Bonn Agreement
Accord de Bonn

MARINE HNS RESPONSE MANUAL

Multi-regional Bonn Agreement, HELCOM, REMPEC

European Union
Civil Protection

WEST
Mediterranean
Marine Oil & HNS
Pollution
Cooperation

This Manual is available at www.westmopoco.rempec.org

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Preface

The Western Mediterranean Region Marine Oil and HNS Pollution Cooperation (West MOPoCo) project supported Algeria, France, Italy, Malta, Morocco, Spain and Tunisia in collaboration with Monaco in strengthening their cooperation in the field of preparedness for and response to oil and Hazardous and Noxious Substances (HNS) marine pollution and in improving the quality and interoperability of their response capacities.

The Project was implemented through an inter-regional effort, including the participation of the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC), the Bonn Agreement for the Greater North Sea and its approaches and the Helsinki Commission (HELCOM) for the Baltic Sea. The project benefits from the technical support and expertise of expert partner institutions such as Cedre, ISPRA and ITOPF.

The present Manual has been developed by Cedre, ISPRA and ITOPF in the framework of the West MOPoCo project at the request of the Secretariat of the Bonn Agreement, HELCOM and REMPEC, to provide state of the art information on HNS pollution preparedness and response. The competent national authorities of Member States of the three regional conventions were consulted at each step of the drafting process, to ensure the Manual meets their operational needs and to enrich it with their national experience in responding to chemical spills at sea.

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The content of this Manual is also available through the decision trees of MIDSIS TROCS 4.0, the new Maritime Integrated Decision Support Information System on Transport of Chemical Substances also updated and upgraded under the West MOPoCo project. This tool, designed as a reference for use in the field (downloadable offline application) or office (Online version), seeks to provide decision-makers with options for response to marine chemical emergencies presented in a structured format through decision trees. MIDSIS TROCS 4.0 is available on REMPEC's website: midsis.rempec.org

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1 INTRODUCTION

1.1 Scope

Maritime transport is often described as "the backbone of globalized trade and the manufacturing supply chain", since more than 80% of the global merchandise trade by volume is carried by sea.

Some of the goods transported are defined as Hazardous and Noxious Substances (HNS). HNS might be released into the sea as the consequence of illegal discharges or maritime accidents such as groundings or collisions; and whilst major incidents involving an HNS spill are rare, they can be very complex and potentially have severe impacts on human health, the environment, and socio-economic resources. The particular challenges associated with responding to HNS incidents are linked to the heterogeneity of the various substances considered as HNS, which include substances presenting various hazards (physical hazards such as fire and explosion, health hazards such as toxicity, and environmental hazards) and behaviours (gases/evaporators, floaters, dissolvers, sinkers).

The objective of this Marine HNS Response Manual is to provide operational guidance for first responders and decision-makers during a maritime incident at sea or in port involving HNS. The manual does not cover all aspects of an incident involving HNS, but specifically addresses relevant offshore and onshore spill response techniques (but excludes topics such as search and rescue, salvage, medical treatment). The HNS Marine Response Manual consists of three parts:

1. Introductory background information relevant for understanding the concepts driving an HNS response strategy in seven chapters;

2. Operational fact sheets and decision-making flowcharts relevant for responders;

3. Annexes I, II and III include regional specificities (information on maritime transport, sensitive resources, etc.) for the Baltic Sea (Helsinki Commission (HELCOM)), North Sea (Bonn Agreement) and Mediterranean Sea (The Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC)) respectively.

1.2 HNS definition

There are two different key definitions of HNS: that of the **2000 OPRC-HNS Protocol** and that of the **2010 HNS Convention** (IMO, 2010). Under the **2000 OPRC-HNS Protocol** (IMO, 2002), HNS are defined as "*any substance other than oil which, if introduced into the marine environment, 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*".

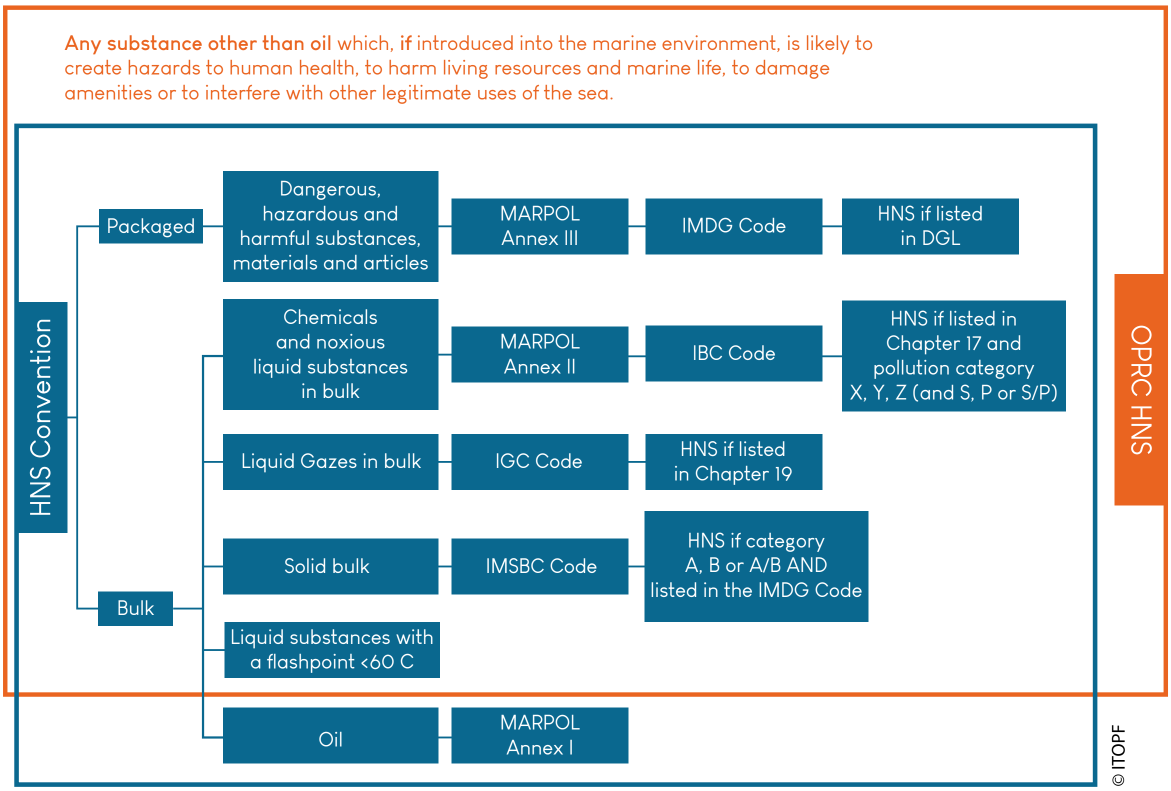


Figure 1: Definition of HNS according to HNS Convention and OPRC HNS Protocol

The **HNS Convention** on the other hand includes oil and provides a detailed list of HNS categories as defined by various International Maritime Organization (IMO) conventions and codes:

a) *"any substances, materials and articles carried on board a ship as cargo, referred to in (i) to (vii) below:*

i. oils, carried in bulk, as defined in regulation 1 of annex I to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto, as amended;

ii. noxious liquid substances, carried in bulk, as defined in regulation 1.10 of Annex II to the International Convention for the Prevention of Pollution from Ships, *1973, as modified by the Protocol of 1978 relating thereto, as amended, and those substances and mixtures provisionally categorized as falling in pollution category X, Y or Z in accordance with regulation 6.3 of the said Annex II;*

iii. dangerous liquid substances carried in bulk listed in chapter 17 of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk, as amended, and the dangerous products for which the preliminary suitable conditions for the carriage have been prescribed by the Administration and port administrations involved in accordance with paragraph 1.1.6 of the Code;

iv. dangerous, hazardous and harmful substances, materials and articles in packaged form covered by the International Maritime Dangerous Goods Code, as amended;

v. liquefied gases as listed in chapter 19 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, as amended, and the products for which preliminary suitable conditions for the carriage have been prescribed by the Administration and port administrations involved in accordance with paragraph 1.1.6 of the Code;

vi. liquid substances carried in bulk with a flashpoint not exceeding 60°C (measured by a closed-cup test);

vii. solid bulk materials possessing chemical hazards covered by the International Maritime Solid Bulk Cargoes Code, as amended, to the extent that these substances are also subject to the provisions of the International Maritime Dangerous Goods Code in effect in 1996, when carried in packaged form; and

b) residues from the previous carriage in bulk of substances referred to in (a) (i) to (iii) and (v) to (vii) above."

2 IMO CONVENTIONS, PROTOCOLS AND CODES

The International Maritime Organization (IMO) is a specialised agency of the United Nations and is the standard-setting authority for the safety, security and environmental performance of international shipping. Its main role is to create a universally adopted and effective regulatory framework for the shipping industry. To achieve this goal, IMO uses five important instruments: Conventions, Protocols, Amendments, Recommendations (includes Codes and Guidelines) and Resolutions. IMO adopts these instruments and the national governments of the current 174 Member States are responsible for implementing them. So far IMO has adopted more than 50 international conventions and agreements (IMO, 2021), as well as numerous protocols and amendments.

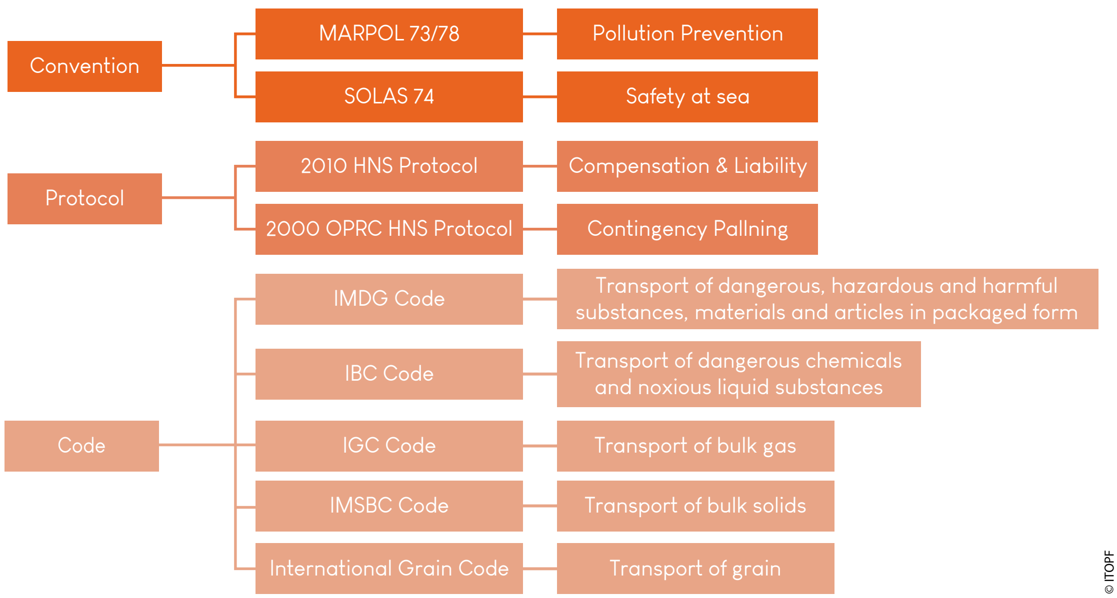


Figure 2: IMO conventions, protocols and codes relevant for the transport of HNS at sea

The two main IMO conventions concerning the safety of merchant ships and the prevention of pollution of the marine environment by ships are: the International Convention for the Safety of Life at Sea (**SOLAS 74**) and the International Convention for the Prevention of Pollution from Ships (**MARPOL 73/78**) respectively. SOLAS (IMO, 2020b) and MARPOL (IMO, 2017) refer to various IMO Codes, relevant for the carriage of HNS as per the HNS Convention:

- **IMDG Code** (International Maritime Dangerous Goods Code);
- **IBC Code** (International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk);
- **IGC Code** (International Gas Carrier Code);

- **IMSBC Code** (International Maritime Solid Bulk Cargoes Code).

> Conventions become mandatory for Contracting Parties/Member States once they are ratified and implemented into national law. IMO Codes (such as IMDG Code), on the other hand, are often a recommendation.

In addition to conventions, the 2010 HNS Protocol addresses the topic of liability and compensation and the OPRC-HNS Protocol focuses on contingency planning and preparedness.

> A protocol forms additional legislation which adds to or complements an existing convention or treaty. Parties to the original Convention may separately accede to its Protocol.

2.1 IMO conventions related to HNS transport

SOLAS 1974 specifies minimum standards for the construction, equipment and operation of ships, compatible with their safety. Chapter VII of the Convention specifically addresses the carriage of dangerous goods in packaged form, in solid form in bulk, dangerous liquid chemicals in bulk and liquefied gases in bulk.

MARPOL 73/78 is the main international convention covering the prevention of pollution of the marine environment by ships from operational or accidental causes and addresses regulations for the prevention of pollution by oil (Annex I), noxious liquid substances in bulk (Annex II), harmful substances carried by sea in packaged form (Annex III), sewage (Annex IV), garbage (Annex V) and air pollution (Annex VI).

MARPOL Annex II and the IBC Code divide noxious **liquid substances** into four pollution categories:

- **Category X**: substances which present a major hazard to either marine resources or human health, therefore, the discharge into the marine environment is prohibited (e.g. phosphorus, white or yellow);
- **Category Y**: substances which present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea and therefore justify a limitation on the quality and quantity of the discharge into the marine environment (e.g. styrene);
- **Category Z**: substances which present a minor hazard to marine resources and/or human health and therefore justify less stringent restrictions on the quality and quantity of the discharge into the marine environment (e.g. acetone);
- **Category OS**: other substances, which are not considered harmful and are not subject to any requirements of MARPOL Annex II (e.g. molasses).

MARPOL Annex III sets out regulations for the prevention of pollution by harmful substances in **packaged form** and includes general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications for preventing pollution by harmful substances.

2.2 IMO protocols related to HNS transport

The Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances (**2000 OPRC-HNS Protocol**) seeks to provide a global framework for international co-operation and compel national preparedness for combating major incidents or threats of marine pollution from ships carrying HNS. It follows the principles of the International Convention on Oil Pollution Preparedness, Response and Co-operation (**OPRC 1990**).

The International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (**1996 HNS Convention**) was adopted in 1996. It aims to ensure compensation to those who have been affected by damage to persons and/or property. It is modelled on the International Convention on Civil Liability for Oil Pollution Damage (**CLC Convention**) and International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (**1992 Fund Convention**) which cover pollution damage from persistent oil from tankers. However, by 2009, the 1996 HNS Convention had still not entered into force (due to an insufficient number of ratifications) therefore a protocol to the HNS Convention (**2010 HNS Protocol**) was developed and adopted. The 2010 HNS Protocol was designed to address practical problems that had prevented a number of States from ratifying the original Convention (IOPC Funds, 2019). The 2010 HNS Protocol is not yet in force, therefore compensation following an HNS incident remains subject to national regulations (6.1.1 Legislation - Legal basis for compensation).

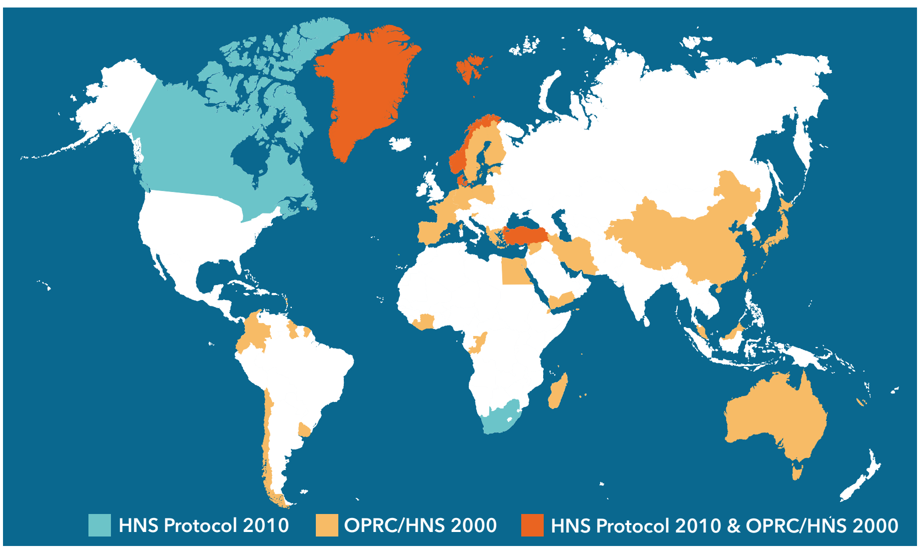


Figure 3: Countries which have ratified the 2010 HNS Protocol and/or 2000 OPRC-HNS Updated information can be found on www.imo.org/en/About/Conventions/Pages/StatusOf-Conventions.aspx

2.3 IMO codes related to HNS transport

There are various IMO codes addressing the safe transport of HNS and grain, all of which are explained in more detail in the relevant sub-sections. All codes are amended periodically. It is worth noting that the IBC, IGC and IMSBC Codes include provisions for non-hazardous cargo, whereas the IMDG Code only addresses HNS.

The International Code for the Safe Carriage of Grain in Bulk (International Grain Code) covers specific transport considerations for wheat, maize (corn), oats, rye, barley, rice, pulses, seeds and processed forms thereof. Since the Code's content does not address physical or environmental hazards associated with a spill of such substances, it is not further elaborated.

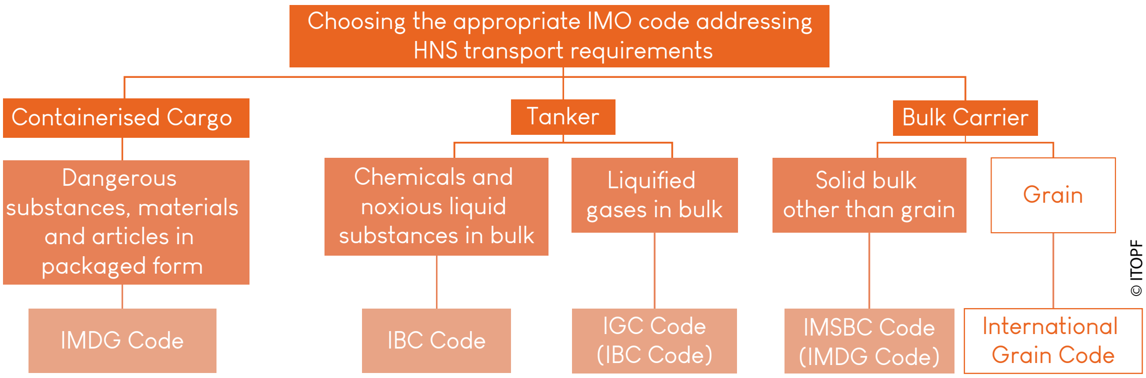


Figure 4: Overview of IMO codes

2.3.1 International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)

Coral Leaf *ethylene carrier in heavy seas*

The **IGC Code (International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk)** sets out the international standards for the safe carriage of liquefied gases in bulk by sea. The Code defines vessel design and construction standards as well as equipment requirements aiming to minimise the risk to the ship, its crew and the environment (IMO, 2016). Additional standards for vessels operating with gas or low flash point liquids such as fuel are provided in the **IGF Code** (International Code of Safety for Ships using Gases or other Low-flashpoint Fuels).

The three types of gas cargoes to be distinguished are **LNG** (Liquefied Natural Gas), **LPG** (Liquefied Petroleum Gas) covering butane and propane (or a mixture of the two) and **a variety of chemical gases** (such as ammonia).

Depending on the nature of the cargo, it might be transported in LNG carriers, fully refrigerated ships, ethylene carriers, semi-pressurised ships or pressurised ships. All vessels subject to the IGC Code are assigned one of four types (1G, 2G, 2PG, 3G) based on the hazard potential of the cargo they carry:

- Type 1G vessels are intended to transport products which present the greatest overall hazard (e.g. chlorine, ethylene oxide),
- Types 2G/2PG are designed to carry cargoes with a lesser degree of a hazard (e.g. ammonia, propane)
- Type 3G carry the least hazardous products (e.g. nitrogen, carbon dioxide).

Depending on the type of vessel, the product can be carried in independent tanks:

- Type A (box-shaped or prismatic)
- Type B (spherical or prismatic)
- Type C (spherical or cylindrical), membrane tanks, integral tanks or semi-membrane tanks.

All liquefied gases considered in the Code are listed in Chapter 19 of the IGC Code; all product names followed by an asterisk are also covered by the IBC Code.

2.3.2 International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk (IBC Code)

Chemical tanker

Chemical tankers built after 1st July 1986 are required to comply with the IBC Code, which sets out the international standards for the safe carriage of dangerous chemicals and noxious liquid substances, in bulk by sea. The IBC Code prescribes the design and construction standards of ships involved in the transport of bulk liquid chemicals and identifies the equipment to be carried to minimise the risks to the ship, its crew and to the environment, with regard to the nature of the products carried (IMO, 2016a).

The IBC Code (in concordance with MARPOL Annex II) divides noxious liquid substances into four pollution categories.

In addition to these pollution categories, the Code also indicates whether a substance is a safety ("S") and/or a pollution ("P") hazard with regard to fire, health, reactivity and marine pollution hazards.

Chapter 17 of the IBC Code contains a list of chemicals, organised by their product name (column a), followed by the pollution category (column c) and hazards (column d), followed by columns addressing ship/tank type and minimum equipment requirements.

a	c	d	e	f
Hydrochloric acid	Z	S/P	3	1G

Table 1: Example of hydrochloric acid entry as per IBC Code
(a) Product name: Hydrochloric Acid, (c) Pollution category: Z, substance which presents a minor hazard to marine resources and/or human health for operational discharges but is considered (d) Hazard: Safety/Pollution, (f) Tank type: 1G, independent gravity tanks

(a)	(c)	(d)	(e)	(f)
Product name	Pollution category	Hazards	Ship type	Tank type
Hydrochloric acid	Z	S/P	3	1G
	Substance which presents a minor hazard to marine resources and/or human health and therefore justifies less stringent restrictions on the quality and quantity of the discharge into the marine environment	Safety/pollution hazard	Chemical tanker intended to transport products with sufficiently severe environmental and safety hazards which require a moderate degree of containment to increase survival capability in a damaged condition	Independent gravity tanks

Table 2: Example of a partial IBC Code entry for Hydrochloric acid

The hazards of all noxious liquid substances transported in bulk (MARPOL Annex II) listed in the IBC Code are evaluated by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP). GESAMP is an advisory body, established in 1969, that advises United Nations (UN) bodies on the scientific aspects of marine environmental protection ▶ 2.1 GESAMP hazard profiles

2.3.3 International Maritime Solid Bulk Cargoes Code (IMSBC Code)

Handysize La Briantais

The **IMSBC Code (International Maritime Solid Bulk Cargoes Code)** addresses special requirements for the safe stowage and shipment of solid bulk cargoes by providing information on the hazards associated with their carriage (IMO, 2020c). The IMSBC Code categorises cargoes into three groups:

- **Group A**: cargoes that may liquefy (e.g. fish, coal slurry);
- **Group B**: cargoes possessing chemical hazards (according to either the IMDG Code's hazard criteria (e.g. magnesium nitrate) or the IMSBC Code's "materials hazardous only in bulk" (MHB) criteria (e.g. lime);
- **Group C**: cargoes that are neither liable to liquefy nor possess chemical hazards (e.g. iron ore, pebbles).

Appendix 1 of the IMSBC Code lists the physical properties of each substance to which the Code applies, its hazards, equipment and shipping requirements as well as emergency procedures.

Magnesium Nitrate UN 1474

Description

White crystals, soluble in water. Hygroscopic.

Characteristics

Physical properties			
Size	Angle of repose	Bulk density (kg/m³)	Stowage factor (m³/t)
Not applicable	Not applicable		
Hazard classification			
Class	Subsidiary hazard(s)	MHB	Group
5.1	Not applicable		B

Emergency Procedures

Special emergency equipment to be carried	Emergency procedures	Emergency action in the event of fire	Medical first aid
Protective clothing (gloves, boots, coveralls and headgear). Self-contained breathing apparatus. Spray nozzles.	Wear protective clothing and self-contained breathing apparatus	Use copious quantity of water, which is best applied in the form of a spray to avoid disturbing the surface of the material. The material may fuse or melt, in which condition application of water may result in extensive scattering of the molten materials. Exclusion of the aire or use of CO_2 will not control the fire. Due consideration should be given to the effect on the stability of the ship due to the accumulated water.	Refer to the Medical First Aid Guide (MFAG), as amended.

Figure 5: IMSBC Code entry example - magnesium nitrate UN 1474

2.3.4 International Maritime Dangerous Goods Code (IMDG Code)

Container ship/RoRo vessel

The **IMDG Code (International Maritime Dangerous Goods Code)** sets provisions for the safe transport of dangerous, hazardous and harmful substances, materials and articles in packaged form by sea (IMO, 2020a). IMDG Code is based on the UN Recommendations on the Transport of Dangerous Goods, also known as the UN Model Regulations (▶ 3.2 GHS vs UN TDG), which provides a framework of rules for the safe carriage of dangerous goods by all modes of transport (air, road, rail and sea).

The term "dangerous goods" in this context means the substances, materials and articles covered by the IMDG Code. **Dangerous substances** have an immediate physical or chemical effect, whereas **hazardous substances** pose a risk to human health. **Harmful substances** are those identified as a marine pollutant in the IMDG Code.

At sea, packaged goods are usually transported in "cargo transport units" (CTU) such as freight containers on board container ships or car carriers. There are multiple types of intermodal containers such as dry storage, tank containers, flat racks and temperature-controlled containers, of which the most common standard sizes are 20 ft and 40 ft (which differ in volume but not in maximum gross weight). One 20-foot container equals one TEU (twenty-foot equivalent unit).

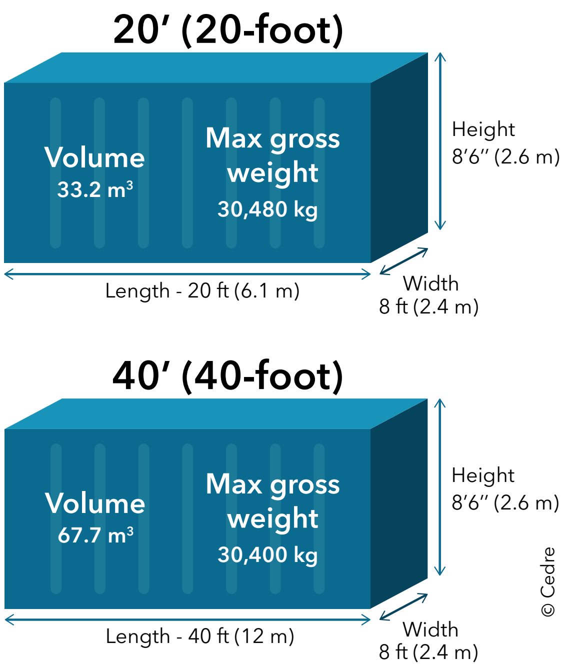


Figure 6: Dimensions of the two most common intermodal dry freight container sizes

Inside a container, packaged goods are carried in inner packaging (such as drums, boxes, bags) which is most commonly fixed onto wooden pallets. The IMDG Code specifies which inner packaging and which CTU is suitable for which HNS.

The IMDG Code comprises two volumes and a supplement, which are published bi-annually:

- **Volume 1** addresses general provisions/definitions/training, classification, packing and tank provisions, consignment procedures, testing requirements for receptacles and transport operations requirements.
- **Volume 2** covers the Dangerous Goods List (DGL), special provisions and exceptions where substances are listed by their assigned UN number and proper shipping name.
- **The supplement** contains Emergency Response Procedures for Ships Carrying Dangerous Goods (EmS Guide) and the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG), which is the supplement to the International Medical Guide for Ships published by the World Health Organization (WHO). The information contained in the EmS Guide and MFAG is primarily for shipboard use but may be of use to shore-based personnel when responding to an incident involving a container within a terminal.

All goods listed in the IMDG Code are allocated one of nine "classes" (excluding subdivisions), according to the main danger they present. More detail in Chapter 3.

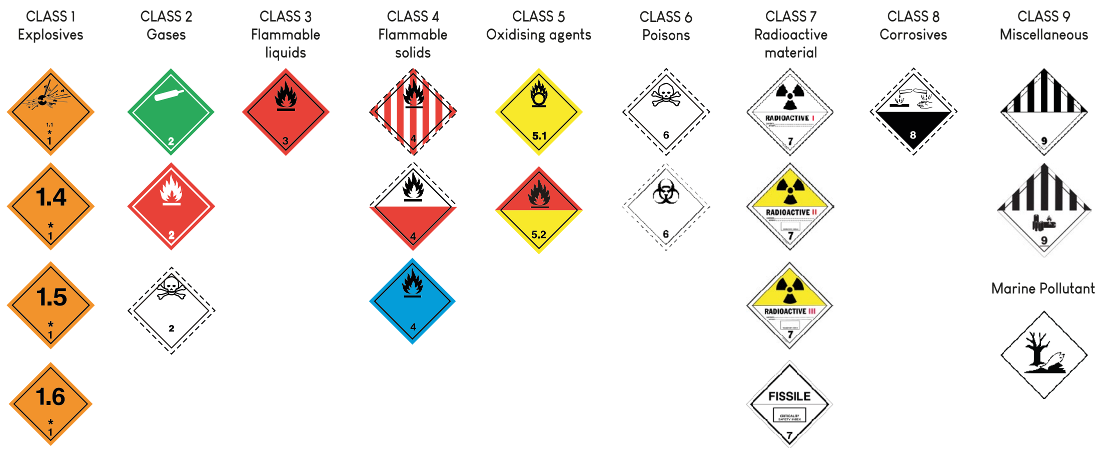


Figure 7: IMDG Code classes' pictograms

The UN number is a four-digit number which identifies and groups all dangerous, hazardous and harmful substances, materials and articles according to their hazard profile and composition with regard to their international transport. There are four different types of UN Number entries:

- Single entries for well-defined substances or articles (e.g. UN 1194 ETHYL NITRITE SOLUTION)
- Generic entries for well-defined groups of substances or articles (e.g. UN 1130 PERFUMERY PRODUCTS)
- Specific entries not otherwise specified (N.O.S.) (e.g. UN 1987 ALCOHOLS, N.O.S)
- Generic entries not otherwise specified (N.O.S.) (e.g. UN 1993 FLAMMABLE LIQUID, N.O.S).

A chemical in its solid state may receive a different UN number to the liquid phase if their hazardous properties differ significantly. Similarly, substances with different levels of purity (or concentration in solution) may also receive different UN numbers.

UN numbers are different from CAS Registry Numbers, which are assigned to each chemical compound uniquely, indifferently of its physical state, by the Chemical Abstract Service (CAS). As of 2020, there were 159,000,000 unique chemical substances indexed by CAS.

Example:

UN 1823 Sodium hydroxide, solid
UN 1824 Sodium hydroxide solution
BUT CAS Sodium Hydroxide: 1310-73-2

For each UN Number, there are coded instructions on packaging, labelling, marking, stowage and segregation based on the substance's hazard classification, including one of three packing groups in accordance with the degree of danger they present:

- Packing Group I: high danger
- Packing Group II: medium danger
- Packing Group III: low danger

UN No.	Proper shipping name (PSN)	Class or division	Subsidiary hazard(s)	Packing group	Special provisions	Limited and excepted quatity provisions		Packing		IBC	
						Limited quantities	Excepted quantities	Instructions	Provisions	Instructions	Provisions
(1)	(2) 3.1.2	(3) 2.0	(4) 2.0	(5) 2.0.1.3	(6) 3.3	(7a) 3.4	(7b) 3.5	(8) 4.1.4	(9) 4.1.4	(10) 4.1.4	(11) 4.1.4
1001	Acetylene, dissolved	2.1	-	-	-	0	E0	P200	-	-	-
1002	Air, compressed	2.2	-	-	-	120 mL	E1	P200	-	-	-
1003	Air, refrigerated liquid	2.2	5.1	-	-	0	E0	P203	-	-	-
1005	Ammonia, anhydrous	2.3	8 P	-	23 379	0	E0	P200	-	-	-

Portable tanks and bulk containers			EmS	Stowage and handling	Segregation	Properties and observations	UN No.
(12)	Tank instructions (13) 4.2.5 4.3	Provisions (14) 4.2.5	(15) 5.4.3.2 7.8	(16a) 7.1 7.3-7.7	(16b) 7.2-7.7	(17)	(18)
-	-	-	F-D, S-U	Category D SW1 SW2	SG46	Flammable gas with slight odour. Explosive limits: 2.1% to 80%. Lighter than air (0.907). Rough handling and exposure to local heating should be avoided, since these conditions may result in delayed explosion. Empty cylinders should be carried with the same precautions as filled cylinders.	1001
-	-	-	F-C, S-V	Category A	-	Non-flammable gas.	1002
-	T75	2.2	F-C, S-W	Category D	-	Liquefied, non-flammable gas. Strong oxidizing agent. Mixtures of liquid air with combustible materials or oils may explode. May ignite organic materials.	1003
-	T50	-	F-C, S-U	Category D SW2	SGG18 SG35 SG46	Liquefied, non-flammable, toxic and corrosive gas with a pungent odour. Lighter than air (0.6). Suffocating in low concentrations. Even though this substance has a flammability hazard, it only exhibits such hazard under extreme fire conditions in confined areas. Reacts violently with acids. Highly irritating to skin, eyes and mucous membranes.	1005

Figure 8: IMDG Code page entry example

The Dangerous Goods List (DGL) specifies which substances when transported in small quantities may be carried as **Limited** or **Excepted Quantities**, which are exempt from some of the transport regulations (since small quantities are considered safer to carry). A **Limited Quantity** is defined as "the maximum quantity per inner packaging or article for transporting dangerous goods as limited quantities". An **Excepted Quantity** is defined as "the maximum quantity per inner and outer packaging for transporting dangerous goods as excepted quantities".

In addition, the IMDG Code specifies that packaged dangerous goods must be accompanied by the appropriate transport documents or a signed declaration (**Multimodal Dangerous Goods Form**, Figure 8) stating that the consignment is properly packaged, marked, labelled and in proper condition for carriage. The document must contain information relating to transport (sender/receiver, vessel name, etc.) but also details about the article itself such as UN Number, Proper Shipping Name, Hazard Class, Packing Group (where assigned) and if the article is a marine pollutant (Chapter 3.2.6.1 Hazardous to the environment (ecotoxicity)).

<table>
<tr><td colspan="2" rowspan="3">1. Shipper/Consignor/Sender</td><td colspan="3">2. Transport document number</td></tr>
<tr><td>3. Page 1 of pages</td><td colspan="2">4. Shipper's reference</td></tr>
<tr><td></td><td colspan="2">5. Freight fowarder's reference</td></tr>
<tr><td colspan="2">6. Consignee</td><td colspan="3">7. Carrier (to be completed by the carrier)</td></tr>
<tr><td colspan="2"></td><td colspan="3">SHIPPER'S DECLARATION
I hereby declare that the contents of this consignement are fully and accurately described below by the proper shipping name, and are classified, packaged, marked and labelled/placarded and are in all respects in proper condition for transport according to the applicable international and national governmental regulations.</td></tr>
<tr><td colspan="2">8. This shipment is within the limitations prescribed for:
(Delete non-applicable)</td><td colspan="3" rowspan="4">9 Additional handling information</td></tr>
<tr><td>PASSENGER AND CARGO AIRCRAFT</td><td>CARGO AIRCRAFT ONLY</td></tr>
<tr><td>10.Vessel/flight No. and date</td><td>11. Port/Place of loading</td></tr>
<tr><td>12. Port/place of discharge</td><td>13. Destination</td></tr>
<tr><td>14. Shipping marks</td><td colspan="2">Number and kind of packages; description of goods</td><td>Gross mass (kg)</td><td>Net mass (kg) Cube (m^3)</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>15. Container identification No./ vehicle registration No.</td><td>16. Seal number(s)</td><td>17. Container/vehicle size and type</td><td>18. Tare mass (kg)</td><td>19. Total gross mass (including tare) (kg)</td></tr>
<tr><td colspan="2">CONTAINER/VEHICLE PACKING CERTIFICATE
I hereby declare that the goods described above have been packed/loaded into the container/vehicle identified above in accordance with the applicable provisions.
MUST BE COMPLETED AND SIGNED FOR ALL CONTAINER/VEHICLE LOADS BY PERSON RESPONSIBLE FOR PACKING/LOADING</td><td colspan="3">21. RECEIVING ORGANISATION RECEIPT
Received the above number of packages/containers/trailers in apparent good order and condition, unless stated hereon:
RECEIVING ORGANISATION REMARKS:</td></tr>
<tr><td colspan="2">20. Name of company</td><td colspan="2">Haulier's name</td><td>22. Name of company (OF SHIPPER PREPARING THIS NOTE)</td></tr>
<tr><td colspan="2">Name/status of declarant</td><td colspan="2">Vehicle registration no.</td><td>Name/status of declarant</td></tr>
<tr><td colspan="2">Place and date</td><td colspan="2">Signature and date</td><td>Place and date</td></tr>
<tr><td colspan="2">Signature of declarant</td><td colspan="2">DRIVER'S SIGNATURE</td><td>Signature of declarant</td></tr>
</table>

Figure 9: Multimodal Dangerous Goods Form, as given in the IMDG Code. The layout of the form is non-binding, but the content is mandatory (IMDG code, Vol. 1 Chapter: Consignment procedures)

3 HNS HAZARD AND BEHAVIOUR CLASSIFICATIONS

During a marine incident involving HNS, it is crucial to obtain information about the spilled substance's chemical and physical properties, associated hazards and likely behaviour when spilled at sea. This information is key in the development of a response strategy.

Decisions on the first actions to be taken are often driven by the potential hazards associated with HNS, such as explosion, flammability, oxidation, corrosivity, reactivity, toxicity and ecotoxicity. However, depending on the timespan of the hazards, the longer term response strategy will tend to be driven by the chemical's behaviour (as described by the Standard European Behaviour Classification (SEBC)).

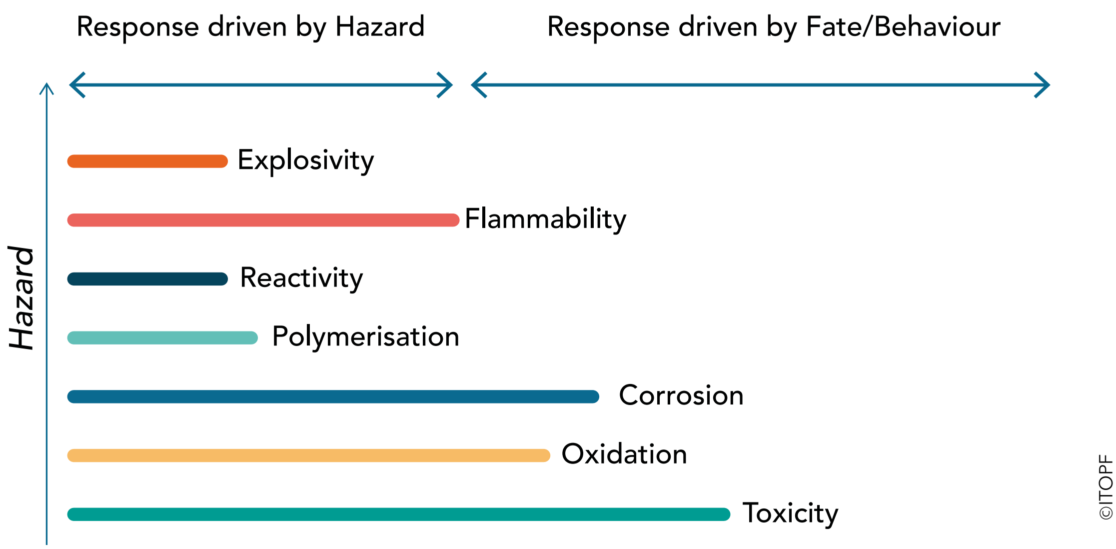


Figure 10: How first response actions driven initially by hazards and later by fate and behaviour change over time

For operational advice related to hazards and fate/behaviour, see Chapter 5.

3.1 Physical fate and behaviour of HNS when spilled at sea

The **Standard European Behaviour Classification (SEBC)** determines the theoretical behaviour of a substance according to its physical and chemical properties, and classifies it into one of the five main categories **gases** (G), **evaporators** (E), **floaters** (F), **dissolvers** (D), **sinkers** (S). However, substances might show not only one but several behavioural phases throughout a spill – depending on the characteristics of the product(s) and its/their exposure to environmental processes; this explains why seven further sub-categories were developed (Figure 11).

The four physical/chemical properties relevant to predict a substance's behaviour are solubility, density, vapour pressure, and viscosity. These are usually documented for a standard temperature, typically 20°C, which is generally used in the ▶ 3.1 Safety data sheet content. However, the atmospheric temperature will affect the values of these properties and adjustments may need to be applied.

The **Safety Data Sheet (SDS)** is a document which provides information on chemical products that helps users in their situation assessment. It is mandatory for all chemical suppliers to issue SDS and they should be made available online. The document includes information about a chemical's properties and hazards, and provides information on handling, storage and emergency measures in case of accident.

- **Solubility** (S) is the ability of a given substance (the solute) to dissolve into a liquid (the solvent); it is usually measured in mg/L (or ppm) or in percentage (where 1% is 1 g of solute in 100 mL of solvent). Therefore, a solubility of 500 mg/L equals 0.05%. If not specified, water is considered to be the solvent.

  A substance is soluble if $S > 5\%$

- The **relative density** (d) (or specific mass) of a substance is defined as its mass per unit volume – or its "compactness". It is often measured in g/cm^3 or kg/m^3 and is used to determine whether the substance is heavier or lighter than a reference (air or water typically).

  A liquid floats if its $d < d_{seawater}$, ($1{,}025\ kg/m^3$ at 20°C)

- **Vapour pressure** (Vp) is an indicator describing the tendency of a liquid to change into the gaseous state. Vapour pressure is measured in Pascal (Pa) and the standard atmospheric pressure is 101.3 kPa.

  A substance is an evaporator if its $Vp > 3$ kPa

- **Viscosity** is the measure of a liquid's resistance to flow measured in cSt centistokes (mm^2/s). Viscosity varies with temperature, and in most cases an increase in temperature will lead to a decrease in a substance's viscosity and an increase in the substance's tendency to spread.

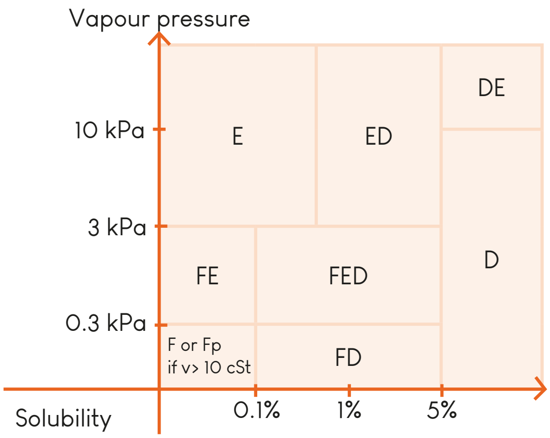
  A substance will form persistent slicks if $v > 10$ cSt at 20°C with a density $d < d_{seawater}$, $Vp \leq 0.3$ kPa, $S \leq 0.1\%$ (for liquids) or $S \leq 10\%$ (for solids)

It is important to note, the SEBC does not take viscosity into consideration.

GAS (Vapour pressure >101.3kPa at 20°C)

	G	GD
Solubility	10%	

FLOATING LIQUIDS (density < seawater)



SINKING LIQUIDS (density > seawater)

	S	SD	D or DE *if VP>10kPa*
Solubility	0.1%	5%	

FLOATING SOLIDS (density < seawater)

	F or Fp *if v>10 cSt*	FD	D
Solubility	10%	100%	

SINKING SOLIDS (density > seawater)

	S	SD	D
Solubility	10%	100%	

PACKAGE

	PF	PI	PS
Weight / volume ratio		dsw+0.01	

Figure 11: Using solubility, vapour pressure and density to determine a substance's behaviour in seawater

Classifications are based on laboratory experiments conducted in a controlled environment. Therefore, a substance's behaviour observed during an incident may differ significantly from the predictions.

If a substance is carried in packaged form, the weight weight/volume (w/v) ratio of the unit will give an indication as to whether a package will float, immerse or sink. The formula given below is provided for information purposes only, as it does not take into consideration whether a package is airtight.

If $w/v > d_{seawater} + 0.01$, the package will sink

3.2 Hazards

A substance's chemical and physical properties not only determine its behaviour but also its hazard(s). In general terms, a hazard is defined as something that can cause harm to people and the environment whereas a risk is the probability to be harmed if exposed to the hazard. Flammability, explosivity and toxicity are some of the hazards that are crucial to assess in order to understand the potential effects and risks of an HNS spill on human health, the environment, and other resources.

There are two main guidance documents governing and harmonising all communication on substances' hazards:

1. The "UN Orange Book" or "UN Recommendations on the Transport of Dangerous Goods – Model Regulations" (UNECE, 2015), which forms the basis for most transport regulations such as the IMDG Code and IATA.
2. The "UN Purple Book" or "Globally Harmonized System of Classification and Labelling of Chemicals (GHS)" (UNECE, 2019), which 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 key differences between the two are explained in ▶ 3.2 GHS vs UN TDG. As per the UN Model Regulations, there are nine hazard classes (Chapter 2). The following sub-chapters introduce the concepts behind the hazards: explosivity, flammability, oxidation, corrosion, toxicity, ecotoxicity and reactivity, and link them to the corresponding UN Hazard Class. Infectious Substances (Class 6.2) and Radioactive Materials (Class 7) are outside of the scope of this manual and will not be addressed further.

Dangerous substances have an immediate physical or chemical effect, whereas hazardous substances pose a risk to human health. Harmful/environmentally hazardous substances are harmful to the aquatic environment.

3.2.1 Hazard: explosivity

An explosion is a reaction that produces gas at a greatly accelerated rate, in a brief period of time. The explosion can be a detonation (due to rapid decomposition and high pressure, such as TNT) or deflagration (due to fast burning and low pressure, such as black and smokeless powders). In a confined environment, deflagration explosives build up pressure, which can lead to detonation. The energy produced during the release is dissipated in the form of a shockwave that can cause significant damage.

UN Model Regulations

An explosive substance is "a solid or liquid substance (or a mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings."

UN Class 1: Explosives includes six subcategories:

Mass Explosion Hazard (e.g. Octonal)

Projection Hazard (e.g. Rockets)

Fire Hazard and Minor Blast and/or Minor Projection Hazard

Minor Explosion Hazard (e.g. Pyrotechnics)

Very Insensitive with Mass Explosion Hazard

Extremely Insensitive; No Mass Explosion Hazard

Boiling liquid expanding vapour explosions

In the field of maritime emergency response, it is important to understand the concept of a Boiling Liquid Expanding Vapour Explosion (**BLEVE**) especially in cases involving liquefied gas tankers.

As see in Figure 12, when a tank containing pressurised liquid on board a ship is heated, the pressure inside the tank increases (a). This activates a pressure relief valve -a requirement of the IGC Code- which can temporarily reduce the overpressure in the tank (b). If the liquid's temperature exceeds its boiling point and the pressure relief valve's capacity is exceeded, the tank might no longer be able to contain the pressure (c). This leads to a mechanical failure, causing an explosion (d). A BLEVE does not systematically involve a fire, however if the substance is flammable, it is likely to ignite and potentially form a "fireball" or vapour cloud explosion.

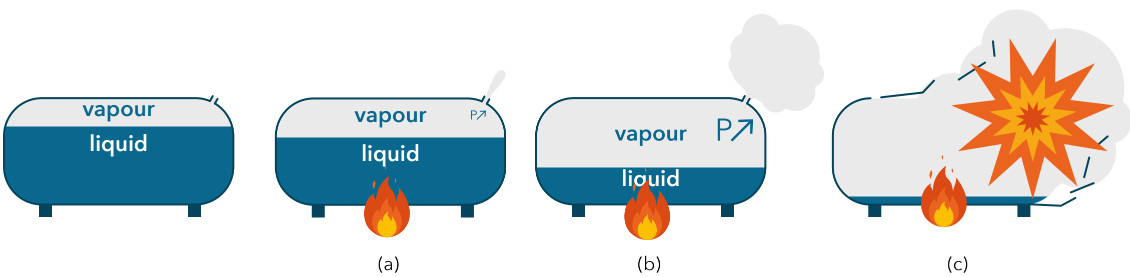


Figure 12: Boiling Liquid Expanding Vapour Explosion (BLEVE) sequence

3.2.2 Hazard: flammability

UN Model Regulations

- **UN Class 2.1**: Flammable gases at a standard pressure of 101.3 kPa at 20°C (e.g. propane)
- **UN Class 3**: Flammable liquids with a flash point of not more than 60°C (e.g. diesel/gasoline)
- **UN Class 4.1**: Flammable solids, which are readily combustible or may cause or contribute to fire through friction (e.g. magnesium)

The flammability of a substance is defined as the ease with which a combustible substance can be ignited, causing fire or explosion. For a fire to ignite, three components are necessary: an combustion source, an ignition source and a flammable source. This is often called the fire triangle or combustion triangle to illustrate that a fire can be fought or prevented by removing one of the three components.

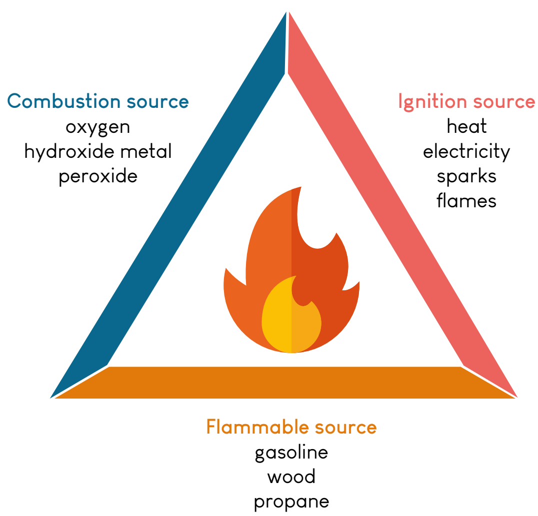


Figure 13: Combustion triangle

The defining properties of flammability are the flash point, the auto-ignition temperature and the lower/upper flammable/explosive limits:

- **The flash point** is the lowest temperature at which the vapours of a material can ignite when exposed to an ignition source.

The lower the flash point temperature, the easier it is to ignite a material.

E.g. benzene: -11.1°C (in closed capsule)

- **The auto-ignition temperature** is the lowest temperature at which the vapours of a material can self-ignite (without an ignition source).

The lower the auto-ignition temperature, the easier it is for the material to self-ignite.

E.g. benzene: 538°C

- **The lower flammable/explosive limit** (LFL/LEL) and **upper flammable/explosive limit** (UFL/UEL) mark the range within which a concentration of combustible material and oxygen in the air can burn (flammable range).

If a flammable substance is released during an incident, its concentration in the air may vary – the atmosphere can change from a highly concentrated non-flammable mixture, too rich to burn, to flammable (combustible substance/air mixture) when it drops below the UEL. The atmosphere will change from flammable to non-flammable (substance/air mixture too lean to burn) when it drops below the LEL.

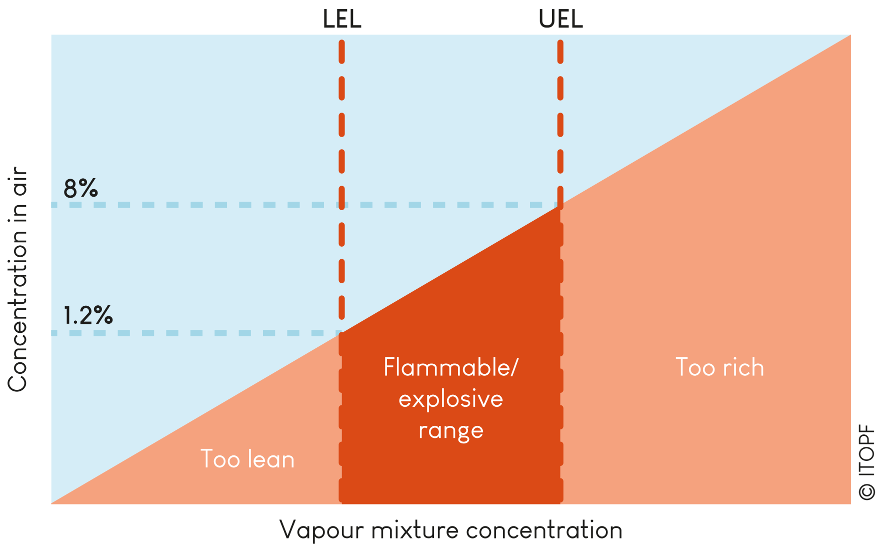


Figure 14: Flammable range of benzene. Benzene: 1.2 % or 12,000 ppm LFL/LEL and 8% or 80,000 ppm UFL/UEL [% in air]

3.2.3 Hazard: oxidation

UN Model Regulations

- **UN Class 5.1**: Oxidising substances includes "substances which, while not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material" (e.g. hydrogen peroxide)

- **UN Class 5.2**: Organic peroxides "are thermally unstable substances, which may undergo exothermic self-accelerating decomposition". In addition they may be liable to explosion or fire and react with other substances" (e.g. benzoyl peroxides)

Oxidising materials have the ability to decompose and release oxygen or an oxidising substance. In case of fire, they can cause the fire to expand by providing oxygen. Oxidising materials may also cause a combustible material to ignite without the presence of an ignition source.

3.2.4 Hazard: corrosion

UN Model Regulations

UN Class 8 Corrosive substances (liquids and solids) are substances which, "by chemical action, will cause irreversible damage to the skin, or, in case of leakage, will materially damage, or even destroy, other goods or the means of transport".

A corrosive material is defined as a highly reactive substance that causes damage to or destroys another material by chemical reaction. The deterioration process might be almost instantaneous (e.g. hydrochloric acid on skin) or slow progressing (e.g. rusting metal through oxidation). Corrosive substances can cause death or severe tissue damage to living organisms. A corrosive substance might be called an irritant at low concentrations.

An indicator of corrosiveness is a substance's pH, which specifies how acidic or basic a solution is. Pure water has a neutral pH of 7 and is neither acidic nor basic, whereas the pH of seawater varies between 7.5 and 8.4. In the absence of additional information, a substance with a pH < 2 or > 11.5 is classified as skin corrosive by GHS.

Corrosive substances and human health

- Corrosive liquids (such as sulphuric acid) present a severe hazard to the eyes and skin by direct contact;
- Corrosive gases (such as ammonia) are hazardous to all body parts, but certain areas such as the respiratory tract might be particularly sensitive;
- Corrosive solids (such as sodium hydroxide pellets) can cause severe burns to the skin. Inhalation of corrosive solid dust might also impact the respiratory tract.

3.2.5 Hazard: reactivity

UN Model Regulations

- **UN Class 4.1**: Flammable solids/self-reactive substances are readily combustible substances or may cause or contribute to fire through friction; "thermally unstable substances liable to undergo a strongly exothermic decomposition even without participation of oxygen" (e.g. matches)

- **UN Class 4.2**: Spontaneously combustible solids are either pyrophoric substances "which even in small quantities ignite within five minutes of coming in contact with air" or self-heating substances which in contact with air are liable to self-heating (e.g. white phosphorus)

- **UN Class 4.3**: Dangerous when wet includes substances "which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases" (e.g. sodium)

In addition to a substance's individual fate, behaviour and hazards, responders need to consider its reactivity with water, air, other products, and/or itself (e.g. polymerization) potentially producing heat, and or flammable/explosive gases.

Reactive substances can be gaseous, liquid or solid. They do not belong to a homogeneous chemical group and show very different properties and behaviour. The hazard classification for these substances is therefore associated with the type of reaction and the related by-products.

Substances reacting with themselves, each other or the environment often release heat (exothermic reaction) or produce flammable gases or explosive, corrosive or toxic materials, with serious consequences for human health and the environment. During an incident involving multiple HNS (such as container ship incidents), substance reactivity and the related risk of explosion/fire are often challenging to predict, which increases the difficulties associated with any response operations.

▶ 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

Examples of self-reacting substances

Monomers (e.g. vinyl acetate, styrene) can self-react (polymerisation) violently, hence they are usually transported with either:

- an inhibitor (such as quinones) which almost completely suppresses the polymerisation reaction. The inhibitor has to be completely consumed before the polymerisation reaction can continue;
- a retarder, which reduces the rate of polymerisation, hence the rate of reaction steadily increases as the retarder is consumed.

Without an inhibitor or retarder (or incorrect concentrations of them) the cargo might self-react, triggering the polymerisation process, which causes heat and expansion of the cargo, following which the structural integrity of a cargo tank could be impacted.

Examples of substances reacting with water

Calcium carbide is a solid which sinks, reacting with water and forming acetylene, a highly flammable and explosive gas. Lithium, sodium and potassium are very reactive metals which float and react violently with water, forming flammable hydrogen gas mixtures with air. The heat of the reaction often causes the hydrogen to ignite and explode.

Mixed substance reactivity

Substances can react violently with each other when spilled. Avoiding such substance reactions during transport is one of the key components addressed in the IMO codes listed in Chapter 2, which include elaborate storage and segregation plans for bulk cargo as well as for packaged goods. However, in case of an HNS incident, substances might mix. Predicting the behaviour of multiple substances and their interactions during an incident is extremely challenging.

Some response software or compatibility charts include predictions on reactivity. However, it is crucial to be aware that these rarely consider individual substances. Instead, they usually consider substance groups (e.g. alcohol, ketones, etc.) at concentrations encountered in air/water and/or packaging.

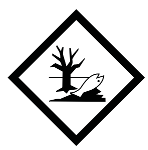
3.2.6 Hazard for the Environment and Human Health

3.2.6.1 Hazardous to the environment (ecotoxicity)

Marine pollutants

The phrases "Harmful substances carried by sea in packaged form" (MARPOL Annex III), "Marine Pollutant" (IMDG Code) and "Environmentally hazardous substance (aquatic environment)" (GHS) can be used interchangeably and are based on the same GHS, UN Model Regulations and GESAMP criteria ▶ 2.1 GESAMP Hazard Profile.

Marine pollutants are goods with properties that are adverse to the marine environment (e.g. hazardous to aquatic life (marine flora and fauna), tainting seafood, or accumulating in aquatic organisms).



Toxicity is defined as the degree to which a substance can harm a cell, an organ, or a whole organism. Toxicological data are usually expressed as dose descriptors, which identify the relationship between a specific effect of a chemical and the dose at which it takes place. These dose descriptors, usually expressed in mg/L or ppm, can therefore be used to describe the no-effect threshold for human health or the environment. They are derived from toxicological and ecotoxicological studies to assess a substance hazard profile and usually consist in:

- **No Observed Effect Concentration (NOEC)**: concentration below which an unacceptable effect is unlikely to be observed;
- **Lowest Observed Effect Concentration (LOEC)**: lowest tested concentration at which no effects were observed;
- **Median Effective Concentration (EC_{50})**: concentration of a substance expected to produce a certain effect in 50% of test organisms. Usually expressed in mg/L or ppm;
- **Median Lethal Concentration (LC_{50})**: concentration of a substance at which 50% of the test species are expected to die. Usually expressed in mg/L or ppm.

When assessing a substance's toxicity, short-term as well as long term effects need to be considered, therefore a differentiation is made between acute and chronic toxicity.

Acute toxicity describes the adverse effects of a substance on a specific test species resulting from a single exposure or from multiple exposures during a short period of time (usually less than 24 hours). It is measured in EC_{50} and LC_{50}.

The higher the LC_{50} or EC_{50} of a given chemical, the lower the acute toxicity.

Chronic toxicity describes the adverse effects of a substance occurring as a result of repeated daily dosing with, or exposure to, a substance for a long period of time (up to the lifespan of the test species). It is usually expressed as NOEC or LOEC – all within a given exposure time.

The higher the LC_{50} or EC_{50} of a chemical of concern, the lower is the acute toxicity.

Both acute and chronic toxicity can have short and long-term consequences (Table 3).

	Short-term effect	Long-term effect
Acute exposure	Short-term skin irritation due to acute contact with a diluted solution of caustic soda	Persistent respiratory issues due to short term exposure to a high concentration of chlorine gas
Chronic exposure	Short-term skin irritation due to chronic exposure to a substance such as use of acetone in a lab and dermatitis	Cancer linked to chronic vinyl chloride exposure

Table 3: Short and long-term exposure and effects - examples

Whilst toxicity focuses on individual organisms or even individual cells, ecotoxicity combines ecology and toxicity and addresses the potential for a substance to affect a specific community of organisms or an entire ecosystem.

There are several parameters which determine whether a substance is considered hazardous to the aquatic environment:

- acute and chronic aquatic toxicity;
- potential for bioaccumulation;
- persistence;
- degradability (biotic or abiotic).

- **Bioaccumulation** is the increase of contaminant concentrations in organisms following uptake from the environmental medium. The bioaccumulation potential of a substance depends on its affinity for water – the lower the affinity, the higher the bioaccumulation potential. In Safety Data Sheets,the bioaccumulation potential is often given in the form of a Log Kow value, also named Log Pow, which represents the octanol/water partition coefficient. The Log Kow value ranges between -3 and 7 and, as a general rule, substances with Log Kow values >4.5 are likely to bioaccumulate. For organic chemicals with Log Pow values of ≥4, a measured Bioconcentration factor (BCF) is required to provide definitive information on the potential of a substance to bioaccumulate under steady state conditions. The bioconcentration factor is defined as the ratio (on a wet weight basis, normaliszed to a 5% fish fat content) between the concentration of the chemical in biota and the concentration in the surrounding water, at steady state (GESAMP, 2020).
- **Degradability** refers to the potential for a substance to degrade in the environment through chemical, physical or biological processes (e.g. oxidation, hydrolysis, biodegradation). Degradability data is sparse, especially for marine environments, hence, it is not always included in SDSs. Degradability data can be given as degradation half-lifes, which refers to the time it takes for an amount of a substance to be reduced by half through degradation. A substance with an extended degradation half-life is considered persistent. An organic substance is considered "readily biodegradable" if it passes the corresponding laboratory test, which indicates that the chemical is expected to undergo rapid and ultimate biodegradation in the environment.
- **Persistence** 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.

Whilst toxicity data relevant for human health and safety are relatively easy to access, ecotoxicological data focusing on aquatic species might be more difficult to obtain and interpret (▶ 5.3 Information resources). In the case of an HNS incident, it might be necessary to complement existing data by additional sampling/monitoring to assist the hazard assessment and guide the response.

There might also be a discrepancy between published/lab-based ecotoxicity data and information collected/observations made in-situ. This might be due to a) different species being tested or b) the effects of dilution encountered in the open sea, which is an important factor when considering detrimental effects. Careful consideration must be given to the applicability and transferability of lab-based studies to real-life incidents.

3.2.6.2 Hazardous for human health

UN Model Regulations

- **UN Class 2.3**: Toxic gases are either known to be so toxic or corrosive as to pose a human health hazard or gases which "are presumed to be toxic or corrosive to humans because they have an LC50 value equal to or less than 5 000 ml/m^3 (ppm)".

- **UN Class 6.1**: Toxic substances are "substances liable to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact".

Occupational exposure limits are published by many different organisations around the world and different limit values and terminology might be used. For occupational health and safety, exposure limits are often stated for various routes of contact such as inhalation, dermal exposure, ingestion with different exposure times.
The Protective Action Criteria for Chemical (PAC) dataset uses a single set of values (PAC-1, PAC-2, and PAC-3) for each chemical, but the source of those values are likely to vary depending on data availability.

During an emergency response, PACs can be used to evaluate the severity of the event, to identify potential outcomes, and to decide what protective actions should be taken. Each threshold stands for:

- **PAC-1**: Mild, transient health effects.
- **PAC-2**: Irreversible or other serious health effects that could impair the ability to take protective action.
- **PAC-3**: Life-threatening health effects.

The PAC dataset uses various occupational exposure limits, which are explained below.

The international term **Threshold Limit Value** (TLV) (equivalent to the EU Occupational Exposure Limit, EU OEL) of a chemical substance is the level to which a **worker** can be safely exposed 8 hours a day, 5 days a week without adverse effects. There are typically three categories of TLV:

- **Threshold Limit Value**: Time-Weighted Average (TLV-TWA) for daily life-time exposure;
- **Threshold Limit Value**: Short-Term Exposure Limit (TLV-STEL) for maximum exposure during a 15-minute period;
- **Threshold Limit Value**: Ceiling (TLV-C) for maximum exposure at any given time.

To predict the severity of chemical exposure in humans, emergency response planners and responders use public exposure guidelines such as **Acute Exposure Guideline Levels (AEGL)**. AEGLs are expressed as concentrations of airborne chemicals at which health effects might occur following "rare/once in a lifetime" exposure. They are calculated for five exposure periods (10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours) and concentrations are given in three "levels":

- **AEGL Level 1**: the concentration predicted for the population to experience notable discomfort. The effects are not disabling and are transient upon cessation of exposure.
- **AEGL Level 2**: the concentration predicted for the population to experience irreversible, serious, long-lasting health effects or an impaired ability to escape.
- **AEGL Level 3**: the concentration predicted for the population to experience life-threatening health effects or death.

	10 min	30 min	60 min	4 hr
AEGL-1	30 ppm	30 ppm	30 ppm	30 ppm
AEGL-2	220 ppm	220 ppm	160 ppm	110 ppm
AEGL-3	2,700 ppm	1,600 ppm	1,100 ppm	550 ppm

Table 4: AEGL Example - ammonia (Source: EPA)

In the USA, if AEGLs are not available, Emergency Response Planning Guidelines (ERPG) or Temporary Emergency Exposure Limits (TEELs) may be used.

- ERPGs estimate the concentrations at which most people will begin to experience health effects if they are exposed to a hazardous airborne chemical for 1 hour. It also has three levels and for responders, the most useful being ERPG-2, which corresponds to the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without developing irreversible or other serious health effects.
- TEELs can be used when AEGLs and EPRGs are not available. These limits are developed through a formulaic approach using available data on LD50 values, occupational exposure limits etc. for the substances involved. TEELs are divided into four levels and are defined for 1 hour of exposure.

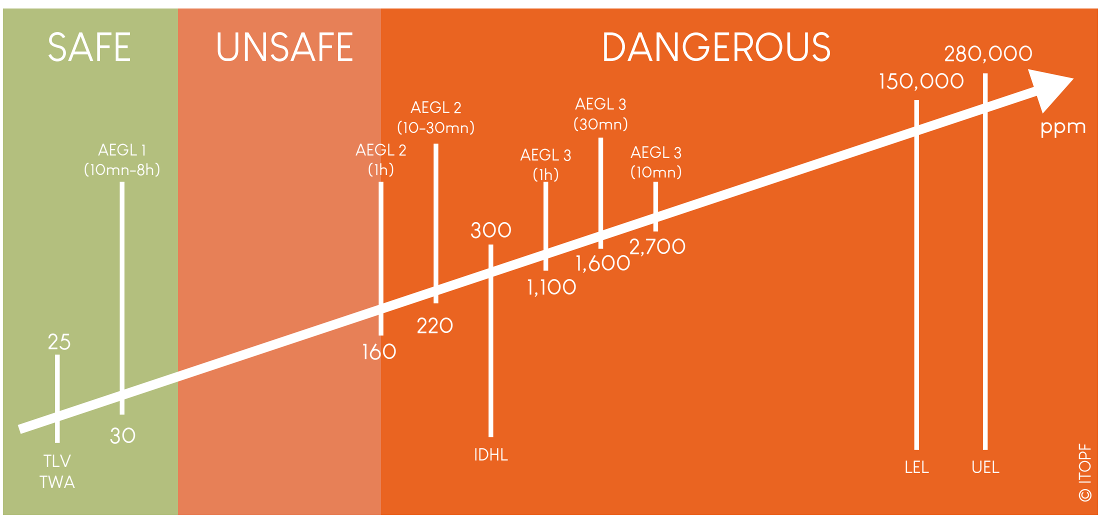


Figure 15: Representation of flammability and inhalation hazards of ammonia for responders

Responders may also encounter the IDLH value (Immediately Dangerous to Life and Health), which is the maximum concentration from which one could escape within 30 minutes without irreversible adverse effects. In practice, if airborne concentrations are above the IDLH, SCBA must be worn.

For a given chemical, several values and limits may be available, and it is useful to put these values into perspective for responders. In the example in Figure 15, the flammable range is higher than the AEGL-3 and the IDLH.

Some atmospheric modelling software can estimate how a toxic cloud from a chemical release might travel and disperse ▶ 5.11 HNS spill modelling. Such modelling results often include the visualisation of a "threat zone", which is the area where predicted hazards (such as toxicity, flammability, thermal radiation, or damaging overpressure) exceed a specific value. These can help to guide the ▶ 5.18 First actions (responders).

4 PREPAREDNESS

4.1 Introduction

Because of the variety of behaviours, properties and fates of chemicals, HNS spills are likely to require expertise not only from civil and governmental agencies but also private entities and industries. Certain components of preparedness are more critical for HNS spills, in particular health and safety aspects. Therefore, aspects relating to Personal protective equipment (PPE), decontamination and monitoring must be thoroughly planned.

Once the scope and objectives have been clearly defined, the overall preparedness process will follow different steps which are illustrated in the diagram below and detailed within the present chapter.

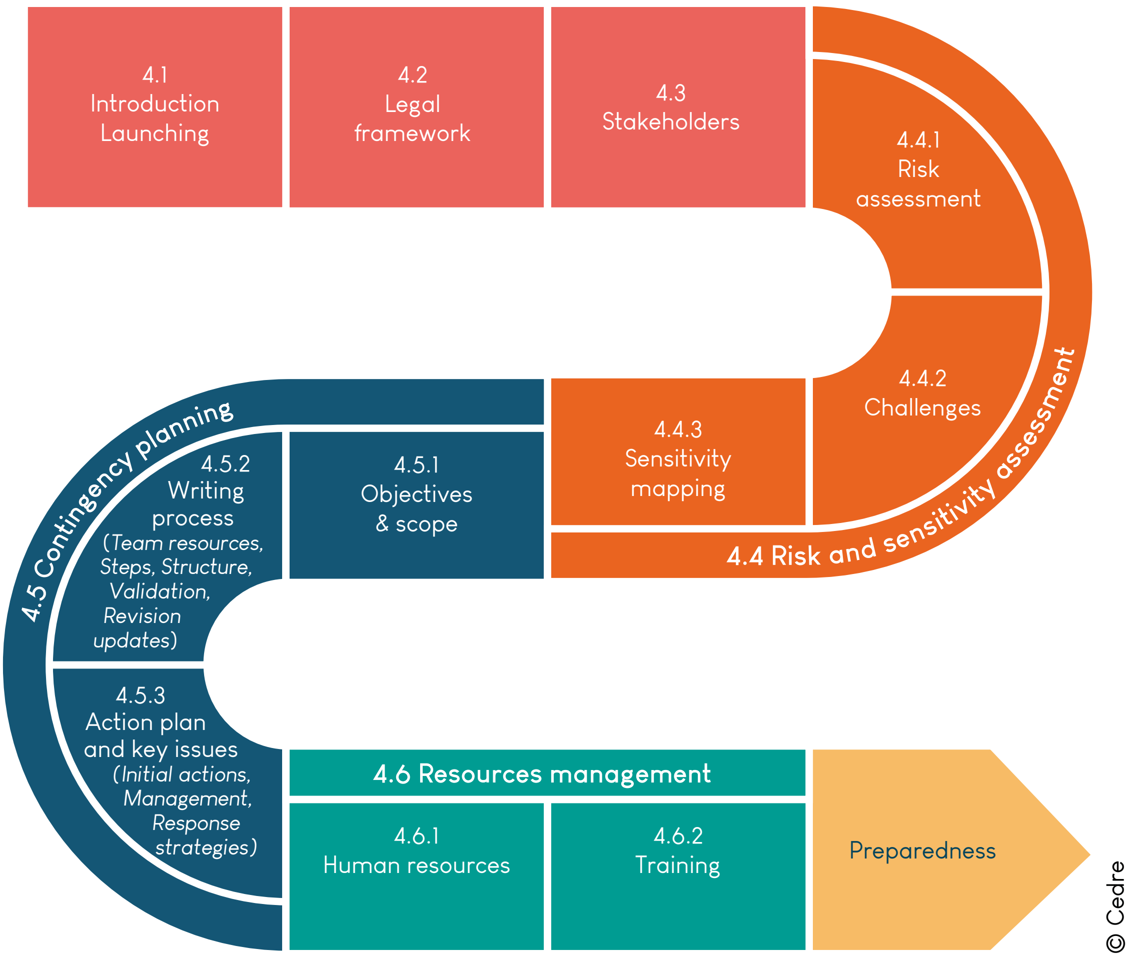


Figure 16: Main steps in the preparedness process

4.2 Legal framework

The 2000 OPRC-HNS Protocol highlights the importance of preparedness through contingency planning and a national system as defined in Article 4 of the Protocol; it prompts contracting states to develop an integrated framework of HNS spill response plans extending from individual facilities handling HNS to a major incident on a national or international scale. These arrangements are intended to provide the ability to escalate a response to an incident through a series of interlocking and compatible plans.

Authorities developing a contingency plan therefore need to consider the international, national, regional and local regulations and agreements in place in conjunction with other emergency plans (harbours, industrial plans, etc.) to ensure a seamless framework.

In the Baltic Sea, the North Sea, and the Mediterranean Sea, dedicated intergovernmental organisations (HELCOM, Bonn Agreement and REMPEC) have been established to provide support and to ensure regional coordination of prevention, preparedness and response measures.

Figure 17: Regional coordination within the West MOPoCo area

As per MARPOL Annex I, Annex II and Article 3 of the 2000 OPRC-HNS Protocol, vessels are required to carry onboard an approved Shipboard Marine Pollution Emergency Plan (SMPEP). The plan stipulates the reporting requirements, the steps to be taken to control the discharge and the national and local-contact points (List of National Operation Contact Points).

▶ 5.17 First actions (casualty)

4.3 Stakeholders

Stakeholders are a group or organisation with an interest in or concern for response preparedness and likely to be consulted or participate in spill response. Engagement with stakeholders is a key to a successful contingency planning process and response.

Early identification of stakeholders and consistent engagement throughout the contingency planning process should lead to meaningful discussions and the resolution of conflicting interests and opinions while in a non-emergency situation. It also provides planners with the opportunity to identify important environmental resources and socio-economic features and their value to the community, a keystone before contingency plan drafting.

The figure below presents the main stakeholders involved in the preparedness process and HNS spill response.

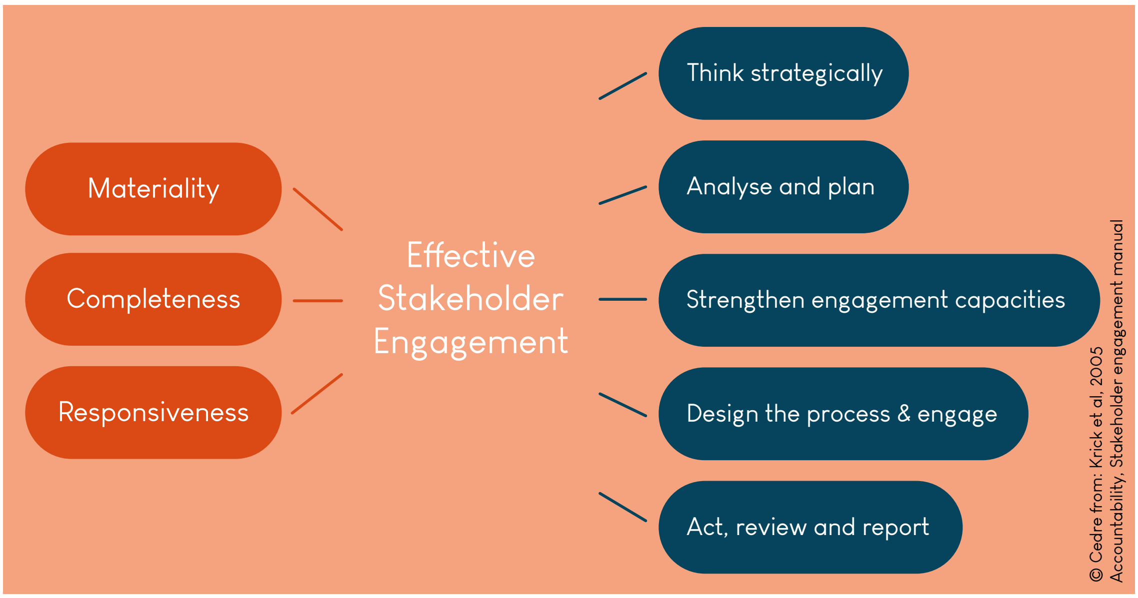
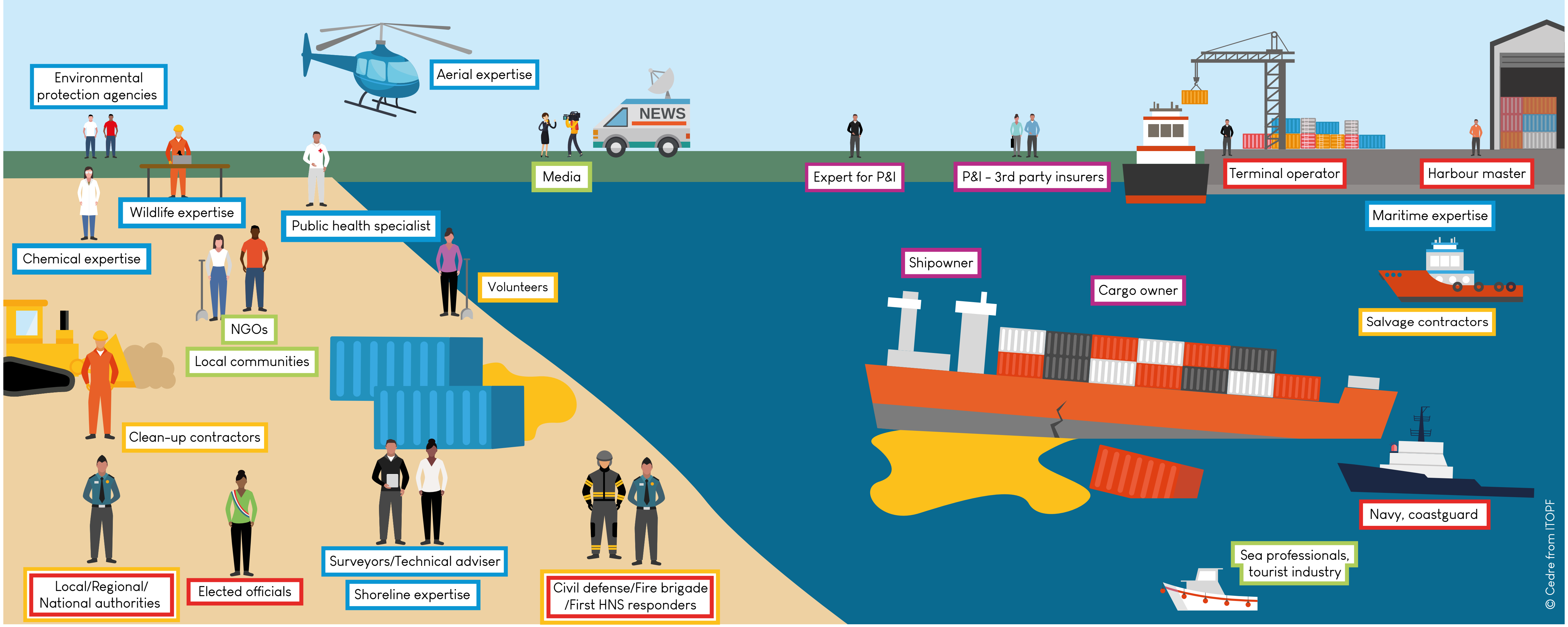


Figure 18: Attributes and main tasks of effective stakeholders involved in a spill response



Authorities

Navy, coastguard - R, I
Usually lead or oversee the response depending on the scale of the incident. Liaise with other governmental agencies in particular when potential impacts are expected on land

Civil defense/Fire brigade/First HNS responders - R, I
Usually lead the first actions response and works with salvers to take the first measures on board or on the shore

Local/Regional/National authorities - R, T, I, DP
Liaise with the at sea responders and are involved mostly if spill is likely to impact the shore

Elected officials - D, R, T, I, DP

Harbour master - D, R, T, I, DP

Terminal operator - D, R, T, DP

Expertise

The bodies listed below may fall under authorities

Aerial/Maritime/Shoreline/Wildlife expertise, Public health specialist, R, I, DP

Environmental protection agencies - R, I, DP
Provide specific input and make recommendations on their field of expertise during response operations and damage assessment

Chemical expertise - R, I, DP
MAR-ICE network, CEFIC, Chemical industries, manufacturers. Useful sources of information of the substances, their behaviour and how to handle a spill.

Surveyors/Technical advisers R, I, DP
Government, department, agencies or independent technical specialists. Carry out surveys, make recommendations on their field of expertise. Assess and propose strategies, techniques.

Concerned parties

Sea professionals, tourist industry - D, R, T, I
May suffer economic losses (due to interruption of activities or spill). May be involved in the response (logistics or operations). May claim for compensation under national or international legislation.

Local communities - D, T, I, DP
May suffer from health hazards (loss of life, injuries) and financial loss due to the exposure to the substance(s) spilled (loss of recreational space, loss of activities due to lockdown).

NGOs - T, DP

Media - T, I, DP

Liable parties

Shipowner - D, R, T, I, DP
Responsible for carrying out the response supervised by authorities, until they take the entire responsability of it. May be represented on site by a local shipping agent (DPA, Designated Person Ashore), surveyors or lawyers.

Cargo owner - D, R, T, I, DP
Support response efforts by providing precise information on the cargo. May participate in the clean-up or waste treatment if they have the necessary resources available.

P&I - 3rd party insurers - R, T, I, DP
Assist the shipowner in dealing with the incident, legal advice, finding appropriate advisers/contractors, approving claims. Represented on site by a local correspondent.

Expert for P&I (ITOPF) - I, DP
Mobilised by the P&I Clubs and make recommendations on their field of expertise.

Responders

Salvage contractors - R, T, DP
Usually appointed by the P&I Club, shipowner or authorities. Lead the effort to salvage the ship and reduce environmental damage caused by the ship or its cargo at source. May appoint additionnal experts (e.g. marine chemists).

Clean-up Contractors - D, R, I
Contracted by the shipowner, P&I Club or authorities. Provide the equipment and workforce for response activities.

Public responders - D,R,I
First responders (Firemen, civil defence, etc.) or member of administration, local communities, harbours.

Volunteers - D, T, DP

D = Dependency, those who are directly or indirectly dependent on the organisation or those whom the organisation is dependent upon for operation;

R = Responsibility, those towards whom the organisation has, or in the future may have, legal, operational, commercial, or moral/ethical responsibilities;

T = Tension, groups or individuals who need immediate attention with regard to financial, wider economic, social, or environmental issues;

I = Influence, those who can have an impact on strategic or operational decision-making;

DP = Diverse perspectives, those whose different views can lead to a new understanding of the situation and identification of unforeseen opportunities

Figure 19: Main roles and relevance of potential stakeholders involved in the response implemented after a marine HNS incident

4.4 Risk and sensitivity assessment

4.4.1 Risk assessment

What is a risk assessment?

According to the International Organization for Standardization's Risk management Guidelines (ISO 31000:2018):

"The risk management process involves the systematic application of policies, procedures and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing, recording and reporting risk."

Various international standards or examples of risk assessment exist and can be used to kick-start an assessment.

Understanding and assessing the risk posed by transported chemicals is an essential starting point for writing a contingency plan. Conducting a risk assessment is a multi-sectorial effort. By modelling and analysing volumes of chemicals transported locally or regionally, a representation of risk can be derived. This must be coupled with the likelihood of a spill occurring as well as determining the probable consequences for the health and safety of workers and the population, whilst identifying environmental and economic resources that could potentially be affected. The incorporation of local marine/land sensitivity data as well as weather conditions into the assessment can further improve the risk assessment process. All this data drives the determination of likely spill scenarios (Figure 20).

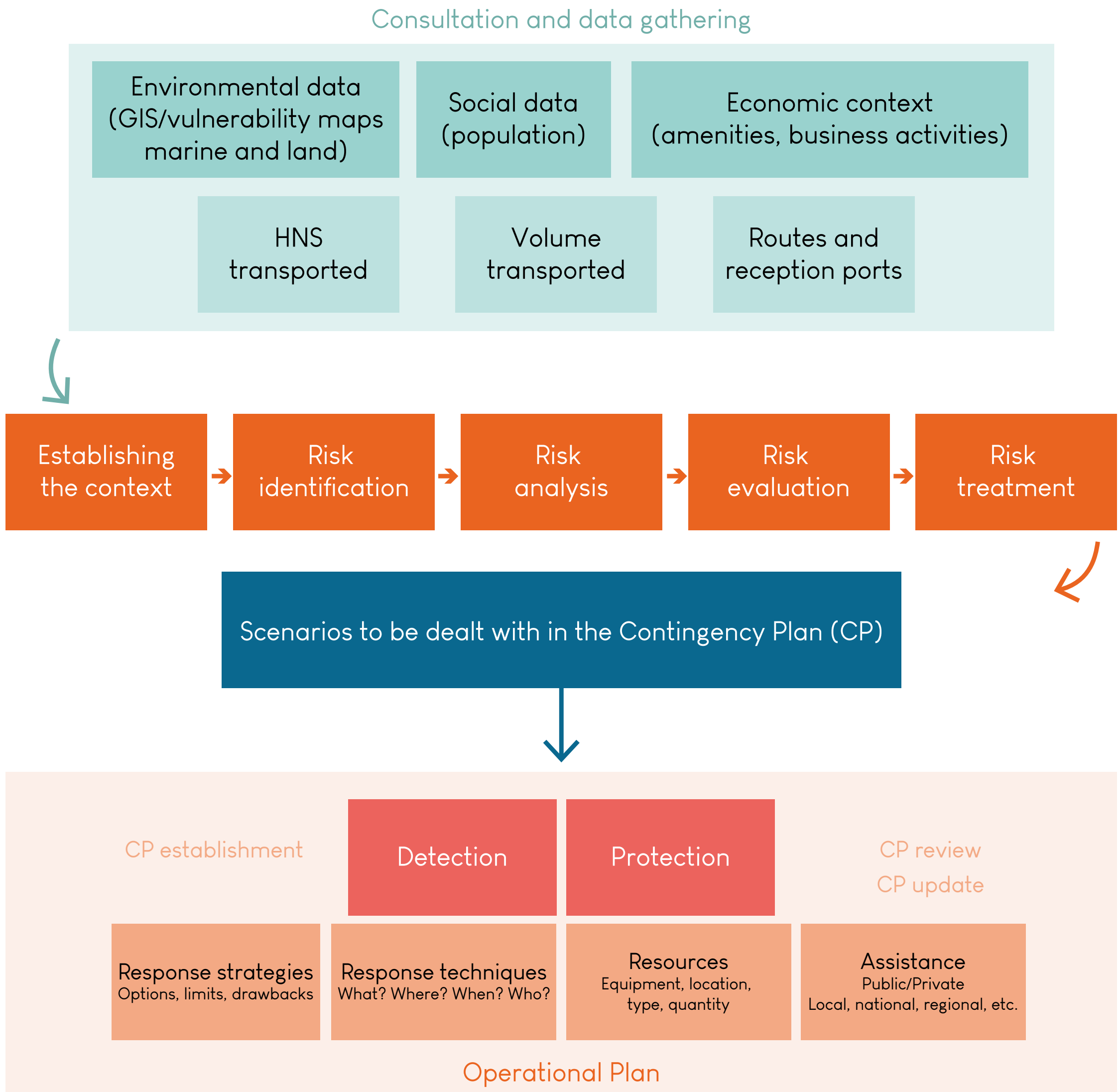


Figure 20: Risk assessment process and downstream steps to elaborate a Contingency Plan (CP)

4.4.2 Challenges

Some challenges are specifically linked to the location of an incident (at sea or in port) and can be very diverse. Therefore, it is essential to tailor risk assessments to the reality of the risks for each location or each situation.

		Port	At sea
Detection		Can be stationary and computerised Otherwise led by a dedicated specialised team	Specialised team to be sent on board with dedicated equipment (logistics to plan) Aerial detection should be considered
Evaluation	Resources	Specialised team Assisted by and headquartered in the harbour area	On board for immediate actions (specialised crew member) External specialised team sent on board Support and decision-making at external headquarters on shore
Evaluation	Information access	Information on extent of contamination relatively easy to obtain	Potentially difficult to assess
Evaluation	Affected area	Heterogeneous	Homogenous
Modelling		Usually difficult due to the lack of reliable data and micrometeorological phenomena near shore	More complex in areas close to the coast and in sheltered areas Bathymetric and current data to be integrated into the model
Hazards	Navigation	Floating & sinking containers	Floating or sunken containers
Hazards	Amenities	Nearby and very exposed	Remote and not very exposed (except in the case of onshore winds)
Hazards	Other legitimate uses	Navigation, etc.	Commercial, touristic, fishing activities Water intakes/outfalls to be careful of
Evacuation if required	Crew	Relatively straightforward	Asset depending, potentially challenging
Evacuation if required	General public	Might become necessary in case of toxic gas cloud for example	Unlikely to occur
Response	Personnel, vessel and equipment availability	Potentially in close proximity	Not readily available
Response	Strategies and techniques	May be possible and recommended to contain and manage spill	Potentially difficult to contain and manage Monitoring to be planned

Table 5: Response challenges of actions to be implemented after an HNS spill, in different environments

Some ports have produced detailed risk assessments for each of the HNS commonly loaded and discharged. These, coupled with rapid access to information during an incident by trained responders, are the key to an effective response.

4.4.3 Sensitivity mapping

Once planners have defined what incidents could occur, where the pollutant might go and how it could behave and weather in the environment, it is necessary to:

- determine which environmental, geomorphological and socio-economic resources could be affected;
- define the degree of sensitivity of those resources to HNS spills.

The combined modelling output of all the spill scenarios defines the overall zone of potential spill impact and outlines the geographic area of interest for sensitivity mapping. Potentially vulnerable sites within this area of interest should be identified and characterised, and the probability of the HNS spill having an impact on these resources should be considered. The sensitivity data is used in the risk assessment process to determine the potential consequences of a spill scenario and the probable impacts. The evaluation will provide planners with the information on the location of high risk areas and resources to support their priority ranking for protection or response.

Strategic sensitivity maps should be developed in addition to standardised sensitivity atlases. Such maps can also be expanded to contain a wide range of operational planning information such as logistics data, site specific tactics for priority protection areas, trajectory modelling, equipment stockpiles, staging areas, emergency medical facilities, potential command centres, etc. Such maps will convey essential information to planners, decision-makers, as well as to on-site responders in charge of equipment deployment.

Sensitivity mapping can be presented as a simple hard-copy map with tables listing resource details, or integrated into a geographic information system (commonly referred to as GIS) capable of containing large volumes of data. GIS-based sensitivity maps can also be integrated into electronic emergency management systems, and linked to other databases for enhanced command and control and a depiction of response activities, resources and status.

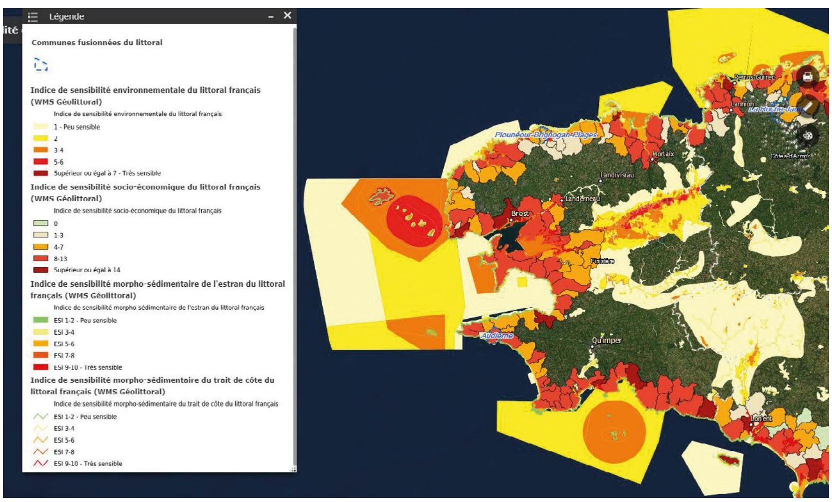


Figure 21: Example of sensitivity mapping with colour coded areas corresponding to different levels of sensitivity

4.5 Contingency planning

4.5.1 Objectives and scope

Based on risk assessments, an effective contingency plan is an operational document formalising the actions and procedures to be implemented in the event of an incident and aims at minimising unforeseen events. Therefore, a fully developed contingency plan is not merely a written document but comprises all the practical requirements necessary for an immediate and effective response.

To do so, a contingency plan must comprise all the actions that can be completed ahead of time to ensure a prompt and appropriate response in the event of an emergency in order to mitigate the impacts on:

- Population;
- Environment;
- Property and socioeconomic activities.

Why a plan?

- To comply with legal frameworks and internal policies
- To provide a response framework
  - ✓ Establish alert and communication procedures and immediate actions to be implemented;
  - ✓ Define roles and responsibilities
- To develop a complex response in a non-emergency context free from pressures;
  - ✓ Prioritise sites for protection;
  - ✓ Specify response strategies and techniques;
  - ✓ Identify and allocate resources to be mobilised.

4.5.2 Writing process

4.5.2.1 Teams and resources

First of all, a team in charge of drawing up the contingency plan must be called together. Regardless of the scope of the document to be created, the project team must be aware of the context and more specifically of the regulatory framework within which the plan will apply.

The drafting may be entrusted to expert organisations who will submit each deliverable for validation by the management team. In addition, for each specific section of the plan, complementary resources and expertise may be mobilised, notably:

- authorities to specify what is expected when taking over the supervision or management of operations;
- geomatics specialists and environmentalists to produce sensitivity maps and atlases;
- modelling specialists for the study of product fate behaviour;

- pollution experts for the definition of strategies, techniques and equipment;
- insurer or P&I representatives for input to the sections dedicated to record-keeping and compensation procedures, etc.
- the drafting of a contingency plan should be managed like any standard project and therefore requires the:
- setting up of an action plan and a schedule;
- definition of a global budget for carrying out such an action and the method for monitoring the associated expenditure;
- holding of regular meetings to check on the work progress and to identify any obstacles;
- procurement of adapted tools (GIS, drift models, fate and behaviour models for example) or the outsourcing/sub-contracting of such tools and expertise to use them;
- establishment of a review process by specialists with the appropriate expertise;
- definition of a validation procedure by the legitimate organisations.

4.5.2.2 Steps to consider

Generally speaking, contingency plans address five crucial points:

- identification of risks related to substances handled or transported;
- identification of potential stakeholders and their responsibilities;
- inventory and preparation of equipment (protective equipment, response equipment);
- actions to be taken in the event of a spill;
- training of persons liable to be involved in response.

Figure 22: The overall process for industrial contingency planning

4.5.2.3 Structure

Contingency planning is an exercise in preparing response strategies and tactics to minimise the adverse impacts of a pollution incident and in bringing together numerous aspects of spill operations, environmental policy, and regulatory compliance. Effective guidance for on-scene initial emergency response and transition into a project-managed response is fundamental to the success of a spill response plan.

During the writing process, a large amount of material will be produced and generate difficulties in navigating the core procedure. Simple techniques, such as the use of tabs, arranging pages into sections, and creation of a well-organised table of contents will help users to navigate to key information in the plan, and will also simplify the plan update process. Moreover, some materials may be integrated as appendices or as separate documents, for instance: modelling results, action cards, forms, sensitivity atlases, tactical maps or material requiring frequent updates and redistribution such as contacts and resource directories. Background information and capability justification, which has been compiled over the course of the planning effort, should be included as a separate supporting document.

Numerous guides and examples are available for the content of a National Contingency Plan (NCP), including a "fill-in-the-blanks" template. The IMO Manual on Oil Pollution Section II – Contingency Planning lists the following basic content for a NOSCP (National Oil Spill Contingency Plan).

While a variety of templates exist for NCPs dedicated to oil spills, there are fewer examples available for HNS spills. Arguably, the two will be quite similar but with an additional focus on health and safety and collaboration with experts. On the other hand, as for oil, the format of these contingency plans should vary depending on the specific scope and should be scalable.

Arpel (2005). How to develop a national oil spill contingency Plan. Available at : https://arpel.org/library/publication/195/

IMO (2005). Manual on oil pollution. Section IV : Combating oil spills. London : IMO, 212 p.

IMO (2018). Manual on Oil Pollution. Section II: Contingency planning. London: IMO, 103 p.

IMO (2020). Guide on the implementation of the OPRC convention and OPRC-HNS Protocol. Available at: wwwcdn.imo.org/localresources/en/publications/Documents/Newsletters%20and%20Flyers/Flyers/I559E.pdf

Ipieca and IOGP (2015). Contingency planning for oil spills on water. Available at: www.ipieca.org/resources/good-practice/contingency-planning-for-oil-spills-on-water/

Figure 23: Tools and references for drafting a contingency plan

A basic structure is given, as an example, in the table below.

Action plan	
Introduction	• Table of contents • Document control (distribution, review, update and records, level of confidentia-lity) • Scope and perimeter • Overall response priorities and objectives • Interface with other existing plans
Initial actions	• Alert and notification (alert flowchart, assessment, notification) • Tier level assessment and escalation • Health and safety issues and initial actions • Activation of Contingency Planning (CP) and response management team
Management	• Activation and location • Organisation (location, functioning, composition) • Roles and responsibilities/assignment sheets • Processes and procedures to ensure pollution follow-up • Communication (internal/external) • Financial management
Response strategies	**Scenario** **Assessment (NEBA/SIMA)** • Site health, safety and security assessments • Spill surveillance methods (aerial surveillance, tracking buoys, etc.) • Spill trajectory modelling • Identification of vulnerable and sensitive resources **Strategies**: Decision support flowcharts, Response procedures • First actions • Protection • Monitoring • Response **Waste management** **Material resources** • Inventory of equipment and resources available for deployment • Specialised expertise and back-up resources
Termination	Demobilisation of equipment and personnel • Crisis closure • Document archiving • Claims and compensation • Feedback and debrief • CP review • Equipment renewal and maintenance

Table 6: Example of a basic structure for a contingency plan

Appendices or supporting documentation	
Back-ground information	• Regulatory context • Description of the context (framework/activities/sites to be considered) • Baseline environmental and socio-economic information • Meteorological and hydro-dynamic information (including both prevailing and limiting/extreme conditions)
Sensitivity atlases	• Environmental • Socio-economic • Geomorphological
Potential pollutants	• Type • Characteristics • Behaviour when spilled • Risks and safety issues
Response	• Strategical and tactical maps • Incidence response sheets • Description of techniques and operational aspects
Actions cards	• Detailing roles and tasks of key actors
Directories	• Contact details for each stakeholder, partners, technical experts, or potential subcontractors
Wildlife	• Dedicated management plan or procedure to deal with impacted or endangered wildlife
Plan justification	• Risk assessment and scenario planning • Spill prevention and detection • Training and exercise programme • Plan and equipment review and audit schedule

Table 7: Appendices or supporting documentation

4.5.2.4 Validation

A contingency plan must be tested through exercises in order to ensure that it is relevant and that the personnel likely to be mobilised to implement the plan are fully familiar with it. Through training and exercises, contingency plans can be implemented, validated and improved (see Chapter 4.6.1).

4.5.2.5 Revisions and updates

Intrinsically, a contingency plan is a living document and it is the responsibility of everyone involved to ensure it remains relevant. The plan must be regularly updated, in particular following an incident or organisational change, or when new protection or response measures become available. Any major changes in the level of HNS transport activities, populations or neighbouring industrial activities require a revised risk analysis and, consequently, a revision of the contingency plan.

When the contingency plan is adopted by a law, updating it can be difficult. Therefore, it is essential to define, from the beginning and within the legislative process, the contingency plan's section or supporting documents which will require to be updated on a regular basis (also to be defined). The 2000 OPRC-HNS Protocol and the IMO manuals on chemical pollution define the living documents of contingency plans.

4.5.3 Action plan – Key issues

4.5.3.1 Initial actions

Alert and notification

Initial response information is critical in guiding responders through the first hours or days of an incident. The first information to be obtained in the alert phase is necessary to:

- assess an incident and mitigate hazards;
- activate an informed, immediate response;
- make required notifications;
- activate additional response resources including the incident management team, as needed.

Timely notification of key internal and external personnel and organisations is instrumental in mounting an effective response. Notification procedures, responsibilities and regulatory requirements (including forms, timelines and instructions) should be provided along with a directory of contact information. Flowcharts and diagrams are effective ways of displaying the flow of notifications that are often required.

The provision of a checklist and log will assist in the documentation and evidence of timely reporting and alerts. It is important to specify the management role responsible for ensuring that notification and reporting requirements are met (IPIECA and IOGP, 2015).

Level of response

Tiered preparedness and response are recognised as the basis for a robust framework. This establishes a capability that can be escalated and cascaded to the scene. This avoids the proliferation of impractical stockpiles of large quantities of response resources yet can still provide an appropriate and credible response through the integration of local, regional and international capabilities.

The established three-tiered structure allows contingency planners to describe how an effective response to any spill will be provided, i.e. from small operational spillages to a worst credible case release at sea or on land.

The tier classification system helps to define the resources required to deal with potential spill scenarios and are broadly considered as follows:

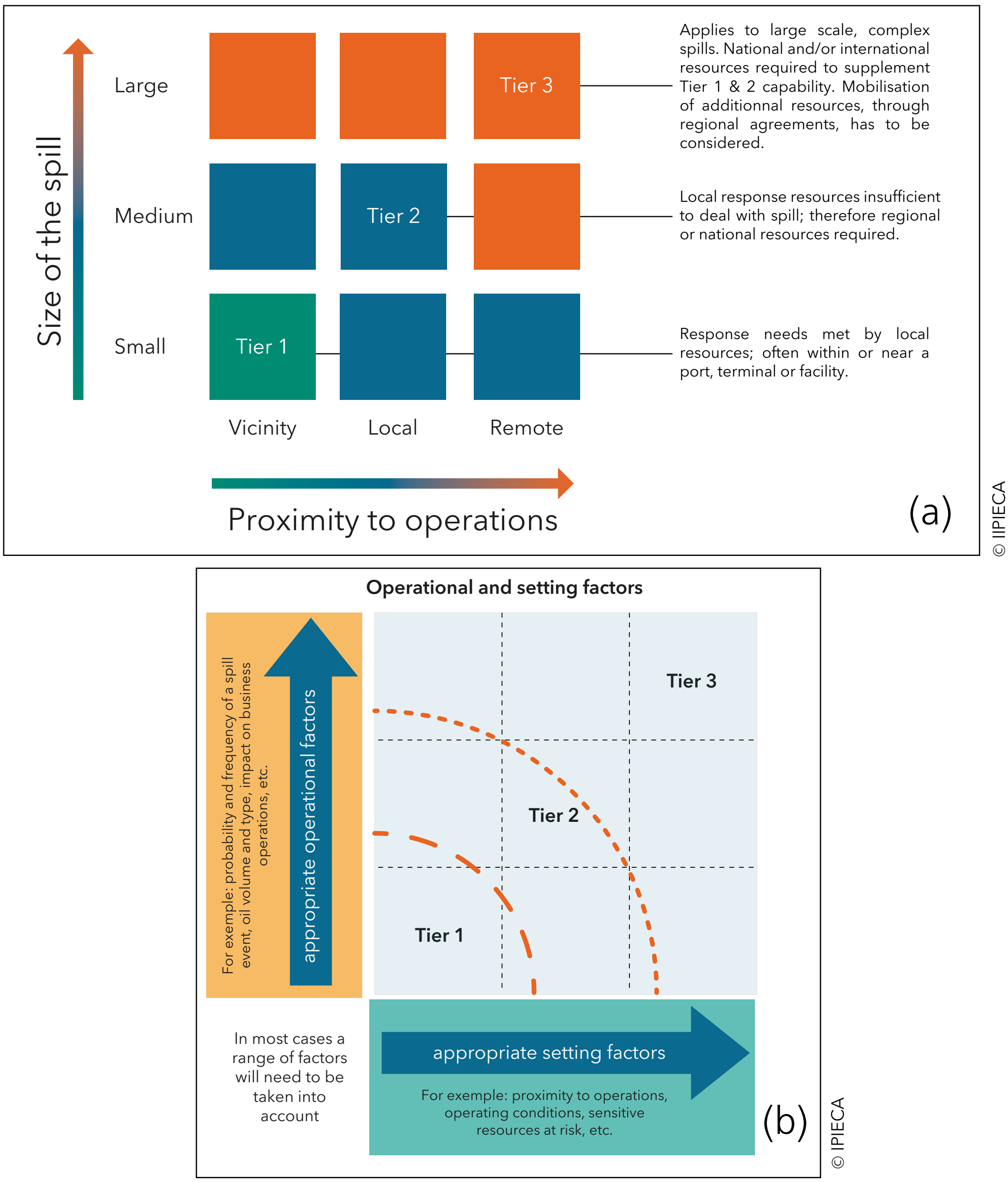


Figure 24: The conventional definition of tiered preparedness and response (a) and concentric circle model to define tiered response capability (b)

4.5.3.2 Management

Organisation

Contingency plans provide the structure for the management of response operations and should be prepared and updated by agencies, organisations and stakeholders liable to be involved in the response and that have specific knowledge of the context.

An organisational structure or **Incident Management System (IMS)** is necessary to provide leadership through the difficult decisions and compromises that have to be made at all stages of the response. Organisational structures vary considerably from country to country. Many examples are available, most of which have evolved according to national preferences, prior experience and lessons learnt during incidents and exercises. The primary difference between **generic functions** and **team-based** structures are the division and location of command and the management of specific activities.

- The **Incident Command System (ICS)**, commonly used in the US and by the oil and gas sector, is an example of a standardised, function-based organisational structure. The ICS is designed specifically to bring together personnel from different organisations and agencies at short notice to work as members of a single structure, within which their roles and responsibilities are well established and understood. Familiarity with the structure provides a practical means of building a coherent, transferable and replicable response organisation within a very short timescale. The ICS requires substantial pre-investment and resources, on a scale which is usually unavailable in many other countries.

- The alternative **team-based structure** has been used successfully in the response to incidents in various parts of the world. The same principles are applied but the structure is less strict and the teams are not separated into individual functions. Instead, positions are established to fulfil different aspects of the response, most commonly at sea and onshore, with support services allocated to each. This has the advantage of promoting self-contained units that can focus on specific elements of the response within their remit and can readily accommodate the requirements of the response and the organisations involved.

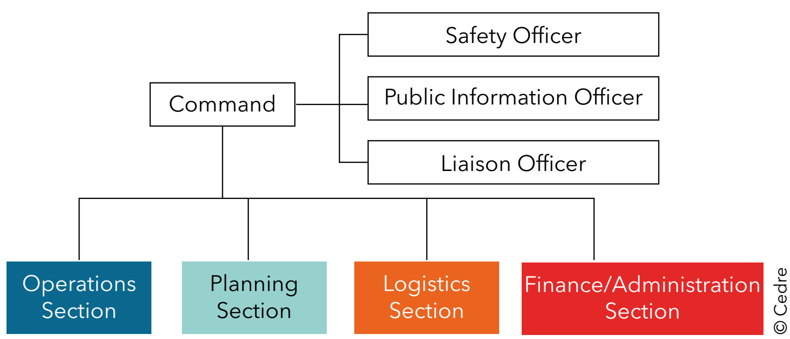


Figure 25: Typical Incident Command System structure

Communication

Cooperation at all levels is likely to be a key factor in the success of an effective and coordinated response. Two very distinct communication strategies need to be established:

- Internal, which highlights how the various teams involved in the response communicate with each other;
- External, which deals with how the information is shared with the wider public using various media.

▶ 4.1 External communication
▶ 4.2 Press conferences
▶ 4.3 Internal communication

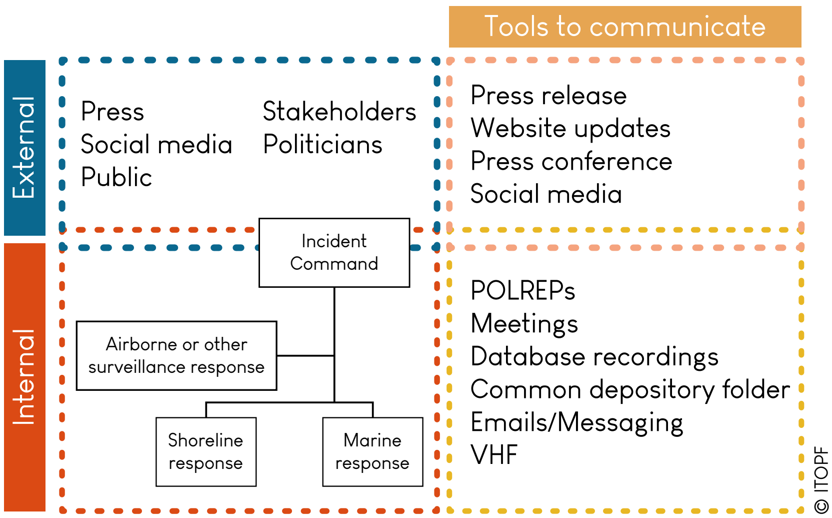


Figure 26: Flowchart of a typical communication structure in a function-based structure

4.5.3.3 Response strategies

Scenarios

Preparing an effective operational response requires various incident scenarios to be defined and analysed and their consequences examined. To make these scenarios as realistic as possible, they should be based on past incidents and a recent analysis of the context and the risks associated with activities involving HNS. They must be adapted to the various response levels indicated in the contingency plan. The plan should include a limited number of scenarios along with the associated initial operational response strategies. In order to specify the pollution scenarios as precisely as possible, modelling can be useful in order to:

- anticipate pollutant fate and behaviour;
- determine potential impacted areas;
- define response timeframes.

To do so, different types of models exist: prediction and stochastic models.

▶ 5.11 HNS spill modelling

This information is also useful for developing training activities and exercises for personnel directly involved in handling HNS during transport as well as for responders in the event of an incident.

For each scenario, the impact assessment must be realistic and must consider the immediate vicinity, in particular the population, the environment and industrial activities.

Assessment

Once a range of oil spill planning scenarios have been selected, consideration shifts to the development of appropriate response strategies, which are comprised of available and viable response techniques to adequately mitigate the impact and consequences of each scenario.

Planners should consider how the response for a given scenario might develop over time and how the strategy may need to be adjusted as the spill evolves. The realities of the situation and the limitations of techniques and equipment must be well understood. The choice of response strategy is essentially dictated by three criteria which should be outlined in the contingency plan:

- the accident area (offshore, inshore, port area);
- the location of the product (in the vessel or released);
- the behaviour of the product spilt.

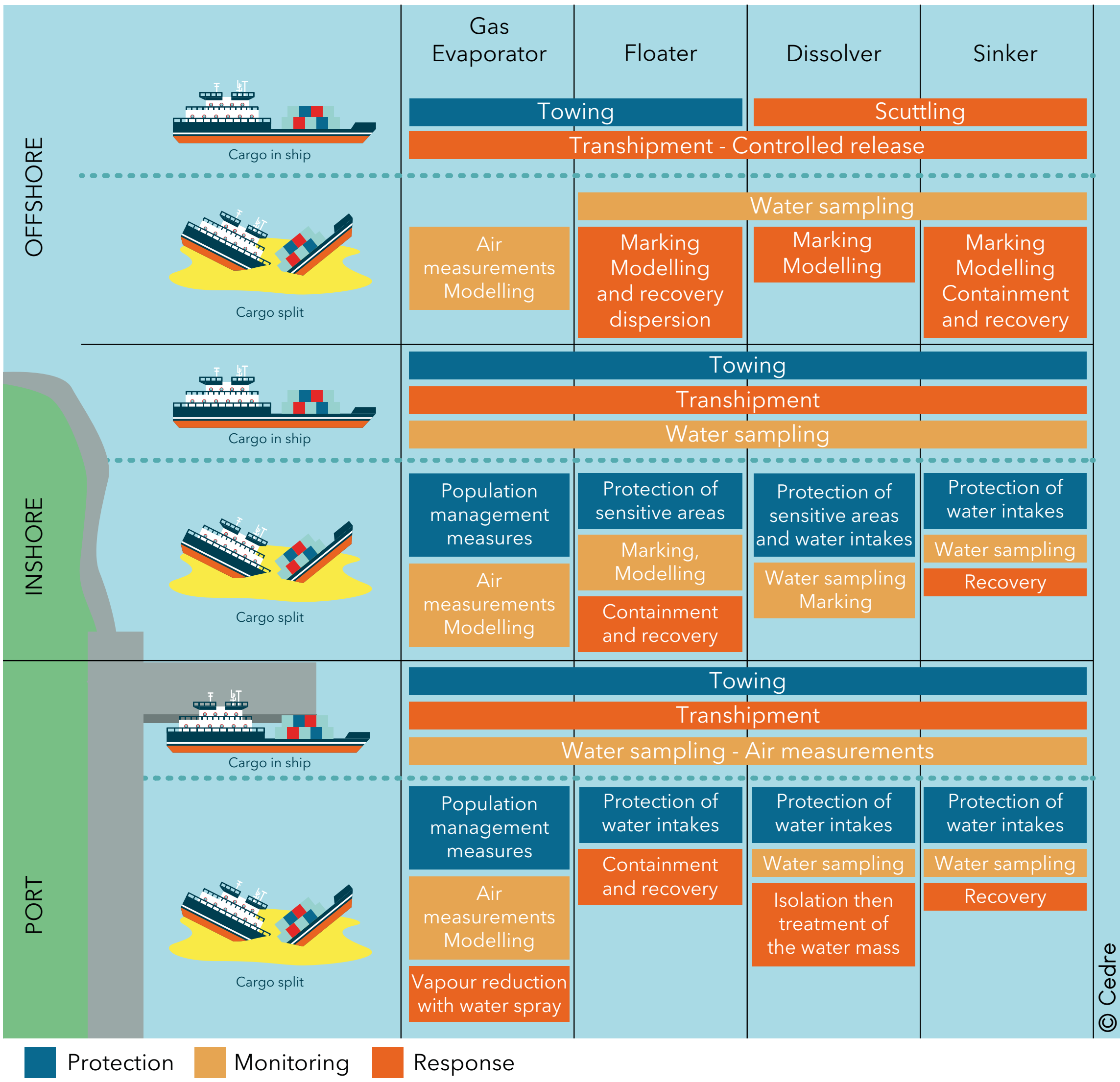


Figure 27: Decision support for response to spills of bulk HNS cargoes depending on their main behaviour and the location of the incident

For each strategy, see the dedicated response sheets in Chapter 5.

As the situation may evolve very quickly, the chosen strategy must be adjusted according to the reality in the field.

The selection of suitable response techniques can be heavily influenced and restricted by various factors: extreme weather conditions, hazards of HNS spilled, remote locations, and proximity to highly sensitive areas. Strategies should be focused on clear, attainable goals by taking into account a number of inputs:

- health, safety and security issues for responders and the public;
- regulatory requirements and restrictions regarding the use of specific strategies (dispersion or in situ burning for instance);
- equipment availability and mobilisation timeframe;
- sensitive sites within the potentially impacted area.

All response techniques have advantages and disadvantages. A response strategy therefore generally consists of a combination of techniques. An appropriate strategy for a minor scenario may comprise one or two techniques. Scenarios that are more complex may require various combinations of techniques at different tier levels, possibly in different locations or for varying seasonality. Whatever the case, the strategy should be established in consultation with the stakeholders, with consideration given to the greatest net environmental benefit. The NEBA (Net Environmental Benefits Analysis) process provides a useful framework to achieve science-based planning and stakeholder consensus prior to, and away from, the emotive atmosphere prevalent at the time of a spill. It weighs up the advantages and disadvantages, or trade-offs, of the available techniques so that an effective response may be formulated to achieve the maximum overall benefit for the environment.

NEBA/SIMA

The term NEBA (Net Environmental Benefits Analysis) has been used to describe a process for guiding the selection of the most appropriate response option(s) to minimise the net impacts of spills on people, the environment and other shared resources. Considering that the selection of the appropriate response action(s) may be in practice guided by additional considerations, the oil and gas industry sought to transition to a term that also reflects the process, its objectives and the decision-making framework. In 2016, the term Spill Impact Mitigation Assessment (SIMA) was introduced to encompass ecological, socio-economic and cultural considerations. This new term also eliminates the perceptions associated with the word 'benefit'.

Regardless of terminology, effective implementation of NEBA/SIMA processes is incumbent on the use of competent and knowledgeable experts to understand specific event conditions and local resources, and make reasonable response trade-off decisions (IPIECA and IOGP, 2015).

Strategies

Varying degrees of response may be required: prevention measures, assessment and monitoring of the spreading of the pollution and/or clean-up actions. For each of them, decision trees are commonly used within contingency plans to facilitate choices for decision-makers. For responders on site, each technique to be implemented will also be detailed in specific and operational action cards (often attached in the appendices).

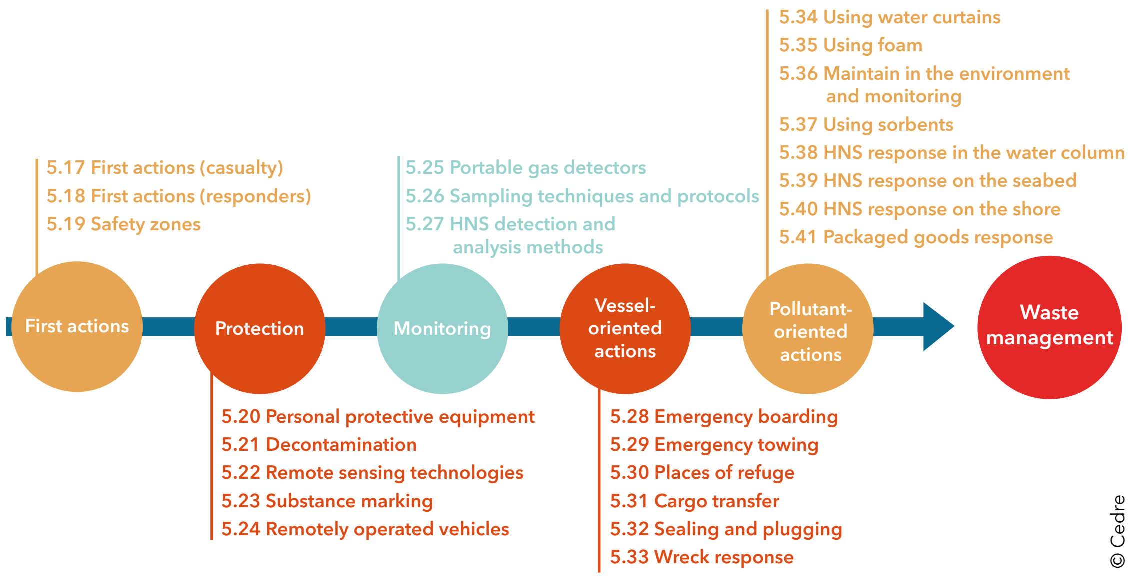


Figure 28: Main steps to be detailed within strategies and developed through operational action cards

Each of the following steps is described in detail in Chapter 5.

Waste management

HNS-contaminated liquids and solids collected in the context of recovery, dredging or decontamination operations implemented following an HNS spill are considered as "waste". "Waste" is "*any substance or object which the holder discards or intends or is required to discard*", according to the Directive 2008/98/EC of 19 November 2008 on waste (the Waste Framework Directive (WFD)).

In the event of a maritime pollution incident involving HNS (carried in bulk or packaged form), recovery operations can generate diverse hazardous (as well as non-hazardous) waste materials, with a wide range of hazard level, toxicity or ecotoxicity, sometimes in great quantities. The classification of waste as non-hazardous or hazardous is regulated by the WFD. The WFD Annex III defines hazardous waste as waste that displays one or more of the hazardous properties (HPs) HP1 to HP15: it refers for most hazardous properties directly to the hazard statement codes (HSCs) introduced in the CLP (Classification, Labelling and Packaging) Regulation for chemical substances or mixtures having hazardous properties.

One of the objectives of the contingency plan is to anticipate, and to detail, the global process to implement for waste management should it need to be in place.

The upstream phase should take place at the same time as operations begin. This covers:

- **temporary storage facilities**, in the immediate vicinity of the site and linked to the duration of the site;
- **intermediate storage facilities**, serving several primary storage sites, set up a few hundred metres or even up to several kilometres from the clean-up sites (these intermediate storage sites are closed once operations at the clean-up sites have been completed);
- **final storage area(s)**, to which all the separated polluted waste from one geographical area is transferred. Such sites may be in operation for over a year depending on the performance of the downstream phases;
- **transportation between storage sites**.

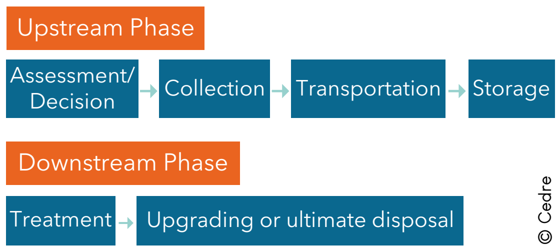


Figure 29: Global waste management process

The implementation of the downstream phase can be deferred. This stage includes:

- **treatment processes**, with different procedures suitable for different waste types;
- **disposal of treated waste**;
- **restoration of sites** dedicated to intermediate or final storage.

A useful model when dealing with a waste stream originating from any source is the "waste hierarchy". This concept uses principles of waste reduction, reuse and recycling to minimise the amount of ultimate waste produced, thus reducing environmental and economic costs and ensuring that regulatory and legislative requirements are met. It provides a tool for structuring a waste management strategy and can be used as a model for all operations. In the past, most spills have involved crude oil or refined products, so the diagram below is based on oil.

Figure 30: The 'waste hierarchy' or waste management steps

It is essential that planners do not lose sight of the need to pre-plan waste management. The lack of proper waste handling, storage, transport and disposal or a simple weak link in this chain will reduce the response capacity of the whole process and can lead to potential violations of regulatory requirements. Details and guidance for implementing the waste management strategy and recycling, treatment or disposal arrangements should be included in the contingency plan or as a separate waste management plan. They should specify in advance:

- responsibilities;
- type and capacity of facilities required;
- methods and rules of collection and transportation.

▶ 4.4 Waste management

4.6 Resource management

An effective response to an HNS spill critically relies on the preparedness of the entities and individuals involved. Responding to an HNS spill affecting a broad range of people and organisations requires a wide variety of decisions to be made very quickly. This can only be achieved if teams in charge of the response:

- are sufficiently prepared to appreciate the unfolding situation;
- can make crucial decisions;
- can safely mobilise appropriate resources without delay.

Such skills rely on resource preparedness; for both responders and managers, it relies on training and exercises.

4.6.1 Human resources

Robust preparedness should include training and exercises carried out on a regular basis, aimed at:

- providing responders with knowledge of how to minimise impacts on human health and the environment due to HNS spills in the ecosystem;
- familiarising stakeholders with response methods aiming to minimise the effects of chemical pollution and techniques to recover or neutralise chemical substances;
- exchanging expertise, experience, and opinions amongst stakeholders;
- enhancing the capability of institutions tasked with managing maritime emergencies because they are likely to differ from other incidents;
- regularly checking the applicability of the HNS contingency plan and making any necessary improvements;
- improving the overall response capability.

4.6.2 Training

Providing training and organising exercises for response teams are the best ways to improve the overall response capability. All personnel liable to be called upon to handle hazardous materials must acquire specific knowledge and skills. In particular, they must be familiar with:

- the intrinsic hazards of various substances, in particular by referring to the UN Recommendations on the Transport of Dangerous Goods (TDG), and understand their fate and behaviour;
  ▶ 3.2 GHS vs UN TDG
- all relevant sources of information, such as Safety Data Sheets (SDS), dangerous good declarations, shipping documents, as well as all other relevant documents;
- protective equipment and clothing;
- chemical detection kits;
- amergency procedures, first actions to implement;
- specialised response strategies, techniques and equipment;
- methods and procedures for communicating clearly as per the communication plans.

4.6.3 Exercises

Regular and realistic exercises are essential for validating the response plan and response capability, and enable all parties involved to:

- maintain and improve the theoretical and technical knowledge acquired during training;
- clarify roles and responsibilities;
- optimise communications within the Incident Management System (IMS);
- meet and exchange with various people involved in the response (often from different departments with otherwise very little interaction);
- integrate the procedures set out in the contingency plans to be validated or updated;
- validate the response capabilities;
- to effectively prepare first responders, various types of exercises should be organised as part of an exercise programme.

The frequency with which the exercises are carried out should be tailored to the complexity of preparation and implementation, but will also be regulated according to the human, material and financial resources available. For instance, if table-top exercises are to be carried every six months, large-scale exercises may be carried out on a three-yearly basis.

	Seminars	Workshops	Table-top ALPHA	Functional BRAVO	Equipment deployment CHARLIE	Full Scale DELTA
Aims	Provide an overview of oil spill contingency plans and their related policies.	Build or achieve a product. Produce new or revised plans, procedures, mutual cooperation agreements, etc.	Test procedures for cooperation. Learn and test the framework on response matters relating e.g. to organisation, communication and logistics.	Test the agreed procedures and communication for reporting. Test requesting and providing assistance. Get a picture of the current response readiness of the contracting parties.	Test and learn the use of specific equipment.	Test the national or multi-national response capability and equipment. Test and train complex cooperative abilities or the coordination of several different participants, units and equipment.
Who's for	Public or private operators. Local, regional, national authorities.	Operators & authorities. Level of interaction increased compared to seminar.	Decision-makers.	Different levels of decision-makers.	Responders.	All levels of the pollution response task.
Type	Informal orientation event.	Informal orientation event.	Paper format. No deployment of equipment. Remotely tested or in one location.	Exercise scenario with event updates drives activity.	Deployment on site.	Several crisis management cells. On different sites. At sea and on the shoreline.
May involve	Organisations that are developing or making major changes to existing plans or procedures.	Organisations that are developing or making major changes to existing plans or procedures.		Movement of personnel and equipment is usually simulated.		Public or private operators. Local, regional, national and international authorities.
Timing	One for induction. No constraints imposed by real-time simulation	One per heading.	One per quarter.	One per semester.	One per semester.	One per year.

Figure 31: Progressive development of different types of exercise programmes

4.6.4 Material and equipment

4.6.4.1 Response equipment

Certain response equipment is required to respond to an incident involving HNS. There are various categories of pollution response equipment to be inventoried (type/quantity/origin):

- plugging and sealing devices (e.g. inflatable plugs, sealing plates for sewer manhole cover);

Equipment storage room

- fire hose nozzles;
- neutralising agents (e.g. lime, vinegar, citric acid);
- dispersants;
- sorbents (socks, pads, etc.);
- containment devices (e.g. floating boom);
- pumps and skimmers;
- waste storage and recovery systems (e.g. leak-proof drums or containers).

4.6.4.2 Stockpiles and storage

Response equipment is often deployed in an emergency. The location and mode of storage must therefore be selected and arranged to allow for a rapid response and easy deployment, preferably near high risk sites. Their position should be defined in advance to ensure maximum efficiency in case of deployment; such positions should be specified in the contingency plan or located on strategical/tactical maps.

Within stockpiles, it is advisable to gather in the same place, rack or pack (container, trailer, etc.) all the equipment necessary for a given technique. For instance, a skimmer will be packed with a pump, power unit, set of hoses, ropes, etc. Containment devices will be grouped together, and so on.

It is preferable to protect the equipment from sunlight, frost and bad weather (sea spray, wind, rain...). In areas where the climate is cold, hot or humid, special care must be taken. Ventilation will prevent mould and accelerated deterioration. Protection against rodents must also be ensured.

4.6.4.3 Maintenance and care

As part of the preparedness process, it is essential to draw up detailed and regularly updated inventories of the available equipment (number, type, quantity, state) and to associate them with technical data sheets as well as implementation and maintenance protocols.

▶ 4.6 Acquisition and maintenance

5 RESPONSE

5.1 Introduction

There are no universally applicable response and intervention techniques in case of incidents involving HNS at sea: each response to tackle a release at sea and mitigate the potential impacts is unique and depends on numerous variables:

- The list of HNS potentially involved in a spill is very long and their behaviour is difficult to predict;
- The complexity is increased by the specificities of the incident location, environmental conditions, possible mixing of chemicals, reactivity, etc.;
- The level of preparedness as well as the availability of suitable equipment and training level are key factors in the effectiveness of the response.

This manual aims to guide involved personnel (decision-makers, responders) through the different phases of a marine HNS emergency, and assist with the response. It is essential to be able to rely on a well-developed contingency plan.

The response phases are not necessarily sequential, they may be carried out simultaneously, always keeping in mind that the priority objective must be to save lives in danger and to preserve the health of responders.

Chronologically the following phases can be identified:

Incident notification

- reporting of incident by observers (casualty's captain, pollution observation systems, general public)
  ▶ 5.1 Incident notification

Information gathering

- data gathering: research into the characteristics of involved substances (physical, chemical and biological data) and/or containers as well as their behaviour, weather and sea conditions and forecasts, ecological and economic characteristics of affected area.
  ▶ 5.2 Incident data gathering

Decision-making

- selection of strategies to eliminate or reduce the pollution (or threat thereof) based on:
  - **Hazards**: evaluation of hazards deriving from the released substances;
  - **Behaviour**: their behaviour which will make it possible to identify the compartment(s) (air, surface, water column, seabed) that will be impacted by the pollution;
  - **Modelling**: to predict the trajectory, fate and behaviour of spilled pollutants.
    ▶ 5.11 HNS spill modelling

First actions

- usually initial emergency measures taken by responders and crew of involved ship(s)
  - ▶ 5.5 Situation assessment
  - ▶ 5.18 First actions (responders)
  - ▶ 5.19 Safety zones

On-scene response

- once response strategy is established, multiple actions may be conducted:
  - Protection: identification of the necessary Personal protective equipment
    - ▶ 5.20 Personal protective equipment
    - ▶ 5.21 Decontamination
  - Monitoring: depending on the characteristics of the accident, different types of monitoring could be carried out: remote detection (wherever possible), use of portable detectors, and sampling of water, sediment and biota for laboratory analyses
    - ▶ 5.22 Remote sensing technologies
    - ▶ 5.23 Substance marking
    - ▶ 5.24 Remotely operated vehicles
    - ▶ 5.25 Portable gas detectors for first responders
    - ▶ 5.26 Sampling techniques and protocols
    - ▶ 5.27 HNS detection and analysis methods
  - Response techniques: in combination with monitoring, two types of intervention can be distinguished:
    - Vessel-oriented actions – direct interventions on the vessel such as:
      - ▶ 5.28 Emergency boarding
      - ▶ 5.29 Emergency towing
      - ▶ 5.30 Places of refuge
      - ▶ 5.31 Cargo transfer
      - ▶ 5.32 Sealing and plugging
      - ▶ 5.33 Wreck response
    - Pollutant-oriented actions – operations to contain, treat and/or recover pollutants on the vessel or in the environment:
      - ▶ 5.34 Using water curtain
      - ▶ 5.35 Using foam
      - ▶ 5.37 Using sorbents
      - ▶ 5.38 HNS response in the water column
      - ▶ 5.39 HNS response on the seabed
      - ▶ 5.40 HNS response on the shore
      - ▶ 5.42 Containment techniques: Booms
      - ▶ 5.43 Recovery techniques: Pumps and skimmers
  - Logistical organisation: identification of suitable areas for setting up decontamination zones; establishment of a waste management strategy.
    - ▶ 4.4 Waste management

Post-spill management

- the following topics must be taken into consideration:
  - Documentation and record-keeping: these aspects are important from the very the beginning of the response and become crucial during the claims process.
    - ▶ 6.1 Claim process

- Post-spill monitoring: necessary to assess environmental damage and decide upon measures for environmental restoration and recovery.
  ▶ 6.2 Environmental restoration and recovery

- Incident review and lessons learnt: identify strengths and weaknesses of the response, implement changes to the contingency plan.

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

5.2 Overview of possible response options

INCIDENT

- Fact sheet 5.1 Incident notification
- Fact sheet 5.2 Incident data gathering
- Fact sheet 5.3 Information resources
- Fact sheet 5.4 Packaged goods identification

Fact sheet 5.13 Response considerations: Gases and evaporators

Fact sheet 5.14 Response considerations: Floaters

Fact sheet 5.15 Response considerations: Dissolvers

Fact sheet 5.16 Response considerations: Sinkers

POST-SPILL MONITORING

- Fact sheet 6.1 Claims process
- Fact sheet 6.2 Environmental restoration and recovery

HAZARDS

- Fact sheet 5.5 Situation assessment
- Fact sheet 5.6 Response considerations: Flammable and explosive substances
- Fact sheet 5.7 Response considerations: Toxic substances
- Fact sheet 5.8 Response considerations: Corrosive substances
- Fact sheet 5.9 Response considerations: Reactive substances
- Fact sheet 5.10 LNG
- Fact sheet 5.12 Non dangerous goods cargo
- Fact sheet 5.17 First actions (casualty)
- Fact sheet 5.18 First actions (responders)
- Fact sheet 5.19 Safety zones
- Fact sheet 5.20 Personal protective equipment
- Fact sheet 5.21 Decontamination

MONITORING

- Fact sheet 5.11 HNS spill modelling
- Fact sheet 5.22 Remote sensing technologies
- Fact sheet 5.23 Substance marking
- Fact sheet 5.24 Remotely operated vehicles
- Fact sheet 5.25 Portable gas detectors for first responders
- Fact sheet 5.26 Sampling techniques and protocols
- Fact sheet 5.27 HNS detection and analysis methods

RESPONSE TECHNIQUES: VESSEL-ORIENTED ACTIONS

- Fact sheet 5.28 Emergency boarding
- Fact sheet 5.29 Emergency towing
- Fact sheet 5.30 Places of refuge
- Fact sheet 5.31 Cargo transfer
- Fact sheet 5.32 Sealing and plugging
- Fact sheet 5.33 Wreck response

RESPONSE TECHNIQUES: POLLUTANT-ORIENTED ACTIONS

- Fact sheet 5.34 Using water curtain
- Fact sheet 5.35 Using foam
- Fact sheet 5.36 Natural attenuation and monitoring
- Fact sheet 5.37 Using sorbents
- Fact sheet 5.38 HNS response in the water column
- Fact sheet 5.39 HNS response on the seabed
- Fact sheet 5.40 HNS response on the shore
- Fact sheet 5.41 Packaged goods response
- Fact sheet 5.42 Containment techniques: Booms
- Fact sheet 5.43 Recovery techniques: Pumps and skimmers
- Fact sheet 5.44 Wildlife response

5.3 Notification and information gathering

5.3.1 Notification

Notification of an incident involving HNS can be received via:

- ship reporting system produced by the captain of the casualty or a responding or passing vessel;
- Pollution Report (POLREP) by a coastal state as part of their intergovernmental pollution notification system ▶ 5.1 Incident notification
- pollution observation report/detection log produced by a trained aerial observer ▶ 5.1 Incident notification
- automated spill response notifications (satellite-based surveillance);
- unofficial written/verbal reports from members of the general public (report of visually observed pollution in port for example).

The level of detail of any initial report will be dependent on whether there is a direct link between the pollution observed and the polluter: if there is no attributable source to the pollution observed, information about the type of cargo spilled will not be immediately available but instead will need to be gathered by first responders on site through monitoring and sampling (Chapter 5.6).

5.3.2 Data gathering

Once the initial incident notification has been received, it is crucial for decision-makers and responders to gather objective information about the case to support the first response actions ▶ 5.18 First actions (responders). Initially, data might be scarce and difficult to verify. However, with time and access to various information sources, the overall understanding of the situation increases. The quantity of incoming information might be challenging to verify, prioritise and filter.

All information should be funnelled and relayed to the Command Centre, which is in charge of analysing it and passing it Once the initial incident notification has been received, it is crucial for decision-makers and responders to gather objective information about the case to support the first response actions ▶ 5.18 First actions (responders). Initially, data might be scarce and difficult to verify. However, with time and access to various information sources, the overall understanding of the situation increases. The quantity of incoming information might be challenging to verify, prioritise and filter.

All information should be funnelled and relayed to the Command Centre, which is in charge of analysing it and passing it on to responders ▶ 4.3 Internal communication and to the relevant stakeholders ▶ 4.1 External communication.

There are two types of data that can be collected:

Information specific to the incident that could not have been known ahead of time:
Responders should aim to obtain essential information on the location of the incident and the status of the vessel, bunkers and cargo, as well as in-situ meteorological data, as quickly as possible.
▶ 5.2 Incident data gathering

The first information likely to be received would be from the captain and the vessel's crew as they follow the procedures outlined in the Shipboard Marine Pollution Emergency Plan (SMPEP), which includes reporting requirements, response protocols/procedures and national and local contact points.
▶ 5.17 First actions (casualty).

Shipping documents such as Cargo Certificate/Shipper's Declaration/Dangerous Good Declaration and the appropriate SDS are the best initial sources of information for substance-specific information.
▶ 5.4 Packaged goods identification

Information on resources:
Additional information, that could be collected prior to an incident, might be required to complement the reports obtained directly from the incident in order to aid the design and implementation of the response strategy ▶ 5.3 Information resources. HNS contingency plans (Chapter 4) should include an information resource directory covering human health and safety issues ▶ 5.20 Personal protective equipment and environmental resources (Environmental Sensitivity Index maps) and should make reference to operational response guides.

In order to assist in predicting the fate/behaviour and trajectory of a spilled substance, software models can be useful throughout the response ▶ 5.11 HNS spill modelling. Modelling results can add valuable information to the decision-making process with regard to first actions and emergency response measures ▶ 5.19 Safety zones. However, modelling results need to be verified in situ and the general rule applies that any model result is only as good as the underlying data.

5.4 Decision-making

5.4.1 Who is in charge of decision-making?

The Incident Commander establishes the strategy to be followed to stop the spill and mitigate impacts. For this purpose, they are in charge of announcing command and immediate priorities and approves the **Incident Action Plan**. They are also responsible for ordering demobilisation. They are also the focal point for deciding on the release of information through the Public Information Officer.

An **Incident Action Plan** (IAP) is established in order to convert the overall strategy, goals and objectives into tactics. The IAP represents a roadmap to guide the implementation of actions. Just as the situation should be regularly reassessed, the IAP should also be periodically updated.

5.4.2 Decision-making dynamics within the Incident Management Team

The decision-making process should not be improvised (Chapter 4). As far as possible, the structure, organisation, resources (human and material) and procedures must have been prepared and included in the contingency plan as a reference document. The exercises organised beforehand must have made it possible to evaluate the response capacity in the face of realistic HNS spill scenarios.

However, every incident is unique and the incident management team will have to make important decisions in a context of potentially high pressure, especially from media or political leaders. It will be necessary to make crucial decisions quickly, sometimes with a very incomplete picture of the situation. The Incident Management Team must be capable of making reasonable decisions, tailored to the situation and the extent of the pollution (Tier 1, 2 or 3).

5.4.2.1 Escalation

Information obtained through notification ▶ 5.1 Incident notification and data gathering ▶ 5.2 Incident data gathering can be crucial to support the situation assessment ▶ 5.5 Situation assessment. During the first moments following the incident, the situation assessment may both be limited and offer an opportunity to trigger first actions that could drastically mitigate the impact of the HNS spill. Indeed, certain provisional measures, mostly based on real risks or the possible worsening of the situation, could be implemented, especially when previously identified in the contingency plan.

Risks can be generated by the HNS transported but also by the bunkers. It is important to note that the propulsion fuels currently in use may be of different natures. The risks and behaviour of these products must therefore be taken into account, as well as possible mixtures or reactions with a cargo of HNS, or interactions related to environmental conditions (e.g. contact between a gas and a nearby source of ignition). With this in mind, a sheet is provided on a propulsion fuel which is becoming very widely used: ▶ 5.10 LNG.

Considering these aspects, the first actions are mostly orientated towards protecting the population, the environment or amenities. Examples of first actions to respond to the HNS are stopping the leakage or mitigating the extent or the impact of the spill. A decision tree based on hazards is presented in the following figure and can trigger first actions ▶ 5.17 First actions (casualty).

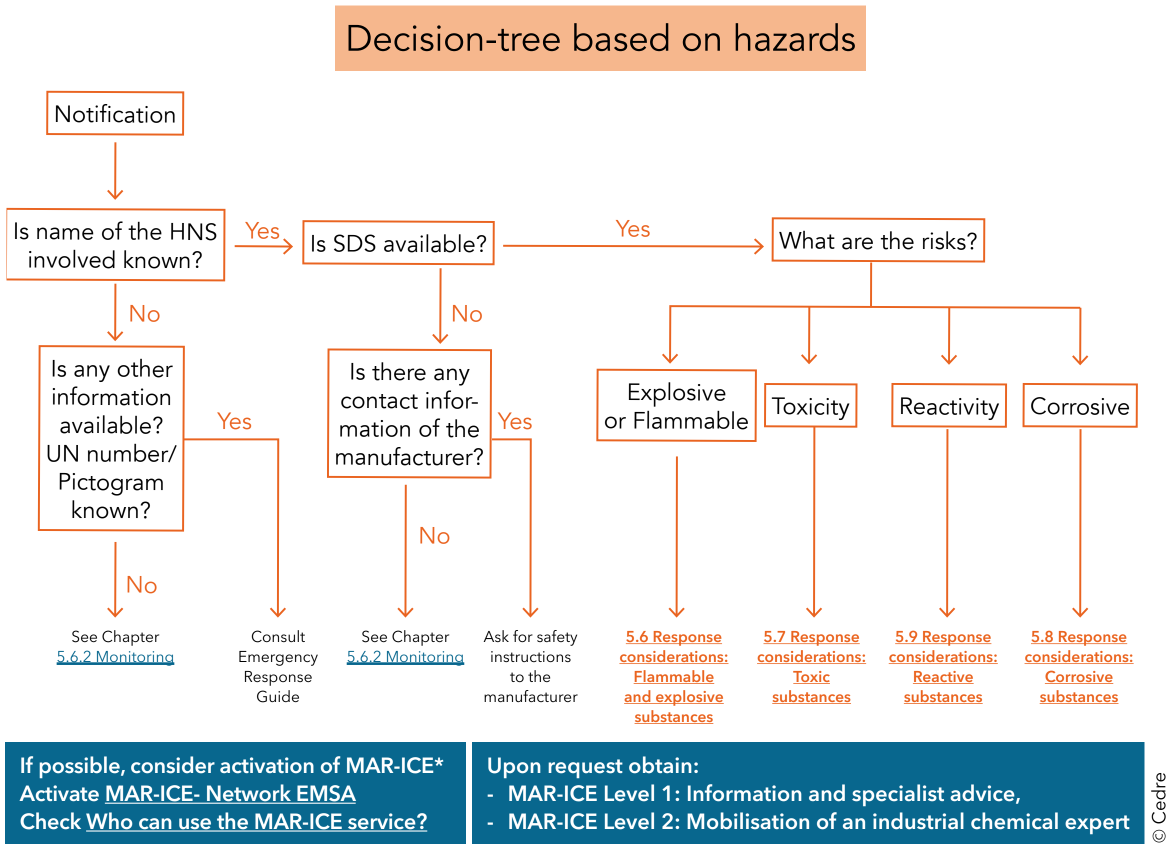


Figure 32: Decision tree based on hazards

**MAR-ICE offers a 24/7 remote information service on chemicals in the event of a maritime emergency. Product and incident-specific information and advice on chemical products and their associated risks are provided within 1 hour of the request and more detailed information shortly thereafter*

Modelling is a decision support tool that can provide relevant information for the decision-making process and can be a high priority, especially when the risks for the population or environment require to be assessed in more detail.
▶ 5.11 HNS spill modelling.

When an incident occurs with HNS that are not classified as dangerous goods, their release in water or storage in improper conditions may nonetheless create risky conditions for responders or the population. Such substances should also be thoroughly considered.
▶ 5.12 Non dangerous goods cargo

5.4.2.2 Feedback loop for decision-making based on hazards and response

Throughout the management of the HNS incident, the decision-making process should integrate a continuous assessment of the risks and behaviour.

Every new or relevant output from the situation itself (for instance weather conditions) or from actions implemented (for instance stopping of leakage) can provide input for information gathering. The situation assessment can therefore be conducted at regular intervals or triggered by a particular event in the field and may lead to new decision-making.

Knowledge of both chemical hazards and behaviour represents decisive information required to drive the response with the most suitable approach. Indeed the response tactics are mostly based on the behaviour of the chemical, while hazards must be considered with the greatest of care to continue to conduct the response in safe conditions. Flowcharts have been established to help decision-makers to select possible techniques to respond to the vessel or the pollutant (**Chapter 5.2**).

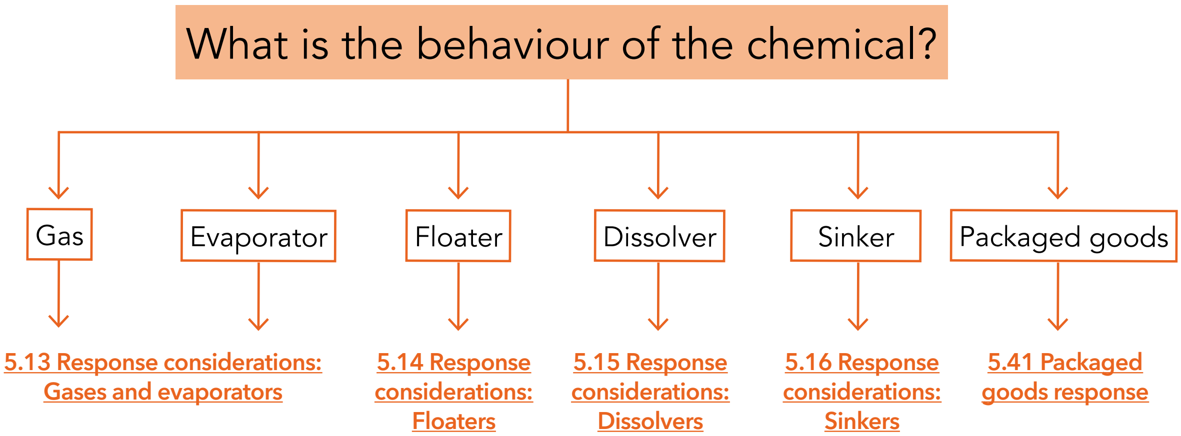


Figure 33: Decision tree to access flowchart based on behaviour

All the efforts deployed during the response should aim to ultimately return the scene to normal or acceptable pre-emergency conditions. Moreover, the response tactics and techniques used must not be more harmful to the environment than the pollutant itself. The guidelines defined by the Incident Action Plan should meet stakeholders' expectations as far as possible and seek their agreement through a collaborative approach. However, agreement can lead to significant delays in decision making, for instance when stakeholders are numerous. In case of disagreement, the Incident Commander is responsible for deciding on the best way forward.

While the strategy represents a guideline, the actions implemented for the response are based on the tactics defined. The On-scene Commander is responsible for the management of tactical operations, including supervision of operations, management of resources, consolidation of divisions bordering on overload and coordination of simultaneous operations. The objectives should meet the SMART criteria:

Specific	Instructions must be clear, as well as for as must the description of activities and logistics. They must cover correspond to a set of time called an operational period (hours, day, etc.) and be regularly updated during the response and its evolution.
Measurable	
Action oriented	
Realistic	
Timely	

5.5 First actions

First actions cover all actions that should be implemented at an early stage after notification of an HNS incident as soon as they are deemed necessary and can be implemented in safe conditions. The aim is to deploy a response team in the field in order to immediately mitigate the potential impact on human lives, the environment and amenities.

▶ 5.17 First actions (casualty)
▶ 5.18 First actions (responders)
▶ 5.19 Safety zones

5.6 On-scene response

5.6.1 Protection

Decision-making must necessarily take into consideration what equipment is suitable to be used in response to an HNS spill. During an HNS spill it is necessary to devote greater attention to the choice of suitable **Personal protective equipment (PPE)** for the protection of responders, considering the different hazards that numerous substances present. Moreover, the choice of equipment always needs to take into consideration chemical compatibility with the substance involved.

It is essential that the contingency plan (Chapter 4) foresees how to obtain the appropriate PPE, related stockpiles and that involved personnel is trained in its use. Particular attention must be paid to maintenance as this is often delicate equipment which, if necessary, must be immediately ready for use.

▶ 4.6 Acquisition and maintenance

It is necessary to appoint, and include in the contingency plan (Chapter 4), a person in charge of the management of PPE and a health and safety officer to ensure the correct use of equipment, especially PPE.

▶ 5.20 Personal protective equipment

Every time equipment is used, the subsequent decontamination phase, as well as waste management, should be considered.

▶ 5.21 Decontamination
▶ 4.4 Waste management

The main objective of the decontamination phase is to remove or neutralise contaminants that have accumulated on personnel and equipment, reducing risks inherent to the presence of toxic substances on the Personal protective equipment of responders. The method used involves neutralising the toxicity of the chemical substance(s) present and washing equipment with water or a cleaning agent. Decontamination operations must be managed and carried out by trained personnel.

5.6.2 Monitoring

Assessment of the extent and severity of impacted environmental compartments is based on three main components of monitoring methods (Figure 34).

These monitoring systems are complementary and might all need to be considered during a response. Indeed, remotely sensed data needs to be verified with in situ data, while models rely on in situ measurements and remote sensing. The integration or consultation of environmental monitoring experts in the Incident Management Team is recommended. The objective is to help decision-makers to provide information to allow for a rapid response in case of an HNS incident.

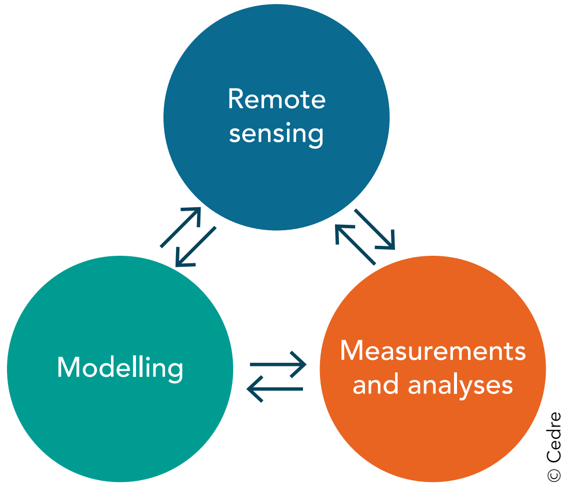


Figure 34: Three main components of surveying and monitoring

5.6.2.1 Modelling

Computer-based HNS fate, behaviour and trajectory are used to predict and prepare for potential impacts. However, the level of relevance and reliability depends, on the one hand, on the capability and reliability of the modelling software and, on the other hand, on information gathered as input for the model (Chapter 5.3). To validate the outputs from modelling, it is thus necessary to obtain quantified field data, either by remote sensing or by measurements obtained via in situ measurements or sampling and analysis.

▶ 5.11 HNS spill modelling

5.6.2.2 Remote sensing

Existing remote sensors used to detect and map oil spills may be used to detect floating HNS or packaged goods. For HNS with other types of behaviour, remote sensing still remains challenging. For instance the kinetics dissemination of a vapour cloud is too fast to be detected easily with satellite detection. However emerging technologies, such as autonomous sensors integrated on Remotely Piloted Aircraft Systems (RPAS), may be promising to improve the detection of HNS. The development of innovative and miniaturised sensors may offer the possibility to identify a wider range of HNS and, their integration on RPAS will improve the capacity to detect HNS, avoiding direct exposure to responders in the field, especially for explosive, flammable or toxic plumes. In the aquatic compartment, remote sensing may be possible with active sonar to detect sinker HNS or packages on the seabed, or some floating HNS.

▶ 5.22 Remote sensing technologies
▶ 5.23 Substance marking
▶ 5.24 Remotely operated vehicles

5.6.2.3 Measurements and analyses

Both in situ and laboratory analysis, described hereafter, may sometime be used to obtain different level of information or for different purpose. For instance a rough or qualitative analysis performed in situ may be useful to get first operational information while further sampling and analysis at laboratory may appear necessary to obtain more accurate information. As much as possible duplication of efforts should be avoided and anticipated through preparedness (See Chapter 4).

- **In situ analysis**

In-situ analysis can be carried out provided that certain requirements can be met. The performance of the detector must be sufficient in relation to the expected measurement result (For instance limit of detection or accuracy) but it must also be able to operate under possibly harsh conditions and over a given period of time.

▶ 5.27 HNS detection and analysis methods

The use of portable or miniaturised detectors has been largely developed over recent decades and on-going improvements should be expected in the coming years, offering a greater response capacity for responders and more reactivity for the Incident Management Team.

Ensuring the health and safety of all responders during an incident should be the highest priority of the response. Incidents involving HNS can frequently involve substances in a gaseous state, increasing the risk when conducting search and rescue operations, entering confined spaces, or working in the vicinity of the spill. Therefore, anyone responding to the incident, especially those first on the scene, should be adequately protected ▶ 5.20 Personal protective equipment. Portable gas monitors are one of the key equipment to assess the level of protection.

▶ 5.25 Portable gas detectors for first responders

- **Laboratory analysis**

Sampling for future laboratory analysis may be required or desired for a variety of reasons, some of which are listed below:

- In situ analysis might not possible for technical reasons (e.g. lack of portable equipment for analysis, time limitations, risky or harsh conditions in the field);
- The chain of custody for liability investigations might require specific procedures excluding in situ analysis;
- The chemical of interest is unknown;

▶ 5.26 Sampling techniques and protocols
▶ 5.27 HNS detection and analysis methods

5.6.2.4 Implementation of monitoring

5.6.2.4.1 Why monitor?

Monitoring should be implemented as soon as possible after notification and might potentially be continued throughout the emergency response phase and during post-spill monitoring. The following figure shows the reasons for monitoring during different phases of the incident management.

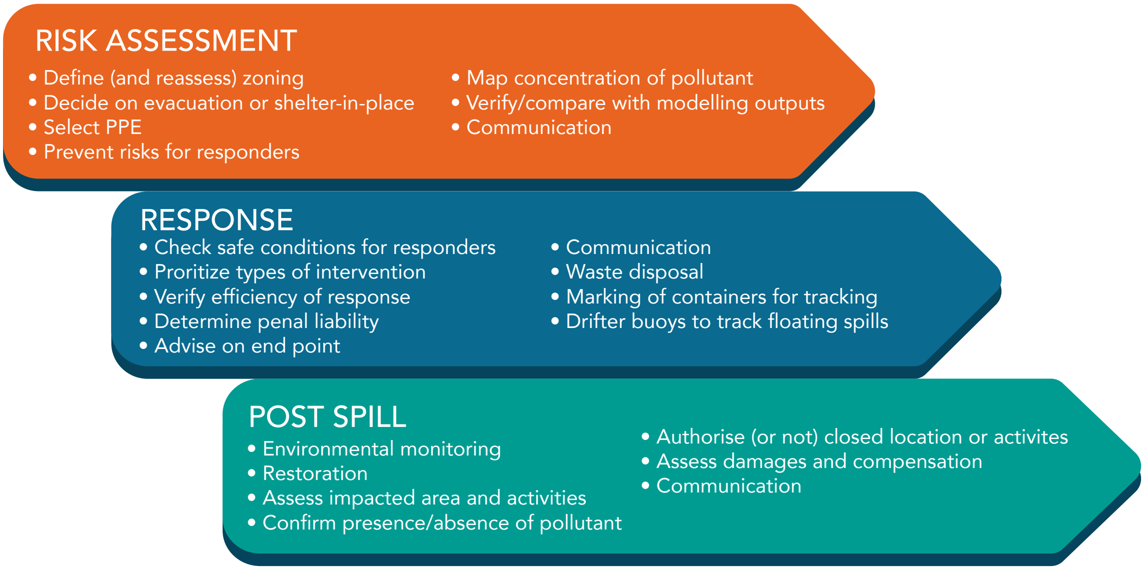


Figure 35: Objectives of monitoring for different phases of the response

5.6.2.4.2 Who is responsible for monitoring?

The objectives of monitoring mentioned earlier must be prioritised and integrated in a coordinated monitoring programme to avoid duplication of work, as well as to avoid missing chances of important measurements. The strategy must be led by a Monitoring Coordinator and should be built in a collaborative effort between experts and with the advisory opinion of possible third parties. It must be accepted that the survey strategy may continue after the response phase and will cover long-term clean-up or environmental follow-up. The Environmental Monitoring Coordinator should continue their activity during the whole period, including post-spill. The objective is to gather information potentially from multiple sources or various locations over a period of time to obtain a better/more accurate overview of the situation.

To implement the monitoring strategy, different duties fall under the responsibility of the Environmental Monitoring Coordinator, among them:

- establish a plan for documentation of the work and introduce a "chain of custody";
- make arrangements for appropriate monitoring if health risks are liable to occur;
- make sure that necessary measurements can be taken concerning the extent, severity and accuracy of both the spill and contaminated items as well as suspected sources;
- judge whether special examinations of the spill are needed to facilitate spill response measures;
- judge if short-term and/or long-term environmental impact may be expected. If so, contact the appropriate agencies;
- judge whether special examinations and analyses are needed when providing for general and specific needs for information;
- contact responsible bodies for transport and disposal. Check what special information is needed in this context and make arrangements for relevant analyses.

5.6.2.4.3 Where should monitoring be performed?

As explained in Chapter 3, HNS can exhibit one or several behaviours that result in them distributing to different environmental compartments e.g. the atmosphere, water surface, water column, seabed or shoreline. In addition to the behaviour of the chemical and its toxicological data, the location of the incident and the corresponding ecosystem can specifically affect biota (flora or fauna).

From the location of the incident, the short-term behaviour of the chemical (SEBC), the forecast modelling outputs or the expected fate, a sampling strategy may be established. It will detail the number and location of analyses to be performed for each parameter to monitor (chemical, temperature, etc.) making it possible to compare values, interpret and achieve the set objectives. It allows the creation of iso-concentration curves (isoclines) that will indicate the fluctuation of a pollutant in space and time.

5.6.2.4.4 Preparation of a monitoring strategy

Depending on the objective and behaviour of the chemical, the proper method for sampling or analysing will need to be selected.

Monitoring can occur at different stages of the incident management, from the very beginning after the HNS spill up to Post-spill stage, and can be implemented under various ways. It is essential to select the type of measurement: what must be monitored with what type of detection device? The target product should be the

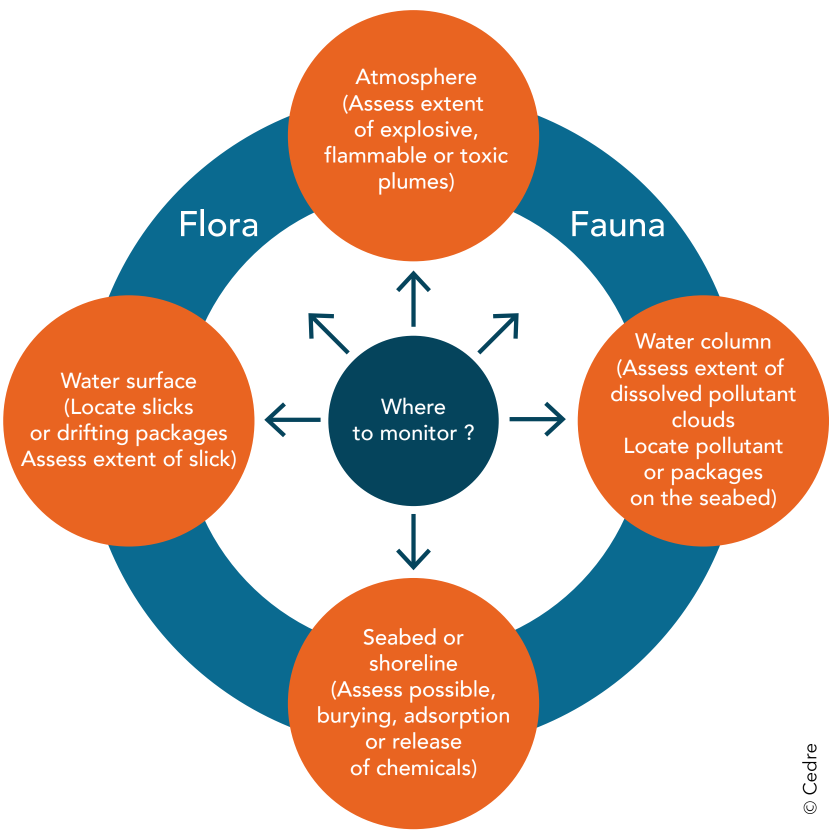


Figure 36: Environmental compartments and corresponding measurement objectives

chemical spilled or, when not possible or more relevant, any other chemical or biological indicators and reflecting the level of pollution. The analytical method used should reflect the presence of pollutant. A critical analysis must be done on the results to determine whether they accurately reflect reality. For example, interfering compounds or parameters may cause the output to vary. Field data can be collected either by in situ analysis or by sampling followed by analysis in the laboratory. During the response phase it is important, possibly urgent depending especially on the spilled substance, to perform measurements to assess the situation and decide on suitable counter-measures.

Beforehand, it is important to have identified, within the contingency plan or at least during the planning stage, procedures and resources able to perform analysis, for instance with sampling protocols, guidelines or expert input. Three main types of strategy, if possible combined, can be used to establish an impact assessment following an HNS spill:

- comparison of post-incident data with pre-incident data;
- comparison of data from impacted sites with data from reference sites;
- analysis of post-incident data monitored over a period of time to describe the recovery process.

Once the monitoring strategy has been decided, sampling should be performed as soon as possible as preserving sample may be possible (for instance by freezing them) before determining a parameter to be measured at a later stage.

Selection of type of detection

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

5.6.3 Response techniques

When intervention is possible, different response techniques can be used depending on the behaviour(s) and the hazard(s) of the substances released. The range of counter pollution measures to be applied depends on the type and characteristics of the pollutant, the form in which it is transported, as well as the overall situation (vessel status, weather conditions, environmental sensitivities). Nevertheless, in all cases, their main goals are to minimise the risks created by the incident, to protect people, the environment and human activities, and to restore the affected zone to as close as possible to its pre-emergency conditions.

▶ 6.2 Environmental restoration and recovery

If the risk for operators is high, the option of leaving the pollutant in the environment must always be given consideration and, if safe, a monitoring plan could be put in place (See 5.6.2 Monitoring).

▶ 5.36 Maintain in the environment and monitoring

If intervention is considered feasible, response techniques could be divided in two categories:

- vessel-oriented actions, namely interventions on the stricken vessel;

- pollutant-oriented actions, control dispersion, spreading/diffusion and recovery of the pollutant.

5.6.3.1 Vessel-oriented actions

These are generally among the first actions to be considered. The suggested techniques can generally be applied regardless of the behaviour of the substances involved. The status of the ship, the hazards of the substance(s), the environmental and weather conditions and the availability of the means and the necessary equipment are key considerations in this phase.

▶ 5.28 Emergency boarding
▶ 5.29 Emergency towing
▶ 5.30 Places of refuge
▶ 5.31 Cargo transfer
▶ 5.32 Sealing and plugging
▶ 5.33 Wreck response

5.6.3.2 Pollutant-oriented actions

Techniques to control the pollutant, its dispersion, spread and diffusion will depend on the location of the incident: open sea, harbour or coastal area. Controlled release tends to be applicable in the open sea, far from populated or sensitive areas, and can be applied regardless of the behaviour of the substance involved. Techniques for the reduction and control of vapours (water curtains and use of foams) can be applied both in port areas and in coastal areas, especially to protect the nearby population, as well as in the open sea, to allow intervention by the response team.

▶ 5.34 Using water curtain
▶ 5.35 Using foam
▶ 5.36 Maintain in the environment and monitoring

Response actions to contain and recover pollutants spilled in marine environment are highly dependent on the behaviour and the hazards of the substance(s) involved. In general terms, containment and recovery are possible especially in the case of substances that float or sink as their main behaviour. In general terms, containment and recovery can be effective if the substance remains at sea for more than a few days, otherwise it is useless to plan such operations, considering the time needed to reach the area with the necessary equipment.

▶ 5.37 Using sorbents
▶ 5.38 HNS response in the water column
▶ 5.39 HNS response on the seabed
▶ 5.40 HNS response on the shore
▶ 5.41 Packaged goods response
▶ 5.42 Containment techniques: Booms
▶ 5.43 Recovery techniques: Pumps and skimmers

Above all, response actions involving the recovery of products on board the ship or spilled at sea will determine the production of waste, whose management must be taken into consideration well before the response techniques are put in place. It is important that waste management is included in the contingency plan with consideration of all the phases of the waste cycle: recovery, storage, transport, treatment, and disposal of waste.

▶ 4.4 Waste management

Intervention on marine wildlife should always be taken into consideration; marine wildlife can be affected by a spill of HNS. The intervention protocols are in many cases similar to those followed during an oil spill emergency

▶ 5.44 Wildlife response

6 POST-SPILL MANAGEMENT

6.1 Documenting, recording and recovering costs incurred during a ship-source HNS incident

A marine spill involving HNS can cause significant loss or damage to a variety of organisations and individuals: HNS may cause harm to human health, environment, damage to property and lead to economic loss. Despite the best efforts of those concerned, the clean-up can be protracted and costly. Those placed at a financial disadvantage as a result of an HNS spill may be eligible for compensation.

6.1.1 Legislation - Legal basis for compensation

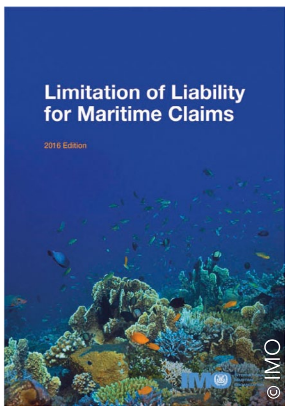
International legislation

At this point in time, there is no international convention in force governing compensation from marine HNS spills (a gap that the HNS Convention, see below, aims to close). Therefore, in the case of an incident, compensation will be dependent upon national legislation but may be subject to limitation under the global limitation regime by virtue of LLMC. It is therefore essential that the national contingency plan clearly states the sources of compensation available and the legislation that would be applicable, known by all.

National legislation

Liability and compensation for loss or damage caused by hazardous and noxious substances transported by sea currently depends on national legislation, and applicable international conventions. As a result, liability and compensation vary widely.

This may mean that, in the absence of specific legislation or strict liability, potential claimants may be required to prove fault on the part of the shipowner and that compensation will be limited to any damages recovered from the shipowner. The shipowner may be entitled to limit liability under applicable national or international regimes such as under the **Convention on Limitation of Liability for Maritime Claims (LLMC)** (IMO, 1996). The 1996 Protocol, as amended, is in force in 61 countries, with the earlier 1976 Convention solely in force in a further 20 countries.



LLMC Convention cover

The LLMC Conventions allows the shipowners or salvors of a sea-going ship to establish limitation for a wide range of maritime claims, with the exception of certain circumstances, including those that may arise out of an HNS incident, such as:

- claims for loss of life and personal injury;
- claims for loss or damage to property;
- claims in respect of the raising, removal, destruction or the rendering harmless of a ship which is sunk, wrecked, stranded or abandoned, including anything that is or has been on board such a ship;
- claims in respect of the removal, destruction or the rendering harmless of the cargo of the ship (which could cover HNS cargo in bulk or packaged form);
- claims for clean-up costs in respect of measures taken to avert or minimise loss and further loss caused by these measures.

The Convention sets two separate limits for claims related to:

1. loss of life or personal injury
2. other claims (e.g. property claims, economic loss)

Liability is limited to an amount dependent on the size of the ship.

LLMC Protocol 1996 as amended	Shipowner's limit of liability (approximate US$)	Liability limits for five vessel sizes (approx.US$)
Property	The limit of liability for property claims i.e. excluding loss of life and personal injury, for ships not exceeding 2,000 gross tonnage is SDR 1.51 million SDR ($2.1 million). For larger ships, the following additional amounts are used in calculating the limitation amount: • For each tonne from 2,001 to 30,000 tonnes, 604 SDR ($845) • For each tonne from 30,001 to 70,000 tonnes, 453 SDR ($630) • For each tonne in excess of 70,000 tonnes, 302 SDR ($420).	2,000GT = $2.1 million 10,000GT = $8.8 million 50,000GT = $38.4 million 100,000GT = $63.8 million 200,000GT = $106 million
Loss of life/ Personal injury	The separate limit of liability for loss of life or personal injury claims for ships not exceeding 2,000 gross tonnage is SDR 3,02 million ($4.1 million). For larger ships, the following additional amounts are used in calculating the limitation amount: • For each tonne from 2,001 to 30,000 tonnes, 1,208 SDR ($1,662) • For each tonne from 30,001 to 70,000 tonnes, 906 SDR ($1,246) • For each tonne in excess of 70,000, 604 SDR ($831)	2,000GT = $4.1 million 10,000GT = $17.3 million 50,000GT = $75.5 million 100,000GT = $125.4 million 200,000GT = $291.6 million

Table 8: Shipowner's liability limits under the amendments to the LLMC 1996 Protocol (SDR: Special Drawing Rights. The daily conversion rates for Special Drawing Rights (SDRs) can be found on the International Monetary Fund (IMF).

In the event of an HNS incident, the applicable legislation will set out the provisions addressing liability and compensation. These may include information regarding the timeframe within which claims should be made. Should the shipowner be liable by law to provide compensation to those who suffered loss or damage as a result of the incident, third party claims will normally be covered by the P&I insurer of the ship.

6.1.2 Protection & Indemnity (P&I) Club/ The insurer

Claims for compensation should be made in the first instance to the shipowner or to the insurer of the vessel's third party liabilities, usually a Protection & Indemnity (P&I) Club. The shipowner's P&I Club will provide insurance cover for ship sourced pollution damage and will handle and assess any pollution damage claims accordingly, and up to an amount set by relevant international conventions (often with a direct liability on the insurer/P&I Club where this is the case) or by national legislation.

The 13 P&I Clubs that are members of the International Group of P&I Clubs (IG), between them, provide cover for approximately 90% of the world's ocean-going tonnage. These P&I Clubs provide cover on behalf of their shipowner and charterer members for a wide range of third party liabilities relating to the operation of ships, including:

- loss of life and personal injury to crew, passengers and others on board;
- cargo loss and damage;
- pollution by oil and other hazardous substances;
- wreck removal, collision and damage to property.

P&I Clubs also provide a wide range of services to their members on claims, legal issues and loss prevention, and often play a leading role in the management of casualties. P&I Clubs are non-profit mutual (i.e. cooperative) insurance associations enabling shipowners to share risk and the payment of claims.

A number of commercial vessels, many of which operate solely in domestic markets, are insured for third party liabilities by other, usually smaller, P&I providers either on a mutual or fixed-premium basis. Military vessels as well as other government vessels, including warships and other vessels on military duty or charter, usually operate outside established P&I and other commercial insurance.

Sinking of Ievoli Sun

In the event of a large incident where the total cost of claims exceeds the compensation available from the shipowner, the settled claims may be pro-rated to the maximum amount available. Compensation to supplement money available from a vessel's insurer may be available from other sources, including international and domestic funds.

Examples of HNS incidents where compensation was provided by the shipowner and P&I insurer: *Ievoli Sun*, chemical tanker incident in France, 2000.

6.1.2.1 HNS Convention and its 2010 Protocol

At the time of writing, the HNS Convention (its 2010 Protocol) is not yet in force. When in force, the HNS Fund will be a potential source of additional compensation for the ratifying countries, in addition to potential money available from the shipowner's insurer (IMO, 2010).

The 2010 HNS Convention will cover damage caused by HNS within the Economic Exclusion Zone (EEZ) of a country in which the Convention is in force, as well as damage caused by HNS carried on board ships registered in, or entitled to fly the flag of, a signatory country outside the territory of any State (country). Compensation will be available for pollution damage and damage caused by other risks, e.g. fire and explosion, for loss of life or personal injury on board or outside the ship carrying HNS, damage to property outside the ship, damage caused by contamination of the environment, loss of income in fishing, tourism and other economic sectors, and the costs of preventive measures.

Where damage is caused by HNS in bulk, the shipowner will normally be able to limit their financial liability to an amount between 10 million and 100 million SDR (approximately US$15 million to US$150 million), depending on the gross tonnage of the ship. Where damage is caused by packaged HNS, the maximum liability for the shipowner is 115 million SDR (approximately US$175 million), also dependent on the vessel's gross tonnage. The HNS Fund will provide an additional tier of compensation up to a maximum of 250 million SDR (approximately US$380 million), including any amount paid by the shipowner and their insurer.

Once in force, claims under the HNS Convention should be submitted within three years of the damage or ten years of the date of the incident, whichever is sooner.

6.1.2.2 European Union - Environmental Liability Directive

The 2004 Environmental Liability Directive (ELD) establishes a framework of liability and compensation for environmental damage only (excluding personal injury, property damage or economic loss claims) caused by potentially polluting commercial operations within the Member States of the European Union and EEA (and as such, not exclusive to marine HNS incidents). The operator is liable for costs incurred either by the operator or by the competent authority within the Member State in preventing or remediating environmental damage. Remedying of environmental damage, in relation to water or protected species or natural habitats, is achieved through the restoration of the environment to its baseline condition by way of primary, complementary and compensatory remediation.

Implementation of the Directive was completed across the EU in 2010. The ELD has been amended three times subsequently to broaden the scope of strict liability and of damage to marine waters. The ELD does not apply to incidents covered by the international conventions where those Conventions are in force). Therefore, when the HNS Convention will enter in force, incidents subject to it will be expressly excluded from the scope of the ELD. However, in those Member States of the EU that are not signatory to a convention, or where a convention is not in force, the ELD may be applicable. The ELD does not prejudice the right of the operator to limit liability under the LLMC.

Examples of incident where it applied: none yet related to any maritime incident.

6.1.3 Type of claims

There are four main categories of claims in general arising from an HNS incident:

- **Clean-up and preventive measures**

Cost will be incurred as the result of the deployment of resources to prevent/minimise pollution damage, protect sensitive areas and carry out clean-up response. Activities such as aerial observation, at-sea response, and shoreline clean-up all fall under this category as well as the personnel engaged for carrying out this work.

- **Property damage**

Property damage may arise for cleaning, repairing or replacing items damaged by the chemicals or as a result of clean-up activities (e.g. damage to roads used for access by workers).

- **Economic losses (pure economic losses, consequential economic loss)**

A spill may impact companies, individuals or organisations in a different way: either pure economic loss when no damage to the property has occurred (e.g. beach access blocked by response activities, business interruption) or consequential economic loss when the spill has directly damaged assets (e.g. fishing nets).

- **Environmental monitoring, damage and restoration**

These claims are related to monitoring, impact assessment studies and possibly restoration studies.

Fishing nets

6.1.4 The claims process

Anyone who has suffered a loss or damage as a result of an incident, provided a link of causation can be established, is entitled to submit a claim. Claimants can file either an individual claim or submit it as a group (group of municipalities or consolidated government claims) to the relevant paying parties. Ultimately, it is the responsibility of the claimants to prove their loss.

Detailed information on the preparation and submission of claims in general can be found in a number of claim manuals (e.g. EMSA 2019, MCA). Whilst the IOPC Funds' claims manuals (IOPC Funds, 2019) are specifically tailored for oil pollution damage resulting from spills of persistent oil from tankers, they provide helpful guidance for other incidents outside of their scope (IOPC Funds, 2019). Good practice recommendations can be found in the sheet ▶ 6.1 Claims process. The entity paying compensation may send a representative on site and may appoint experts to provide advice on claim submission to those involved in the incident. If the incident is likely to generate a large number of claims, the insurers are likely to set up a local claim office to help, collect and guide the submission of the claims.

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 (ITOPF, 2014).

When drafting and updating the national contingency plan, clear guidance should be included on cost recovery, the importance of on-going recording of costs incurred and evidencing such, and the department in charge of this aspect.

During an incident, it is recommended to keep and document all records of activities, damage and actions undertaken. Together with early engagement with the compensating body, these are key to ensure a smooth claim submission process and a common understanding by both parties of the issues that would naturally arise during an incident.

The claim submission and assessment are an iterative process between the parties until a suitable settlement can be reached.

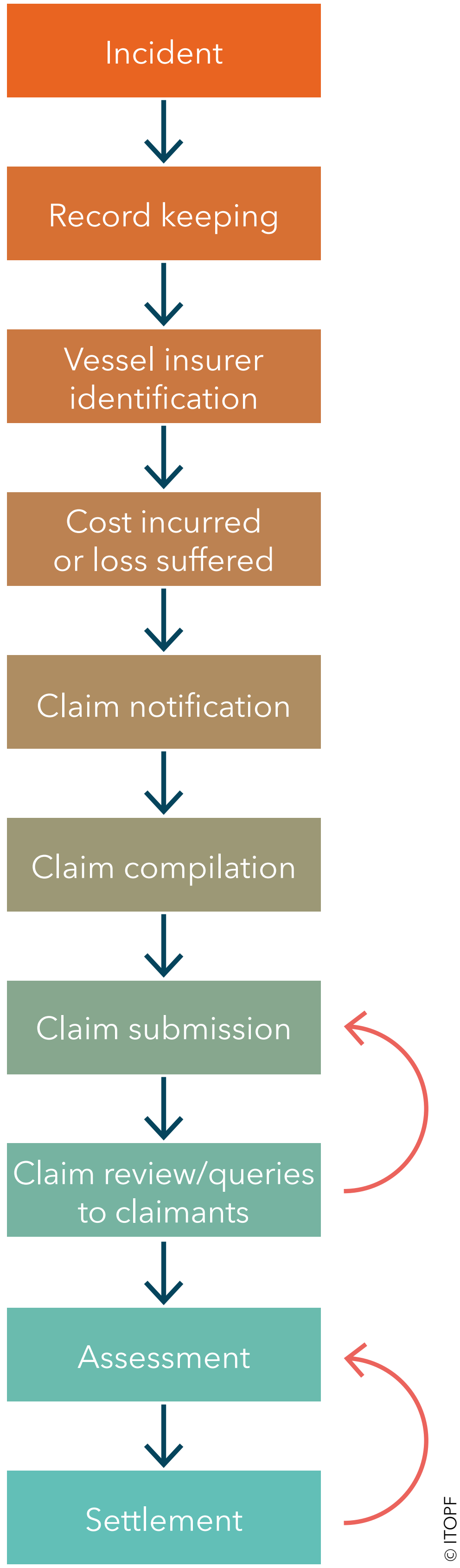


Figure 37: From incident to settlement: the claim process

6.1.5 Summary

- All costs should be fully identified, recorded and supported at the time they are incurred as ultimately, it is the responsibility of the claimants to prove their loss.
- The sources of compensation should be identified and engagement with their representatives should be made at an early stage.
- Understanding the types of costs that are admissible under the applicable regimes is key to the submission of claims.
- Early engagement with the compensating body will facilitate the assessment and is likely to speed up the settlement process.
- The compilation of the claim and its submission to the paying party may have to be done quickly.
- The process leading to settlement is iterative and can be lengthy.

6.2 Post-spill monitoring

Post-spill monitoring is a very useful activity, in order to evaluate the:

- environmental consequences of an HNS spill and the extension of the effects both in space and in time;
- natural recovery of the environment involved as well as the effectiveness of any restoration and recovery activities and assess when these activities are considered to be complete.

▶ 6.2 Environmental restoration and recovery

This is a very complex matter, therefore it could be considered in a post-spill monitoring guide included in the contingency plan to define the objectives to be achieved and strategies for sampling, transport and analysis of sediment samples, water and marine organisms (IMO and UNEP, 2009; Kirby and Law, 2010; Kirby et al., 2018; Kirby, Gioia, Law, 2014; Neuparth et al., 2012).

It is especially necessary in case of spills of significant quantities of pollutants and in the case of permanent substances in the marine environment and/or products with long-term effects (e.g. mutagenicity and carcinogenicity effects).

To perform good post-spill monitoring, the quality of data acquired during the emergency phase is important and especially useful for understanding the behaviour of substances involved and their final fate in the marine environment. This allows the biota most involved (seafloor, shoreline, water column ecosystems) to be identified and investigations to focus on these. For this reason, field activities must be preceded by a detailed post-spill monitoring plan.

Monitoring is usually carried out by comparing data obtained with baseline data, when available, or with data measured at a reference site, chosen with environmental and morphological characteristics similar to those of the affected area but certainly not affected by spilled pollutants.

Choosing a reference site is a challenging process due to the difficulties in identifying an area with characteristics very similar to those of impacted one, where there are no other possible impacts that alter its characteristics. Statistical comparison of results obtained in terms of chemical, biological, ecotoxicological and ecological status analyses leads to an understanding of the extent of negative effects on the affected area.

The monitoring strategy must prioritise surveys on matrices that are representative of the environment that is intended to be assessed. For this reason, analyses of marine sediments are a priority with respect to water and air, which will move on, driven by sea currents and winds. The choice of organisms to be sampled must also take the same approach: sampling of specimens that live in close contact with the bottom (sedentary species with a small home range) compared to species that have more erratic behaviour (e.g. pelagic fish).

Post-spill monitoring uses a multidisciplinary approach to acquire evidence; common elements monitored to assess impact could include ecological community structure (abundance, diversity, etc.), sub-lethal biomarkers of effect in a range of species (e.g. enzyme levels, reproductive and behavioural parameters), contamination and/or tainting in commercial species, ecotoxicological assessments of contaminated water/sediment and recovery and recruitment measurements in the affected area. Indicators for ecological and chemical status are currently being developed as part of the European Water and Marine Strategy Framework Directives and it would also make sense for those conducting post-incident impact assessments to take account of them.

The investigations that could be taken into consideration during post-spill monitoring include:

- chemical analysis of samples, mainly sediment and possibly air and water;
- biological assays on sediment and water samples;
- ecotoxicology of specimens of sedentary marine organisms;
- assessment of the ecological status of characteristic populations of the area.

Equipment useful for sampling sediment, water and biota is reported in the fact sheet ▶ 6.2 Environmental restoration and recovery

Chemical analyses

As previously mentioned, chemical analyses are mainly conducted on sediments which represent the sector of the marine environment indicating long-term pollution. Investigations that can be conducted are both generic and specific to the pollutants involved: particle size, pH and Eh, Total Organic Carbon (TOC), concentrations of pollutant(s) and their degradation products.
Granulometry (particle size) is an important value to know, because smaller particles are more able to "retain" pollutants, therefore fine-grain sediment is a better matrix in which to search for the presence of spilled substances.
Total Organic Carbon indicates the quantity of the organic component capable of "retaining" lipophilic and hydrophobic pollutants.

As an alternative to sediment and water analyses, the latest scientific research suggests the use of passive sampler devices, capsule-shaped instruments to be placed in the sea, containing a resin, specific to each category of substance, capable of concentrating pollutants present in the water column or in sediment.

Biological assays

A biological assay (or bioassay) is an analytical method to determine the concentration or potency of a substance by its effect on living animals (in vivo) or tissue/cell culture systems (in vitro) (Cunha et al., 2017). In practical terms, the water or sediment sample is placed in contact with living marine organisms or with cells or tissues and specific variations are observed such as: the presence of the contaminant in the tissues; alteration of enzymatic activity, change in mortality rate, change in larval development, etc. Comparison with results obtained with similar samples taken in the reference area provides indications of effects related to the presence of pollutant(s).

Also in this case, use of sediment matrix or the so-called interstitial water (water that is between sediment grains) is preferable. For the purposes of example only, some examples of possible bioassays are:

- a set of three biological tests conducted on sediment as it is or on the interstitial water by means of species representing three trophic levels: *Vibrio fischeri bacterium* (Microtox®) (variation of bioluminescence); alga *Dunaliella tertiolecta* (its development); *crustacean Tigriopus fulvus* (its larval development). The application of a set of tests provides an indication of the existence of acute pollution at different levels of the food web.
- spermiotoxicity and larval development test on specimens of *Paracentrotus lividus* (sea urchin). The test is performed on the interstitial water and also in this case it provides an indication of the existence of acute pollution.
- Bioaccumulation on annelid *Hediste diversicolor*; the test is carried out by placing specimens of the worm in the sediment for about 10, 15 days. The results provide an indication of the accumulation of chemicals.

Ecotoxicology

Many analyses conducted with bioassays can be applied to specimens of marine organisms taken from the affected and reference areas. In this case, researchers are applying ecotoxicology. As mentioned above, the use of sedentary species is important because their health status can be an indicator of the state of the environment studied. Examples of sedentary organisms: fish such as rockfish, scorpion fish, conger eel or moray eel; sea urchin, mussels.

Below are some examples of ecotoxicological analyses:

- bioaccumulation of pollutant and its degradation products in target tissues;
- analysis of cellular damage, such as: lysosomal stability; lipid peroxidation; typical biomarkers of detoxification and oxidative stress processes (enzymatic alterations); histopathology;
- spermiotoxicity and larval development;
- Health Assessment Index (HAI), macroscopic evaluation of the state of the sampled organisms and their internal tissues.

Assessment of impacted area's ecological status

Finally, it is possible to evaluate effects at ecosystem level by carrying out an assessment of the ecological status of some characteristic biocoenoses (living communities) present in the area. Some characteristic parameters of each biocoenosis are analysed, which are based above all on the abundance and diversity of species, whose values are used to establish specific indices that help to define the ecological status which is usually expressed with qualitative evaluations such as: high, good, sufficient, insufficient, poor.

Assessment of the ecological status can be conducted on the water column, on typical populations of the seabed or on the shore.

In the Mediterranean Sea, for example, the ecological status of coastal areas can be assessed by evaluating the status of the populations of Posidonia oceanica, an endemic phanerogam (typical of the Mediterranean basin) which forms meadows at depths between 5 and 50 metres. At the international level, several specific indices have been defined for these meadows that are used to provide a judgment of its ecological status (high, good, sufficient, insufficient, poor). If a Posidonia meadow has been damaged by an HNS spill, once the source of damage has been eliminated, it is possible to evaluate its ecological status, compare it with that of the reference area and evaluate over time when its natural recovery is complete. ▶ 6.2 Environmental restoration and recovery

6.3 Incident review

Every crisis management and incident response, independently of its size or nature, will be exposed to scrutiny. Such scrutiny can be helpfulto learn lessons from past incidents and to improve the response for future operations.

The main objectives of incident review are to:

- draw lessons that are primarily of benefit to local stakeholders;
- keep track of events;
- identify avenues for progress;
- strengthening communication and co-ordination between different stakeholders during the response

For this purpose, the incident review can be substantiated through the following items, depending on the size of the incident: statistics, briefing note/report or even description and analysis of events for better understanding.

Most of all, incident reviews as well as lessons learned must be used to raise awareness and to update the contingency plan (Chapter 4). The guidelines or policy to conduct incident review should be written, or at least referred to, in it. Among other relevant information, the triggering criteria for conducting, or not conducting, an incident review should be included. The criteria can be based on the level of current affair disruption, the learning potential and the main evolution of the response and/or crisis management.

Incident review is a two-step process, composed of an informal evaluation followed by a formal review, both described in the following table:

Type of evaluation	Informal evaluation	Formal review
When should it be held?	Immediately after an incident when emergency personnel and units are still on the scene (hot wash up).	No later than a few months after the end of the incident.
What should be assessed?	All aspects of spill management should be covered (techniques, decision-making process, internal/external communication, etc.).	
	- For small incidents: how well specific tactics worked and what changes might induce better results.	- Detailed analysis and review of large-scale and other complex or tactically challenging operations. - Every aspect of the incident is carefully reviewed (including compliance with standard operating procedures (SOPs)) and analysed to identify root causes for problems.
Who should be involved?	Tactical and response team who conducted the response on scene and within the crisis management team. A dedicated trained member of the crisis management team will gather all information and feelings about how the incident was managed.	- Representative/head of responders, Government /contractors/head of departments/NGOs/shipowners. Some contributions might be preferred indirectly (e.g. for shipowners).
How should it be assessed?	In all cases a project manager should be appointed to conduct the incident review and keep this responsibility up until the delivery of the final incident report.	
	- Depending on the incident this can be done orally or possibly through a short questionnaire.	- Detailed questionnaire specific to the incident
Advantages	- Gather all impressions and facts, reducing the risks of forgetting, - Actions taken are still fresh in people's minds	- Sufficient time is allocated to go into specific details of the response, - Possibility to make recommendations or changes to the SOPs in the contingency plan
Limitations	- Ensure that informal evaluation will not publicly embarrass those responsible for any mistakes, - Possibly, lack of time allocated to complete the review.	- Not all incidents have the same level of importance or frequency. For this reason the level of evaluation for incident review must be adjusted.

Table 9: Main characteristics of informal evaluation and formal review to establish incident reviews

The project manager must have a reliable structural organisation, communication and trained people. Performing incident review requires honest dialogue between all stakeholders (in charge, counteractant, responders, etc.), and discussions to favour disagreement over disrespect.

Everyone involved in the management of the incident, regardless of their hierarchical level or status, should be involved in the review.

The timeline to conduct an incident review is summed up in the following figure:

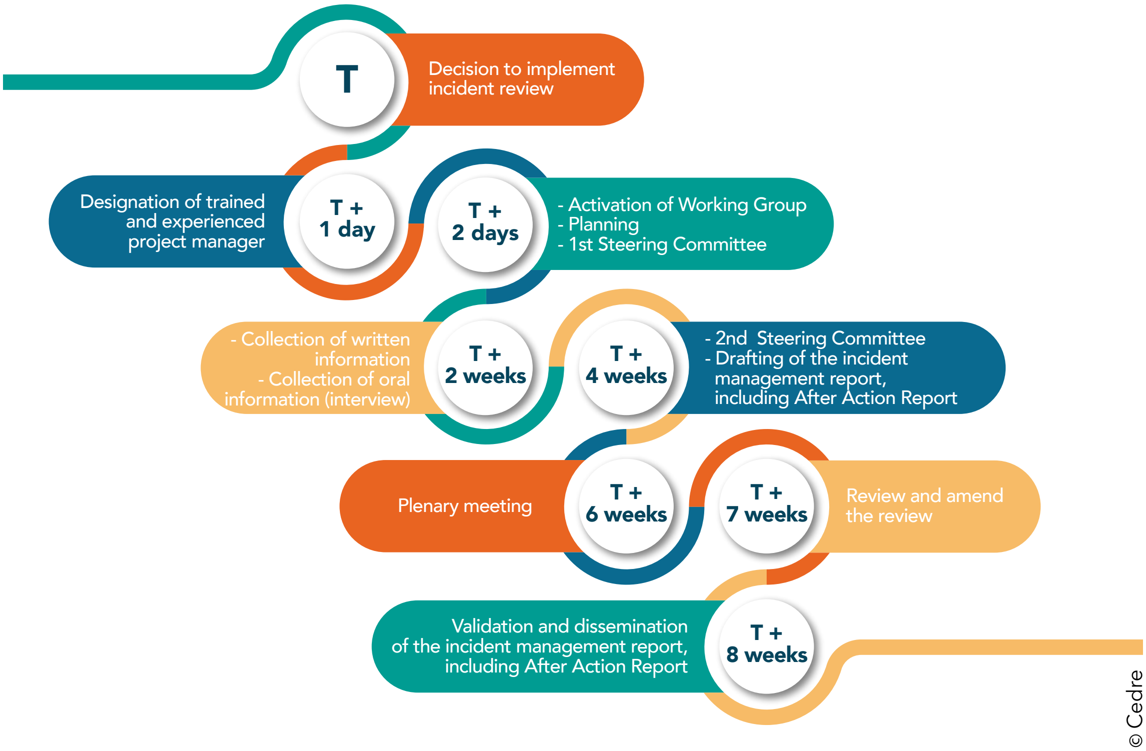


Figure 38: Main steps to conduct the incident review process

Ideally, this process is led by a project manager (usually the operations manager and/or an external moderator), if possible experienced in the field of incident management. Their role is to:

- ensure proper feedback from the incident and the related documentary monitoring;
- maintain a network of correspondents, sources of feedback information;
- identify, according to the local context, the structures that should participate or would bring added value to the feedback;
- improve the procedures or channels for collecting feedback;
- ensure training is provided to those in charge of gathering feedback;
- choose a trained person to question incident management personnel.

The aim of the process is to produce a management-approved action plan to resolve the issues raised in the lessons learned portion of the critique.

The After Action Report fulfils the needs of the following critical functions:

- source of documentation for response activities;
- identification of failures and successes during emergency operations;
- analysis of the effectiveness of the participating components;
- description and definition of lessons learned;
- provision of a plan of action for implementing prevention, improvements and closing gaps;
- recommendations to be implemented in the contingency plan.

7 CASE STUDIES

Case studies are of high importance as they can be useful for decision-makers to find out which strategies, tactics or techniques were useful and efficient, and which ones were not, for similar cases or in similar conditions. Some databases exist and are regularly updated and the MIDSIS-TROCS tool also contains summarised information on past incidents for many chemicals.

As examples, the following case studies are presented in this manual for different types of transport or behaviour:

Type of transport/behaviour	Name of incident
Bulk/Evaporator	*7.1 Bow Eagle*
Bulk/Dissolver	*7.2 Ece*
Bulk/Floater	*7.3 Aleyna Mercan*
Bulk/Sinker	*7.4 Eurocargo Venezia*
Packaged goods/-	*7.5 MSC Flaminia*