt< 6	1 < Bft < 6	0-3 Bft <	-	-	0-3 Bft <	-	0-3 Bft <	0-3 Bft <	0-3 Bft <
	DETECTABLITY										
Location of detected HNS	Sea surface	Sea surface	Sea surface	Sea surface	Sea bottom	-	Atmosphere (IR: 5-12 µm), sea surface (if in the visible spectrum)	Sea surface	Sea surface	Sea surface (if in the visible spectrum)	Atmosphere, sea surface (if in the visible spectrum)
Examples	Xylene	Vegetable oil	-	Benzene	-	-	-	-	Styrene, xylene		
	LIMITATIONS										
Operational	False positives, look-alikes	False positives, look-alikes	Need comparison of spectra recorded in a database. In some cases, only substance transmission databases may be required	A database of spectra associated with the types of substances being investigated. In some cases, only substance transmission databases may be required	Long delay of screening for uncertain position	In some cases, only substance transmission databases may be required	False positives, look-alikes A database of spectra associated with the types of substances being investigated. In some cases, only substance transmission databases may be required	A database of spectra associated with the types of substances being investigated. In some cases, only substance transmission databases may be required	-	False positives, look-alikes	HSE limits, fatigue, difference in interpretation, false positives
Determining thickness	No certified method for determining thickness	No certified method for determining thickness	No measurement if thickness < 50 µm	Identification possible If 0.1 < thickness < 10 µm	-	Detection only for lowest thickness values	~ 10 µm	-	~ 0.1 µm	No certified method for determining thickness	No certified method for determining thickness

Table 47: Main types of existing detectors and key characteristics

Substance marking

Objective

Substance marking aims at preventing any other incident, by indicating the location of the pollutant or the risk, or supporting recovery of the pollutant.

Applicability

Depending on the exact conditions of the incident, HNS spilled at sea should be marked for safety or operational reasons. Marking can be performed at early stage of spill management, or at a later stage for instance in case of controlled release in the environment. Marking pollution may be necessary in two main cases:

- **For safety reasons**: to help identify a toxic or explosive cloud. This may be to help responders and the population to visualise a cloud expected to pass over an inhabited area. Concerning floating packaged goods, they represent a threat for seafarers;
- **For operational reasons**: it may be worthwhile marking pollution in order to find it at a later stage, either with a GPS device or visually. This may be the case for packaged goods or insoluble chemicals, or for chemicals with a slow solubility process such as floating slicks or some sinkers.

Type of marker	Benefits of marker	Behaviour of the substance	Application of marker	Advantages/limitations and operational consideration
Odorous additive	Make the substance olfactively detectable, especially for explosive or toxic clouds.	Gas/evaporator	Addition to the substance by mixing with it, before or after evaporation.	Proven technology used for the distribution of some gases, it may be impossible or difficult to implement during an incident.
Fluorescent dye	Make the substance visually detectable.	Floater or dissolver	Addition to the substance by mixing with it. Spreading technique can be performed with xanthan gum or clay balls but still has to be improved.	Lipophilic dye has shown efficiency to colour vegetable oil especially during exercises or experimentations in the field. However spraying of the dye and its homogenisation in the slick may be difficult. The most used dyes are fluorescein (yellow) and rhodamine WT (pink), the fluorescent properties of the latter being more stable. For dissolver substances, the timeframe for visibility is directly correlated to the dilution time.  *Experimentation in the field with fluorescein and rhodamine*

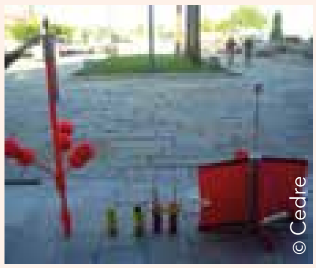
Smoke bombs	Make the location where the substance was spilled visually detectable.	All behaviours	Release from aircraft, helicopter or drone.	Useful for a limited time after an accidental spillage, smoke bombs can be used but the absence of ignition should be checked beforehand with the flash point of the pollutant. Wind direction can be detected with smoke created. 
Buoy	Make the substance visually detectable.	Floater or floating packaged goods	Release from helicopter or ship. For packaged goods the buoy may be attached to the drifting package: e.g. by a magnet or hook	The float must be: - Compatible in size with the aircraft, - Compatible with the launching chamber or tubes of the aircraft, - Resistant to impact during contact with the water and its drift comparable to that of the article to be marked. 
Acoustic transmitter	Facilitates the localisation of the substance on the seabed.	Sinker or packaged goods likely to sink	Release from helicopter, vessel or ROV. Any packaged goods being sought should be marked using an acoustic transmitter in case they sink.	Low frequency (10 kHz) carries further compared to high frequency (40 kHz) but is more difficult to locate exactly. Acoustic transmitters should not stay too close to the packaged goods due to masking effects limiting the range of transmission. A floating rope some twenty metres in length is useful to reduce this effect. When attached to sought or floating packaged goods, the buoyancy of the acoustic transmitter should also be positive to avoid its deterioration during contact with the seabed.

Table 48: Marking

FACT SHEET 5.24

Remotely operated vehicles

BACK

Objective

To outline why and when to use remotely operated equipment during an HNS incident.

General comments

When the incident environment is too hazardous or too remote for responders to approach, remotely operated equipment might be an alternative to obtain information on and/or respond to the spill. In addition, it may perform a task quicker than a human or be a more cost-effective option.

Remotely operated equipment might be used to inspect and map affected areas, for sampling and potentially to carry out containment and recovery operations. An overview of subsurface, surface and aerial technology is given below.

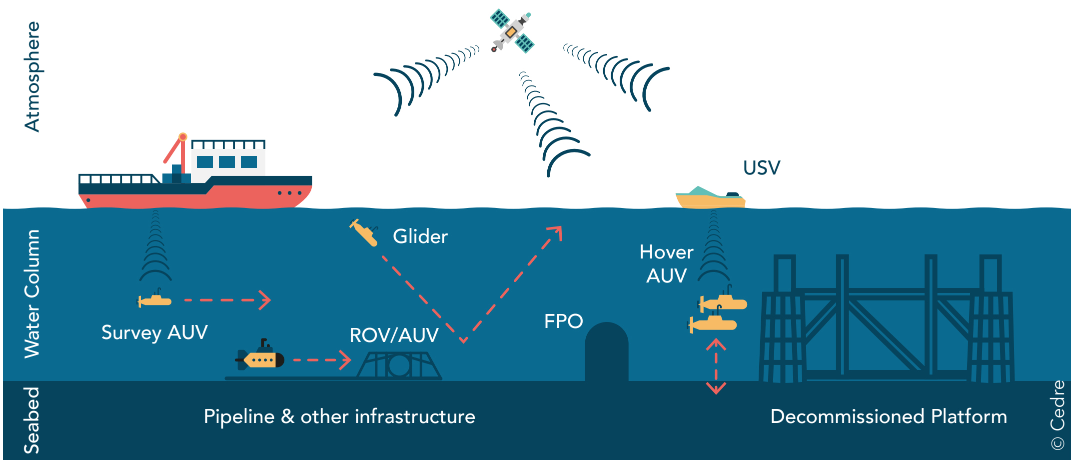


Figure 63: Diagram showing subsurface, surface and aerial technologies: Remotely Operated Vehicle (ROV); Autonomous Underwater Vehicle (AUV), glider, Autonomous Surface Vehicle (ASV), Unmanned Surface Vessel (USV), fixed-wing Unmanned Aerial Vehicle (UAV), rotary wing UAV, satellite.

Uses for remotely operated equipment	Subsurface ROV, AUV, Glider	Surface ASV	Aerial UAV, satellite
Surveying seafloor	X	X (shallow waters)	-
Collecting samples	X (ROV)	-	-
Detecting substances (sea)	X	X	-
Detecting substances (air)	X	X	X
Measuring oceanic properties (i.e., currents, salinity, temperature)	X	X	X (satellite)
Mapping	X	X	X

Table 49: Uses for remotely operated equipment

Subsurface

Remotely operated underwater vehicles (ROV)

A ROV is an underwater vehicle piloted from a remote location, which may be a ship or a fixed location such as a dock in a port. ROVs can be equipped with a launch and recovery system called LARS (Launch And Recovery System) and a TMS (Tether Management System) which is used to manage the cable that connects the underwater vehicle to the operator. ROVs can be equipped with manipulating tools, such as pliers or wrenches (to open a drum for instance) or a sampling system and video camera to make observations.

ROVs can be divided into 3 classes:

Class	Size	Maximum depth	Sensors	Use/Purpose
I	5-20 kg	300 m	Camera and lights	Carry out visual observation of a limited area (2 knots max.)
II	60 – 200 kg	400 – 500 m	Cameras, spot-lights and hydraulic manipulators	Inspections of specific structures on seabed (e.g. pipeline, wreck) as well as by taking samples of water and sediment using specific samplers with a capacity of about 100 ml
III	"Working class" > 200 kg	10,000 m	Multiple	Recover pollutants and containers as well as conduct other operations

Table 50: Classes of ROV

Autonomous Underwater Vehicles (AUVs)

An AUV is an untethered underwater vehicle useful for inspecting and mapping underwater environments. It is a vehicle that does not require an umbilical and is programmed on board or in harbour and then put into the water where it follows pre-established routes. AUVs can be equipped with video cameras and/or specific sensors, probes or instruments to carry out mapping (side-scan sonar for instance).

The main uses of AUVs are:

- Remote sensing;
- Seafloor mapping;
- Detection of objects on seafloor (wreck, containers).

Grab sampler mounted on a Class II ROV

Class II ROV

Example of AUV (glider)

Gliders

Gliders use buoyancy control to propel themselves through the water. They are used within the oceanographic industry and academia as a tool to measure ocean properties, such as currents, salinity, and temperature. Data on these properties can help with modelling the fate and trajectory of pollutants. Gliders are built to navigate over long distances with lower maneuverability compared to ROV.

Surface

Autonomous Surface Vehicles (ASV)

Many different ASV platforms exist. They can be propelled by a motor, wind, or waves and include a navigation system and a data collection and transmission system. These platforms can be equipped with many different sensors for detecting toxic clouds or substances dissolved in the sea and equipment to collect samples. During the Deepwater Horizon incident (2010, Gulf of Mexico, US), ASVs were used to monitor the presence of marine life, such as dolphins (www.asvglobal.com/asv-globals-c-worker-5-participates-marine-mammal-monitoring-expedition-gulf-mexico/).

ASV - Autonomous Surface Vehicle

Aerial

Unmanned Aerial Vehicles (UAVs) or Remotely Piloted Aircraft Systems (RPAS)

▶ 5.22 Remote sensing technologies

Unmanned Aerial Vehicles (UAVs) can be used to obtain an aerial view of large areas over a short period of time. These devices can be equipped with different types of sensors, depending on their payload capacity. UAVs are either fixed-wing or rotary-wing. In general, fixed-wing UAVs have a longer range and can carry heavier payloads, however, they require trained personal, in addition to more ground support for launching and landing. Fixed-wing UAVs can operate beyond the line of sight, however, in most countries, this requires a special permit.
Rotarywing UAVs also require permits in many countries. They generally have a shorter range and carry lighter payloads than fixed-wing UAVs due to battery capacity. They are, however, more versatile, with the ability to hover over a certain area and get closer to surfaces. Some rotary-wing UAVs can be tethered to extend the flight time and provide greater temporal coverage.

Rotary-wing UAV

Satellite

Sensors onboard satellites can measure many ocean properties, such as temperature and currents. If an incident is large enough, cameras and sensors onboard satellites may help with mapping the pollutant, in particular floating and evaporating products.

▶ 5.22 Remote sensing technologies

INTRODUCTION
IMO CONVENTIONS, PROTOCOLS AND CODES
HNS BEHAVIOURS AND HAZARDS
PREPAREDNESS
RESPONSE
POST-SPILL MANAGEMENT
CASE STUDIES
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Portable gas detectors for first responders

BACK

Objective

To present a few examples of detectors used. Particular focus is placed on the key parameters to consider for the acquisition or usage of portable detectors, as well as a reminder on how to proceed when some threshold values are measured.

Context

Portable gas monitors allow readings to be taken and assessments to be made on the safety of implementing response operations at that time.

- It can be very difficult to identify hazards when dealing with an HNS incident, and as such, all measures that can help identify and reduce the risk of a hazard should be used. Portable gas monitors are a crucial piece of equipment for any first responder;
- Different portable gas monitors measure different gases and hence it is essential to check the substances involved in the incident and the monitor's manual to ensure the monitor can accurately measure the gas present.

What portable sensors should be used?

Portable sensors for the detection of hazards, especially gas, represent an incredibly worldwide market. Several experimental studies have been conducted to test sensors. One conclusion is that no detector meets the needs for first responders in full, which highlights the necessity to be trained and aware of its own detection device.

Above all, the different sensing technologies have both advantages and limitations ▶ 5.27 HNS detection and analysis methods and detector manufacturers develop equipment for which acquisition is generally the result of compromise between additional characteristics to be considered, including: being wearable (size and weight), single/multiple measurements, drop resistance, cost and other possible interesting options such as communication functionalities.

Type of detection	Picture
Portable Colorimetric Tubes (PCTs)	
Catalytic bead sensors (explosimeter)	
Thermal conductivity detector/ katharometer	
Photo Ionisation Detector (PID) instruments	

Table 51: Typically used portable detectors

What to measure

The table below describes different variables, reference measures and response actions, in brief and limited to some common issues related to gas. Further training on these variables and appropriate response actions should be provided to all first responders, including the use of gas monitors and confined spaces training.

Measure to be detected Gas detected	Ambient level	Action to be taken
O_2 (oxygen)	< 19.5%	Monitor wearing SCBA. *Caution: combustible gas readings are not valid in atmospheres with < 19.5% oxygen.*
	19.5% - 22%	Continue investigation with caution. SCBA not needed, based on oxygen content alone.
	> 22.0%	Discontinue inspection; fire hazard potential. Consult specialist.
CO_2 (Carbon dioxide)		Evacuate immediately if detected. Monitor only wearing SCBA.
H_2S (Hydrogen sulphide)	5 ppm	Monitor wearing SCBA.
	0.4-0.8% (10-20% LEL)	Continue on-site monitoring with extreme caution as higher levels are encountered.
	> 0.8% (>20% LEL)	Explosion hazards; withdraw from area immediately.
Organic and inorganic vapour/gases	Depends on chemical.	Consult toxicological refence values.
Concentrations		
Lower Explosive Limit (LEL) (For greatest safety reserve nonane is generally used for detecting unknown flammable substances)	< 10% LEL	Continue investigation.
	10% - 20% of LEL	Continue on-site monitoring with extreme caution as higher levels are encountered.
	> 20% LEL	Explosion hazards; withdraw immediately from the area.
Radiation	< 25 µSv/h - 30 µSv/h	Continue investigation. If radiation is detected above background levels, this signifies the presence of possible radiation sources; at this level, more thorough monitoring is advisable. Consult with a health physicist.
	> 100 µSv/h	Potential radiation hazard; evacuate site. Continue monitoring only upon the advice of a health physicist or medical personnel.

Table 52: Different variables, reference measures and response actions related to gas

Limitations of portable detectors

Certain factors may give rise to inaccurate readings:

Lower readings than actual concentrations, may be due to:

- The heat of combustion of the gas or vapour, e.g. carbon disulphide;
- Inappropriate substance used for calibration. For instance if a catalytic bead sensor is calibrated to detect a very sensitive gas, it will display lower readings than the substance's actual concentration;
- Polymer formation of the chemicals which can accumulate on the sensor (polymerising chemicals such as styrene, acrylonitrile). This problem can be anticipated for certain liquid chemicals since these are carried with inhibitor additions.

Invalid readings due to:

- An oxygen concentration < 19.5%;
- Problem of unit conversion: 1 Vol.-% = 10,000 ppm (mL.m-3) = 10,000,000 ppb

Gas meter failure due to:

- Corrosion or loss of catalytic functioning of the sensor caused by the spilled chemical, e.g. halogenated hydrocarbons, hydrogen sulphide;
- Expired validity for instance, if the shelf-life of the reagent has expired (for instance the colorimetric tubes).

Sampling techniques and protocols

BACK

Objectives

To provide advice on techniques and protocols for sampling spilled substances in the field.

Introduction to sampling

Two objectives for taking samples of spilled substances in the field are:

- To serve as a reference for operational needs (e.g. response options, fishery ban) or future scientific studies;
- To identify and characterise the pollutant to provide a reference as evidence for any future claims and to contribute to response strategies.

The protocol and method of sampling should be dictated by the overall objective for undertaking sampling, and the person(s) undertaking the sampling should be trained in the appropriate method.

Tracking the progress

To keep track of the progress of the sampling process, a **Chain of Custody form** is used. This form should be included in the contingency response plan and it should outline the appropriate sampling protocol for different situations and chemicals, including approved laboratories. The contingency response plan should also appoint a **Sampling Coordinator**, who is responsible for the transmission of samples to the appointed laboratories.

The **Chain of Custody form** should include several elements, which should be adapted for different groups of chemicals.

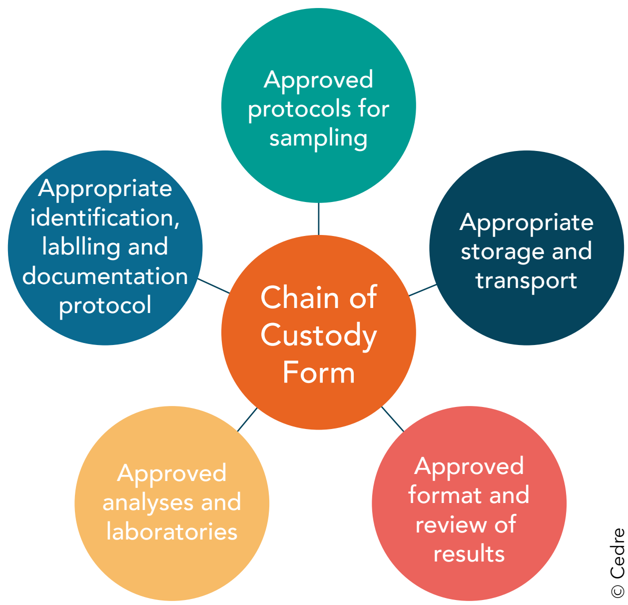


Figure 64: Chain of Custody Form

Key points

- **Objectives**: The final objective for taking samples should drive the process. This should be adaptable, if necessary and possible, to unexpected situations including harsh environments (weather, tide, current), equipment failure and other issues typical of sampling in the field.
- **Rigourous methods**: The protocols should be rigorously followed to reduce the risk of contamination and subsequently invalidating the results. This ensures the use of uncontaminated and clean equipment when sampling, as well as ensuring samples are not contaminated during storage and transport.
- **PPE**: Personal protective equipment (PPE) should be selected to enable sampling in safe conditions and to handle sampling equipment with ease.
- **Sampling kit maintenance**: The sampling kit should be maintained on a regular basis and items should always be replaced after each campaign in order to keep the kit operational.
- **Sampling kit materials**: The material for the sampling equipment should be suitable for the substance sampled. This typically consists of glass, polyethylene, polypropylene or a fluoropolymer (e.g. PTFE) which are known for their lack of interaction with analytical parameters. Section 7 of the ▶ 3.1 Safety Data Sheet for the chemical should be checked ahead of sampling to confirm compatibility.
- **Sample requirements**: The volume or weight of the sample required for analysis should be double-checked. The size of the required sample may differ depending on the type of substance, the type of analyses and the chosen laboratory.

Sampling methods

Sampling should be performed with proper equipment and techniques to ensure the integrity of the sampled substance and the subsequent reliability of analytical results.

Depending on the type of detection selected, some platforms such as ROVs may easily be equipped with in situ detectors. Other types of detection may require sampling prior to further analysis. The sampling technique should be properly performed in compliance with required standards and deterioration. For instance, organic compounds can adsorb to plastic containers, reducing the concentration in the sample, or substances such as PAHs are sensitive to degradation by ultraviolet (UV) radiation, requiring the use of amber glassware or by wrapping samples in foil.

▶ 4.5 Response vessels
▶ 5.24 Remotely operated vehicles
▶ 5.27 HNS detection and analysis methods

The frequency and quantity can vary depending on:

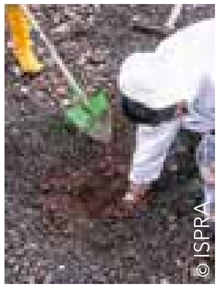
	Atmosphere	Water	Sediments	Biota
	 *Air sampling kit*	 *Bottle to sample water below sea surface*	 *Sampling sediments*	 *Sampling biota*
Sampling technique	In situ detection is preferable to sampling, especially due to potential explosive/flammable/toxic hazards, high spatial/temporal kinetics. Sampling bags should be made of a compatible chemical, tightly closed after sampling and the pollutant analysed rapidly. Air sampling can alternatively be implemented using an active carbon adsorber, followed by desorption in an analytical device such as a GC-MS.	At depths greater than 50m, water sampling can be undertaken using hydrographic sampling bottles, possibly with a PTFE internal lining.	Sediment samples can be collected using grabs or coring devices, or by means of ROVs deployed and controlled from a surface vessel. The choice of grab can be influenced by the type of sediment to be sampled. Corers are generally used to remove a core from the seabed to establish contaminant changes over time. If samples are taken from stable sediment areas, then increasing depth in the sediment (down the core from the sediment surface) represents an increase in time since the sediment was deposited.	The methods used for sampling biota will vary depending on the species of interest and the habitats with which they are associated.
Considerations	On-site monitoring needs to be carried out with extreme caution if explosive/flammable levels are encountered (10%-20% of the LEL). At levels higher than >20% of the LEL there is an explosion hazard and responders must withdraw from the area immediately.	Importance of understanding the vertical stratification in large water bodies and the effects of mixing in flowing streams.	Two main purposes: to assess if the pollutant is entering the sediments and to study changes in benthic communities and determine the impact on the seabed. In intertidal areas, sediment samples can be collected by hand.	In coastal areas, farmed fish/shellfish should also be prioritised for sampling. All contaminants in biota exhibit significant variability in concentrations between individuals and a number of fish and shellfish should be taken and analysed (if possible individually or as pooled samples) in order to reduce the level of uncertainty.

Table 53: Sampling techniques and considerations

Sample storage methods

To ensure good quality samples are submitted for analysis, there are several methods which can aid the preservation of samples and delay the degradation of the substance. These methods, which may include a pre-concentration technique, are listed in the table below.

Sample treatment	Description
Solid Phase Micro Extraction (SPME) or Stir Bar Sorptive Extraction (SBSE)	Solventless sample method using exposure on a fibre or on a magnetic stirring rod coated with extraction materials (polymer or sorbent).
Freezing	Reduces microbial action which may alter the concentration of the substance by biodegradation, for example.
Cooling	Reduces microbial action which may alter the concentration of the substance by biodegradation, for example.
Acidification	Decreases the pH ($pH < 2$) which preserves most trace metals and reduces precipitation, microbial activity and sorption losses to container walls.
Reagent addition	A high-grade reagent can chemically preserve the analytical parameters of the substance.
Solvent extraction	Extraction from sampling matrices based on their ability to be preferentially dissolved in a selected solvent. Also useful for concentrating the molecules involved to be analysed.
Filtration	Organic and inorganic contaminants can adsorb suspended matter in water. Filtration allows dissolved contaminant levels or contaminants associated with suspended matter to be determined.

Table 54: Sample storage methods

More information about sampling, preservation and holding times for commonly encountered chemicals can be found here: www.epa.vic.gov.au/about-epa/publications/iwrg701

FACT SHEET 5.27

HNS detection and analysis methods

BACK

Objective

How to choose the most suitable methods for HNS detection and analysis.

Considerations

- Account for the cost for acquisition, use and maintenance of necessary apparatus.
- Each device requires a trained operator.
- Think critically when analysing data and be aware of errors associated with the instrument.
- No single analytical method is applicable for all chemicals.

HNS detection method selection criteria

When deciding which sensor to use for HNS detection, several criteria need to be considered (Table 55).

Criteria	Explanation
Calibration	Means by which the sensor output is verified against known concentrations to enable confidence in measurements.
Sensitivity	The minimum concentration of a substance needed for a detectable sensor response. The sensitivity limit is the threshold below which a concentration cannot be detected.
Selectivity	Ability to detect the substance of concern in the presence of other substances.
Interference	Other substances/environmental parameters which might lead to false positives/ negatives.
Detection time	Time required to reach a measurement reflecting reality. Typically, the time for 90% of the signal response to be reached after exposure to the substance.
Recovery time	Time required to return to background levels once there is no more exposure to the measured substance.
Operation time	Time after which the sensor no longer outputs sufficiently reliable and accurate results, depending on the application.
Drift	Systematic change of the sensor baseline over longer timeframes as a result of instrument error in the absence of the measured substance.
Electricity consumption	Needs to be considered, especially in the field.

Table 55: Definition of the parameters characterising analytical equipment

The main detection devices are presented in following table with a description of working principle, including what species they target, a short description of their principle and the corresponding advantages and limitations.

Type of detection	Principle
Portable Colorimetric Tubes (PCTs)	A gas or vapour is pulled into a glass tube containing a sensitive reagent that reacts with the gas often causing a colour change, hence identifying the presence of a specific chemical and allowing a qualitative assessment of concentration. Can also be miniaturised on a chip.
Catalytic bead sensors (explosimeter)	When a catalyst-coated ceramic bead with an imbedded platinum coil is exposed to a flammable gas an oxidative reaction with oxygen on the bead surface causes a measurable change in the platinum wire resistance. This signal indicates the concentration of the gas in the air.
Thermal conductivity detector/ katharometer	The difference in thermal conductivity between a reference carrier gas and the measured gas is detected using the changing voltage across an electrode system.
Flame Ionisation Detector (FID) instruments	A gas sample is ionised in a hydrogen flame in the vicinity of an electrical cathode. Ions formed under an electrical potential are attracted and measured thanks to induced electrical current in an electrode system.
Surface Acoustic Wave (SAW)	SAW sensors use the interaction of sound waves with specific material coatings on a piezoelectric system to detect chemical vapours in the air. The material is chosen to detect specific chemical species. Different absorbed chemicals on the material produce a different electrical signal in the piezoelectric system caused by modulation of sound waves.
Infrared (IR) Sensors	Detection based on the absorption of infrared light by certain molecules which are detected by a decrease in transmitted radiation over a beam path. Compared with non-dispersive IR, selectivity can be improved used a FTIR detector.
Gas chromatography (GC) or High Performance Liquid Chromatography (HPLC)	The sample is introduced into a mobile phase in a column. Separation occurs along the column between a mobile phase and a stationary phase. The temperature of the column can be controlled to improve separation of chemicals. Different types of detectors can be used for the measurement or identification of separated chemicals at the outlet of the column.
Mass Spectrometry (MS)	Ionised chemicals are accelerated and then deflected by a magnetic field according to their mass-to-charge (m/z) ratio to separate the ions across a detector screen. MS is often coupled with a separation technique such as chromatography.
Ion Mobility Spectrometry (IMS)	Ionised molecules are separated in a buffer carrier gas as they travel through an electric field. Compounds are identified based on the time required for ionised molecules to drift. This separative technique is generally coupled with another detector type or mass spectrometry.
Inductively Coupled Plasma (ICP)	Ionisation technique using extremely hot plasma, usually made from argon gas. A "hard" ionisation technique as most of the molecules are atomised. A method known for its ability to detect trace metals and non-metals in liquid samples. Often combined with mass spectrometry and other spectroscopy.
Raman Spectroscopy	The substance is illuminated with infrared (IR) radiation thus interacting with the chemical bonds in the molecule and causing the IR radiation to be reflected. The reflected IR signal represents a characteristic signature spectrum of that molecular species and can be compared with reference spectra.
X-Ray Fluorescence (XRF)	The atoms in a molecule are excited by bombardment with x-rays and subsequently release energy including fluorescence and x-rays with specific wavelengths that are characteristic of certain elements. Can also be used as a remote sensor with laser-induced fluorescence.
Metal oxide semiconductor	Chemically resistant layer on a semiconductor chip that reduces a target substance hence inducing changes in conductivity or resistance that can be measured to indicate the concentration or identity of that target species. Different chemiresistors used in an array is called an 'electronic nose'.

Electroanalytical detection	These techniques use electrode systems with a solution bridge and can use different characteristics of electrolysis to measure analyte concentrations that become dissolved in the solution. Different reactions at the electrodes can cause different electrical signals that can be measured to determine the concentration of a target species. Techniques include potentiometry, conductometry, voltammetry and amperometry.
pH meter	Monitoring of acids or bases can be done with a pH meter or with pH indicating paper. In the latter case, the paper is impregnated with an indicator which changes colour on contact with the water sample. The resulting colour is compared with a scale for pH value.

Table 56: Main detection devices - © Cedre

Operational considerations

Type of detection	Used for	Advantages	Limitations
Portable Colorimetric Tubes (PCTs)	Selected gaseous chemicals	- Simple presence/absence test - Cheap, intuitive and fast - Miniaturised version usable in inaccessible places or harsh environments	- Shelf-life - Possible interferences (e.g. water) - Often does not provide a quantitative measurement
Catalytic bead sensors (explosimeter)	H_2, CH_4, combustible gas	- Low cost and robust - Easy to calibrate - Small and easy to handle - Provides a quantitative measurement	- Concentration of oxygen below 12% may affect detection - Detection reduced by polymeri-sing substances (e.g. chlorinated or fluoridated hydrocarbon substances, silicones, hybrid or sulphuric com-pounds) - Baseline calibration required - Low selectivity
Thermal conductivity detector/ katharometer	Organic or inorganic gaseous species	- High accuracy - Wide range of species detec-ted	- Low sensitivity - Not selective - Less accurate with gases with a thermal conductivity close to air (NH_3, CO, NO)
Photo Ionisation Detector (PID) instruments	Volatile Organic Compounds (VOC)	- Can detect low concentrations - Can be used in explosive atmosphere - Inexpensive	- Calibration is required with isobutylene - Some gases not ionised using this method and hence cannot be measured
Flame Ionisation Detector (FID) instruments	Organic or inorganic gaseous species	- Commonly used in chromato-graphy - Can detect low concentrations	- Non-selective - Cannot be used in explosive atmosphere - Very low detection for H_2S, CCl_4, NH_3, and some other gases - Cannot detect CO or CO_2.
Surface Acoustic Wave (SAW)	Selected gaseous chemicals	- Can detect very low concentrations - Wide range of species potentially measured - Can be miniaturised for portability	- Humidity, temperature or other chemicals may cause false positives/ negatives - Many sensors still in development stage
Infrared (IR) sensors	Hydrocarbon gases and vapours, NH_3, CO, CS_2, HCN, HF, H_2S	- Sensor not susceptible to contamination or poisoning - No calibration necessary - Not dependent on oxygen concentration	- Some chemical species not mea-surable - Expensive instrument - High energy consumption
Gas Chroma-tography (GC) or High Perfor-mance Liquid Chromatography (HPLC)	Wide range of compounds	- Flexible, customisable, high resolution and sensitivity - GC: wide range of species measurable - HPLC: many portable instru-ments capable of multiple analysis	- Appropriate detectors must be selected and calibrated - Slow detection time - GC limited by volatility of target species - HPLC not suited to field conditions

Mass Spectrometry (MS)	Wide range of compounds	- Existing portable mass spectrometers - Highly informative of chemical structure - Highly sensitive	- Expensive equipment - Usually not suited to field conditions - Slow detection time
Ion Mobility Spectrometry (IMS)	Molecules that can be ionised	- Low cost - High sensitivity - Fast response time - Portable	- Some detectors (not all) may use low energy radioactive source, authorisation required from nuclear safety authority - Limited selectivity
Inductively Coupled Plasma (ICP)	Wide range of compounds	- Some techniques can analyse liquid samples - Often used with Atomic Emission Spectroscopy (ICP-AES), with high accuracy	In ICP-AES, the sample must be dissolved in a strong acid: aqua regia, a mixture of hydrochloric acid and nitric acid
Raman spectroscopy	Hydrocarbon gases and vapours, H_2, NH_3, CO, CS_2, HCN, HF, H_2S	- Robust instrument for field use - Can detect through plastic, glass or water - High specificity - Low response time	- Interference by fluorescence or biological substances - Only suitable for higher concentrations
X-Ray Fluorescence (XRF)	Wide range of compounds	- Relatively cheap - Multi-elemental analysis - Low contamination risk	- Only suitable for larger atoms - Signal interference from other atoms - Complex equipment only suited to lab studies
Metal oxide semiconductor	Oxidising gases	- Fast response time - Cheap and reliable - Compact, with low power demands	- Low selectivity except when used in array as an '*electronic nose*' - Only suited to a limited amount of oxidising gases
Electroanalytical detection	Wide range of compounds	- Techniques are suited to liquid samples - In situ detection - Wide range of possible species measured - High degree of accuracy	- Sensitivity can depend on the materials used for the electrodes, which can vary - Possible interferences of other chemicals
pH meter	Acids and bases	- Intuitive visual result - Very simple and cheap equipment - Clear results	- Overly simple - Paper indicator is not a quantitative measurement

Table 57: Operational considerations related to detection - © Cedre

Emergency boarding

Method & application

During an incident, it may be necessary for rescue and response teams to board the vessel in distress to carry out evacuations (MEDEVAC), establish a towing connection (▶ 5.29 Emergency towing), or conduct other response or salvage operations. Boarding can be done either via a smaller craft launched from a larger response vessel in the vicinity or by helicopter.

The advantages and challenges associated with boarding via helicopter and via vessel are summarised in Table 58.

	Advantages	Challenges/ Disadvantages
	• The response vessel from which the small boarding craft is launched might act as a work platform • Availability of equipment	• Slower response time • Boarding can be very challenging especially when PPE is worn • Sea state dependent • Requires crew assistance
	• Fast response • Easier to deploy responders • Independent of the crew of the vessel	• Limited flight time and range • Limited load capacity for personnel and equipment • Weather dependent availability • Limited if hazardous atmosphere

Table 58: Advantages and disadvantages of boarding

All boarding options should be discussed in consultation with the casualty's master and other key personnel e.g. HNS experts, relevant authorities and the boarding team. When boarding the casualty via a response craft, the most practical means of access will depend on the vessel's specific layout; access to an up-to-date General Arrangement (GA), from the vessel's master or owner, will provide the required detail to establish a boarding plan. Furthermore, the vessel's fire and safety plan, in conjunction with crew communication to provide vessel-specific knowledge, can be particularly useful to guide the decision-making process when planning boarding operations.

Having crew members involved with the boarding party provides significant advantages with respect to locating and operating deck machinery e.g. to restore the vessel's power or establish a tow.

Options for boarding from another vessel might include the pilot ladder, lifeboat ladders, gangway or stern ramp. When considering boarding the casualty via helicopter, it is important to keep in mind that landing on board a casualty will most likely not be possible, and instead a suitable winching location must be identified.

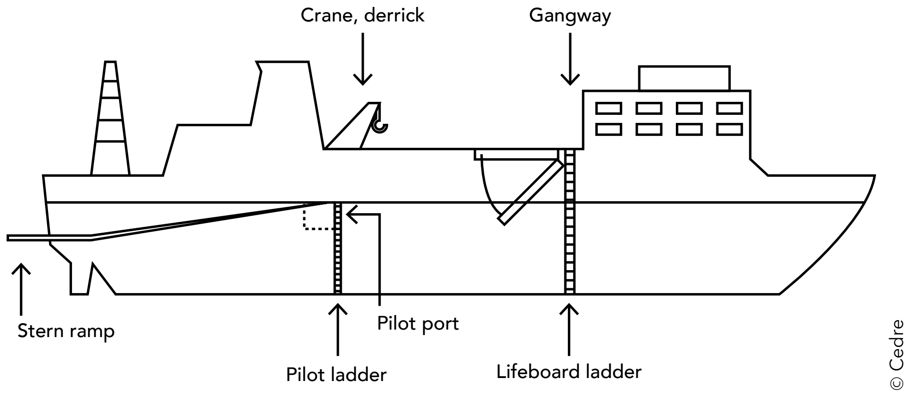


Figure 65: Examples of boarding locations

Procedures

Prior to any teams boarding a casualty a ▶ 5.5 Situation assessment must be carried out and the units/teams involved (e.g. boarding team, back-up team and decontamination team) must be informed of the action plan, associated tasks and have been given a briefing about the scenario the boarding team are likely to encounter on board. Roles and responsibilities need to be clearly defined and team members aware of the exit strategy and ▶ 5.21 Decontamination plan (ideally primary decontamination should be conducted on the vessel and secondary decontamination following disembarkation if feasible).

In the case of chemical accident involving a hazardous vapour/gas cloud ▶ 5.13 Response considerations: Gases and evaporators), it is crucial to bear in mind that all boarding and accident response must be performed from the opposite direction of the cloud (Figure 65). The risk of explosion/fire may be of further concern and will need to be considered prior to approaching the casualty. As for further safety precautions, emergency responders boarding a vessel should be equipped with appropriate PPE ▶ 5.20 Personal protective equipment, monitoring devices suitable for the scenario ▶ 5.25 Portable gas detectors for first responders, as well as safety (lifesaving appliances, communication) and response equipment (firefighting, etc.).

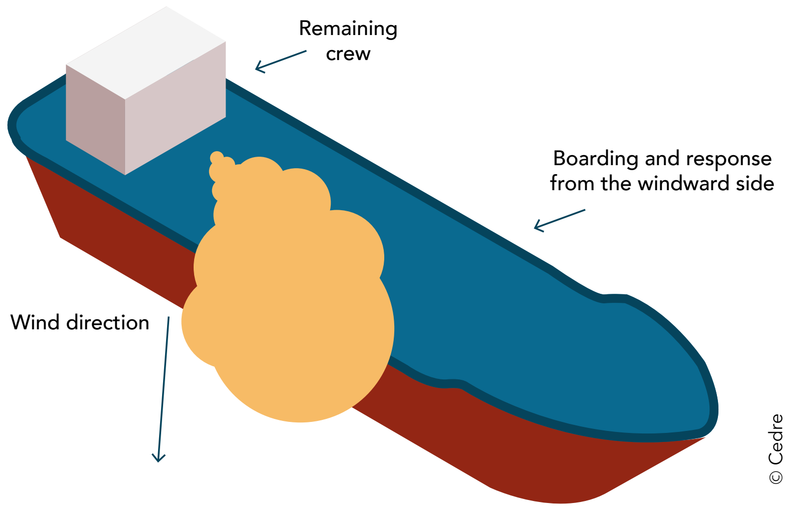


Figure 66: Identification of most suitable boarding location

Once on board the casualty, it is important to establish a safe return space in case a rapid exit from the casualty becomes necessary. A safety back-up team should always be readily available (including stand-by boats) and prepared to assist the response team should their evacuation become necessary.

Emergency towing

Objective

Emergency towing is the alteration of a distressed vessel's heading and/or course using towing equipment by an Emergency Towing Vessel (ETV). The technical requirements of a vessel acting as an ETV can vary greatly but as a minimum they require sufficient horsepower, towing equipment, and in case of an HNS incident, crew protection against potential toxic vapours (▶ 4.5 Response vessels, EMSA (2016)).

Emergency towing can be initiated and carried out by a **Competent National Authority** in charge of the response, by a salvage company contracted by the ship or by any suitable vessel in the vicinity offering assistance. Typically, ETVs are located in strategic ports, near high risk/high traffic areas and can be prepositioned at sea if weather conditions deteriorate for example.

Product tanker under tow

Purpose

Emergency towing could be implemented in following situations:

- To protect the crew or responders from direct vapours or gases by shifting the casualty so that the accommodation block or the mooring station is upwind of the source;
- To tow the casualty either out to sea (to decrease the potential impacts of an HNS spill), to a sheltered area or to a place of refuge where the safe evacuation of the vessel's crew, transfer of cargo (▶ 5.31 Cargo transfer) and/or other response/salvage operations might be carried out in a safer environment.

If a vessel is aground or stranded, salvage operations are likely to involve lightering and refloating the vessel, following which it might be towed to either a wharf or shipyard or to deep water in the case of scuttling. However, this is not considered as emergency towing as this is part of a long-term salvage strategy.

Method description

SOLAS Chapter II-1 Regulation 3-4 requires that all ships should be equipped with an **Emergency Towing Booklet** (ETB) (IMO, 2008). This document is ship-specific and details key towing information such as whether a ship is fitted with emergency towing arrangements, the procedures to follow to undertake a towing operation and mooring-related plans. A minimum of three copies should be located on board (in the bridge, in the forecastle and in the ship's office or cargo control room). The owner or operator will also have a copy of the ETB.

General best practice for towing operations is detailed in many documents produced by salvage or classification societies (examples include: DL Noble Denton, 2016).

Planning

A thorough situation awareness assessment should be undertaken, before the operation can commence, and the purpose of the emergency tow should be clear as it will affect the towing arrangements.

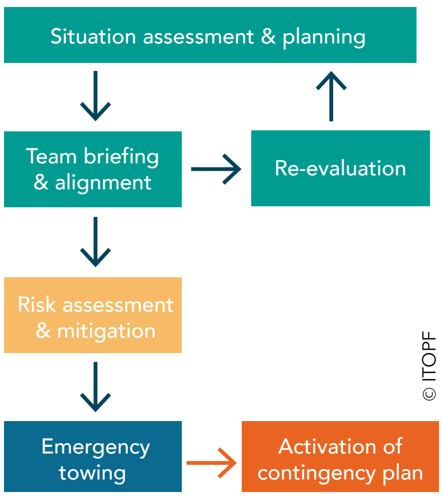


Figure 67: Suggested steps in emergency tow planning

In particular, the following questions need to be asked and answered: what type of HNS is on board, what are the substance-associated hazards, are the crew still on board/can they assist and what type of PPE is necessary (▶ 5.20 Personal protective equipment). All emergency towing procedures in accordance with or adapted from the ETB should be discussed with the vessel's master and other relevant key personnel e.g. SAR/salvage team, crew and authorities (The Finnish Border Guard, 2019). As a minimum, planning should consider the metocean conditions, ship design, rigging and contingency arrangements.

If towing gear (Figure 68) or emergency towing gear is already rigged and ready, it should be checked to ensure it is fit for use. If a skeleton crew remains on board, they should prepare the towing gear as detailed within the ETB. If feasible, before abandoning the vessel, the crew is expected to drop the pre-rigged and buoyed off pick-up gear for the emergency tow overboard to facilitate easy recovery. As a result, it might not be necessary for a salvage team to board the vessel ▶ 5.28 Emergency boarding.

In an emergency scenario, the equipment and resources available on site often have to be used and therefore the success of the towing operation is highly dependent on the standard and experience of the crew.

Checklists and procedures for emergency towing operations used during HNS incidents should be reviewed by HNS experts to anticipate and mitigate potential risks for the responders. Key overarching risks are detailed in Table 59.

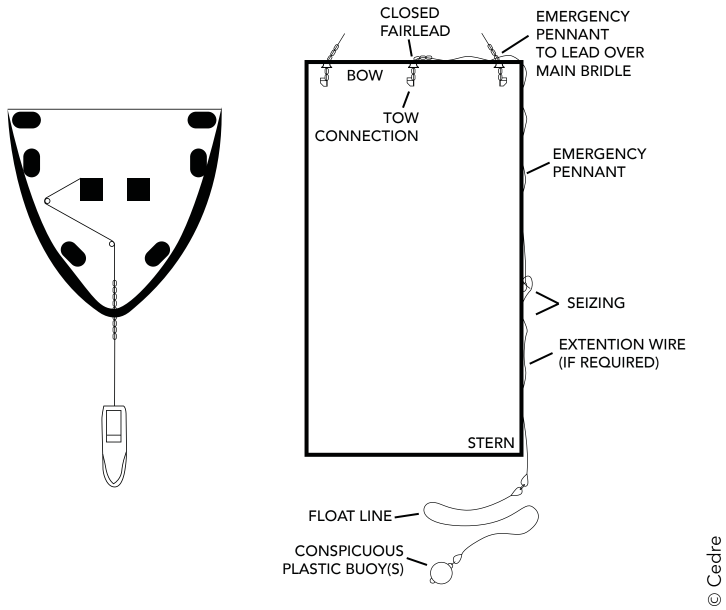


Figure 68: Example of towing line arrangements from the bow of the Ruby-T and example of an emergency towing gear configuration

	Risks	Actions
Risk of HNS cloud formation	Wind force and trajectory should be tracked and forecast	
	Risk of explosive cloud	ETVs and aircraft should be able to move away from the hot zone (▶ 5.19 Safety zones)
	Toxic cloud	Vessel should move upwind to prevent toxic concentrations.
	Liquefied gas release (and other HNS)	Be aware of reduction of visibility due to white fog (condensation of water vapour naturally present in the atmosphere). Other HNS may also drastically reduce visibility.
Conditions deteriorate to such an extent that personnel are unable to operate and handle equipment in a safe manner	Wearing protective suit (type 1) and self-contained breathing apparatus (SCBA).	Consider additional stress and fatigue on responders as well as air consumption.
	Equipment compatibility	Check equipment compatibility with HNS involved (winches, tools, chains, cables, shackles, stoppers, line throwing apparatus and radio communication equipment). *Note*: Chemical contamination often invalidates rigging certification.
Worsening conditions	Sudden HNS release	Ensure that the emergency disconnection procedure can be implemented safely in case of an HNS release

Table 59: HNS-specific risks and relevant actions

Considerations

- The most dangerous and challenging part of towing in the open sea tends to be establishing the initial connection e.g. recovering an emergency towing line, or messenger line; this can be confounded in bad weather.
- All components of the towing gear (e.g. winches, pennants, swivels) should be sufficiently rated (with an appropriate safety factor) and have valid certification.
- All parties should be well briefed on the communications plan including contingency channels.
- If boarding is required and the boarding party is to establish an emergency tow line, equipment location alongside a rigging diagram and inventory is essential. Crew involvement is essential for vessel-specific knowledge.
- A tug with a remotely operated towing winch to provide flexibility to adjust the length of the towing line according to environmental conditions, water depth, other traffic and the width of the navigational area is advised.
- Towing from the forward position might pose a risk for the crew since an HNS cloud could be headed towards the superstructure.

FACT SHEET 5.30

Places of refuge

BACK

Definition

After a ship incident, some operations that are required to prevent further damage to the ship or the environment, such as cargo lightening or ship repair, may not be possible in open sea conditions. A place of refuge is a location where such operations can be carried out safely, and risks for navigation, human life and the environment are reduced compared to the initial location. A place of refuge may be a port, a place of shelter near the coast, an inlet, a lee shore, a cove, a fjord or bay, or any part of the coast.

Places of refuge decision-making process

Gathering information

Where it is deemed safe to do so and when time permits, an inspection team should board the ship for the purpose of gathering evaluation data to support the decision-making process.

Key data to be collected:

- Vessel and crew (name, type, number of persons on board, casualties, position, departure and destination, etc.);
- Incident (nature, damages, ability to anchor, other hazards, etc.);
- Environmental conditions (weather, sea state, tidal and ice conditions, etc.);
- Potential pollution (type and quantity of bunker fuel, cargo, HNS, actual or potential pollution, etc.);
- Environmental and public health (sensitivity, proximity of human population, threats, etc.);
- Owners/insurers (name, details, Classification Society, agents, etc.);
- Initial response (measures already taken, nature of assistance required, etc.);
- Master/salvor's initial risk assessment (master's appraisal of vessel on continuing the voyage or reaching a place of refuge, etc.);
- Future intentions.

Preparing the analysis: structuring previously collected data

The aim is to assist the decision-making process by listing the best options to deal with the casualty, and start the search for a suitable place of refuge at the same time:

- Prioritise key information in terms of threat;
- Assess the realistic worst cases scenarios and potential mitigation;
- Identify which owners of places of refuge are likely to accept the request;
- Evaluate costs for all realistic options, including mechanisms and funds available to cover it.

Sheltering the ship or keeping it in open sea

The decision whether to seek a place of refuge has to be made by assessing the risks involved if the ship remains at sea and the risks that it would pose to the place of refuge and its environment, particularly regarding:

- The necessity and feasibility of emergency towing (▶ 5.29 Emergency towing);
- The safety of the crew and people sent on board the damaged ship;
- The safety of the public living/working at immediate proximity of the place of refuge (fire, explosion, toxicity,…);
- The increased risk of damage to the vessel while en route;
- The risks of pollution in high sea, for the place of refuge and during transfer;
- The maritime natural resources located nearby;
- The obstruction to navigation and disruption of regular activities (economic impacts) on the place of refuge;
- For any proposed place of refuge, can the vessel reach it in time?

Remember that maintaining the ship in the open sea is not an end in itself and the objective remains to neutralise the danger induced by the ship.

Assigning a specific place of refuge

Once technical decisions on seeking a place of refuge have been taken, discussions between owners including harbour master or local authority, the MRCC and the national authorities can be tackled. When a specific place of refuge meets all criteria and is agreed by all parties involved, the entity responsible for the ship formally confirms that the ship is fit for transfer and the relevant authority gives clearance. Places of refuge must already be identified in the NCP so that the process for their detection is completed before an HNS incident occurs.

Cargo transfer

Objective

Lightering is the process of transferring cargo or oil, or even ballasts in some cases, from one vessel to another.

This might become necessary in an HNS incident, if:

a) the vessel is aground and cannot safely be removed or

b) a vessel needs to be towed for instance into shallower waters and it is necessary to reduce its draught.

In addition to enabling further salvage operations, lightering might prevent further cargo loss into the environment.

Applicability

This response technique is suitable for all types of behaviours (gas/evaporator, floater, dissolver, sinker) and all forms of transport (bulk or packaged).

Method description

This technique is often used during normal operations and is known as Ship-to-Ship (STS) transfer. The receiving ship is called the daughter vessel and the delivering vessel is known as the STBL (Ship to be Lightered). STS transfer may be implemented for bunkering, commercial reasons, or lightening a vessel before it enters a harbour.

Ship-to-Ship (STS) transfer requires good coordination, suitable equipment, favourable weather conditions and approval from the authorities. STS transfer follows standard operating procedures, mainly governed by SOLAS and MARPOL. Resolution MEPC 186 (59) amends MARPOL 78/73 Annex I and gives instructions to prevent pollution during the transfer of oil via a STS transfer operation (it does not apply for chemicals).

The masters of both ships are each responsible for the transfer, their vessel and crew for the entire duration of the operation.

The transfer of cargo could also be carried out on a wreck, using specific equipment, professional divers and/or ROVs ▶ 5.33 Wreck response

Actions to be carried out

- Prepare a contingency plan in case of operational failure of the transfer of cargo and release of cargo in the environment;
- Place spill equipment on stand-by throughout the duration of the STS transfer;
- Monitor safety parameters, both nautical and due to the presence of chemicals: explosivity/flammability and toxicity before starting and until the end of operations;

- Equipment must be prepared and tested before the start of operations;
- Verify the compatibility of the equipment with the chemical characteristics of the substances involved;
- Prepare the vessels involved in the transfer operations and in the transport of equipment (including the transfer system's Yokohama fenders and inerting tanks and pipes);
- Approach the ship to be lightered. Approach could be made with assistance from tugs;
- Transfer the substance;
- Continuously monitor ship safety, fire and pollution control conditions throughout the entire operation.

Equipment needed

- Receiving vessel including fenders (Yokohama);
- Transfer equipment e.g.: pumps, grabs, hoses etc., mainly dependent on the physical state of the substance (solid, liquid, gas);
- Inerting equipment: to replace reactive atmosphere (oxidising, flammable, explosive) with an inert gas (nitrogen, CO_2 or argon);
- Communication equipment.

Considerations

This option should be considered as early as possible to prevent the situation from worsening. The main points to consider are:

- Are the environmental conditions (weather forecasts, sea conditions etc.) favourable?
- Is the window of opportunity compatible with the state and deterioration rate of the casualty?
- Can suitable equipment (with regard to the cargo) and cargo receiving vessel(s) be available within that timeframe?
- Are operations feasible under conditions of acceptable risks?
- Would controlled release or leaving in the natural environment be preferable?

▶ 5.36 Natural attenuation and monitoring

Yokohama fenders used to allow approach between two ships

FACT SHEET 5.32

Sealing and plugging

Objective

Leakages may occur in a wide variety of situations and under different conditions. Pipelines can sometimes leak due to undetected corrosion on the deck of a vessel. Damage can also occur on the deck or on loading pipes, especially due to mishandling or overpressure. The potentially released amount of HNS can be limited when from drums or containers but the situation can be very different with packaged goods lost at sea, stranded on the shoreline or in a harbour. Finally, potentially very large amounts of HNS can be spilled at sea when there is a crack in a ship's hull, following collision or shipwreck. Techniques for plugging and sealing, generally used temporarily pending further repairs, should be used as soon as possible, ideally as first actions when safety conditions allow it, to stop or reduce leakage. All techniques described below should always be performed by trained responders.

Safety considerations

- PPE for responders should be considered ▶ 5.20 Personal protective equipment;
- In the case of an explosive or flammable chemical, all sources of ignition must be suppressed;
- Chemical compatibility of equipment and pollutant must be checked;
- Pressurised tanks may represent a risk for responders;
- Extinguishing a flaming gas leak can cause a gas accumulation and an explosion: if possible, cut off the gas supply before extinguishing;
- Closure of a valve should be performed only if no other consequences (such as pressure increase) will result.

Techniques and equipment

Leakage on the ground (dock or deck of vessel)

A retention device (tank, canister, etc.) or a small tarpaulin should be placed under the drain to recover the pollutant during the plugging operations. This may limit the volume spilled at sea or to be recovered later (sorbents, etc.). The material of the retention tank must be chemically resistant and its volume must be large enough.

Leakage from a drum or small package

A chemically compatible overpackage must be used (possibly made of special steel for corrosive chemicals, or high-density polyethylene)

Leakage from a pipeline or storage capacity (tank, drum, etc.)

A cone/wedge is introduced into the breach to be driven in with a hammer.

- The leak-tightness can be improved with an air chamber or by using an inflatable plug, or even an airbag for large holes.

- If the leak does not have any protruding angles to the outside, a toggle screw can also be inserted into the hole to tighten a patch.

Putty can be used if chemically compatible and pressure in the tank is limited.

A sealing pad can be applied and tightened with straps. A flexible hose is used to recover the product.

- Sealing can be improved by using an inflatable sealing cushion.

In the case of an overturned tank, for example on the deck in a harbour, it may be possible to stop the leak with a lifting bag.

Other methods for pipes

A self-adhesive bandage or self-adhesive tape can be applied around the pipe. There should be no sharp angles.

A rigid cuff or wrap can be applied inner a tube around the pipe and hold it with a hose clamp. The seal will be even better if an inflatable sleeve is used.

If the pipe is flexible or malleable (lead, copper, PVC, etc.) it can be strangled with a hydraulic pipe clamp.
If the expansion of a liquefied gas cools the leak area to below 0°C, water can be applied to a cloth to make an ice plug. Caution should be maintained as coldness may weaken the pipe.

For leakage close to a valve

The valve must be closed if the leak is downstream or a valve cover can be installed if the leak is from the valve itself. Caution should be taken not haveto generate other consequences (e.g. increase in pressure).

For leakage from a flange

Tighten the flange bolts or install a flange cover. Do not over-tighten, to avoid damaging or breaking the nut.

For leakage from a vessel's hull

A magnetic patch can be used after consideration of chemical compatibility and holding force:

- above the water line: it may be possible to trim the ship to bring the leak above the water line by ballasting the vessel;
- below the water line: underwater operation to fasten a patch can be performed by divers or ROV/AUV.

This equipment can also be mutualised with other applications, for instance to fasten booms when floating chemicals need to be contained prior to recovery.

Table 60: Techniques and equipment for sealing and plugging

Wreck response

Please, take into consideration the "Nairobi International Convention on the Removal of Wreck" (IMO, 2007).

Objective

When an incident causes a ship to sink, it is necessary to organise the response in order to locate, inspect and reduce negative consequences determined mainly by polluting substances still on board (cargo and fuel). The response time is much longer, months or even year(s), than for floating ships.

Applicability

The techniques reported are generally applicable to all pollutants on board a sunken wreck, both in bulk as well as in packaged form. Interventions on the wreck have limitations determined above all by the depth, but also by other environmental difficulties (currents, exposure of the area, weather conditions, etc.).

Method description

Some operations implemented on vessels still floating can be applicable to shipwrecks, with additional difficulties due to underwater conditions.

▶ 5.32 Sealing and plugging
▶ 5.36 Natural attenuation and monitoring
▶ 5.39 HNS response on the seabed
▶ 5.41 Packaged goods response

Wreck response basically includes four steps:

1. location and detection;
2. wreck inspection;
3. risk assessment;
4. treatment and/or recovery of pollutants.

Location and detection

It is essential to determine the exact position of the wreck as well as its position with respect to the bottom, using several possible underwater vehicles (ROV, AUV, towed vehicles) on which different detection tools could be mounted (side-scan sonar, multibeam, camera). The main limitations are due to the water depth and challenges related to using sophisticated tools. ▶ 5.24 Remotely operated vehicles

Wreck inspection

A close visual examination is the only way to effectively assess the damage (status of breaches, leaks, etc.) and to plan for the possible removal or treatment of pollutants. The examination may be conducted by underwater vehicles (ROV and AUV) or professional divers, in water less than 100 metres deep, equipped with all the necessary PPE.

▶ 5.20 Personal protective equipment

Pollutant recovery

If recovery is possible, various types of equipment can be used:

	Raising the wreck	Lightering by pumping	Controlled release
Principle	Raising the wreck with its contents. Raising method: balloons, metal lifting pontoons with a crane or shearlegs	Recovery of pollutants using pumps, several methods could be applied: Vessel-pumping module with bottom-to-surface riser tube; if pollutant is less dense than water, water injection into the bottom of the tank; using specialised ROV.	Controlled release of pollutants making specific openings in the wreck structure.
Used for substances	Any pollutant	Pumpable pollutants. If necessary, lower viscosity "hot tapping" technique is suggested.	Any floating, evaporating and solving pollutants. Floating substance can be recovered.
Advantages	• Recover all pollutant • Eliminate obstruction on sea bottom	• Eliminate pollutant from marine environment	• Avoid future release of pollutant at an unpredictable moment • Relatively low-cost operation
Depth limitation	• Costs increase with depth	• Below a depth of 100 metres, use exclusively underwater vehicles • Costs increase with depth	• Below a depth of 100 metres, use exclusively underwater vehicles • Costs increase with depth

Limitations	• High-cost operation • Risky operation, feasibility study must first be conducted • Possible leaks of pollutant during operation • Availability of specialised vessels • Monitoring activities	• Medium/high-cost operation • Possible leaks of pollutant during operation • Recovery is usually not 100%, risk of trapping part of the substance in a tank/cargo hold • Monitoring activities	• Pollutants are released in the environment • Risk for wildlife • Risk for operators • Monitoring program to be set up
Examples of past cases	*Irving Whale*, September 1970 off North Point, Prince, Edward Island, Canada	*Prestige*, 2002 in Galicia, Spain. Recovery of fuel oil transported as cargo	*Ievoli Sun*, 2001 in Brittany, France. Controlled release of methyl ethyl ketone (MEK) and isopropylic alcohol (IPA)
PHOTOS	 *Recovery of wreck Tricolor*	 *Positioning of hot tap on the hull of USS Mississinewa*	 *Recovery of oil from* Peter Sif *wreck*

Table 61: Types of equipment for pollutant recovery

In situ treatment of substance (capping the wreck)

If it is not possible to recover the substance, it might be feasible to treat it in situ either as a temporary measure to limit its leakage, as a measure to reduce its hazards before removal or as a final treatment option. This strategy could have benefits for the response operation and for the safety of responders, with minimal impact on the environment, and is considered if the recovery of pollutants is judged not feasible. The introduction of treating substances requires an in-depth technical study, if the injection of an additive followed by homogenisation is required.

Depending on the reactivity of the substance, in situ treatment options can be:

- Inert materials (e.g. sand, clay);
- Chemically active agents (e.g. limestone, activated charcoal) which can neutralise or reduce a substance's toxicity;
- Sealing agents (e.g. cement).

Introducing additional materials may cause further damage to benthic communities and local ecosystems.

Another possibility is to cover the entire wreck with the above-mentioned treating materials, an operation known as capping.

Natural attenuation and monitoring – leaving in the environment

If the cost/benefit evaluation suggests that it is better not to intervene, leaving the pollutant in the environment can be considered, taking into account the fact that the metal structures of the wreck will be subject to marine corrosion, with a consequent risk of leakage. ▶ 5.36 Natural attenuation and monitoring

Scuttling

Scuttling is the deliberate sinking of a ship; this operation is forbidden by several international conventions (i.e. London Dumping Convention, 1972 and its 1986 Protocol; Dumping Protocol of Barcelona Convention, 1976) unless, after taking into account the other clean-up options, it is the only applicable procedure. This option could be chosen if it will reduce risks for populations and/or prevent the risk of further environmental damage by bringing an unstable vessel into a port.

Scuttling often postpones environmental pollution for decades, when marine corrosion allows chemicals to leak out.

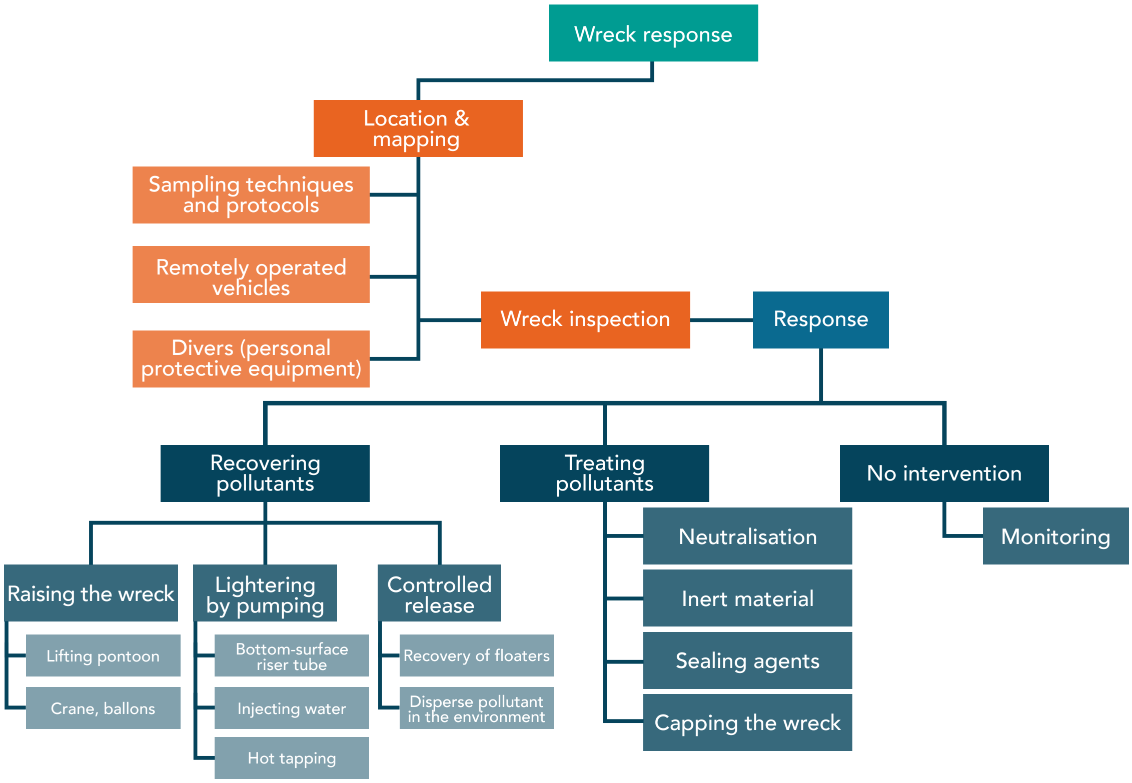


Figure 69: Wreck response decision tree

Considerations

The limitations of active intervention are often due to the sinking depth and the hazards related to the transported cargo. Even if operations are technically feasible, often expenses can be a constraint.

Active intervention is always recommended as far as possible. Marine corrosion is a very slow process that can cause the release of contaminants even many decades after the sinking.

In any case, it is necessary to provide a monitoring plan during all response phases.

Response equipment must be chemically compatible with the substances being treated to avoid the risk of leaks, permanent damage and an overall reduction in efficiency.

Using water curtains

BACK

Objective

To protect people or equipment from a toxic vapour cloud or radiation in case of fire by creating water curtain/fog to block its pathway. The main objective is to limit vapour movement (prevention at the source or protection of a target), by either diluting it in the atmosphere or knocking it down to the ground.

Applicability

This response technique is suitable for evaporators and gaseous substances. Contact of the substance with water should not create additional risks ▶ 3.1 Safety data sheet content. Depending on the characteristics of the gas:

- Water-soluble gases such as ammonia can be "knocked down" to the ground;
- Non-water-soluble gases like methane and propane can be steered, pushed and dispersed at low wind speeds.

Finally, the use of a water curtain is applicable to small or limited gas clouds only.

Method description

The principle of a water curtain – sometimes called fog when droplet diameter is really small – is to create an ascending or descending flow of small droplets of water to create a barrier preventing the toxic or gaseous cloud from reaching people or equipment at risk.

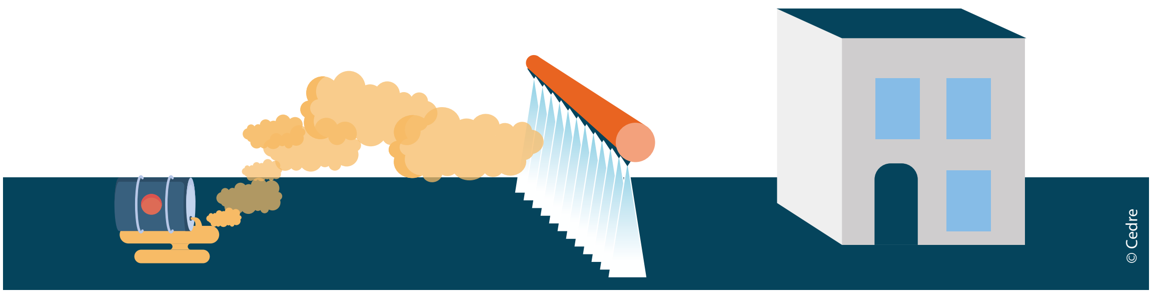


Figure 70: Water curtain

A water curtain works on different parameters depending on the physical and chemical characteristics of the substances involved. Its effectiveness relies on various processes that are complementary yet also competing: absorption, dilution and thermal transfer.

Absorption

When the substance spilled is water-soluble, the droplets of water in the curtain absorb the cloud particles. Key considerations:

- The absorption rate is highly dependent on the saturation of each droplet; sufficient renewal of the water has to be anticipated to ensure that saturation is not reached, and that clean droplets are always available to absorb the gas.
- The water curtain has to be placed as close as possible to the source. The more concentrated the cloud is, the more effective the absorption.
- The droplet diameter is a critical parameter for absorption. The smaller the droplets, the faster the absorption due to the increased contact area, but the impact of the wind will also be stronger on the curtain.
- The solubility of some substances decreases as the temperature rises (ammonia, hydrochloric acid). Low water temperature can support efficiency.
- The resulting water-substance mixture may be highly contaminated and might have to be recovered from the environment (on a ship's deck or inland).

Dilution

The descending or ascending flow of water from the curtain will cause the cloud to be diluted. Air movements induced by the droplets of the water curtain will inject fresh air inside the cloud and contribute to diluting it. By using a descending flow, vapours will be knocked down to the ground. Key considerations:

- Dilution lowers the concentration of the spilled substance near the water curtain;
- Dilution impacts the flammability/explosivity area of the cloud - LFL (LEL) and LSL (UEL);

  ▶ 5.6 Response considerations: Flammable and explosive substances
- Dilution requires a droplets diameter that is high enough to provoke air movements, therefore a fog system is not advised.

Thermal transfer

The difference in temperature between the cloud and the water droplets will induce a thermal transfer. The water curtain can be used as protection against thermal radiation from a fire. Key considerations:

- In the case of a cryogenic cloud (leaking gas tank), the water curtain will heat the cloud which therefore **may become lighter than air**, helping its vertical dispersion.
- In the case of a heated cloud, the water will help to **lower its temperature** and the associated risks.

Absorption is the **most effective process** and should be prioritised. However, it is highly related to the water solubility of the substances, therefore dilution and thermal transfer will also help to reduce the risks caused by the cloud. Depending on the HNS spilled, only one process may work. In this case, the water curtain system has to be adapted to it to ensure better efficiency (droplet size, water temperature…).

Mandatory SCBA with, depending on the circumstances and the nature of the substance, a fire suit or protection suit (type 1 in Europe or level A in North America);
▶ 5.20 Personal protective equipment

Depending on the substances spilled and processes to promote, the equipment required to produce a water curtain is fairly standard and can be bought from specialised resellers.

Creation of a water curtain
From a ship: from the ship's firefighting hose, structurally or by adding a deflector.
Descending: with spray nozzles installed on a pipe, gravity contributing to create the curtain.
Ascending: with a high pressure water jet projected on a deflector.

The efficiency of the water curtain created depends on different parameters, including:
- the system used to create the water curtain (FiFi or nozzles for instance), influencing the size of the water droplets;
- the environmental conditions: mainly wind force for which a low value will ensure optimal efficiency of the water curtain, but also the direction of the wind for which constancy will avoid having to modify the device;
- the positioning of the water curtain: the water curtain must be formed in safe conditions and as close as possible to the source.

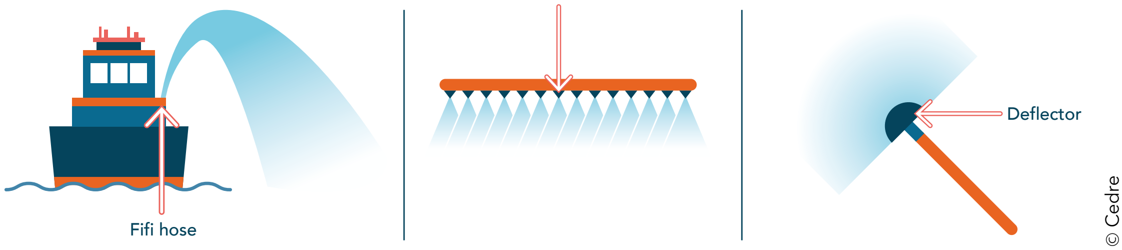


Figure 71: Creation of a water curtain

FIFI hoses/Nozzles/Deflector

Water curtain/Water fog

Fog

Using foam

BACK

Objective

Foam can be used in two main situations:

- to avoid –on the deck, dock or floating chemical– ignition or evaporation of a chemical slick: a foam blanket will stop or limit mass transfer from the slick to the atmosphere and consequently limit the risk of an explosive, flammable or toxic atmosphere. Moreover the foam blanket will limit heat transfer from external sources, e.g. from external surrounding fire or sun radiation;
- on a burning slick, the foam blanket will mainly act by suffocating the fire, but also by cooling it and by limiting emissions of flammable vapours. Smothering relies on various parameters: blocking the fresh air supply, preventing the emission of flammable vapours and isolating the flames from the combustible substance.

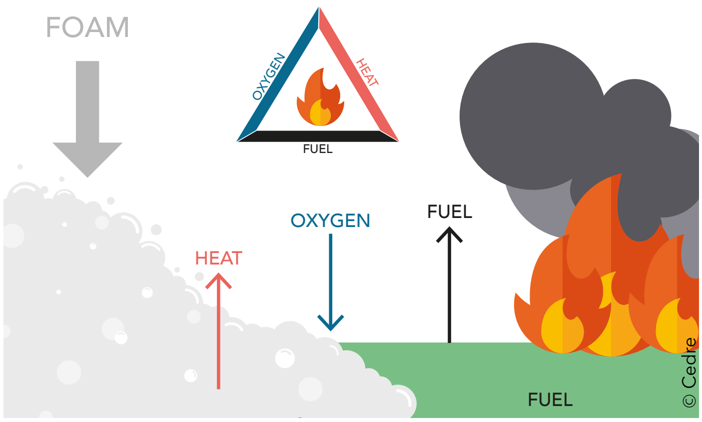


Figure 72: Foam blanket on a burning slick

Applicability

Foam is composed of surfactant, water and air. When possible, foam should be used when water alone cannot be used, or with low efficiency, as a response technique.
Foam can be sprayed in restricted situations such as:

- chemical slicks with a small or limited surface area;
- no or very limited surface current and low sea state;
- limited wind speed.

Basic information on foam

How is foam made?

The formation of foam is a multi-step process:

- **Foam concentrate** is the first compound used. It contains a concentrated aqueous solution of foaming agents, surfactants and various additives.
- Water is added to the foam concentrate to prepare a pre-mix solution. The Expansion Ratio, described below, determines the volume of water to be added.
- Foam can be generated by projection equipment.

It is characterised by an Expansion Ratio, corresponding to the volume of finished foam produced versus the volume of premix solution supplied.

$$Expansion\ Ratio = \frac{Volume_{Foam}}{Volume(Water + foam\ concentrate)}$$

Foam projection equipment

How is the appropriate expansion ratio selected?

The expansion ratio must be chosen depending on operational conditions:

Expansion ratio	Projection distance	Use	Advantages/limitations
Low ER < 20	> 30 metres Stable foam	- Limits evaporation and cooling through an isolating layer. - Polar substances are treated with aqueous film-forming foam (AFFF) or film-forming fluoroproteins (FFFP).	- Effective for reducing evaporation from a puddle, open tank, etc. - Can be projected over long distances with a foam monitor (or foam cannon) on a towable trailer, a fireboat, etc.
Medium 20 < ER < 200	Sensitive to inclement weather ~10 m	- Contains leaks - Leaks of toxic gases or substances in a partially or totally confined location	- Chemical storage container
High ER > 200	< 1 metre Light foam	- Fills large volume areas - Limited fire resistance - Dispersion possible	- Very sensitive to inclement weather

Table 62: Expansion ratio depending on operational conditions

How should foam be selected?

Different criteria should be considered to select the most appropriate foam, based on:

- **Percentage of foam concentrate**: this corresponds to the concentration of surfactant, generally 3% for oil or 6% for polar substances.
- Compatibility with already acquired equipment: the characteristics of the proportioners (viscosity, concentration), water/air flow, the risks of corrosion, as well as the types of hoses or nozzles.
- Different **types** of foam exist with corresponding features described in following table:

Foam type	Protein	Fluoroprotein	Synthetic	Film-forming Aqueous-film forming foam (AFFF)	Film-forming Film-forming fluoroproteins (FFFP)	Alcohol-resistant
Composition	Animal proteins with additional stabilisers	Protein concentrates with additional fluorochemical surfactants	Mixture of synthetic foaming agents with additional stabilisers	Synthetic foaming agents with additional fluorochemical surfactants	Proteins and fluorinated surfactants and stabilisers	Hydrolysed proteins (P), fluoroproteins (FP), synthetic stabilisers with an added polymer ingredient
Main characteristics	- Inexpensive - Very stable - Low chemical resistance	- Superior seal ability - Low chemical resistance - Less mixing with oil products	- Good expansion ratio - May mix with fuel	Ability to form a thin transparent film over the surface of the fuel		Fuel-insoluble membrane
Fire-extinguishing efficiency	- Good ability to direct flame - Low chemical resistance	- More efficient and less re-ignition than protein, - Faster knock down than protein	- Little resistance to re-ignition - All expansion ratios	- Good resistance to re-ignition - Good knock down		Effectiveness similar to fluorinated foam. Large number of different formulations.
Ability to flow	Slow-flowing withhigh shear stress	Better than protein	Flows more freely than protein	Good drainage rate		Flows quickly

Table 63: Type of foam

Considerations for preparedness

- Effect on the environment: depending on the possible impact of foam in the environment, the contingency plan should include recommendations of use, for instance not to project spraying foam in an ecological sensitive area;

- Compatibility and efficiency with seawater used for mixing with emulsifier should be considered;
- The lifetime of the emulsifier should be considered with regular testing.
- Mixing a weathered emulsifier with a new one to fill a storage tank is not recommended and could accelerate weathering of the new one. Never mix proteinic and synthetic emulsifiers;
- Sampling tests and control of emulsifier effectiveness: if possible, homogenise the storage tank or sample at the top and the bottom of the tank. To evaluate the foaming solution, use the water that wshould be used on site or during response. After a 5-years storage period, make a conduct a test on a real small scale fire to verify efficiency;
- Foam concentrate should be stored at T < 50°C and protected from air, in suitable containers, to avoid oxidation and evaporation. Some emulsifiers are sensitive to frost.

Considerations for operations

How to project foam?

- Foam should not be projected directly onto the substance, especially in case of fire, but rather indirectly by spraying on a sloped surface, allowing the foam to slide onto the target;
- Sufficient quantities of foam concentrate and water should be projected to quickly cover the entire surface and maintain the cover. Use a second control method ;
  ▶ 5.34 Using water curtains
- Field constraints should be considered: manoeuvrability of the generator, volume and rate of foam production, availability of electric/hydraulic power supply, etc.

Required personnel /equipment

Foam can be generated with handlines, thermal or hydraulic generators, etc. Depending on the equipment (mesh or net), the size of the bubbles may be different.

Foam can be sprayed manually (hand held or with mobile-wheeled) or from a stationary installation such as foam sprinkler systems or foam pouring systems (used for high expansion ratio foam)

Special attention if recovery may be possible

- Foam spray will reduce the surface tension of the floating spill which will make it more difficult to recover it with skimmers.

Natural attenuation and monitoring

BACK

Objective

Release of cargo in the environment can occur in a wide range of situations. HNS can involuntarily be partially or totally released, immediately or rapidly after an incident, for instance after a collision, shipwreck, etc. In other circumstances, HNS can be voluntarily released following a proper decision-making process and in agreement with the majority of stakeholders and experts. In all cases, monitoring should be implemented.

Applicability

Intervention is justified and appears necessary when an HNS spill, as stated in the OPRC-HNS Protocol, is likely to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea. However some basic conditions must be met:

- Intervention should not create further damage than the spill itself,
- Risks, especially for responders should be monitored and considered acceptable with regards to occupational health and safety when using appropriate equipment.

It may appear that in some cases, direct intervention may not be implemented due to various reasons. For instance, an assumed and voluntary decision not to implement direct intervention (with the exception of monitoring) may be due to:

- Significant risks associated with the prevailing situation or likely to arise due to a probable immediate, or unstable and unpredictable, evolution of the situation, that may threaten the life of responders if they go to the scene;
- The nature and/or level of risk that would justify the need for intervention: direct or indirect hazards linked to the spilled chemical are sufficiently low not to require any intervention.
- Time to respond is not sufficient, due to:
    - Mass transfer kinetics being too fast compared to response time. For example fast evaporation or dissolution process for some chemicals;
    - Deployment or implementation of response means will take too long.

Method description

In all cases, all relevant and objective information supporting decision-making should be recorded. Moreover, if monitoring with portable or fixed detectors can be deployed in safe conditions, mapping of the concentration in the impacted area should be triggered as soon as possible. Depending on the aforementioned conditions and decision-making process, two different situations might be considered and described below.

If no intervention is possible:

- As much as possible, remote monitoring or observation (visual or video recording) should be performed in safe conditions, for instance mapping the concentration of a toxic/explosive cloud in the atmosphere or acute toxic concentration of dissolved chemical in the water column. In all cases monitoring and modelling should be performed, always considering direct and indirect impacts on humans and other living organisms. Such information can be useful for incident review or even necessary to provide evidence for compensation records and justify that no direct intervention could have been carried out;
- Monitoring should be done immediately to assess the immediate impact and consider the possible need for shelter-in-place or evacuation.

Controlled released, if considered to be the best option or at least the least damaging, should be performed through a rigorous process comprising:

- assessment by an expert committee of potential impacts on humans, the environment and amenities in case of release. This evaluation should be based on modelling outputs from different scenarios;
- a pre-study on technical feasibility, including experimentations performed in conditions close to those found in the field, in order to assess behaviour and fate;
- a study on technical feasibility should be performed by recognised experts in the field. Depending on the operation, it could be performed through a collaborative approach, for instance by or with the salvage company for operations at sea;
- establishment of a monitoring plan and a contingency plan in the situation should worsen.

Experimentation column to study the behaviour of a chemical (or oil) as it rises or sinks in the water column.

The techniques and procedure to be used are strongly dependent on the location of the cargo and on the behaviour of the HNS. Dedicated equipment to release cargo in controlled and safe conditions should be used depending on the situation:

- in the case of a wreck, the vessel's hull can be pierced by a ROV or divers using explosives or by mechanical cutting. Floating pollutants such as vegetable oil can be released and left to rise to the surface where they will be contained and pumped. A water circuit can be established in the tanks to evacuate a larger quantity of product. Dissolving chemicals may be released to ensure rapid and total dissolution with no significant impact on the environment;
- in the case of a gas: remote neutralisation (scuttling) with explosives can be performed.

Examples of past incidents for which controlled released has been used: *Ece* (2006), *Ievoli Sun* (2000).

Considerations

- In all cases, the behaviour and fate of the chemical, as well as environmental conditions, should be considered.
- For controlled release, several key points should be considered: presence of currents, agitation, depth of the water and sensitiveness medium in the vicinity.

Using sorbents

Objective

To provide the main indications to protect shoreline and specific structures as well as to recover pollutant following an accident causing release of:

- products on a solid surface (e.g. shoreline, deck of a ship, pier, etc.);
- floaters on the sea surface.

Applicability

The techniques proposed are generally applicable to substances spilled on solid surfaces (shoreline, pier) or which float and have low vapour pressure and solubility (persistent floaters (Fp)). Generally, using sorbents is:

- not suitable for large spills;
- not suitable in the open sea as there is a risk that sorbents soaked with pollutant may spread and remain in the marine environment (secondary pollution);
- useful in combination with the deployment of other response techniques;
  ▶ 5.42 Containment techniques: Booms
  ▶ 5.43 Recovery techniques: Pumps and skimmers
- useful in good weather and sea conditions;
- expensive, considering the quantity of pollutant recovered/quantity of sorbents ratio as well as waste management costs.

Method description

Sorbents may be used to:

- Protect areas that are difficult to clean;
  ▶ 5.40 HNS response on the shore
- Filter the water flow, as the main material of custom-made barriers with properties to adsorb the pollutant;
  ▶ 5.38 HNS response in the water column
- Recover pollutant from the sea or a solid surface.

There are different types of sorbents:

- **Universal sorbents** are capable of absorbing both hydrophilic (polar) and hydrophobic (apolar) substances; they can be of vegetable (e.g. sawdust) or mineral (e.g. zeolite) nature. As they also absorb water, they can sink and are therefore only used on solid surfaces.
- **Hydrophobic sorbents** absorb only non polar pollutants; they are generally synthetic products (organic polymers such as polypropylene and polyurethane). They tend to float and therefore can be used at sea.

Based on their shape and packaging, the following sorbents can be considered: booms, sheets/rolls/pillows, pompoms, bulk sorbents (powder, pellets).

Sorbent booms are used mainly to contain products on the sea surface when used in combination with sorbent sheets or loose sorbents.

Sorbent sheets are applied to recover floating liquid pollutant with low/medium viscosity

Sorbent pompoms are applied to recover floating liquid pollutant with medium/high viscosity.

Bulk sorbents are used (in confined areas) to increase the thickness and viscosity of liquid on the sea surface or to intervene on solid polluted surfaces.

Equipment used for sorption and recovery must be chemically compatible with the substances being treated to avoid the risk of leaks, permanent damage and an overall reduction in efficiency. Moreover, it is important to choose the most specific equipment.

Sorbent materials can be applied in two ways:

- distributed manually from a small boat;
- bulk sorbents can be spread with the help of an air blower, if the wind is not strong.

Used sorbents can be collected by hand (booms, sheets, pillows, pompoms), using manual tools (landing net, fork), or with the use of nets with a mesh finer than the particle size of the sorbents (especially bulk sorbents).

FACT SHEET 5.37

Using sorbents

	Sorbent booms	Sorbent sheets/rolls/ pillows/pompoms	Bulk hydrophobic sorbents	Bulk "universal" sorbents
Principle	• Use in water in combination with containment booms to recover pollutant. • Sometimes main material of custom-made barriers with adsorption properties.	• Use on shore to protect surface. • Use in water in combination with containment booms to recover pollutant. • Sometime main material of custom-made barriers with adsorption properties.	• Use on shore to recover pollutants, in combination with a pressure washer to convey adsorbed chemical to a collection pool. • Use in water in combination with containment booms to recover pollutant • Used in custom-made barriers filling a filtering material	• Use on shore to recover pollutant, in combination with a pressure washer to convey adsorbed chemical to collection pool. • Used in custom-made barriers filling a filtering material
Used for	• Filtering • Recovery	• Protection • Filtering • Recovery	• Filtering • Recovery	• Filtering • Recovery
Where used	• Sheltered sea or port	• Solid surface • Sheltered sea or port	• Solid surface • Sheltered sea or port	• Solid surface
Advantages	• Effective especially with low viscosity products	• Effective especially with low viscosity products	• Effective especially with high viscosity products • High contact surface • Prevents pollutant from spreading, facilitating its recovery	• High contact surface • Can absorb all substances
Limitations	• High waste volumes • Not effective with high viscosity products • Can easily get broken • Soaks up water after a few days	• Low contact surface • Needs to be contained by sorbent or containment booms • Not effective with high viscosity products • Not recommended in open sea as sheets/ rolls etc. can sink and spread	• Needs to be contained by containment booms • Not effective with hydrophilic pollutant • Not recommended in open sea as sorbent material can sink and spread	• Not useful at sea (could sink and disperse) • Not highly efficient in sorption process

Table 64: Use of sorbents

Considerations

Sorbent boom

Depending on their vapour pressure, floating substances may evaporate rapidly and lead to high gas concentrations in the air. When responding to floating chemical spills on the water surface, it is, first of all, important to monitor air concentrations in order to assess fire and explosion risks as well as danger to health.

Once ad/absorbed, an evaporator can still evaporate from some sorbents and therefore the risk of vapours building up where the contaminated sorbent is stored may remain. Before using sorbents, their compatibility with the pollutant should be evaluated.

Some countries have specific legislation on the classification and use of sorbent materials. Always take waste management into consideration, above all because huge quantities of dangerous waste could be produced.

HNS response in the water column

Objective

Provide main indications for intervening following an incident causing the release of a substance in the water column. Since dissolved or suspended products tend to disperse quickly, intervention should be implemented as early as possible.

Applicability

Intervention takes place in the case of the release of a dissolver or an immiscible liquid or solid substance suspended in the water column.

The suggested response techniques are often only theoretical since the ideal conditions for their application are unlikely to occur simultaneously, namely:

- Sheltered area;
- Shallow depth;
- Calm sea state.

Therefore intervention is only conceivable in harbours or sheltered areas. In some cases the suggested treatments could be applied directly in the tanks of a wreck.

Active response in the water column will only be applied if the overall impact is considered preferable to leaving the substance in the environment

▶ 5.36 Natural attenuation and monitoring

Method description

There are two main response options that could be applied:

- Treatment of the water column;
- Filtering the water flow to the sea (river, lagoon, swamp, industrial discharge) or protecting intakes (aquaculture, power plant).

Response techniques take into consideration:

- the predicted spread of the pollutant(s);
- monitoring;
- the prevention of adverse effects (bans on fishing and other uses of the sea, protection of fish farms, etc.).

Often, response is limited to the above-mentioned actions, in particular in the open sea. These types of response techniques remain exceptional.

Treating the water column

In shallow waters or in a harbour, water may be treated in situ or on a mobile unit mounted on a ship, the pier or a truck.

Several treating agents may be used to reduce deleterious effects on the marine environment. Treating agents can include:

- neutralising agents for intervention on acids or bases releases. Two neutralising agents can be used to avoid pH variations: sodium carbonate for acids ($NaHCO_3$) and sodium di-hydrogen-phosphate for base spills (NaH_2PO_4);
- flocculating or coagulating agents which can form a precipitate with the pollutant, particularly suitable in the case of an insoluble substance, in suspension or in emulsion in the water;
- oxidising or reducing agents which can decrease the pollutant's toxicity;
- activated carbon and other ion exchangers which can fix the pollutant ions contained in the water column.

In any case, before applying this method, a strategic plan must be drawn up and should take into account:

- the typology of the agent;
- the equipment required to spray/introduce agents in the water column (e.g. fire hose nozzle equipped with a suction tube);
- the volume of agents needed according to the substance volume;
- when to stop operations.

In all cases, expert advice is essential. When possible, bubble curtain barriers may be used to contain dissolved or suspended chemical spills.
▶ 5.42 Containment techniques: Booms

Treatment at a mobile unit, by pumping contaminated water, is the preferable option; it generally involves treatment with same possible agents as listed above. This approach is applicable if:

- a limited volume of water with no current needs to be treated;
- the capacity of the equipment used (pumping, treatment process) is compatible, in terms of the flow and volumes to be treated, with the nature and extent of the pollution.

There are various processes that can be used by public and private firms specialising in water treatment.

Filtering the water flow and protecting intakes

The filtration and protection of water intakes may be carried out using custom-made barriers or sorbent materials ▶ 5.37 Using sorbents

Embankment and sloped pipes used to filter floating pollutant

These systems will totally or partially block the flow, filter the water column, contain/ divert the spill at the surface. Barriers may be made with wire netting and straw, an embankment and sloped pipes, trapping nets, etc.

Custom-made barriers and sorbent materials may be used for floating, dispersing and sinking substances and are effective to filter limited water flows (e.g. a pipe).

Often filtration cannot be 100% effective and its construction can be difficult. Equipment used for filtering and protecting must be chemically compatible with the substances being treated to avoid the risk of leaks, permanent damage and an overall reduction in efficiency.

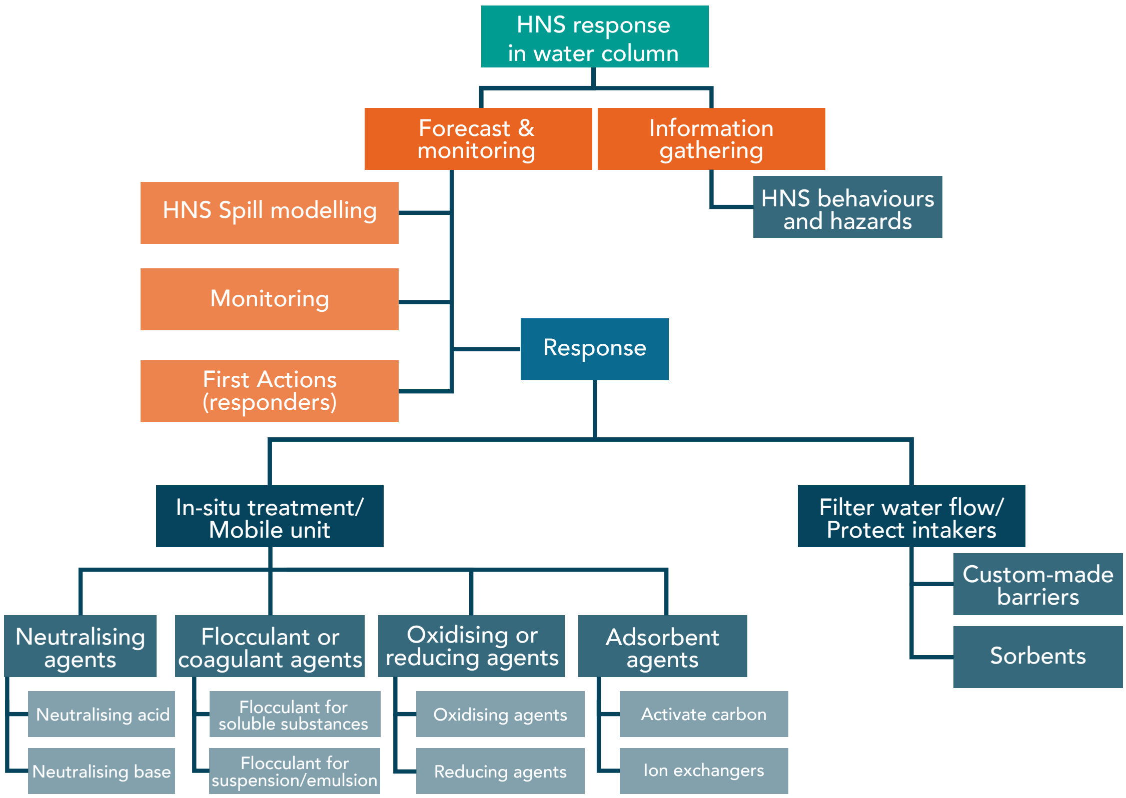


Figure 73: HNS response in water column decision tree

Considerations

Applying a recovery strategy to a water body is reasonably possible only if the following conditions are properly assessed:

- the chosen process has been proven effective and the operator is familiar with/ capable of applying it effectively;
- the water volume is limited, with very low or no flow;
- equipment and materials are available on site or can be delivered very quickly.

HNS response on the seabed

BACK

Objective

To present strategies to map, contain, treat in situ and possibly recover a substance from the seabed.

Applicability

This technique can be used for sinkers (S) and sinker/dissolvers (SD), including both liquids and solids.

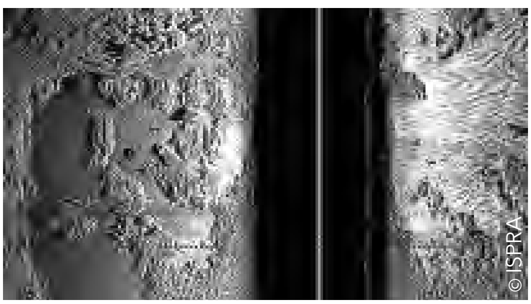
Method description

A liquid pool or solid bulk material can smother the sea floor and create anaerobic conditions harming the benthic ecosystem. In the case of a spill involving a sinker, it is likely that the substance will spread over the seafloor; its distribution will depend especially on the topography and currents. The response to HNS on the seabed starts by locating the substance and mapping its extent. When the substance has been detected, it can be contained and treated in situ, recovered or left in the environment and monitored.

Mapping the spill

The extent of spread can be determined through a combination of two strategies:

1. Direct observation using electroacoustic instruments and/or an underwater camera mounted on a ROV or carried by professional divers, if visibility is good;
2. Sampling the water, interstitial waters, sediments and benthic organisms, followed by chemical analysis required for some substances.



Side-scan sonar image showing a Posidonia meadow partially covered by coal

Picture of the same seafloor taken by professional divers

Depending on the hazards of the substance and the environmental conditions of the spill (e.g. depth, currents, visibility), different tools and equipment can be used:

- Remotely operated vehicle – ROV/AUV, preferred solution, if available for safety reasons ▶ 5.24 Remotely operated vehicles
- Professional divers, specialised to dive in polluted waters and equipped with proper chemical protective diving suits: limited by the hazards (toxicity and corrosivity) and the local environment. They are also often needed as support to operate equipment. ▶ 5.20 Personal protective equipment
- Sampling equipment: This can be sampling poles, dredges (for solids) or absorbent materials towed on the seabed (liquids), a box corer (useful for knowing the thickness of the deposit). ▶ 5.26 Sampling techniques and protocols
- Electroacoustic instruments: such as sonar (side-scan sonar and multibeam), useful both for identifying solids (often relieved on seabed) and liquid substances (which accumulate in bottom pools). ▶ 5.24 Remotely operated vehicles

While all these techniques can be used in shallow waters, increased depth restricts mapping methodologies to electronic instrumentation and Remotely operated vehicles.

The location of the substance needs to be GPS-logged and, if possible in shallow waters, its position at the sea surface physically marked (e.g. marker buoy, poles extending above the surface). This operation might need to be repeated multiple times if the substance drifts due to subsea currents.

Containing the substance

In shallow waters, there are two options for limiting the spread of a substance on the seabed:

- Digging a trench using an excavator/grab/underwater vacuum suction system. To increase the effectiveness of this method, the excavated materials can be used to build a barrier.
- In very shallow water (depth < 10 m) with no currents, it might be possible to build an underwater barrier using sand bags or other materials.

Recovering the substance

If recovery is possible, various types of equipment can be used:

	Dredges (www.european-dredging.eu/Mechanical_dredger)			Simple suction systems	Hand tools/ excavators
	Mechanical dredges	**Hydraulic dredges**	**Pneumatic dredges (airlift)**		
Principle	Use of grab or bucket to loosen the material and raise it to the surface.	The loosened material (which may be helped by mechanical loosening or water jets) is raised from its in situ state in suspension through a pipe system connected to a centrifugal pump.	Submersible air-driven pump. The unit is generally suspended from a crane on land or from a small pontoon or barge.	Substances are sucked by a pump (e.g. Peripheral Injector Jet Suction Pump (PIJESP))	Manual or mechanical assisted removal of substrate
Used for substances	Solid or semi-solid	Loose, insoluble	Insoluble or slightly soluble in water	Insoluble (liquid and solid)	Solid
Selectivity	Low	Moderate	Moderate	Moderate to high	Moderate
Advantages	• Simple to use/ readily available • Use of dredging monitoring software to record operations	• Limit the spread of the spill during operations • Use of dredging monitoring software to record operations	Use of dredging monitoring software to record operations	Good for scattered spill	Simple to use/readily available
Depth limitation	Shallow waters	Shallow to deep waters	Shallow to mid-depth waters	Shallow to mid depth waters (guidance by ROVs)	Shallow waters
Limitations	Cause too much turbulence and run the risk of spreading the spill over larger areas		• Manoeuvred by divers so added limitations to its use • Dredging action is intermittent • Suitable only for readily flowing substance	Manoeuvred by divers in shallow waters so added limitations to its use	
Examples of past cases	*Amalie Essburger* 1973, Port of Gothenburg, Sweden. 400 tonnes of Phenol		*Testbank* 1980, Mississippi River, US. 16 tonnes of Pentachlorophenol (PCP)	*Eurobulker IV* 2001, Sardinia, Italy. Recovery of coal	
PHOTOS	 © Cedre			 © ISPRA	

Table 65: Equipment for recovery

Methods with high selectivity are preferable.

In situ treatment of substance (capping)

If it is not possible to recover the substance, it might be feasible to treat it in situ either as a temporary measure to limit dispersion, as a measure to reduce a substance's hazards before removal or as a final treatment.

Depending on the reactivity of the substance, in situ treatment options can be:

- Inert materials (e.g. sand, clay);
- Chemically active agents (e.g. limestone, activated charcoal) which can neutralise or reduce a substance's toxicity;
- Sealing agents (e.g. cements)

Adding additional materials on the seabed may cause further damage to benthic communities and local ecosystems.

The success of the operation depends on the ability of the covering material to resist erosion and its integration in the local ecosystems (e.g. attraction of suspension feeders).

Leaving in the environment

If a substance cannot be contained ▶ 5.36 Natural attenuation and monitoring

Sediment sampling with a ROV on the deep seafloor

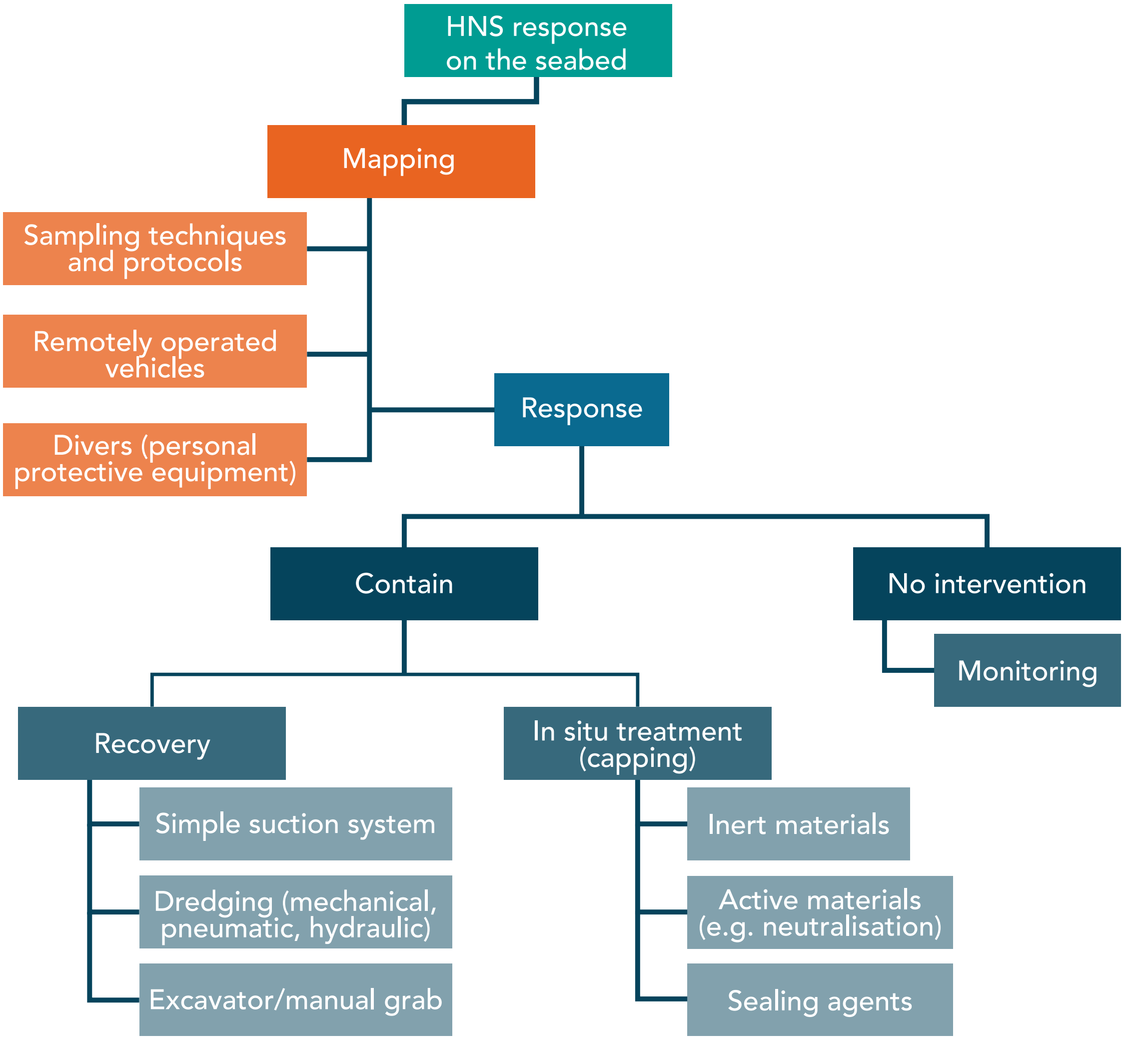


Figure 74: HNS response in the seabed decision tree

Considerations

Some general considerations on response to HNS on the seabed are as follows:

- The mapping of pollutants on the seabed is an issue with difficulties increasing with depth and extension of spread.
- Recovery becomes increasingly challenging and a very expensive operation with depth.
- Even if recovery is technically feasible, expenses may often be a constraint.
- Avoid recovering unpolluted sediments as much as possible in order to reduce waste production (▶ 4.4 Waste management) and to minimise environmental impacts; response should not cause more damage to the environment than "zero action".
- A waste disposal strategy needs to be in place (considering potentially large quantities of waste needing transported, treated and stored).
- Substances will partially be dissolved, even if a chemical is S as per SEBC.

HNS response on the shore

BACK

Objective

To outline the main response techniques commonly used to treat an HNS spill affecting a shoreline.

Applicability

Chemicals in solid and liquid states, with a low evaporation rate, may reach the shoreline and will likely require a response. The recovery of chemicals in package form is addressed in ▶ 5.41 Packaged goods response.

If response is required, containment and recovery operations are possible if the risks related to the dangerousness of the substances can be mitigated with appropriate PPE. ▶ 5.20 Personal protective equipment

Method description

First of all, it is important to consider the potential hazards for the population; in the first instance, a ban on access to the affected shoreline to the population is often required. In addition, it is necessary to protect water intakes of industrial plants (desalination plants, thermal power plants, coastal industrial facilities) and aquaculture and prevent further damage. ▶ 5.18 First actions (responders)

It is recommended to implement a Shoreline Cleanup Assessment Technique (SCAT) as soon as possible.

Chemicals that reach the shoreline may often be recovered using techniques already applied for the recovery of oils. Solid and highly viscous liquid substances can be recovered with methods suggested for the recovery of bitumen or heavy fuel oil; low viscosity liquid substances can be recovered with techniques used for medium/light crude oil or diesel oil (Cedre, 2013).

The logistical aspects to be considered are also the same as those considered for oil clean-up activities: organisation of the work site; area for temporary storage of equipment; for personnel and equipment decontamination; for storing materials. In many cases, it is also necessary to carry out air monitoring.

Rocky shores

	Manual clean-up	Pumping	Sorbents ▶ 5.37 Using sorbents	Flushing or washing	Pressure washing
Principle	Pollutants and debris are removed by hand or manual tools	Suction of pollutant accumulated in pools	Recovery pollutants at sea after treatment with flushing or pressure washing	Remove a surface layer of thick accumulations of pollutants that may then be recovered at sea or left to dilute ▶ 5.42 Containment techniques: Booms ▶ 5.43 Recovery techniques: Pumps and skimmers	Cleaning with a pressure washer to remove thin layers of pollutants that may then be recovered at sea or left to dilute
Used for substances	Solid and highly viscous liquids	Liquids with low or moderate viscosity	Liquid pollutants	Solid and liquid pollutants	Solid and liquid pollutants
Advantages	• Highly efficient • Minimisation of waste volume	• High collection rate • Minimisation of waste volume	Response to small spills of pollutant on the ground (port spill)	• Good efficiency in removal action • High collection rate	• Good efficiency in removal action • High collection rate
Limitations	• Workers in direct contact with pollutant • Low collection rate	• Only pollutant pooled with a thickness > 1 cm • Difficulties to operate in low accessible areas	• High volume of waste • Efficient only for small spill	• Difficulties to operate in low accessible areas • Projection of potentially hazardous waste water on operator	• Difficulties to operate in low accessible areas • Possible damages to rock-dwelling fauna • Projection of potentially hazardous waste water on operator/wider areas
Examples of past cases	Coal spill (*Finacia 32*, Indonesia)				

Table 66: Rocky shores

Sandy shores

	Manual clean-up	Mechanical recovery	Sorbents ▶ 5.37 Using sorbents	Flushing or flooding	Mechanical screening
Principle	Pollutants and debris are removed by hand or manual tools	Recovery with earthmoving equipment in case of heavy pollution	Recovery of pollutants at sea after treatment with flushing or Pressure washing	Low pressure water jets (flooding, flushing), used to saturate coarse sediment, stones and boulders to allow liquid pollutants out from sediment and reach the sea where they may be recovered or left to dilute ▶ 5.42 Containment techniques: Booms ▶ 5.43 Recovery techniques: Pumps and skimmers	Using beach cleaning machines to separate pollutant from sediment
Used for substances	Solid and highly viscous liquids	Solid and highly viscous liquids	Liquid pollutants	Solid and liquid pollutants with low density	Solid and highly viscous liquids

Advantages	• Highly efficient • Minimisation of waste volume	• Good efficiency in removal action • Low contact of workers with pollutant	Manual recovery of pollutant at sea	• Good efficiency in removal action • High collection rate	• Good sediment/pol-lutant separation • Minimisation of waste volume
Limitations	• Workers in direct contact with pollutant • Low collection rate	• Only in accessible areas • Huge quanti-ties of wastes • Enhance-ment of pollutant/sediment	• High volume of waste • Efficient only for small spill	• Erosion of shoreline • Difficulties to operate in low accessible areas • projection of potentially hazardous waste water on operator	• Only on sandy beaches • Only in acces-sible areas • Medium/low collection rate

Table 67: Sandy shores

Considerations

In the same way as for oil, techniques that have the advantage of being more selective in the recovery of the pollutant are preferred, minimising the collection of sediment and water, thus reducing the volume of waste produced and the need to carry out subsequent nourishment. ▶ 4.4 Waste management

However, it is crucial to always consider the compatibility of the equipment used with the pollutant involved.

Protection of a working area with sorbent sheets

PMDI on a shoreline

Paraffin on a shoreline

Waste management

FACT SHEET 5.41

Packaged goods response

BACK

Damaged containers on board a container ship

Objective

To evaluate the behaviour and fate of packaged goods as well as to locate, map, identify and recover them. These goods can either be a whole container or individual packages which may be floating, sinking or beached ▶ 5.4 Packaged goods identification

Method description

Fate and behaviour of a package at sea

Main environmental factors and package characteristics affecting the behaviour and fate in the marine environment

	SEBC package groups		Behaviour	Relevant environmental conditions
1	PF	W/V < dsw-0.01	Floater	Sea and wind conditions; surface sea currents,
2	PI	W/V = dsw-0.01	Immersed	Sea and wind conditions; surface sea currents,
3	PS	W/V > dsw-0.01	Sinker	Sub-surface and bottom sea currents, bottom morphology
W= gross weight of packaged goods (kg) V= gross volume of packages (l) dsw= seawater density				

Table 68: Behaviour and fate in the marine environment

The floatability of the package determines the entity of submerged part of the good. This in turn will determine the influence of current and/or wind in its drifting, as well as its visibility.

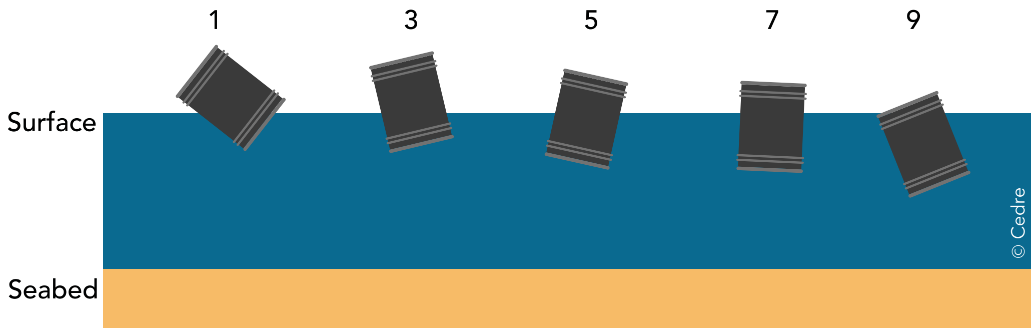


Figure 75: Package floatability. Observed behaviour from 1 (floats totally at the surface) to 9 (submerged below sea surface)

Containers are often observed floating at sea, depending on how much empty space there is inside the container and the density of the contents. Buoyancy also depends on whether the container was damaged when falling overboard; this is true for every package. Even if freight containers are not watertight, in some cases they have been observed to float; on the other hand, tanker containers are watertight.

Floating drum in a harbour

Location and mapping/marking

Packaged goods may be accidentally lost overboard, jettisoned in an emergency or contained in sunken or grounded vessels. They may be carried over considerable distances by the effects of currents, wind, or tides. Depending on the a package's buoyancy they it may:

- float at the surface and ultimately strand on the shorelines and beaches;
- drift in the water column;
- sink to the bottom of the sea.

Floating container and stranded container

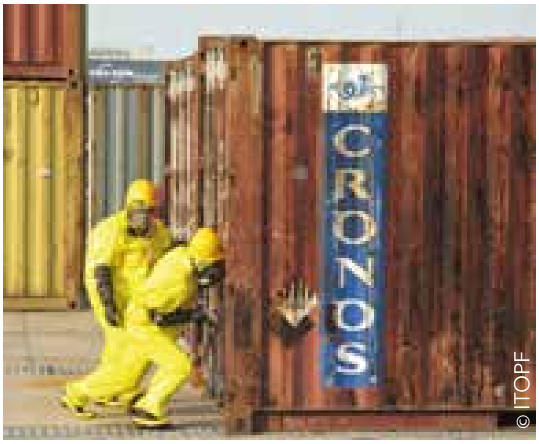
In all cases, containers may pose a navigational hazard in addition to the hazards associated with the container's contents.

Drifting packages may be located by aerial surveillance through the use of IR/UV, SLAR systems. Identifying sunken packages can be very time-consuming and requires more sophisticated equipment such as sonar and/or ROV/AUVs ▶ 5.24 Remotely operated vehicles. It is advisable to search on the bottom with a sonar (multibeam and side-scan sonar), often in combination with a magnetometer; possible containers/goods identified are then inspected by professional divers or by ROVs, especially in deep waters or if direct inspection is considered unsafe, to confirm that it is the lost container/goods and to inspect it in order to verify the state of conservation and the possibility of recovering it. If the presence of contaminants is suspected, it is advisable to collect samples of sediment and water.

Once containers or individual packages have been located, the initial survey provides an overview of the number of containers/individual packages located, their contents (based on marking and labelling) and their condition (leaking, sealed). The goods should be marked with pingers or buoyant bags ▶ 5.23 Substance marking.

Recovery

A package with unknown contents and with no interpretable information on its cover must be assumed to be highly hazardous, therefore the highest level of protection should be put in place for the responders.



Inspection of a container

Before starting the recovery of the packages lost at sea it is important to understand:

- their main characteristics: dimensions and typology;
- their behaviour and fate at sea (floats, sinks, submerges);
- drift determined by wind and currents;
- the hazard profile of carried substances, to plan risk assessment and protective equipment for personnel involved;
- the integrity or mechanical damage incurred during the accident (leaking, sealed).

	Collection nets	Lifting by crane	Salvage drums or special rack	Controlled release	Towing
Method	Use of collection nets to recover drums or small packages	A crane lifts a floating container using slings attached to the corners of the containers.	Put goods in specific salvage drums or in special rack to be transported safely ▶ 5.32 Sealing and plugging	Release of substance from the package can be performed by punching goods	Towage of containers to a safe haven with a towline
Application	Floating and sunken drums or small packages	Floating and sunken containers	Sunken and washed ashore drums	Floating and sunken containers	Floating containers
Advantages	• Limited contact with drum by operators • Less sophisticated technique to recover small packages	Recovery of entire containers without damaging them	• Avoid pollutant release from damaged drums • Reduce risks for operators	• Sophisticated equipment not required • Advantageous choice when recovery is too dangerous and/ or mixing pollutants with water reduces hazard	• Sophisticated equipment not required • Reduces hazard for navigation and the environment
Depth limitation	For sunken goods, applicable where professional divers can operate or use of ROV in deep waters	For sunken containers, applicable where professional divers can operate or use of ROV in deep waters	Applicable where professional divers can operate or use of ROV in deep waters	Applicable where professional divers can operate or use of ROV in deep waters (for sunken containers)	n/a
Limitations	• Package may be damaged during operation • Dependent on sea state	• Operation can only be carried out in good weather conditions • Use of crane with heavy lifting capacity, risk of rupture due to weight of water or mud inside. Containers might need to be drained. • Difficult to pick up a floating container with a crane at sea. Often special crates are used	• Danger of damaging drums during operation • Risk of contamination for operators and equipment • Operation can only be carried out in good weather conditions (for sunken drums) • The construction material of the salvage drum must be compatible with the substance in the inner package	• Not in stagnant waters • Risk of contamination of operators and equipment • Risk of contamination of marine biota and protected areas	• Loss of container during towage. • Equip container with large buoys and pingers/ transponders • Loss of pollutants during towage • Dependent on sea state • Not suitable for containers that may leak hazardous contents
Examples of past cases			*Eurocargo Venezia* (Italy, 2012)		

Table 69: Methods and application of packaged goods response

Recovery operations of sunken packages may be carried out by ROV in deep waters or if direct contact is considered unsafe. In these cases, the costs of operations could increase significantly.

Lifting a drum with a collection net

Lifting a drum with a crane

Recovery of collapsed containers

Specific racks and salvage drums realised to collect drums on sea bottom

Considerations

General considerations on response to packaged goods at sea:

- the water depth and the topography of the sea floor will highly greatly influence the complexity of the search operation. Other important factors affecting the search are package type, size and shape, packing material, as well as sea currents and sea state;
- only when the water is very deep and the goods are scattered over large areas, the no-response option may be the only reasonable alternative ▶ 5.36 Natural attenuation and monitoring;
- scuttling of packaged chemicals may sometimes be suitable for substances whose hazard can be reduced by mixing with water and where recovery would be more hazardous. Take into consideration the possible negative effects on sensitive biota.

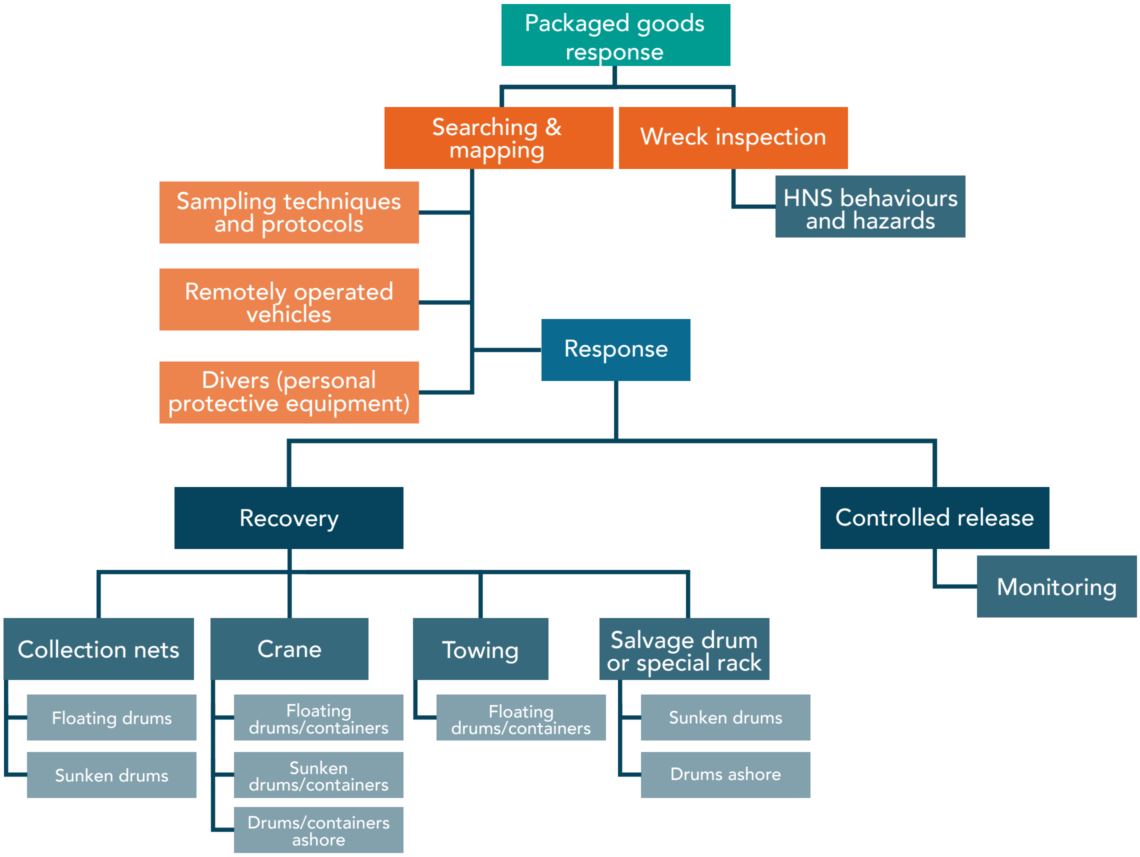


Figure 76: Packaged goods response decision tree

Containment techniques: Booms

Objective

In an HNS incident, if safe to do so, it might be operationally necessary to contain the pollutant and concentrate it before treating or recovering the substance spilled. Containment systems make recovery operations more effective.

▶ 5.43 Recovery techniques: Pumps and skimmers

Figure 77: Step 1 after an HNS incident

Applicability

Containment operations can be applicable in case of a spill of:

- floating liquids, e.g. vegetable oils. They can have a significant persistency the in marine environment (behaviour classification group Fp – Persistent Floater). Fatty oils are an example of chemicals that belong to the Fp group. Some substances in group F may sometimes be difficult to contain because of low viscosity; some of them may very rapidly spread over the water surface, form extremely thin layers and disperse in the water column;
- floating solid chemicals with low vapour pressure and low solubility, e.g. palm stearin.

Method description

Containment booms are devices used to contain oil spills. Various types of booms could be employed in the case of an HNS spill, depending on the conditions (weather, sea state, open sea/harbour) and the area of sea surface involved. All equipment used for containment must be chemically compatible with the substances being treated to prevent the risk of leaks, permanent damage and an overall reduction in efficiency.

Containment systems are limited by several factors:

- Weather and sea conditions, in particular the sea state. Depending on the type of boom, containment is likely to fail in strong current (> 2 knots) and high waves (>1m);
- Availability of towing vessels;
- Coordination necessary between vessels;
- Chemical compatibility.

Boom failure due to strong currents

Containment of substances at the sea surface can be implemented using:

- static booms: to maintain the spill close to the source (around a leaking ship for example) or to protect water intakes. A recovery area can be installed in an accumulation zone. Static booms may be custom-made, using different materials compatible with the chemical spilled (hay for example);
- a bubble curtain: to maintain the spill close to the source in harbour areas;
- dynamic booms: to collect substances spread over the sea surface when the slick is already disseminated and to concentrate and gather the pollutant in order to recover it easily.

Aerial and naval observation are necessary to guide containment and recovery operations. They help to coordinate pollution response vessels and monitor the situation in real-time.

	Containment equipment		
	Bubble curtain	**Static booms**	**Dynamic booms**
Principle	Applying a bubble barrier around floating pollutants by pumping compressed air into a perforated hose placed on the sea bottom	Deploying containment booms around spill source and/or to facilitate recovery process, fixed by anchoring to sea bottom or to the ship or shore. Custom-made booms may be employed	Towing of inflatable booms by one or more vessel(s) with different configurations to collect spread pollutants. Some booms are specifically designed to be used only as a dynamic asset (e.g. Current Buster)
Used for substances	Floating or dispersed pollutants in shallow water or in harbour	Floating pollutants	Floating pollutants
Advantages	• Good containment efficiency in stagnant waters • Limited contact of personnel with pollutant	• Contains substances at source • Able to concentrate product to a thickness suitable for recovery • Good containment efficiency in favourable weather conditions	• Contains and concentrates substances • Collects spread substances
Depth limitations	Depth less than 20 metres	Shallow waters if anchored to the seabed or the shore	No depth limitation
Limitations	• Limited sea surface area • Harbour areas and shallow waters • Coordination with recovery activities	• Not applicable in harsh sea conditions • Availability of towing vessels • Coordination with recovery activities	• Deployment difficulties • Availability of towing vessels • Coordination between vessels • Coordination with pollutant location and recovery activities
Examples of past cases		Incident: *Allegra*, 1997; off the coast of Guernsey, English Channel. Cargo: 15,000 tonnes of palm oil (solid)	

Table 70: Containment equipment

Custom-made boom made from nets and sorbents for a Palm Stearin spill

Custom-made boom made with hay

Vegetable oil spill

Dynamic containment with a Current Buster

Dynamic containment with conventional inflatable booms in a "U" configuration

Considerations

- Since floating products tend to spread and disperse quickly, intervention should be performed quickly to optimise the operation.
- Depending on the vapour pressure, floating substances may evaporate rapidly and lead to high gas concentrations in the air. When responding to floating chemical spills on the water surface it is therefore important to monitor air concentrations in order to assess fire and explosion risks as well as danger to health.
- One or more response vessels will be needed for equipment deployment and storage of waste.

Recovery techniques: Pumps and skimmers

Objective

In an HNS spill, once the substance or product has been isolated or contained, one option is the recovery from the marine environment. Recovery must only take place once containment is effective ▶ 5.42 Containment techniques: Booms.

Figure 78: Step 2 after an HNS incident

Applicability

Substances applicable for recovery as similar to those suitable for containment ▶ 5.42 Containment techniques: Booms:

- floating liquids, e.g. vegetable oils.
- floating solid chemicals with low vapour pressure and low solubility.

Method description

Recovery of substances from the sea surface can take place through the use of:

- mechanical equipment, such as pumps and skimmers, used for liquid pollutants floating at the sea surface in consistent quantities (viscosity < 100,000 cSt);
- manual tools, which can be used to recover substances by filtering, such as scoops, baskets, towing nets, used in case of floating solid substances or highly viscous liquids (viscosity > 100,000 cSt).

Aerial and naval observation are necessary to guide containment and recovery operations. One or more pollution response vessels are need for equipment deployment and storage of waste.

	Mechanical equipment				
	Pumps	**Belt skimmers**	**Rope mop and brush skimmers**	**Weir skimmers**	**Sweeping arms**
Principle	Recovery of consistent accumulations of floating pollutants using pumps positioned at the sea surface	Pollutant is lifted from the sea by a conveyor belt to a collection point on the boat	Recovery of floating pollutants by adhesion to a rotating brush which raises the pollutant from the sea	Pollutant on sea surface falls into a collector that maintains its edge just below the surface of the water	Floating pollutant is intercepted by an arm placed laterally to the vessel; passing through septa placed just below sea surface, the pollutant is separated from the water
Used for substances	Floating liquld substances with low and medium viscosity	Floating solid and medium/ highly viscous liquid substances	Floating liquid substances with capacity to adhere to brushes	Floating liquid substances with low/medium viscosity	Floating liquids

Advantages	• High recovery speed • Equipment readily available	• Good separation of pollutant from water • Limited contact of personnel with pollutant • Moderate collection velocity • Moderate separation of pollutant from water	• Works in moderate/poor sea conditions (Douglas sea scale <4) • Limited contact of personnel with pollutant • Moderate collection velocity • Moderate separation of pollutant from water	• Good pollutant/water separation • Deployable with small boat	• High recovery speed • Works in moderate/ poor sea conditions • Containment and recovery combined • No limitation with respect to viscosity
Limitations	• Not applicable for pollutants less than 1 cm thick • Only with good weather conditions • Production of great quantities of waste and pollutant/water mixture • Coordination with containment activities	• Not applicable to pollutants with low viscosity • Not applicable in poor sea conditions • Coordination with containment activities	• Not applicable for liquids that do not adhere to brushes • Coordination with containment activities	• Not applicable for liquids with high viscosity • Only in good weather conditions and calm sea state • Low recovery rate • Coordination with containment activities	• Production of great quantities of waste and pollutants/water mixture • Specialised response vessel required
Examples of past cases		Incident: Canola oil spill, 2000; Vancouver Harbour. 20 tonnes spilled			

Table 71: Mechanical equipment

Rope mop

Norden *sweeping arms*

	Manual tools		
	Scoops	**Baskets**	**Towing trawl nets**
Principle	Manual scoops to recover pollutants once concentrated in a boom deployed at the ship's side during navigation	Rigid baskets with a specific filtering mesh positioned on board ship. Pollutants are collected during navigation	Use nets or specific types of trawls/net bags with inflatable booms (like those used for heavy fuel oil)
Used for substances	Floating solids and highly viscous liquid substances (lumps)	Floating solids and highly viscous liquid substances (lumps)	Floating solids and highly viscous liquid substances (lumps)
Advantages	• Use of small boats • Often useful to collect pollutants concentrated along docks of a harbour • Unsophisticated equipment • High selectivity • Good pollutant/water separation	• Use of small boats • Unsophisticated equipment • Good pollutant/water separation	• High recovery speed • Unsophisticated equipment • Deployable with small boats • No coordination with containment activities • Good pollutant/water separation
Limitations	• Low recovery rate • Coordination with containment activities • Not applicable for liquids with low viscosity	• Medium/low recovery rate • Coordination with containment activities • Not applicable for low viscosity liquids	• Not applicable for low viscosity liquids • Not applicable in poor weather conditions
Examples of past cases		Spill of paraffins from an unidentified vessel (Tuscany, Italy, June 2017)	Spill of paraffin in Corsica, France, 2018

Table 72: Manual tools

Oil trawl net

Recovery of paraffins with a special basket

Recovery of palm stearin with a scoop net

Oil trawl net

Considerations

Depending on their vapour pressure, floating substances may evaporate rapidly and lead to high gas concentrations in the air. When responding to floating chemical spills on the water surface, it is therefore an important priority to monitor air concentrations in order to assess fire and explosion risks as well as danger to health.

Equipment used for recovery must be chemically compatible with the substances being treated to avoid the risk of leaks, permanent damage and an overall reduction in efficiency.

Always take into consideration waste management. If possible, when choosing between different techniques, it is preferable to opt for the technique that produces less waste. When planning recovery activities it is important to consider the waste storage capacity of the vessels used. ▶ 4.4 Waste management

Wildlife response

Wildlife response

A substance (classified as HNS) that is deliberately or accidentally released into the marine environment could potentially impact marine fauna, directly or indirectly. Effects can be classified as:

- Internal: toxic effects as a result of swallowing, inhaling, skin absorption;
- External: damaged state and function of feathers or fur, skin burns, eye damage, general debilitation preventing animals from displaying critical behaviour;
- ecological: impact on critical food sources, food chain effects, habitat damage.

A wildlife response in the aftermath of an HNS incident may be considered when the overall response measures (containment and recovery, shoreline protection and clean-up) are not sufficient to protect or minimise the effects on certain animal groups – normally birds, mammals and reptiles.

In the case of an HNS spill, wildlife response could be organised in a broadly similar way to oil spills, including monitoring/impact assessment, contamination prevention (e.g. hazing and deterrence), search and capture/collection, stabilisation, decontamination (washing), rehabilitation or euthanasia and release. However, there are some important **differences**:

- The effects of oil on wildlife are well studied and described, and the standard treatment of oiled wildlife is based on the potential for reversibility of the known effects. In the case of HNS, a wide variability of impacts and effects are possible, many of which are unknown as the exact physio-chemical characteristics, behaviour and effects of the substance(s) may not be known. Although standard techniques for capture, transport and stabilisation, detoxication, decontamination (washing) and rehabilitation may be applied, the expected relative success (in terms of recovery and survival) of these operations may be difficult to predict.
- The effects of the substance(s) on animals might also apply to humans. Strict guidelines for preventive and protective measures (such as the use of ▶ 5.20 Personal protective equipment) must be applied, both on the beach and in facilities where animals might be treated. In certain cases, health and safety considerations may lead to a decision that no attempt to rehabilitate should be undertaken. Field euthanasia (under strict safety conditions) may be considered as the best possible treatment for live impacted animals.

If an HNS incident with an unknown substance leads to many animals coming ashore, local emergency operations should ensure that self-mobilising members of the public are discouraged in their attempts to rescue the animals, at least for health and safety purposes. Once the substance has been assessed, a fully trained team should support these operations and/or provide guidance on how to perform any animal collection.

Oiled wildlife response plans, that aim at safe and well-coordinated professional response operations, could be extended by also including generic guidance on how to respond to HNS incidents.

Razorbill Alca torda, covered in polyisobutylene (PIB), Texel, December 1998.

Common Guillemot Uria aalge, smothered in an unidentified green substance, Texel, January 2007

Common Guillemot Uria aalge, smothered in an unidentified green substance, Texel, January 2007

Operational guidance

Apply measures to prevent released HNS from affecting wildlife, by:

- Collecting essential data:
    - What is the expected behaviour of the substance after release (floating, sinking, chemical change into another substance or physical state, etc.), and where is it going?
    - What animals are currently present in that area and could potentially be subject to physical or chemical interaction with the substance?
    - What is the interaction of the substance with aspects of physical integrity of animals (health or functions of skin, feathers, fur), their behaviour (diving, breathing, prey selection), their food sources (toxifying prey animals), or the physical or chemical alteration of their habitats.

- Implementing preventive measures:
    - Remove the HNS from the environment before it reaches the animals or their habitats;
    - Consider scaring threatened animals away, or removing them (pre-emptive capture) from the areas towards which the pollutant is unavoidably moving.

Apply measures that could mitigate the effects of released HNS on animals and responders:

- Quickly identify and communicate the chemical profile of the pollutant and pro-actively share this information with the wildlife response;
- Apply strict protective measures for responders. HNS may include substances that are toxic for animals. If they are, they will often be toxic for humans too. This should be assumed in all cases in which the exact pollutant has not been identified as yet;
- Following a pollution incident involving HNS, the response to wildlife should not begin until clarity can be given about health risks to humans, and advice can be given on the use of the correct PPE;
- Citizens and untrained groups should be kept away from areas where polluted animals are expected, spotted or are arriving. Toxic HNS may be invisible, or have an innocent appearance on the body of animals, and even trained responders may underestimate the health risks of physical interaction with such a polluted animal.

Apply measures to set up a professional response to affected animals on the shore:

- A safe, professional response should be put in place to take care of polluted animals arriving dead or alive on the shoreline.
- Euthanasia of animals should be considered in all cases where the exact polluting substance is not known but apparently toxic, or where it becomes clear that wildlife rehabilitators cannot interact with the live animals safely.
- Euthanasia should be applied only if this can be carried out safely; if this is not the case, no interaction should take place with the animals. Observing and monitoring the scale of impact should be considered as the only applicable response action.
- Rehabilitation should only be considered:
    - if responders can perform these operations safely, without compromising their personal health and
    - if they have a methodology by which the apparent health effects on the animals can be successfully reversed.
    - If the majority of animals are not responsive to the methodology that is applied, euthanasia should be considered as the best applicable alternative.

Apply measures to detect the effects of the spilled HNS on animals and conduct an impact assessment:

- Veterinarian necropsy on dead polluted animals should be undertaken as a priority to find indications of the various effects of the pollutant on the animal, and determine if an effective methodology exists to reverse these effects in live animals via rehabilitation treatment, e.g. via consultation of professional wildlife rehabilitation groups;
- Collect data on all impacted, dead and rehabilitated animals, including results of all necropsies performed, to assess the overall impact of the HNS incident on wildlife as well as to assess the potential impact on wildlife populations.

FACT SHEET 6.1

Claims process

Before and during an incident, key steps should be followed to ensure all necessary documentation for recovering costs is recorded and can be submitted promptly.

During the contingency planning phase, it is recommended to:

- Identify the applicable compensation regime;
- Integrate sufficient and suitable guidance on cost recovery on the relevant contingency plan, and identification of a person or team to be mobilised to record costs and compile the claim;
- Indicate hire rates for personnel and owned resources;
- Identify a person, team or department with responsibility for cost recovery;
- Integrate cost recovery into the overall response structure;
- Include cost recovery as part of a regular plan exercise programme.

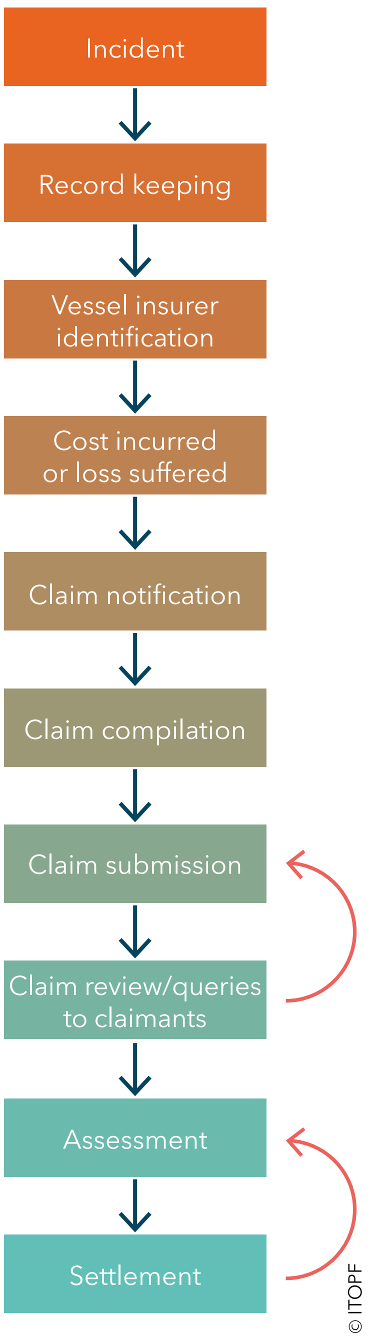


Figure 79: From incident to settlement: the claim process

When an incident occurs, it is recommended to:

- Initiate the cost recovery process from the outset of the incident;
- Mobilise a person or team with a mandate to record expenditure as costs are incurred;
- Document all stages of the pollution incident and response. Record all meetings, decisions made, and activity undertaken;
- Establish a process for persons to log and record expenditure centrally (electronically, on paper or both);
- Collect the documents to be used to support expenditure, including: purchase orders, invoices, charter or hire agreements, contracts, delivery notes, receipts, statements of earnings, time sheets of the personnel involved, work contracts of temporary personnel, etc.;
- Ensure all sub-contractors are aware of the need to record costs and activity clearly;
- Ensure expenditure is linked to activities and work-sites;

- Obtain copies of vessel and aircraft logs to support involvement;
- Record all worksite activity, personnel involvement, consumables used etc. on a daily basis;
- Include sample analysis results and protocols where relevant;
- Record the volumes of waste material, disposal methods and locations and rates;
- Take photos of all resources deployed and work done on a daily basis;
- Ensure the availability of sufficient personnel to maintain the cost recovery process throughout the response.

Tools for manual cleaning

Example of worksite equipment

Example of local fishery market

Engagement with the compensating body

- Identify the vessel casualty's P&I insurer and the contact details of the local P&I correspondent or representative:
    - Notify the intention to make a claim;
    - Determine the process for submitting a claim – has a local claims office been established? What is the time limit for claim submission? Can claims be submitted in stages?
    - Keep the insurer informed of on-going expenditure totals and intentions for future work.

Joint assessment of alleged damaged nets

- Engage regularly with the P&I insurer's experts:
    - Include the insurer's experts in all decision-making processes;
    - Seek advice on reasonable activities and costs from experts;
    - Promote joint surveys with the insurer's experts in order to speed up the future claim settlement process.

- Determine what types of costs are admissible based on advicefrom the P&I insurer's representative and/or experts.

Claim submission

- Compiling a claim:
  - Ensure all costs are fully supported to explain the role of the claimed resource or activity in the response – what was done, where was it done etc.;
  - Generate a master spreadsheet with all claimed items over time and claim total;
  - Attach all the supporting documentation;
  - Include the narrative of the response as background to the claim – explanation of the role of the claimant in the response or incident and a summary of work done or incurred damage.

- Submitting a claim:
  - Submit the claim within the required timeframe (if any);
  - Regularly follow the progress of the assessment by contacting the P&I insurer's representative;
  - Notify the P&I insurer if further response work is required following the submission of the claim;
  - Ensure that the personnel are available to address queries raised as part of the assessment process.

- Settling a claim:
  - Acceptation of the financial agreement;
  - Reimbursement may not be immediate as the collection of the full documentation and the assessment process can be lengthy. If an incident is likely to generate a high number of claims or expensive claims, the total cost of claims might exceed the amount of compensation available. Therefore, the settlement process is unlikely to start before claims from all the parties are submitted. In this case, once all claims have been logged, a pro-rata of the settled amount will be received by each claimant;
  - In the case of unresolved dispute over the proposed settlement, parties can seek arbitration or to court proceedings.

Environmental restoration and recovery

BACK

Definitions

Environmental recovery: the ability of marine environments to recover their characteristics after severe perturbations (natural phenomena, anthropic pollution) due to an HNS incident.

Environmental restoration: human intervention aimed at supporting and speeding up natural recovery processes after an HNS incident.

To promote the natural recovery of the environment or before starting environmental restoration activities, as much pollutant as possible must have been recovered, especially if it is persistent, as well as all equipment and structures used in the response phase. This is particularly true when intervening with underwater activities in which structures have been installed, for example, for the recovery of wreckage or sunken substances.

Environmental recovery

After a pollution incident, when the spill source has been eliminated or reduced, ecosystems tend to recover and achieve a new balance that tends to be similar to their status prior to the accident. The recovery speed will depend substantially on two factors:

1. The characteristics of the damaged ecosystems;
2. The presence of spilled pollutants, especially if they have high persistence in the marine environment.

Ecosystems that are characterised by species with a very long reproductive cycle will have particularly long recovery times, since the time required to generate new juveniles is prolonged. This is the case for many ecosystems that develop in close contact with the seabed (benthic biocenoses); among other things, being linked to the seabed, they suffer the most damage caused by spills if the product reaches them, as they cannot escape. Ecosystems that develop throughout the water column, such as planktonic ecosystems, are instead characterised by faster recovery times.

Many marine ecosystems that fall within the list of the Habitats Directive 92/43/EEC (on the conservation of natural habitats and of wild fauna and flora) are characterised by being very sensitive to harmful events and having long recovery times. In the Mediterranean, two particularly sensitive habitats, included in the Directive, that can suffer very negative consequences from an HNS spill are: coralligenous (characterised by sessile and colonial species such as sponges, coelenterates, especially gorgonian, coral algae, bryozoans, etc.) and *Posidonia oceanica meadows* (a marine plant with a stem, roots and leaves) endemic to the entire Mediterranean basin.

Environmental recovery can take place over a number of years, even for particularly complex ecosystems, if the time required to return to the initial biodiversity and productivity values is considered; but it may take decades to achieve a structure similar to the original one. During the first years, in fact, populations will be characterised mainly by juveniles; the ecosystem will not yet have a correct balance and will still be fragile.

Humans can facilitate environmental recovery by reducing some stress factors that normally act on these ecosystems, through:

- ban or reduction of fishing activity;
- prohibition of anchoring and diving activities;
- continuous surveillance of the area;
- protection of a natural nearby breeding habitat to provide a reservoir for recolonisation of the damaged area.

Environmental recovery should always be accompanied by environmental monitoring activities.

Environmental restoration

Clearly, clean-up activities are considered an important part of environmental restoration.

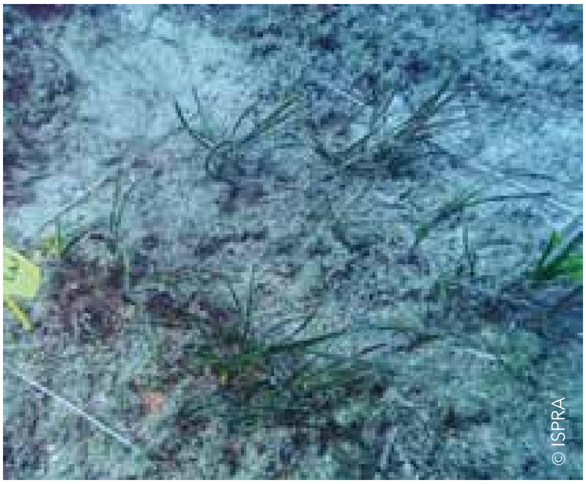
Marine environmental restoration is not always possible, in fact, most of the time it is not feasible or not advisable; it is always appropriate to evaluate the real support that this activity would actually give to the natural environment.

The following activities fall into the category of marine environmental restoration:

- Restoration of the morphological and geological characteristics of the seabed and coastlines, if sediment removal has been carried out to recover sunken pollutants or a wreck;
- Replanting or introduction of characteristic species of the specific damaged ecosystem; they represent the basic structure on which the other components of the ecosystem will develop. Once replanting or introduction operations have been carried out, other forms of biological life will develop.

In the marine environment, restoration operations are often limited; depth is often the major limiting factor. Furthermore, it is necessary to consider taking specimens to be replanted or introduced. It is strongly discouraged to collect specimens from a natural environment in a good state of conservation; this operation would risk damaging an environment in good condition.

In the case of introduction of fish species, the use of farmed specimens could be evaluated. In the case of vegetable or sessile invertebrate organisms, it is suggested to use specimens present in the sea which have been dislocated by waves and anchor actions. This is the trend in the world of marine sciences; in the Mediterranean environment this procedure is followed for the reimplantation of the *Posidonia oceanica* and for gorgonians. Again, restoration activities should be accompanied by environmental monitoring.



Replanting of Posidonia oceanica

Replanting of Eunicella cavolinii *(gorgonian) using a special glue*

FACT SHEET 7.1

Evaporator

Bow Eagle

Vessel information

- Built in 1984, 15,829 GT, 24,725 DWT
- Norwegian flag

Information on chemicals

- Ethyl Acetate (CAS 141-78-6), SEBC DE.
  Usage: many applications, for instance as a solvent for nitrocellulose and other cellulose derivatives, various resins in protective coatings and plastics.
- Cyclohexane (CAS 110-82-7), SEBC E.
  Usage: manufacture of nylon intermediates, adipic acid, caprolactam, and hexamethylenediamine.

Date & location

26th August 2002,
off the coast of Sein island,
Finistère, France

Hazard identification

- Ethyl Acetate
- UN number: 1173
- GHS pictograms:

- hazard class: 3 flammable liquids
- MARPOL Category: C
  Cyclohexane
- UN number: 1145
- GHS pictograms:

- hazard class: 3 flammable liquids
- MARPOL Category: C

Short summary of incident

On Monday 26th August 2002, in the middle of the afternoon, the chemical tanker *Bow Eagle*, on the way from Brazil to Rotterdam, informed the MRCC (Marine Rescue Co-ordination Centre) CROSS Jobourg of a breach on her port side, which led to a leak and hence the loss of 200 tonnes of Ethyl Acetate.
The French Maritime Authority for the Channel and North Sea ordered the intervention of aerial and maritime assets. It also requested advice from the French Navy analysis laboratory (LASEM) and Cedre about the pollution risks.
Meanwhile, the French Maritime Authority for the Atlantic was looking for the ship responsible for sinking the trawler *Cistude* and made the connection between the two incidents. The incident unfortunately turned out to be a tragedy. Investigations showed that on Monday 26th August, at 2 a.m., a nightly collision occurred between the port bow bulb of the chemical tanker *Bow Eagle* and the trawler *Cistude*. The crew of the *Bow Eagle* did not offer assistance and four fishermen from the *Cistude* died. The description of this incident will focus on the risk of pollution due to the HNS present onboard the chemical tanker.

The Maritime Prefect decided to stop the vessel and to be escorted by a coastguard patrol boat towards Dunkirk. She anchored on the morning of the 28th August as the harbour was not equipped to treat the cargo in safe conditions. An assessment team and law officers boarded the ship. Two crew members confessed to having been aware of the collision, and the shipowner's representative admitted liability. In the middle of the afternoon, the *Bow Eagle* was authorised to leave the harbour and to make for her destination, Rotterdam.

The cargo

- Bulk ☒ Packaged PG ☐
- Quantities:
• 510 MT soy lecithin (MARPOL category D);
• 1,652 MT sunflower oil (MARPOL category D);
• 1,050 MT of methyl ethyl ketone (MARPOL category III);
• 4,750 MT of cyclohexane (MARPOL category C);
• 3,108 MT of toluene (MARPOL category C);
• 500 MT of vegetable oil FA201 (MARPOL category D);
• 2,100 MT of ethyl acetate (MARPOL category D);
• 4,725 MT of benzene (MARPOL category C);
• 5,250 MT of ethanol (MARPOL category III) .

Risk assessment

Assessment of Ethyl Acetate shows that this is a colourless volatile solvent, which has a perceptible odour, evaporates easily in the air and is moderately water-soluble. It is a highly flammable liquid and its vapours may in certain conditions form explosive combinations with air, and water can help spread such a fire.
However, there was almost no risk of a marine pollution, a fact established by the GESAMP's data base.
This information was immediately sent to the French Maritime Authority for the Channel and North Sea, and contributed, alongside the possible involvement of the *Bow Eagle* in the *Cistude* tragedy, to the Maritime Prefect's decision to stop the vessel entering a French harbour.
The French Maritime Authority called upon chemical experts from Cedre.
Cyclohexane is a highly evaporable product, whose vapour is three times denser than air. Cyclohexane is not soluble in seawater. As a result, a leakage can produce a flammable and irritant gas cloud, which may be blown along the water surface by the wind. This substance can be harmful to aquatic organisms in large spills. The cocktail of chemicals on the vessel was such that an accidental grounding would have been absolutely disastrous (see the *Cason* case).

Worsening parameters

Due to the hazards of both Ethyl Acetate and Cyclohexane, certain basic precautions had to be taken by the assessment team as there was no equipment available to treat the cargo in safe conditions.

Favourable parameters

The tanker belonged to a highly reputable company, Odfjell, the second largest international chemical transport company, insured by the world-class Protection and Indemnity Club Gard.

Response

On Tuesday 27th August, further information was obtained about the situation in terms of risk of pollution. The Ethyl Acetate tank leakage had been controlled, by transferring the product to another tank and sealing work was in progress. However the vessel was transporting nine different products, of which two were heavy pollutants (Benzene and Toluene). There was also a breach in the tank next to the one which had been leaking Ethyl Acetate, containing Cyclohexane. Chemical tankers transport many different products, and the mixture of these products can pose a serious threat to the environment. Moreover, collisions between fishing boats and merchant ships, which end up too often in the loss of human lives, can also be a source of water pollution.

Post-spill

No specific restoration had to be implemented as the substance spilled was an evaporator (Cyclohexane).

FACT SHEET 7.2

Ece

Vessel information

- Built in 1988, 23,409 GT, 38,498 DWT
- Maltese flag

Information on chemical

- Phosphoric Acid (CAS 7664-38-2), SEBC D. Usage: manufacture of fertiliser (superphosphates), the protection of metals, the pharmaceutical industry, water treatment, cleaning, paint and certain food product.

Date & location

31st January 2006, 50 nautical miles (90 km) west of Cherbourg, near the Casquet Traffic Separation Scheme in international waters.

Hazard identification

- Phosphoric Acid
- UN number: 1805
- GHS pictograms: 
- Hazard class: 8 corrosives
- Marine pollutant: yes ☐ no ☒

Short summary of incident

On the night of 30th to 31st January 2006, the Maltese bulk carrier the *General Grot Rowecki*, transporting 26,000 tonnes of Phosphates from Safi in Morocco to Police in Poland, collided with the Marshall Islands chemical tanker the *Ece* en route from Casablanca in Morocco to Ghent in Belgium.

The *Ece*, transporting 10,000 tonnes of Phosphoric Acid, developed a leak and a significant list.

The regional MRCC, CROSS-Jobourg, coordinated the crew rescue operation, in collaboration with the British Maritime and Coastguard Agency. The 22 crew members were safely evacuated to Guernsey. The tug boat the *Abeille Liberté* was sent to the scene of the accident.

The French Maritime Authority for the Channel and North Sea then carried out a pollution risk analysis, with the support of the French Navy Centre of Practical Expertise in Pollution Response (CEPPOL) and Cedre. The *General Grot Rowecki*, whose bluff bow was slightly damaged, was able to continue her journey.

The tug boat the *Abeille Liberté* arrived on site on 31st January towards 7 a.m. The assessment teams did not note any pollution, and boarded the two damaged ships. The *Ece* showed a 25° stabilized list to port and was no longer operating. When the assessment had been completed, the vessel was taken in tow by the tug the *Abeille Liberté* at around 3:30 p.m., bound for the port of Le Havre. In the course of towing, the *Ece* sank 70 m deep 50 nautical miles west of the point of La Hague, on 1st February at 3:37 a.m. The wreck lies in international waters, on the continental shelf of the United Kingdom, in the French exclusive economic zone and the French pollution response zone. The Manche Plan, a bilateral Franco-British mutual aid agreement for rescue and pollution response, was activated on 1st February.

The cargo

- Bulk ☒ Packaged PG ☐
- Quantities:

• 10,000 MT Phosphoric Acid (MARPOL category Z);
• 70 MT of Propulsion Fuel (IFO 180);
• 20 MT of Marine Diesel;
• 20 MT of Lubricating Oil.

Risk assessment

Oil sheen surfaced and exploration of the wreck confirmed the hypothesis that Phosphoric Acid may seep out via cracks in the hull, piping, or tank vents. The leakage could reach 25 m^3/hour. There were therefore no major pollution risks, but a risk of progressive leakage remained.

The main risk for humans was essentially linked to contact with the skin or mucus membranes, causing irritation or even burns in the case of prolonged contact with a concentrated solution. The same risk applies to marine animals. Phosphoric Acid leaking from the wreck would mix with water and acidify the immediate surroundings. Once the leaking stopped, the neutralising power of the seawater would quickly raise the pH back to its original value (around 8) in the affected zone. The environmental impact would be too temporary and localised to be quantifiable.

GESAMP gave the pollution 0, on a scale of 0 to 5, for persistence in the environment, 1, on a scale of 0 to 6, for acute aquatic toxicity and 3, on a scale of 0 to 4, for toxicity to aquatic mammals due to contact or ingestion.

Worsening parameters

Phosphoric Acid is a colourless or nearly colourless chemical, with a refractive index close to that of water. Leaks were therefore difficult to detect by video observation. Media highlighting the presence of heavy metals.

Favourable parameters

Phosphoric Acid is non volatile and does not produce vapour. It has a higher density than that of seawater and therefore sinks when spilled. It is totally soluble in water and does not accumulate in the food chain.

Response

There was therefore no immediate major pollution risk from the Phosphoric Acid. However the question which came to light, as with all wrecks, was the question of whether to remove the potential pollutants (Acid and Fuel) trapped in the wreck.

To help decide what observation operations should be carried out and what action should be taken, a series of dilution tests were carried out in Cedre's laboratory using coloured Phosphoric Acid and water acidity measurements. The first results showed that the acid spread out at the bottom, before diluting in a matter of a few minutes without any currents. When strong currents were simulated, the acid diluted rapidly as soon as it touched the water. It progressively decomposed into hydrogen ions (H+), responsible for the decrease in pH, and into phosphate ions (PO_4--).

Cedre was asked about the possible fertilising effect of the phosphate ions, which could lead to an anarchical development of green algae in the event of a major spill. This question is Ifremer's domain. However in this case the pollution did not involve a major spill and the availability of phosphate ions in February is not a key factor in the development of green algae.

Negotiations between French and British authorities on the one hand and the ship-owner and insurers on the other led to an agreement being met on 16th June 2006 for the removal of the oil remaining onboard the wreck (approximately 40 tonnes) and for the planned controlled release of the Phosphoric Acid, by opening the access channels to the six tanks using a remote controlled robot. The operation was undertaken by the ship-owner during the summer period, under the control of the authorities. The operations was completed by 15th September. Until this date, fishing continued to be banned around the wreck. The flag state was asked to take position.

Post-spill

No specific restoration or monitoring survey was implemented.

FACT SHEET 7.3

Aleyna Mercan

Vessel information

- Built in 2005, 2,897 GT, 4,037 DWT
- Maltese flag

Date & location

15th – 23rd June 2017
North Thyrrenian Sea,
Tuscany Archipelago

Information on chemical

- Identity: Paraffin wax, CAS number: 8002-74-2
- SEBC Fp
- Usage: lubrication, electrical insulation, candles

Hazard identification

- UN number: 1993
- Hazard class: Class 3
- Marine pollutant: yes ☒ no ☐
  (category Y, noxious substance, MARPOL Annex II)

Short summary of incident

- Cause: illicit discharge during navigation from washing process of cargo tanks after unloading of paraffin wax in Genoa harbour. The operation was carried out in violation of Annex II of the MARPOL Convention and IBC Code. In particular, the temperatures of the unloaded product were manually modified on the Cargo Record Book.
- No Notification; illicit discharge has been communicated by Italian Coast Guard when product reached shoreline and the Ministry of the Environment activated the pollution response system
- Environmental conditions: It has been observed that after its release into the sea, the parafin wax was solid, floated and persisted in the marine environment (floaters Fp). Therefore the surface of the sea and shoreline were the main environments involved. Its low rate of solubility and evaporation led to the hypothesis that there were no evident consequences for the marine ecosystems.
- Specificities on the location: the summer period in which the spill occurred led to the temporary closure of the beaches and some bathing facilities.

The cargo:

- Bulk ☒ Packaged PG ☐
- Quantity: estimated at a few tonnes

Risk assessment:

- No emergency response by the crew;
- No salvage actions;
- Monitoring: visual observation (from vessels or along shoreline) and partially aerial observations (the product moved just below the sea surface due to the wave motion and was therefore partially visible). Modelling was applied to locate, the possible source of pollution through backtracking
- First actions: none
- Communication: illicit discharge reported by Italian Coast Guard when product reached shoreline.

FACT SHEET 7.3

Aleyna Mercan

Worsening parameters

- Summer season, presence of tourists along the coast.

Favourable parameters

- Good weather conditions;
- Relatively limited quantities spilled;
- Good cooperation between the institutions to identify the party responsible for the illegal discharge.

Response

- Recovery of spilled product was carried out manually along the coast and using special baskets mounted on antipollution vessels;
- Identification of the pollution source identification was carried out by laboratory analyses of the product characteristics and investigating which ships transported this product on waters of Northern Tyrrhenian Sea in the days prior to the spill;
- Lesson learned: relevance of cooperation between institutions to identify the perpetrator of illegal discharges, especially useful for avoiding new episodes in the future.

Post-spill

- Restoration: no restoration because of no evident negative consequences for any marine ecosystem;
- Environmental monitoring: none;
- Compensation: investigation by the Italian judiciary for illegal dumping of pollutants.

Parafin on the coast

Parafin wax collected with special baskets

FACT SHEET 7.4

Eurocargo Venezia

Vessel information
- Built in 2011, 32,841 GT, 10,765 DWT
- Italian flag

Information on chemical:
- Identity: Molybdenum oxide, CAS number 1313-27-5
- Nickel oxide, CAS number 1313-99-1
- SEBC S. Product is in granules, a few millimetres in diameter, denser than water and not soluble in water
- Usage: catalyst for desulfurisation in refining process of crude oil

Date & location
17th December 2011
North Thyrrenian Sea,
Tuscany Archipelago, off Gorgona Island

Hazard identification:
- UN number: 3191
- Hazard class: 4.2

- Marine pollutant: yes ☐ no ☒

Short summary of incident:
- Cause: during the night, the Ro-Ro Cargo *Eurocargo Venezia*, sailing from the port of Catania to Genoa harbour, lost two semi-trailers that fell into the sea, carrying 224 drums containing exhausted catalyst made from nickel and molybdenum oxides. 26 drums were still found on board in the aft area. The incident was caused by a sudden change of route to avoid a collision with another cargo vessel during severe weather conditions;
- Notification: notification of the loss of the drums was made at sunrise by the captain of the ship as soon as the accident was discovered. Backtrack reconstruction indicated that accident area was likely to be the Tuscany archipelago, near to Gorgona Island;
- Environmental conditions: the drums sunk to a depth of about 400 metres (410-450 m) on a muddy bottom composed of typical ecosystems of bathyal environments;
- Specificities on the location: trawling activities are conducted along these seafloor areas.

The cargo:
- Bulk ☐ Packaged PG ☒
- Quantities: each drum contained 170/180 kg of product stored in high-thickness PET plastic bags. As a result, 33-34,000 kg of products were lost at sea.

Risk assessment:
- Emergency response by the crew: Securing drums left on board;
- No salvage actions;
- Monitoring: no on board monitoring measurements of air and water, only sediment monitoring as part of environmental monitoring;

- Communication: notification of the loss triggered the intervention of the Italian Coast Guard and the Ministry of the Environment which, with the support of ISPRA, developed the search and recovery strategy for the drums. The polluter was in charge of proposing and funding the survey and recovery project as well as environmental monitoring.

Worsening parameters

- The incident occurred during the night and this led to a delay in notification and therefore an extension of the possible stretch of sea where searching activities for the sunken drums were required;
- Drums sank at great depths (about 400 metres) making search and recovery operations more difficult and expensive.

Favourable parameters

- Nickel/Molybdenum oxides were contained inside high thickness PET plastic bags which reduced the dispersion of the substances on the seabed.

Response

In February 2012 a survey of the main release area was carried out with side scan sonar (SSS) and a Remotely Operated Vehicle (ROV). A total area of 9 nm at a depth of 400–550 m was investigated, resulting in the discovery of the two trailers and many of the drums (about 130) concentrated in an area 0.8 km2 wide. The material was in different states of conservation: closed bag without drum, closed drum, open drum with bag inside. In June 2012 the drums were recovered using a robotic system. A work class ROV was able to place the drums found in specific racks and skips placed on the seabed. The racks were then recovered on board a supply vessel and transported to the shore for disposal. About 70 drums and their content were dispersed across the seafloor at 400-600 m depth. Due to the high depth and the supposed wide dispersion, public institutions deemed that it was not feasible and not reasonable to continue searching for unrecovered drums.

Lesson learned: transport of HNS must be avoided during severe weather conditions.

Post-spill

- Restoration: no restoration activities. Fishing and other uses of the seabed are banned near the sea bottom where the unrecovered drums are thought to be located. Specific recommendations have been given to fishermen, describing pollutant behaviour and procedures to be adopted if they accidentally collect drums in their fishing nets
- Environmental monitoring: a triennial environmental monitoring program has been carried out to evaluate the environmental status of involved benthic ecosystems, involving bioassays on the pollutant, chemical and ecotoxicological analyses of sediment and biological samples. Bioassay analyses confirmed the negative consequences of pollutants on marine biota;

chemical and ecotoxicological analyses indicated that after three years there was no evidence of adverse effects on the sea bottom where residual pollutant was located. It has been supposed that in the future exhausted catalyst will disperse on the seafloor in a solid phase with a grain size of few millimetres. It could generate negative environmental consequences when ingested by benthic organisms with several feeding behaviours: scavengers, non-selective benthic predators, filter-feeders, suspension feeders;

- Compensation: the polluter covered the costs of searching for and recovering the drums as well as those relating to environmental monitoring activities.

Open drum with bag inside

Specific racks where recovered drums were placed on sea bottom by a work class ROV

FACT SHEET 7.5

MSC Flaminia

Vessel information

- Container Ship (6,732 TEU) built in 2001, 75,590 DWT
- German flag

Date & location

14th July 2012, 08:04 UTC (Explosion),
Atlantic ocean,
ϕ 48°13,8'N λ 027°57,9'W

Information on chemical (DG Class)

- 2.1 gases (flammable) (2 containers on board in total /1 container damaged)
- 2.2 gases (non-flammable) (14/13)
- 3 flammable liquids (33/16)
- 4.1 flammable solids (1/1)
- 4.2 substances liable to spontaneous combustion (3/2)
- 4.3 substances which in contact with water emit flammable gases (1/1)
- 6.1 toxic substances (18/5)
- 8 corrosive substances (35/22)
- 9 miscellaneous dangerous substances (44/35)

Hazard identification

- All hazard classes except class 1 and 7
- Marine pollutant: yes ☒ no ☐

Short summary of incident:

- The *MSC Flaminia* was in transit across the Atlantic from New Orleans to Antwerp when smoke was detected in cargo hold No4. The smoke turned out to be vapour from a cargo of Divinyl-benzene (DVB, UN 3082) that had begun a runaway autopolymerisation process;
- Efforts to extinguish what was thought to be a fire led to an explosion and ensuing fire that extensively damaged the vessel and its cargo and led to the loss of three lives;
- The vessel was abandoned. A salvage team remanned the vessel later, extinguished the fire as far as possible and the vessel was towed to Europe. A place of refuge was granted at Wilhelmshaven, Germany where the vessel was unloaded under a high level of protection (environment and personnel). On the 15th March 2013 the vessel sailed from Germany to Romania for repair.

The cargo:

- Bulk ☐ Packaged ☒
- Quantities: 151 containers of dangerous goods

Risk assessment:

- Before granting a place of refuge two very detailed risk assessments were performed by the German government, the first one on the Atlantic, the second one in the German Bight;
- The first salvage activities (fire fighting) were performed by a professional salvage company after the vessel was abandoned by the crew;

- Monitoring: very close monitoring of the vessel was performed out at sea and in the harbour. Chemists took several samples and the water and air quality was permanently monitored with different devices (e.g. GC-MS) The offloading in the harbour was monitored under safety regulations for daily working places.

Worsening parameters:

Explosion and ongoing fire that heavily damaged the cargo holds 3-7, producing huge amounts of contaminated waste and water

Favourable parameters:

None, no impact on the World Heritage Wadden Sea or any damage to working personnel except for the crew of the vessel

Response:

- The fire fighting in the damaged environment was challenging and resulted in a huge amount of extinguishing water;
- The offloading operation was also challenging as most of the containers were at least partly damaged and normal equipment could not be used.

Post-spill:

A monitoring programme was launched.

9 ANNEXES

Annex 1 - General information

International level

HNS Convention Secretariat: www.hnsconvention.org

IMO

- List of conventions: www.imo.org/en/About/Conventions/Pages/ListOfConventions.aspx
- Chemical response: www.imo.org/en/OurWork/Environment/Pages/Pollution-Response.aspx
- Global integrated shipping information system: gisis.imo.org
- List of IMO OPRC-HNS related guidance and manuals: www.imo.org/en/OurWork/Environment/Pages/List-of-IMO-OPRC-HNS-related-guidance-and-manuals.aspx

EQUASIS: www.equasis.org

UNECE: www.unece.org

European level

European Commission

- Transport data hub: https://ec.europa.eu/transport/facts-fundings/statistics_en
- The European Union system for the evaluation of substances: https://ec.europa.eu/jrc/en/scientific-tool/european-union-system-evaluation-substances

EMSA

- MAR-ICE: www.emsa.europa.eu/we-do/sustainability/pollution-response-services/123-hns-pollution/1613-mar-ice-network-marine-chemical-emergency-information-service.html
- Vessel traffic monitoring in EU waters (SafeSeaNet): www.emsa.europa.eu
- CleanSeaNet services: http://emsa.europa.eu/csn-menu.html
- Port state control inspection database –THETIS: https://portal.emsa.europa.eu/web/thetis

INTERSPILL Conference & Exhibition: www.interspillevent.com

Useful tools or manuals

SAR: https://blogit.utu.fi/chemsar/material/

Emergency response guide: c.canada.ca/en/dangerous-goods

- Chemical response guides: www.cedre.fr
- Decision support tool: www.hns-ms.eu
- MIDSIS-TROCS: www.rempec.org

Knowledge tool to access projects related to HNS: http://knowledgetool.mariner-project.eu

Annex 2 - Information on regional specificities - Bonn Agreement

Bonn Agreement
Accord de Bonn

Preparedness

Maritime traffic (Maritime lines, HNS transported)

- ais.bonnagreement.org
- www.bonnagreement.org/site/assets/files/1129/be-aware_technical_sub_report_9_hns.pdf
- www.bonnagreement.org/site/assets/files/1129/beaware_technical_sub_report_1_ship_traffic-1.pdf

Regional plans

- **Bonn Agreement** www.bonnagreement.org
- **DenGerNeth (Denmark, Netherlands and German response zones)**
  www.vliz.be/imisdocs/publications/103736.pdf
- **Manche Plan (Channel waters between France and the UK)**
  https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/338795/130715_International_Assistance_and_Co-operation.pdf
- **NorBrit Plan (offshore zone between the UK and Norway)**
  www.bonnagreement.org/site/assets/files/25745/norbritplan_revised_july_20_2012x.pdf

Training courses

www.cedre.fr
www.nhlstenden.com/en/miwb/about-maritime-institute-willem-barentsz
www.centrojovellanos.es
www.msb.se/en/training--exercises

Exercises

www.bonnagreement.org/activities/counter-pollution-exercises
www.bonnagreement.org/site/assets/files/25745/1_1-1_11_national_chapters.pdf

Operational concern

SAR: www.bonnagreement.org/site/assets/files/25745/1_1-1_11_national_chapters.pdf

Emergency response on HNS: www.bonnagreement.org/site/assets/files/25745/1_1-1_11_national_chapters.pdf

Environmental Sensitive Index: www.bonnagreement.org/activities/projects/ii/final-report
www.hns-ms.eu/tools/vulnerability_maps

List of equipment: www.bonnagreement.org/site/assets/files/25745/1_1-1_11_national_chapters.pdf

Dispersants: www.bonnagreement.org/site/assets/files/25745/2_5_dispersants.pdf

Annex 3 - Information on regional specificities - HELCOM

Preparedness

Maritime traffic (HNS transported, Maritime lines)

- maps.helcom.fi/website/mapservice/?datasetID=95c5098e-3a38-48ee-ab16-b80a99f50fef
- maps.helcom.fi/website/aisexplorer
- www.helcom.fi/wp-content/uploads/2019/08/BSEP152-1.pdf

Regional plans (Training courses, Exercises)

- helcom.fi
- portal.helcom.fi/meetings/EWG%20OWR%207-2017-407/MeetingDocuments/4-1%20Training%20and%20exercise%20packages%20on%20OWR.pdf
- helcom.fi/action-areas/response-to-spills/helcom-balex-delta-and-other-exercises

Operational concern

SAR: See Chapter 1 of the HELCOM response manual: helcom.fi/action-areas/response-to-spills/manuals-and-guidelines
Emergency response on HNS: See Chapter 1 of the HELCOM response manual: helcom.fi/action-areas/response-to-spills/manuals-and-guidelines
Environmental Sensitive Index: stateofthebalticsea.helcom.fi
List of equipment: helcom.fi/wp-content/uploads/2020/11/HELCOM_Response_Equipment.xlsx

Annex 4 - Information on regional specificities - REMPEC

Preparedness

Maritime traffic (Maritime lines - HNS transported)

- Study on trends and outlook of marine pollution from ships and activities and of maritime traffic and offshore activities in the Mediterranean (REMPEC 2020): www.dropbox.com/s/331lv9o-g39q50sl/20201014_Final_Study.pdf?dl=0
- AIS Technical Report (April 2014 MEDESS-4MS): www.rempec.org/en/knowledge-centre/online-catalogue/ais-technical-report-april-2014-medess-4ms

Regional plans

- The United Nations Environment Programme - Mediterranean Action Plan (UNEP/MAP): www.unenvironment.org/unepmap
- The UNEP/MAP, structure: www.unenvironment.org/unepmap/who-we-are/institutional-set
- The Barcelona Convention (1995): wedocs.unep.org/bitstream/id/00dfd941-5c92-426b-8ec5-65f175572d40/BarcelonaConvention_Consolidated_eng.pdf
- The Prevention and Emergency Protocol (2002): https://wedocs.unep.org/bitstream/handle/20.500.11822/2912/02ig14_final_act_alllangs_emergprotocol_eng.pdf
- The Offshore Protocol (1995): wedocs.unep.org/bitstream/handle/20.500.11822/2961/94ig4_4protocol_eng.pdf
- The Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC): www.rempec.org/en/about-us/mandate
- The Mediterranean expertise:
    - The Mediterranean Technical Working Group (MTWG): www.rempec.org/en/about-us/regional-cooperation/technical-groups-1/the-mediterranean-technical-working-group-mtwg
    - The Mediterranean Assistance Unit (MAU): www.rempec.org/en/about-us/regional-cooperation/technical-groups-1/mediterranean-assistance-unit-mau
    - The Mediterranean network of law enforcement officials relating to MARPOL within the framework of the Barcelona Convention (MENELAS): www.rempec.org/en/about-us/regional-cooperation/technical-groups-1/menelas
- The Sub-regional agreements and contingency plans in the Mediterranean sea:
    - Ramoge between France, Italy, Monaco
    - Lion between France and Spain
    - South-Eastern Mediterranean between Cyprus, Egypt and Israel
    - South-Western Mediterranean between Algeria, Morocco and Tunisia
    - Adriatic between Croatia, Italy and Slovenia

- South-Eastern Mediterranean between Cyprus, Greece and Israel: www.rempec.org/en/our-work/pollution-preparedness-and-response/preparedness/contingency-planning/sub-regional-contingency-plans-in-the-mediterranean-sea

Training courses

Trainings and workshops 2002 -2018 (update under progress):
https://www.rempec.org/en/knowledge-centre/activity-reports/oprc-hns-technical-trainings

Exercises

Weblink(s) to know the date of last exercise and contact detail:
www.rempec.org/en/knowledge-centre/activity-reports/exercises

Operational concern

SAR

Contact for emergency
Existence of special rescue team (for instance MIRG)

Emergency response on HNS

Country Profile: www.rempec.org/en/knowledge-centre/country-profiles
Emergency Communication Procedure: www.rempec.org/en/our-work/pollution-preparedness-and-response/emergency-response/emergency-response/contact-rempec-in-case-of-emergency
Mediterranean Assistance Unit (MAU): www.rempec.org/en/our-work/pollution-preparedness-and-response/emergency-response/request-assistance-1/experts-of-the-mau
Members of the MAU: https://www.rempec.org/en/about-us/regional-cooperation/partners

Environmental Sensitive Index

MEGISMAR: medgismar.rempec.org

List of equipment:

MEGISMAR: medgismar.rempec.org
Template of the Manual on national mechanisms for the mobilization of response equipment and experts in case of emergency: www.rempec.org/en/knowledge-centre/online-catalogue/webinar-medexpol-2020-wg-47-5-2.pdf

Acronyms

B/L	Bill of Lading
BLEVE	Boiling Liquid Expanding Vapor Explosion
CAS Number	Chemical Abstracts Service. Unique numeric identifier for only one substances
CLP	Classification, Labelling and Packaging
DGL	Dangerous Goods List
EEZ	Exclusive Economic Zone
ELD	Environmental Liability Directive
EMSA	European Maritime Safety Agency
ERPGs	Emergency Response Planning Guidelines. The concentrations at which most people will begin to experience health effects if they are exposed to a hazardous airborne chemical for 1 hour
ESI	Environmental Sensitivity Index
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection. United Nations advisory group
GHS	Globally Harmonized System
HELCOM	Baltic Marine Environment Protection Commission
HNS	Hazardous and Noxious Substances
HSC	Hazard Statement Code
IAP	Incident Action Plan
IBC code	International Bulk Chemical code. International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk
ICS	Incident Command System
IMDG code	International Maritime Dangerous Goods code. Code for the maritime transport of dangerous goods in packaged form, in order to enhance and harmonize the safe carriage of dangerous goods and to prevent pollution to the environment
IMS	Incident Management System
IMSBC code	International Maritime Solid Bulk Cargoes code. The aim of the this code is to facilitate the safe stowage and shipment of solid bulk cargoes
IGC code	International Gas Carrier code. International code of the construction and equipment of ships carrying liquefied gases in bulk
IMO	International Maritime Organization
IOPC Funds	International Oil Pollution Compensation Funds
IUCN	International Union for Conservation of Nature

LEL	Lower Explosive Limit. Lowest concentration of a gas or vapour that will burn in air
LFL	Lower Flammability Limit. Minimum concentration of fuel vapour in air below which propagation of a flame will not occur in the presence of an ignition source
LLMC	Convention on Limitation of Liability for Maritime Claims
MARPOL	International Convention for the Prevention of Pollution from Ships
MT	Metric Tonne
NCP	National Contingency Plan
NEBA	Net Environmental Benefits Analysis
NOSCP	National Oil Spill Contingency Plan
OSC	On-Scene Commander
OSPAR	OSPAR is the mechanism by which 15 Governments and the EU cooperate to protect the marine environment of the North-East Atlantic
OPRC	International Convention on Oil Pollution Preparedness, Response and Co-operation
OPRC HNS	The protocol on Preparedness, Response and Co-operation to pollution incidents by Hazardous and Noxious Substances
PG	Packing Group in the context of the IMDG Code
pH	Abbreviation of potential of hydrogen, parameter used to determine whether a medium is acidic or basic
POLREP	POLlution REPort
PPE	Personal protective equipment
PSN	Proper Shipping Name
P&I Club	Protection & Indemnity Club, the insurer of the vessel's third-party liabilities
REMPEC	The Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
ROV	Remotely Operated Vehicle
RPAS	Remotely Piloted Aircraft System
SDS	Safety Data Sheet. Document which provides information on chemical products that help users in their situation assessment
SDR	Special Drawing Rights
SEBC	The Standard European Behaviour Classification determines the theoretical behaviour of a substance according to its physical and chemical properties, and classifies it into one of five main : gases, evaporators, floaters, dissolvers, sinkers
SIMA	Spill Impact Mitigation Assessment
SMPEP	Shipboard Marine Pollution Emergency Plan

SOLAS	International Convention for the Safety of Life at Sea
SOPEP	Ship Oil Pollution Emergency Plan
TDG	Transport of Dangerous Goods
UAV	Unmanned Aerial Vehicle
UFL	Upper Flammability Limit. Maximum concentration of fuel vapour in air above which propagation of a flame will not occur in the presence of an ignition source
UN Number	United Nations Number. A 4-digit identification number for hazardous goods whose transportation is regulated
WFD	Waste Framework Directive

Glossary

Aircraft	Device that is able to fly (plane, helicopter, balloon)
Auto-ignition	May be caused either by self-heating or, in the case of unpiloted ignition, by heating from an external source, as long as the external source does not include an open flame (or spontaneous ignition or self-ignition)
Backdraft	Rapid flaming combustion caused by the sudden introduction of air into a confined oxygen-deficient space that contains hot products of incomplete combustion
Bioaccumulation	The accumulation of a substance in living organisms up to concentrations far higher than those in the environment
Bioavailable	The ability of an element to be absorbed and to cross the cell membranes of living organisms
Biodegradable	Qualifies a substance that can be broken down by living organisms
Charterer	Cargo owner or another person/company who hires a ship for a particular voyage or a period of time
Chimney effect	Upward movement of hot fire effluent caused by convection currents confined within an essentially vertical enclosure
Containment	Actions implemented to maintain spilled substance within a barrier or drainage area
Cross contamination	Occurs when a person who is already contaminated makes contact with a person or object that is not contaminated, disseminating contamination
Dredger	Machine used to remove mud and solids from the seafloor
Drift	Drift (for a spill) Trajectory taken by a spill, according to environmental factors (for instance wind or current)
Ecotoxicity	It combines ecology and toxicity and addresses the potential for a substance to affect a specific community of organisms or an entire ecosystem
Flash point	Minimum temperature to which a fuel must be heated for the vapours emitted to ignite momentarily in the presence of flame under specified conditions
Flashover	Transition to a state of total surface involvement in a fire of combustible materials within an enclosure. (other possible terminology found: ventilation induced flashover, roll over, ghosting flames)
Flushing	Clean-up techniques used to dislodge residual clusters of trapped pollutant or to wash and rinse rocks and pebbles
Ignition temperature	Minimum temperature at which, if the vapours of a fuel are ignited with heat source, the combustion reaction of a fuel becomes self-sustaining
Persistance	Refers to the resistance of a chemical to degradation; as such, persistence cannot be measured directly, and only the continued measurable presence of a certain chemical in the environment, or the systematic resistance to degradation under laboratory conditions can suggest its persistence

Pyrolysis	Chemical decomposition of a substance by the action of heat, often used to refer to a stage of fire before flaming combustion has begun
Pyrophoric material	Material capable of auto-ignition when brought into contact with air
Scuttle	To deliberately sink a vessel
Shipowners	An owner, manager or operator having commercial or operational control of the vessel
Stakeholders	Group or organisation with an interest or concern in response preparedness to their potential consultation or participation in spill response
Stowage	The placing of goods in a ship to ensure the safety and stability of the ship

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