



**RESPONSE GUIDANCE TO
SPILL OF HAZARDOUS AND
NOXIOUS SUBSTANCES
(HNS) AT SEA**

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Chapter-1: Fate and Behaviour of HNS

1.1. The foremost step to an HNS incident is to prevent its release. If released, due to insufficient time to react; safety, environmental and socioeconomic impact need to be determined that will relate to chemical and physical properties of the material. It depends on substances flammable, reactive, toxic, explosive and corrosive potential. It is the physical fate, once released into wider environment that will determine, if these properties will have an impact depending upon its physical properties of volatility, density and solubility. Decision on first action will be governed by the potential hazards of the chemicals spilled. However, if timespan to response increases which in turn depends on hazards associated with the chemicals, the longer-term response strategy shall be governed by the chemical's behaviour.

1.2. Classification of HNS

1.2.1. **HNS are classified into five different categories depending on their physical and chemical properties, gases (G), evaporators (E), dissolvers (D), floaters (F) and sinkers (S).** As per Standard European Behaviour Classification (SEBC) they are divided into following 12 groups¹:-

Notation	Property Group	Properties
G	Gas	Evaporate immediately
GD	Gas/Dissolver	Evaporate immediately, dissolve
E	Evaporator	Evaporate Rapidly
ED	Evaporator/Dissolver	Evaporate Rapidly, dissolve
FE	Floater/Evaporator	Float, evaporate
FED	Floater/Evaporator/Dissolver	Float, evaporate, dissolve
F	Floater	Float
FD	Float/Dissolver	Float, dissolve
DE	Dissolver/Evaporator	Dissolve, evaporate
D	Dissolver	Dissolve
SD	Sinker/dissolver	Sink, dissolve

¹ Pg 5, ITOFF TIP 17, Response to Chemical Incidents

S	Sinker	Sink
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Table 1: The Standard European Behaviour Classification (SEBC) System for Chemicals

1.2.2. But substances might show several behavioural phases throughout a spill depending on the characteristics of products and their exposure to environmental processes. The physical and chemical properties are predicted in the Safety Data Sheets (SDS) for standard temperature about 20 deg C. However, atmospheric temperature at any given place will affect the values of these properties.

1.3. Predicting Drift and Spread of Chemicals

1.3.1. The drift and spread of chemicals must be predicted as soon as possible in the marine environment in order to develop risk analysis for the spill. The estimation will depend on the physical properties of the HNS spilled as well as the weather conditions in area eg temperature, pressure, current/tidal conditions etc. There are various prediction models present, but those may mislead or provide erroneous picture if unable to account for spilled HNS physical properties. Forecasting the Gas Clouds is not easy to predict due to the peculiar properties of different HNS and therefore assumptions shall be considered with the reservations. It is complicated to forecast the behaviour of a chemical spill that floats on the water surface. The spill's fate is generally influenced by drift and spread on the surface, evaporation, dissolution, chemical reactions and other similar processes of conversion. Similarly, it is difficult to calculate the fate of spill that sinks to bottom. The density of the chemical affects the velocity by which the chemical sinks to bottom. The surface tension and solubility of the chemical influence its behaviour on water surface as well as dispersion and spread in water body during sinking to water bed. The underwater current along with chemical density and water depth will decide for how long distance will chemically move in direction of current prior settling at bottom. The chemical may also penetrate into sediment which will depend on sediment's properties and structure.

1.4. Fate and Behaviour of HNS when spilled at Sea

1.4.1. Key physical properties to assess the fate and behaviour of chemicals are as given under the table 2².

Property	Description
Density	Density, ρ , (substance)= mass/volume. Gives an indication of

² Pg 6, ITOFF TIP 17, Response to Chemical Incidents

Property	Description
	the likelihood that a substance will float or sink (average density of sea water: $\rho = 1.025 \text{ g/cm}^3$). ρ (benzene) = 0.88 g/cm^3 , floats. ρ (solid phosphoric acid) = 1.864 g/cm^3 , sinks.
Specific Gravity	Specific Gravity = ρ (substance)/ ρ (water) is a non-dimensional parameter i.e. does not have units. In fresh water also relative density.
Solubility	The ability of a solid, liquid or gas to dissolve in a liquid (usually given for fresh water). In sea water: s (benzene)=0.07%, slightly soluble; s (phosphoric acid)=100%, miscible.
Vapour pressure	Describes the likelihood that a substance will evaporate to form a vapour. The higher the vapour pressure, the more a substance tends to evaporate (Slow evaporator $VP > 300 \text{ Pa}$, fast evaporator $VP > 3 \text{ kPa}$), VP (ethylene glycol)= 500 Pa ; VP (ethanol)= 5 kPa ; VP (propane)= 2.2 MPa .
Vapour Density	Relative weight of a gas or vapour compared to air, which has an arbitrary value of one. If a gas has a vapour density of less than one it will generally rise in air. if the vapour density is greater than one, the gas will generally sink in air. The property is based on molecular weights. Molecular weight of air= 29 atomic mass units (AMU). Hydrogen = 2 AMU and thus a vapour density of $2/29=0.068$, rises. Hexane= 84 AMU; vapour density = $84/29=2.9$, sinks.
Flash Point	The flash point of a volatile material is the lowest temperature at which it can vaporise to form a mixture in that will ignite when exposed to an ignition source. Flash Point T (phenol)= 79°C , Flash Point T (benzene)=- 11.1°C ,
Lower Explosive Limit (LEL)	The lowest concentration (percentage) of a gas or a vapour in air capable of igniting in the presence of an ignition source. At a concentration in air below the LEL, insufficient fuel is available to burn and the air/fuel mixture is 'too lean'. Also expressed as lower flammable limit (LFL). LEL (benzene)= 1.2% by volume of air ($12,000 \text{ ppm}$), LEL (methane(CH_4)) at 20°C = 5.1% .
Upper Explosive Limit (UEL)	Highest concentration (percentage) of a gas or a vapour in air capable of igniting in the presence of an ignition source. Concentrations higher than the UEL are 'too rich' to burn, also expressed as upper flammable limit (UFL). UEL (benzene)= 7.8% by volume of air ($78,000 \text{ ppm}$).
Flammable Range	The concentration range between the upper and lower flammable limits.
Auto-	Minimum temperature at which a chemical ignites when no

Property	Description
Ignition Temperature	ignition source is present. Auto-Ignition T(benzene)= 538 ⁰ C.
Boiling Point	Boiling Point T(propane)= -42 ⁰ C, T (ammonia)= -33 ⁰ C, T(sulphuric acid)= -337 ⁰ C, T

Table 2: Key physical properties to assess the fate and behaviour of chemicals

1.4.2. **Hazard** is an important element that needs to be considered apart from physical and chemical behaviour of HNS spilled. **Hazard may be defined as something that may harm human beings and environment.** Explosivity, flammability and toxicity are considered as potential hazards and assessment of risk may be undertaken to understand effect on human health, marine ecosystem and other resources.

1.4.3. **Explosivity.** In accordance with UN Model Regulations, an explosive substance is '*A solid or liquid substance or 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.*' An explosion is a reaction that produces gas at an accelerated rate in short span of time. It may be in form of detonation or deflagration. In confined environment like liquid tankers, deflagration explosives build up pressure, leading to detonation. The energy thus produced during such release is phenomenal in the form of shockwave and therefore may lead to significant damage.

1.4.4. **Flammability.** The flammability of substance can be defined as ease with which a combustible substance can be ignited causing fire or explosion. Flammability is generally defined by flash point, auto ignition temperature and lower/upper flammable limit. Fire triangle plays a dominant role in flammability with three components in action viz combustion source, ignition source and flammable source. Hence, fire can be prevented by removing one of the sources from scene of fire.

1.4.5. **Oxidation.** Oxidising materials have capability to decompose and release oxygen. In case of fire, they can cause fire to expand by providing oxygen. These oxidising materials may cause combustible material to ignite without presence of any source of ignition. Oxidising substances and organic peroxides are defined under UN Model Regulations.

1.4.6. **Corrosion.** Corrosive material is highly reactive substance that cause damage to another material by chemical reaction. This process may take instantaneously or progress slowly. Corrosion may cause death, severe tissue damage to living organism and may become irritant at low concentrations.

Corrosion is indicated by pH value of any substance. Pure water has pH value of 7, it's neither acidic nor basic. Any substance with pH value < 2 or > 11 are termed as skin corrosive by GHS. UN Model Regulations under Class 8 define Corrosive substances, both 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*".

1.4.7. **Types of Hazards & Effects.** Types of hazards and its effect can be classified as given below:-

(a) **Ecotoxicity.** Toxicity is defined as degree to which harm a substance can harm cell, organ or whole organism. Toxicological data is described as dose descriptors in terms of mg/l or ppm indicating no-effect threshold for human health or environment. Toxicity is measured from no effect concentration to the effective or lethal concentration also known as EC50 or LC50 test. It is also assessed for a substance with respect to short term to long term toxicity, also termed as chronic and acute toxicity. Toxicity generally implies to individual organisms but ecotoxicity is a combination of ecology and toxicity. It addresses potential for a substance to affect community of organisms or an entire ecosystem.

(b) **Bioaccumulation.** It is the increase in concentration of contaminants via environmental medium. The bioaccumulation potential of substance depends on affinity for water, lower the affinity, higher the bioaccumulation potential. The data on bioaccumulation is available in the SDS.

(c) **Degradation.** Degradation is ability of substance to degrade in the environment through chemical, physical or biological processes. Degradation data is generally not available in the marine environment. It is therefore not available in SDS. The biodegradation data is provided in terms of half-life which means time taken for an amount of substance to be reduced by half through degradation.

Chapter-2: Occupational Health and Safety Related to HNS

2.1. Hazard

2.1.1. 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 marine environment whereas a risk is the probability to be harmed if exposed to the hazard. There are two main guidance documents governing and harmonizing all communication or substances hazards, which are:-

(a) 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.

(b) The "**UN Purple Book**" or "Globally Harmonised System of Classification and Labelling of Chemicals (GHS)" (UNECE, 2019), which defines physical, health and environmental hazards of chemicals, harmonises classification criteria and standardizes the content and format of chemical labels and Safety Data Sheets.

2.2. Type of Hazards

2.2.1. It is important to understand the hazards related to HNS Cargo which will have a bearing on the occupational safety and health, associated with HNS handling / spillage. **The IMDG Code** has divided the dangerous goods into the various classes based on United Nations classes. The same can be categorised as follows: -

(a) **Class 1 Explosives**. In accordance with 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. In the field of maritime emergency response, it is also important to understand the concept of a "Boiling Liquid Expanding Vapour Explosion (BLEVE)" especially in cases involving liquefied gas tankers. When a tank containing pressurized liquid on board a ship is heated and if the liquid's temperature exceeds its boiling point and the pressure relief valve's (a mandatory requirement of the IGC Code, which can temporarily reduce the overpressure in the tank) capacity is exceeded, the tank may not be

able to contain the pressure which can lead to mechanical failure leading to explosion. 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. As per the UN Class 1 Categorisation, the explosive category of cargo are further subdivided into following six subcategories:-

- (i) Division 1.1 - Substances and articles which have a mass explosion hazard.
- (ii) Division 1.2 - Substances and articles which have a projection hazard but not a mass explosion hazard.
- (iii) Division 1.3 - Substances and articles which have a Fire Hazard and either a minor blast and or minor projection hazard.
- (iv) Division 1.4 - Substances and articles which present no significant hazard.
- (v) Division 1.5 - Very Insensitive which have a mass explosion hazard.
- (vi) Division 1.6 - Extremely Insensitive article which do not have a mass explosion hazard.

(b) **Flammability.** The flammability of a substance can be defined as the ease with which a combustible substance can be ignited causing fire or explosion. Flammability is generally defined by:-

- (i) **Flash Point.** It 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.
- (ii) **Auto Ignition Temperature.** It 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.
- (iii) **Lower / Upper Flammable / Explosive Limit (UFL / UEL / LFL/LEL).** It marks 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, wherein

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.

(c) As per the UN Model Regulations, the flammable category of cargo falls under **Class 2 and 3** which are further subdivided into following three sub-categories:-

(i) **UN Class 2.1.** Flammable gases at a standard pressure 101.3 kPa at 20⁰C.

(ii) **UN Class 3.** Flammable liquids with a flash point of not more than 60⁰C.

(iii) **UN Class 4.1.** Flammable solids, which are readily combustible or may cause or contribute to fire through friction.

(d) **Oxidation.** Oxidising materials have ability to decompose and release oxygen or an oxidising substance. In case of fire, they can cause fire to expand by providing oxygen. These oxidising materials may also cause a combustible material to ignite without presence of any source of ignition. The UN Model Regulations define the following two classes of cargo which can be prone to oxidation :-

(i) **UN Class 5.1.** Oxidising substances which include "substances which while not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material".

(ii) **UN Class 5.2.** Organic peroxides, which 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) **Corrosion.** A corrosive material is a highly reactive substance that cause damage to or destroys another material by chemical reaction. This deterioration process might be almost instantaneous or slow progressing. Corrosive substances can cause death or severe tissue damage to living organisms. A corrosive substance might be called an irritant at low concentrations. Corrosion is indicated by pH value of any substance, which specifies how acidic or basic a solution.

Any substance with pH value < 2 or > 11 are termed as skin corrosive by GHS. UN Model Regulations specify corrosive substances under Class 8, which defines corrosive substances (both liquids and solids), as 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". The effect of corrosive substances on human health includes:-

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

(f) **Reactivity.** In addition to a substance's individual fate, behaviour and hazards, responders need to consider its reactivity to water, air, other products, and / or itself potentially producing heat and or flammable / explosive gases. Reactive substances can be gaseous, liquid or solid. They do not belong to a homogenous 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 substance reactivity and the related risk of explosion / fire are often challenging to predict which increases the difficulties associated with any response operations. The UN Model Regulations categorise the reactive cargo into following three categories:-

- (i) **UN Class 4.1.** Flammable solids / self-reactive substances which are readily combustible substances or may cause or contribute to fire through friction.
- (ii) **UN Class 4.2.** Spontaneously combustible solids which are either pyro-phosphoric 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.

(iii) **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.

2.2.2. **Hazard for Environment (Ecotoxicity).** There are several parameters which determine whether a substance is considered hazardous to the marine environment, which include: -

(a) **Toxicity.** Toxicity is defined as the degree to which a substance can harm cell, an organ or a whole organism. Toxicological data are described as dose descriptors in terms of mg/l or ppm indicating no-effect threshold for human health or environment. They are divided into following categories: -

(i) **No Observed Effect Concentration (NOEC).** Concentration below which an unacceptable effect is unlikely to be observed.

(ii) **Lowest Observed Effect Concentration (LOEC).** Lowest tested concentration at which no effects are observed.

(iii) **Median Effective Concentration (EC₅₀).** Concentration of a substance expected to produce a certain effect in 50% of test organisms.

(iv) **Median Lethal Concentration (LC₅₀).** Concentration of a substance at which 50% of the test species are expected to die.

(v) **Acute Toxicity.** It 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. The higher the LC₅₀ or EC₅₀ of a given chemical, the lower the acute toxicity.

(vi) **Chronic Toxicity.** It 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.

(b) **Bioaccumulation.** It is the increase in contaminant concentrations in organisms following uptake from the environmental medium. The bioaccumulation potential of substance depends on affinity for water, lower the affinity, higher the bioaccumulation potential. The data on bioaccumulation is available in the SDS.

(c) **Degradability**. It refers to the potential for a substance to degrade in the environment through chemical, physical or biological processes. Degradability data is sparse, especially for marine environments, hence, it is not always included in SDSs. The degradability data is provided in terms of half-life which means time taken for an amount of substance to be reduced by half through degradation.

(d) **Persistence**. It refers to the resistance of a chemical to degradation. As such the persistence cannot be measured directly and only the continued measurable presence of a certain chemical in the environment or the systematic resistance to degradation can suggest its persistence.

2.2.3. **Hazard for Human Health**. 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 (PAC) for chemical dataset, are used to evaluate the severity of the event, to identify potential outcomes and to decide what protective actions should be taken. The threshold stands are:-

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

2.2.4. The Threshold Limit Value (TLV) 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:-

- (a) Time Weighted Average (TLV-TWA) for daily life-time exposure.
- (b) Short-Term Exposure Limit (TLV-STEL) for maximum exposure during a 15minutes period.
- (c) Ceiling (TLV-C) for maximum exposure at any given time.

2.2.5. To predict the severity of chemical exposure in humans, emergency response planners and responders are to 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:-

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

2.2.6. As per UN Model Regulations, the toxic hazard for human health is categorised as:-

- (a) **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 5000 ml/m³ (ppm).
- (b) **UN Class 6.1**. Toxic substances are liable to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact.

2.3. Details in IMDG Code

2.3.1. Chapter 3.2 of Volume-2 of International Maritime Dangerous Goods (IMDG) Code, as amended from time to time, published by IMO provides details **of properties and observations of different dangerous goods transported over sea** and so of HNS. Hence, the same may be referred in the event of HNS spill at sea.

2.4. Categorisation of Noxious Substances

2.4.1. As per regulation 6 of Annex II of MARPOL, noxious substances are categorized into following categories³:-

- (a) **Category X**. Noxious liquid substances which, if discharged into sea from tank cleaning or deballasting operations, are deemed to

³ Pg 175, Annexe II, Reg 6 Ch 2 of MARPOL

present a major hazard to either marine resources or human health and, therefore, justify the prohibition of the discharge into the marine environment.

(b) **Category Y.** Noxious liquid substances which, if discharged into sea from tank cleaning or de-ballasting operations, are deemed to present a major hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of sea and, therefore, justify a limitation on the quality and quantity of the discharge into the marine environment.

(c) **Category Z.** Noxious liquid substances which, if discharged into sea from tank cleaning or de-ballasting operations, are deemed to present a minor hazard to either marine resources or human health and, therefore, justify less stringent restrictions on the quantity or quality of the discharge into the marine environment.

(d) **Other Substances.** Substances indicated as OS (Other Substances) in the pollution category column of the International Bulk Chemical Code which have been evaluated and found fall outside category X,Y or Z as defined in regulation 6.1 of Annex II of MARPOL because they are, at present considered to present no harm to marine resources, human health, amenities or other legitimate uses of sea from tank cleaning or deballasting operations. The discharge or bilge or ballast water or other residues or mixtures containing only substances referred to as Other Substances shall not be subject to any requirements of Annex II of MARPOL.

2.5. Symbology of Various HNS

2.5.1. Symbology of HNS substance is placed at **Appendix.**

Chapter-3: Analysis and Monitoring

3.1. Analysis

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

3.1.2. Situation assessment / analysis is required for any intervention. Depending on the size and conditions of the incident, the risk assessment may be different. The following aspects may broadly be considered towards this:-

(a) For a small leakage, proficient personnel trained in chemical hazards can assess the situation and on the basis of procedures indicated in the emergency plan, can implement first measures to stop or mitigate the HNS release.

(b) For more complex situations involving HNS, such as a large spill, a high potential impact, a high level of hazard, difficult salvage or response operations, a more robust assessment of the situation is required before response implementation. In this case, the situation assessment is performed according to the planning section of the structural organization.

(c) Three main steps in the situation analysis / assessment include:-

(i) **Hazard Identification**

(aa) Physical hazards of HNS – danger, class(es), sub class(es) of danger.

(ab) Toxicological levels.

(ac) Hazards related to the vessel.

(ad) Environmental conditions.

(ae) Hazards of the HNS cargo on environment – Ecotoxicological effects.

(af) Hazards for areas or entities (shore areas, aquaculture, water intakes, tourism etc.)

(ii) **Estimation of Risk and Vulnerability**

(aa) Probability of population being exposed to HNS.

(ab) Probability of the pollutant reaching environmentally sensitive areas.

(ac) Probability of the pollutant to reaching socio-economically sensitive areas.

(iii) **Evaluation of Consequences**

(aa) Number of proven or potentially injured people.

(ab) Health impact on population, responders.

(ac) Proven air potential impacts on the environment.

(ad) Losses (proven or potential), costs, loss of activity etc.

3.2. Incident Data Gathering

3.2.1. Situation assessment is required for any intervention. During an HNS incident, it is crucial to obtain verified details about the spilled substance's correct name and its properties. It is essential that the following information be obtained as soon as possible in order to assess the situation:-

(a) **Basic Information**

(i) Details of vessel.

(ii) Date and time of incident (LT/UTC).

(iii) Position (Latitude / Longitude).

(iv) Number of crew (including health status).

- (v) Cause of the incident.
- (vi) Nature of damage.
- (vii) Status of vessel and response operations as well as actions taken so far.
- (viii) Cargo on board and description of pollution or dangerous cargo lost overboard / spilled.

(b) **About Cargo**

- (i) Cargo Certificate / Shipper's Declaration / Dangerous Goods Declaration, SDS.
- (ii) UN or CAS Number, State of Chemicals – solid, liquid, gas, bulk or packaged.
- (iii) Manufacturer's contact details which might be needed to obtain the most recent and up-to-date SDS (or other substance – specific information).

(c) **About Bunkers**

- (i) Bunkering Certificate.
- (ii) Main characteristics – density, viscosity, pour point, distillation characteristics, wax & asphaltene content and volume.
- (iii) Distribution of cargo / bunkers / location relative to damage using the ship's General Arrangement Plan.

(d) **Pollution Observation Report.** Pollution observation – pollution incident report by the vessel, pollution observation report by authorities / general public.

(e) Source for each key piece of information for each vessel type is as follows:-

Key Information	Containment Cargo	Tanker	Bulk Carrier
Exact Cargo Name	Bill of Lading		

Key Information	Containment Cargo	Tanker	Bulk Carrier
Exact Cargo Properties	Safety Data Sheet		
Summary	Dangerous Goods Declaration/Cargo Manifest	Cargo Certificate/Cargo of Origin	Shipper's Declaration
Location onboard	Stowage Plan	Tank Arrangement Plan	Cargo stowage plan

Table 3: Piece of Information of Vessels

3.2.2. The first information gathered, followed by the results of measurements and analyses, as well as the predictions made by modelling dictate the emergency measures to be taken and the response techniques to be deployed. Three possible scenarios exist in terms of response: -

- (a) Response is impossible because the window of opportunity is too small. For example, in case of the sudden complete disintegration of a ship.
- (b) Response is too risky because the substance is too reactive or because no information is available on the substance(s) involved.
- (c) Response is possible because the risk is known, measured or even controlled.

3.2.3. The choice of response strategy is essentially dictated by the following three criteria for which the thorough analysis / assessment of the scenario is to be undertaken: -

- (a) The accident area (offshore, inshore, port area).
- (b) The location of the product (in the vessel or released).
- (c) The behaviour of the product spilt (Gas, Evaporator, Floater, Dissolver, Sinker).

3.3. Monitoring

3.3.1. It is important to monitor the pollution in order to track changes to the situation and adjust the response strategy if the initial approach proves to be ineffective or inappropriate. The transfer of information to response coordinators is a key stage. Assessment of the extent and severity of impacted environmental compartments is based on three main components of monitoring methods. These monitoring systems are complementary and might all need to be considered during a response. These are:-

- (a) Modelling.
- (b) Remote Sensing.
- (c) Measurements and analysis.

3.3.2. **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. 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.

3.3.3. **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 miniaturized 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.

3.3.4. **Measurements and Analysis**. 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.

(a) **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.

(b) **Laboratory Analysis.** Sampling for future laboratory analysis may be required or desired for a variety of reasons, some of which are listed below: -

(i) 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).

(ii) The chain of custody for liability investigations might require specific procedures excluding in situ analysis.

(iii) The chemical of interest is unknown.

3.3.5. The objectives of monitoring 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. 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, which include: -

(a) Establish a plan for documentation of the work and introduce a chain of custody.

(b) Make arrangements for appropriate monitoring if health risks are liable to occur.

(c) 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.

- (d) Judge whether special examinations of the spill are needed to facilitate spill response measures.
- (e) Judge if short-term and/or long-term environmental impact may be expected. If so, contact the appropriate agencies.
- (f) Judge whether special examinations and analyses are needed when providing for general and specific needs for information.
- (g) Contact responsible bodies for transport and disposal. Check what special information is needed in this context and make arrangements for relevant analyses.

3.3.6. **Where should Monitoring be Performed?** 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 needs to 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.

3.3.7. **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 and what must be monitored with the type of detection device. The target product should be the 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. 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:-

- (a) Comparison of post-incident data with pre-incident data.
- (b) Comparison of data from impacted sites with data from reference sites.
- (c) Analysis of post-incident data monitored over a period of time to describe the recovery process.

3.3.8. 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.

Chapter-4: Modeling Tools

4.1. Modelling

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

4.2. Predicting the Fate of Pollutants

4.2.1. Fate models predict how a pollutant changes both physically and chemically when released into the environment. Such models are used as a tool to help understand the expected characteristics and behaviour of a pollutant and prepare for an efficient response. Although fate models can be stand-alone, they are usually built within a trajectory model, as physical and chemical changes can alter a pollutant's behaviour and subsequently, its trajectory. Fate models require detailed specifications of the pollutant, such as physical and chemical properties, along with environmental data, such as temperature and wind speed.

4.3. Predicting a Pollutant Trajectory in Water

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

4.4. Predicting A Pollutant Trajectory in the Air

4.4.1. Trajectories of hazardous gas clouds that are a result of an HNS incident can be modelled using an atmospheric dispersion model. Generally, these models can estimate how quickly the chemical will be released into the

atmosphere and how it will travel downwind. Along with the pollutants' physical and chemical properties, the models require environmental data, relating to wind and temperature. The model results can then be used as an indication of where there may be significant threat to human life.

4.5. Analysing Response Methods

4.5.1. Models can also be used to analyse different response methods. They are used only as a guide to help manage resources, which is particularly useful in the case of a large incident with limited resources. Fate models are usually used in conjunction with response models as the pollutant may change physically and chemically over time, resulting in different possible recovery totals. However, they can also be combined with trajectory models, allowing for an overall prediction of how the incident will evolve and be managed.

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

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

4.6. Models Available

4.6.1. Specialist training to learn to use models for an HNS incident and understand their limitations is advised. Alternatively, many modelling providers or developers can carry out the modelling themselves and provide an explanation of the results, through contract based work. Usually, modelling providers will also have access to the environmental data needed for the model, such as wind speed and direction, sea temperatures, wave heights, in addition to chemical and SDS databases. The table below lists some, but by

no means all, models that have been created for use in an HNS incident. Oil spill models have been added since they might be suitable to predict the fate and behaviour of substances such as vegetable oils.

Model	Developer/provider	Capability
AIRMAP	RPS ASA	Chemical air trajectory and fate
ALOHA (open source)	NOAA	Chemical air trajectory and fate
CALPUFF	TetraTech	Chemical fate
CHEMMAP	RPS ASA	Chemical air and sea trajectory and fate
MOHID Water	MOHID	3D at-sea and air chemical trajectory
MOTHY	Meteo-France	2D at-sea oil and floating objects (such as containers) trajectory
OpenDrift/OpenOil (open source)	MET Norway	Chemical/objects at sea and air trajectory and fate

Table 4: Modelling Tools Available for Prediction of HNS Trajectory

4.7. Monitoring of Gas Clouds

4.7.1. Modelling of gas cloud in air would require chemical and physical parameters of the substance, weather condition and forecast, type of spill source. Monitoring can be achieved using remote measuring instruments and search techniques. Aerial surveillance through aircraft cannot be applied in case of explosive or unknown gas. Drones offer a good alternate. Markers can be employed.

Chapter-5: Hazardous and Noxious Substances Response Guidance

5.1. General

5.1.1. 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, such as:-

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

5.2. Guidance for Responders

5.2.1. This chapter 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 the responders. Chronologically the following phases can be identified:-

(a) **Incident Notification**. Reporting of incident by observers such as casualty's captain, pollution observation systems, general public etc. 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. Notification of an incident involving HNS can be received via:-

- (i) Ship Reporting System produced by the Captain of the casualty or a responding or passing vessel.

(ii) Pollution Report (POLREP) by a Coastal State as part of their intergovernmental pollution notification system.

(iii) Pollution observation report/detection log produced by a trained aerial observer.

(iv) Automated spill response notifications (satellite-based surveillance).

(v) Unofficial written/verbal reports from members of the general public (report of visually observed pollution in port for example).

(b) **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. 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. 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. There are two types of data that can be collected: -

(i) **Information Specific to the Incident**. 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. 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. 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.

(ii) **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 HNS contingency plans. Should include information on resource directory covering human health and safety issues and environmental resources (Environmental Sensitivity Index maps) and 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. Modelling results can add valuable information to the decision-making process with regard to first actions and emergency response measures. 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.

(d) **Decision Making.**

(i) 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 (IAP). 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. However, every incident is unique and the Incident Management Team (IMT) 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.

(ii) The IMT must be capable of making reasonable decisions, tailored to the situation and the extent of the pollution. Information obtained through notification and data gathering can be crucial to support the 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. 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).

(iii) 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. 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.

(iv) 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. 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, Measurable, Action Oriented, Realistic, Timely).

(v) Selection of strategies to eliminate or reduce the pollution (or threat thereof) based on:-

(aa) **Hazards.** Evaluation of hazards deriving from the released substances.

- (ab) **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.
- (ac) **Modelling.** To predict the trajectory, fate and behaviour of spilled pollutants. 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.
- (e) **First Actions.** Usually, initial emergency measures are taken by responders and crew of involved ship(s). 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.
- (f) **On-Scene Response.** Once response strategy is established, multiple actions may be conducted in terms of:-
- (i) **Protection.** Identification of the necessary PPE. 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 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. Every time PPE is used, the subsequent decontamination phase, as well as waste management, should be considered. 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 PPE 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.
- (ii) **Monitoring.** Depending on the characteristics of the accident, different types of monitoring could be carried out, which includes by remote detection (wherever possible), use of portable

detectors, and sampling of water, sediment and biota for laboratory analyses. Assessment of the extent and severity of impacted environmental compartments is based on three main components of monitoring methods. 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.

(iii) **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. 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. If intervention is considered feasible, response techniques could be divided in two categories:-

(aa) **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. Direct interventions on the vessel such as emergency boarding, emergency towing, place of refuge, cargo transfer, sealing and plugging, Wreck response etc.

(ab) **Pollutant Oriented Actions**. Operations to contain, treat and/or recover pollutants on the vessel or in the environment including using water curtains, using foam, using sorbents, HNS response in the water column,

HNS response on the seabed, HNS response on the shore, use of Containment techniques like Booms, Recovery techniques like pumps and skimmers etc. 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. 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. 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.

(iv) **Post Spill Management.** The following must be taken into consideration: -

(aa) **Documentation and Record Keeping.** These aspects are important from the very beginning of the response and become crucial during the claims process.

(ab) **Post-Spill Monitoring.** Necessary to assess environmental damage and decide upon measures for environmental restoration and recovery. Post-spill monitoring is a very useful activity, in order to evaluate the environmental consequences of an HNS spill, 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.

(ac) **Incident Review and Lessons Learnt.** Identify strengths and weaknesses of the response and implement changes to the contingency plan, if required. The main objectives of incident review are to, draw lessons that are primarily of benefit to local stakeholders, to keep track of events, to identify avenues for progress and to strengthening communication and co-ordination between different stakeholders during the response.

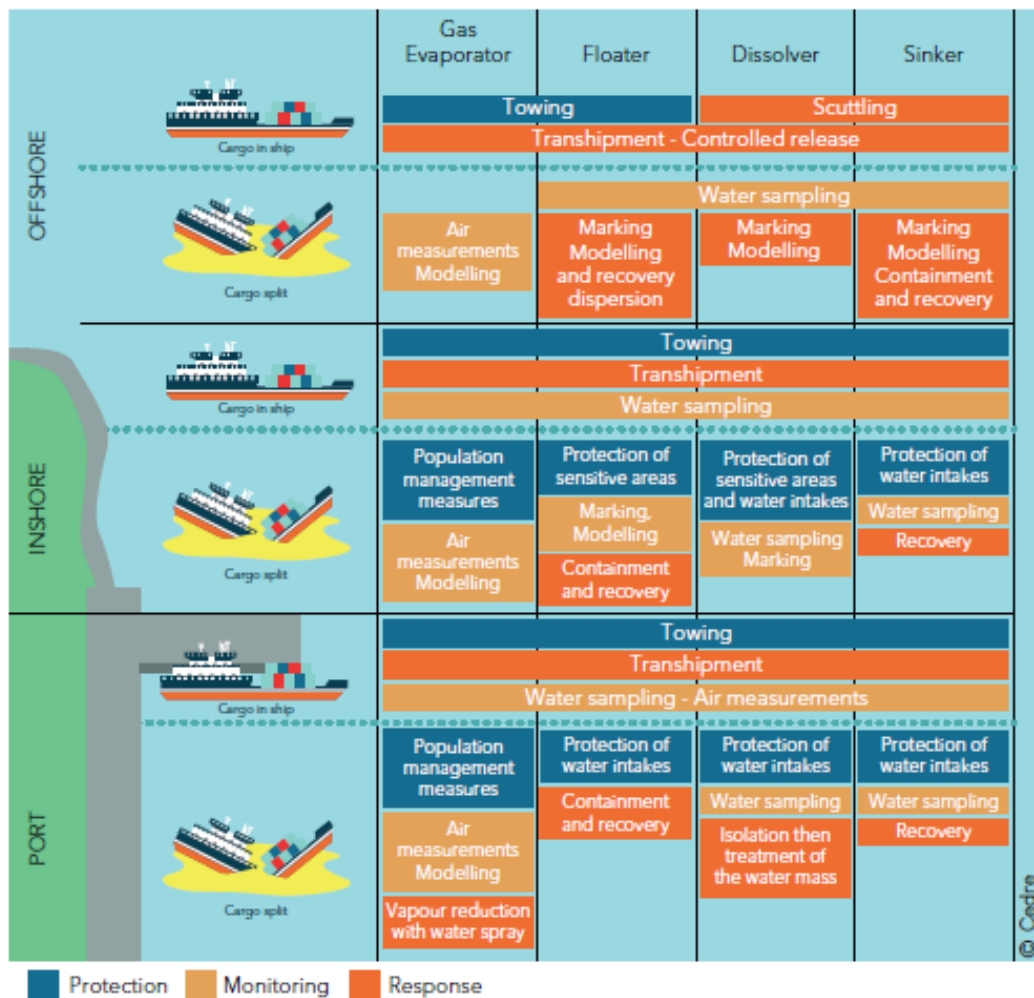


Figure 1: Decision Support Spills of Bulk HNS Cargoes Depending on their main behaviour and Location of Incident (Source pg 48, Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC)

5.3. Response Considerations to Flammable and Explosives

5.3.1. Response considerations against various HNS are brought out in the subsequent paragraphs.

5.3.2. The related GHS and UN pictogram are given in figure below: -



Figure 2: GHS and UN Pictogram of Flammable and Explosives (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 125)

5.3.3. Applicability and main risks are involved in a spill of HNS which are flammable and explosives are as given in the table given below⁴: -

Applicability	Risk for Humans / responders	Risk for Environment	Risk for Amenities
<ul style="list-style-type: none"> - Leakage of gas from a sealine (subsea pipeline) - Leakage of liquefied gas - Mixing of reactive chemicals forming gas - Evaporation from slicks - Gas cloud formed after reaction of chemicals 	<ul style="list-style-type: none"> - Direct injuries due to fire or explosion - Anoxia, asphyxia, especially in confined space - Depending on chemicals: toxicity or corrosivity 	<ul style="list-style-type: none"> - No major expected chronic impact expected - Possible indirect impact (e.g. fire residues) 	<ul style="list-style-type: none"> - Window-shattering explosion, - Building destruction

⁴Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 125

Table 5: Applicability and main risks are involved in a spill of HNS which are flammable and explosives (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 125)

5.3.4. **Risk Assessment.** The following steps may be followed for risk assessment⁵: -

- (a) Risks of flammability or explosion must be assessed by monitoring the LEL/LFL and UEL/UFL values and the evolution of concentrations over time. Portable gas detectors to be used by first responders. Sampling techniques may be used as discussed in this document.
- (b) Forecast of gas cloud must be requested from experts.
- (c) Consider area for intervention.
- (d) Consider (and control) aggravating factors:
 - in the event of fire, prevent the risk of BLEVE by cooling tanks in direct contact with heat radiation; risk of toxic gas production.

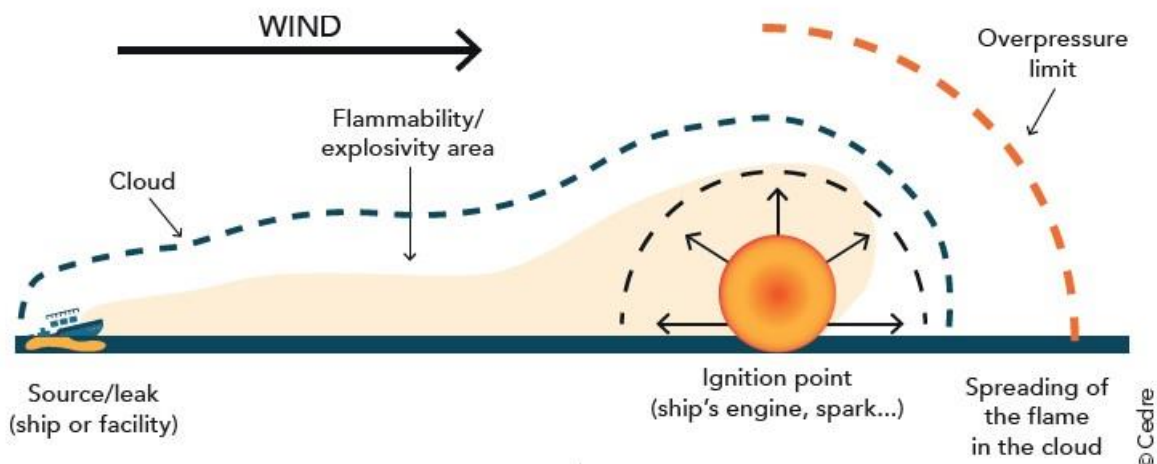


Figure 3: Risk Assessment (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 126)

5.3.5. **Protective Measures (Human, Health and Amenities)**⁶.

⁵Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 126

⁶Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 126

- (a) Evacuations has to be undertaken: -
 - (i) Rescue helicopter or vessels should approach downwind.
 - (ii) Modelling should be carried out to determine the specific areas to be evacuated or containment measures to be implemented.

- (b) Protective measures to be undertaken are: -
 - (i) Ventilation of the explosive atmosphere in order to lower the LEL/LFL.
 - (ii) Activation of the existing fire fighting systems.
 - (iii) Gas or vapour cloud should be prevented from entering confined or closed areas and obstacles must be removed (if possible) to reduce turbulence.
 - (iv) Protection of responders against inhalation of vapours or mist.
 - (v) PPE to be used are Type 1 Cat III(or level A).

- (c) Response measures should include: -
 - (i) Stopping leakage using sealing and plugging devices.
 - (ii) Response consideration of gases, evaporators and floaters are also to be considered depending on the type of spill.
 - (iii) Response techniques include establishment of safety zones, use of foam, use of water curtain or even natural attenuation and monitoring.

5.4. Response Considerations to Toxic Substances

5.4.1. **Alert Notifications**⁷. Depending on the location of the accident, the Maritime Rescue Coordination Centre (MRCC), and public emergency services must be alerted. Ships (crew) and the population downwind (vapour cloud) and downstream (spill) must also be warned in order to prevent complications arising.

⁷Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 128

5.4.2. The related GHS and UN pictogram are given in figure below: -



Figure 4: GHS and UN Pictogram Toxic Substances (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 128)

5.4.3. Applicability and main risks are involved in a spill of HNS which are toxic are as given in the table given below⁸: -

Applicability	Risk for Humans / responders	Risk for Environment
<ul style="list-style-type: none"> - Leakage of toxic gas from drum or tank - Leakage of toxic chemicals - Mixing of reactive chemicals forming gas - Evaporation from slicks - Gas cloud formed after reaction of chemicals 	<ul style="list-style-type: none"> - Injuries due to direct contact with substance (skin/mucosa contact, ingestion, inhalation) - Carcinogenetic issues 	<ul style="list-style-type: none"> - Direct impact on animals and the environment - Chronic impact - Possible indirect impact (e.g. extinguishing water, dissolver in water curtain)

Table 6: Applicability and main risks are involved in a spill of HNS which are toxic (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 128)

5.4.4. The following steps may be followed for risk assessment⁹: -

- (a) Assess the risks of atmospheric and marine toxicity by gathering data on the substances.

⁸Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 128

⁹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 129

- (b) Consider toxic exposure limits to assess the risk for the population;
Model the behaviour and movements of the toxic cloud.
- (c) Evaluate the environmental compartment(s) (atmosphere, water column...) liable to be impacted by the toxic substance or any by-products that may be formed in the scenarios.
- (d) Assess route of entry of the toxic substances (dermal contact, ingestion, inhalation...).
- (e) Consider (and control) aggravating factors:-
 - (i) Weather conditions: wind, current, temperature, rain and fog, atmospheric stability, etc.
 - (ii) Reactions between chemicals, reactions due to the increase in temperature, time of exposure.

5.4.5. **Protective Measures(Human, Health and Amenities)**¹⁰.

- (a) Protective measures must be tailored to the penetration process of the substance involved and its characteristics. Toxicity is not only related to airborne substances; the population and responders can also be affected through contact, ingestion, etc.
- (b) PPE to mitigate dermal risks and breathing apparatus self-contained compressed air should be worn.
- (c) Portable gas detectors are to be used by the first responders.
- (d) Evacuations has to be undertaken: -
 - (i) Rescue helicopter or vessels should approach downwind.
 - (ii) Modelling should be carried out to determine the specific areas to be evacuated or containment measures to be implemented.
- (d) Protective measures to be undertaken are: -

¹⁰Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 129 & 130

- (i) In the case of marine toxic substances, resources (e.g. fisheries, water intakes...) liable to be impacted should be assessed along with measures to protect them if required.
 - (ii) Additional contamination due to by-products resulting from the response to the incident must be avoided by containing and recovering these substances (residual water from water curtain techniques, extinguishing water...).
- (e) Response measures should include:-
- (i) The source of the leakage must be isolated if possible (tank or drum storage) to facilitate the response.
 - (ii) Protective Action Criteria should be used for intervention and to select proper PPE.
 - (iii) Depending on the substances behaviour response criteria for following may be adhered: -
 - (aa) Gases and evaporators.
 - (ab) Floaters.
 - (ac) Dissolvers.
 - (ad) Sinkers.
 - (iv) Techniques adopted may include: -
 - (aa) Using water curtains.
 - (ab) Using foam.
 - (ac) Natural attenuation and monitoring.

5.5. Response Considerations for to Corrosive Substances

5.5.1. The hazard pictogram of corrosive substance are as given below: -



Figure 5: Hazard Pictogram Corrosive Substances (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 131)

5.5.2. **Alert Notifications¹¹**. Depending on the location of the accident, the Maritime Rescue Coordination Centre (MRCC), and public emergency services must be alerted. Ships (crew) and the population downwind (vapour cloud) and downstream (spill) must also be warned in order to prevent complications arising.

5.5.3. Applicability and main risks are involved in a spill of HNS which are corrosive are as given in the table given below¹²: -

Applicability	Risk for Humans / responders	Risk for Environment	Risk for Amenities
<ul style="list-style-type: none"> - Leakage of corrosive liquid or gas from drum or tank - Mixing of reactive chemicals forming corrosive gas or compound - Evaporation from slicks 	<ul style="list-style-type: none"> - Injuries due to direct contact with substance (dermal necrosis, inhalation, ingestion) 	<ul style="list-style-type: none"> - Direct impact on animals and the environment - Acute and chronic impact - Possible indirect impact (e.g. extinguishing water, dissolver in water curtain) 	<ul style="list-style-type: none"> - Chemical corroding drums or tanks, leading to a pollution spill - Corrosion of metals (ship's deck, crane, etc.) (limitation/interference to with the legitimate uses of the sea/amenities)

Table 7: Applicability and main risks are involved in a spill of HNS which are corrosive (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 131)

5.5.4. The following steps may be followed for risk assessment¹³: -

¹¹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 131

¹²Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 131 & 132

¹³Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 132

- (a) Assessing the risks of atmospheric and marine toxicity by gathering data on the substances.
- (b) Assessing the risks of exposure to corrosive substances on the basis of its physical state and behaviour, monitoring pH if applicable.
- (c) Assessing associated hazards if present and evaluate the priority for response; corrosive substances are often associated with other hazards such as flammability and/ or explosivity and/or toxicity. Response considerations of Flammable and explosive substances, Toxic substances and Reactive substances may be considered.
- (d) Analysing weather data and detector measurements.
- (e) Modelling the behaviour and movements of the corrosive gas/vapours/fume clouds, if applicable. Consider modelling corrosive floater/dissolver/sinker if spilled in water column, if applicable.
- (f) Assessing measures to protect sensitive areas (environmental, ecological, social, industrial sites) and facilities, including through preventive shutdown, determining the hazards posed by any products that may be formed in the scenarios and assessing the associated hazard levels (smoke from fire, reaction with the environment, etc.); For which incident data gathering has to be undertaken.
- (g) Evaluating the location of facilities and equipment for quick response.
- (h) Evaluate/model the extent of the area affected by dangerous concentrations of corrosive substances in the water column and/or in the atmosphere to limit legitimate uses of the sea and amenities. Safety zones are to be established.
- (j) Aggravating factors to be considered are:-
 - (i) Reactions between acids and bases, reactions due to the increase in temperature, time of exposure; Possible highly exothermic reaction when certain acids or bases are spilled in water.
 - (ii) Maximum precautionary measures must be taken especially in the case of in situ response on the vessel (confined space).

(iii) High viscosity values slow down dilution and dispersion processes at sea.

5.5.5. Protective measures (human health, environment & amenities) As corrosive substances gather a large group of chemicals, protective measure must comply with the conclusions of the risk assessment¹⁴: -

(a) Corrosive liquids (mineral acids, alkali solutions and some oxidisers): eyes and skin are particularly vulnerable due to splashes of the substance and effects on tissues are generally very fast.

(b) Corrosive gases and vapours: effect is generally related to the solubility of the substances in the body fluids. Highly soluble gases like ammonia or hydrogen chloride cause severe nose and throat irritation, whereas lower solubility vapours (phosgene, sulphur dioxide, etc.) penetrate deep into the lungs.

(c) Corrosive solids: direct contact can cause burns to the skin (phenol, sodium hydroxide...) and dust affects the respiratory system. Many corrosive solids may produce highly exothermic reactions when dissolved in water.

(d) In case of a water-reactive product, the substance must be prevented from reaching the water surface and the spill must be contained (construct berms, sand dikes...).

(e) PPE to be used.

(f) Portable gas detectors to be used by first responders.

5.5.6. Onboard measures shall include¹⁵: -

(a) Attention should be paid to avoiding direct contact with the skin and protecting against inhalation of vapours or mists. Check atmosphere before entering a confined space; do not operate without Self Contained Breathing Apparatus (SCBA).

(b) PPE to be used.

(c) Portable gas detectors for first responders.

¹⁴Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 133

¹⁵Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 133

(d) Evacuation must be implemented immediately downwind (gas/evaporator/fumes).

(e) Attention should be paid to decontaminating protective clothing: wash down with water and then remove.

5.5.7. For population and amenities¹⁶: -

(a) Modelling will need to be conducted to determine the specific area to decide on the implementation of evacuation or shelter-in-place measures (in case of a corrosive cloud or marine environment contamination).

(b) Evacuation must be implemented in downwind impacted areas (in case of hazardous vapours, gas clouds, fumes).

(c) Zoning - downstream area of the spill (targets of polluted runoff, liquid and solid spills) and evaluate any limitations on the use of the sea and amenities.

5.5.8. **Response Measures Onboard**

(a) If possible, other chemicals or organic products must be isolated from the leaking substances until its reactive potential has been assessed.

(b) If the substance is not water-reactive, acids and bases may be neutralised by a dilution process in order to reduce the concentration (overboard washing with indirect water jets if possible). pH should be measured before discharging the diluted mixture in the environment.

(c) Using water curtains.

(d) Natural attenuation and monitoring water-reactive substances may be treated by compatible sorbent or inert materials.

(e) **Using sorbents**. In the case of an on board leak, appropriate containment and recovery methods and techniques according to the substances involved and scenarios should be used (Emergency Schedules (EmS), IMO, 2018).

¹⁶Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 134

5.5.9. In the Environment. Refer to the characteristics, behaviour and fate and of the spilled (or leaked) substances, using specific precautions for the risk of corrosivity¹⁷. For understanding the behaviour response considerations for the following may be considered: -

- (a) Gases and evaporators.
- (b) Floaters.
- (c) Dissolvers.
- (d) Sinkers.
- (e) Packaged goods response.

5.6. Response Considerations Reactive Substances

5.6.1. The hazard pictogram of reactive substances are as given below: -



Figure 6: Hazard Pictogram Reactive Substances (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 135)

5.6.2. Alert Notifications¹⁸. Depending on the location of the accident, the MRCC, and public emergency services must be alerted. Ships (crew) and the population downwind (vapour cloud) and downstream (spill) must also be warned in order to prevent complications arising.

¹⁷Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 134

¹⁸Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 136

5.6.3. For the spill of a reactive substance, the potential risk is based on the chemical nature of the substance. In the case of a fire/spillage involving self-reactive substances, non-water-reactive but flammable substances, polymerising substances response considerations of Flammable and explosive substances are to be considered¹⁹. In the case of fire/spillage of chemicals which form toxic or corrosive products by reaction with other materials or other spills Response considerations of Toxic substances and corrosive substances are to be considered²⁰.

5.6.4. Applicability and main risks are involved in a spill of HNS which are corrosive are as given in the table given below²¹: -

Applicability	Risk for Humans / responders	Risk for Environment	Risk for Amenities
Leakage of reactive substances that cause ignition/explosion	<ul style="list-style-type: none"> - Direct injuries due to fire or explosion or highly exothermic reactions (violent explosion) - Oxidising substances could ignite combustible material or destroy material (e.g. responder equipment) - Anoxia, asphyxia, especially in confined spaces 	<ul style="list-style-type: none"> - No major expected chronic impact expected - Possible indirect impact (e.g. fire residues) 	<ul style="list-style-type: none"> - Direct and indirect damages (or destructions) to vessels, buildings, other maritime infrastructures (in some scenarios, even at a considerable distance from the incident).
Leakage of	- Injuries due to direct	- Direct impact on animals	- Chemical corroding drums or tanks,

¹⁹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 136

²⁰Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 136

²¹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 131 & 132

Applicability	Risk for Humans / responders	Risk for Environment	Risk for Amenities
reactive substances that form corrosive products	contact with substance (dermal necrosis, inhalation, ingestion)	and the environment - Chronic impact - Possible indirect impact (e.g. extinguishing water, dissolver in water curtain)	leading to a pollution spill - Corrosion of metals (ship's deck, crane, etc.) (limitation/interference with the legitimate uses of the sea/amenities)
Leakage of reactive substances that form toxic products	- Injuries due to direct contact with substance (skin/mucosa contact, ingestion, inhalation) - Carcinogenetic issues	- Direct impact on animals and the environment - Acute and chronic impact - Possible indirect impact (e.g. extinguishing water, dissolver in water curtain)	Contamination of the marine environment by toxic-persistent product may lead to a closure/ limitation/interference to with the legitimate uses of the sea

Table 8: Applicability and main risks are involved in a spill of HNS which are Reactive (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 137)

5.6.5. **Risk Assessment**²².

- (a) The general considerations are: -
- (i) Assessing the risks of atmospheric and marine toxicity by gathering data on the substances.
 - (ii) Assessing the risks of exposure to corrosive substances on the basis of its physical state and behaviour, monitoring pH if applicable.

²²Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 137

- (iii) Assessing associated hazards if present and evaluate the priority for response; corrosive substances are often associated with other hazards such as flammability and/ or explosivity and/ or toxicity, response considerations of flammable and explosive substances, toxic substances and reactive substances are to be considered.
 - (iv) Analysing weather data and detector measurements.
 - (v) Modelling the behaviour and movements of the corrosive gas/vapours/fume clouds if applicable. Consider modelling of corrosive floater/dissolver/sinker if spilled in water column, if applicable.
 - (vi) Assessing measures to protect sensitive areas (environmental, ecological, social, industrial sites) and facilities, including through preventive shutdown, determining the hazards posed by any products that may be formed in the scenarios and assessing the associated hazard levels (smoke from fire, reaction with the environment, etc.).
 - (vii) Evaluating the location of facilities and equipment for quick response.
- (b) Areas to be considered for intervention are: -
- (i) Evaluate/model the extent of the area affected by dangerous concentrations of corrosive substances in the water column and/or in the atmosphere to limit legitimate uses of the sea and amenities.
 - (ii) Safety zones to be considered.
- (c) Consideration of aggravating factors are:-
- (i) Reactions between acids and bases, reactions due to the increase in temperature, time of exposure.
 - (ii) Possible highly exothermic reaction when certain acids or bases are spilled in water.
 - (iii) Maximum precautionary measures must be taken especially in the case of in situ response on the vessel (confined space).

- (iv) High viscosity values slow down dilution and dispersion processes at sea.

5.6.6. Protective Measures (Human Health, Environment & Amenities)²³. As corrosive substances gather a large group of chemicals, protective measure must comply with the conclusions of the risk assessment:

-

- (a) **Corrosive liquids (mineral acids, alkali solutions and some oxidisers)**. Eyes and skin are particularly vulnerable due to splashes of the substance and effects on tissues are generally very fast.
- (b) **Corrosive gases and vapours**. effect is generally related to the solubility of the substances in the body fluids. Highly soluble gases like ammonia or hydrogen chloride cause severe nose and throat irritation, whereas lower solubility vapours (phosgene, sulphur dioxide, etc.) penetrate deep into the lungs.
- (c) **Corrosive solids**. direct contact can cause burns to the skin (phenol, sodium hydroxide...) and dust affects the respiratory system. Many corrosive solids may produce highly exothermic reactions when dissolved in water.
- (d) In case of a water-reactive product, the substance must be prevented from reaching the water surface and the spill must be contained (construct berms, sand dikes...).
- (e) PPE to be used.
- (f) Portable gas detectors for first responders to be used.
- (g) On board measures should include: -
- (i) Attention should be paid to avoiding direct contact with the skin and protecting against inhalation of vapours or mists. Check atmosphere before entering a confined space; do not operate without self-contained breathing apparatus.
- (ii) Personal protective equipment.
- (iii) Portable gas detectors for first responders.

²³Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 138 & 139

- (iv) Evacuation must be implemented immediately downwind (gas/evaporator/fumes).
 - (v) Attention should be paid to decontaminating protective clothing: wash down with water and then remove.
- (h) Population and amenities:-
- (i) Modelling will need to be conducted to determine the specific area to decide on the implementation of evacuation or shelter-in-place measures (in case of a corrosive cloud or marine environment contamination).
 - (ii) Evacuation must be implemented in downwind impacted areas (in case of hazardous vapours, gas clouds, fumes).
 - (iii) Zoning-downstream area of the spill (targets of polluted runoff, liquid and solid spills) and evaluate any limitations on the use of the sea and amenities.

5.6.7. **Response Measures**²⁴.

- (a) Onboard measures should include: -
- (i) If possible, other chemicals or organic products must be isolated from the leaking substances until its reactive potential has been assessed.
 - (ii) If the substance is not water-reactive, acids and bases may be neutralised by a dilution process in order to reduce the concentration (overboard washing with indirect water jets if possible). pH should be measured before discharging the diluted mixture in the environment. Using water curtain and natural attenuation and monitoring may be resorted to.
 - (iii) Water-reactive substances may be treated by compatible sorbent or inert materials.
 - (iv) In the case of an onboard leak, appropriate containment and recovery methods and techniques according to the substances involved and scenarios should be used- (Emergency Schedules (EmS), IMO, 2018).

²⁴Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 139

(b) In the environment, refer to the characteristics, behaviour and fate and of the spilled (or leaked) substances, using specific precautions for the risk of corrosivity. For understanding the behaviour response considerations for the following may be considered: -

- (i) Gases and evaporators.
- (ii) Floaters.
- (iii) Dissolvers.
- (iv) Sinkers.
- (v) Packaged goods response.

5.7. **Response Considerations Liquefied Natural Gas(LNG)**

5.7.1. The hazard pictogram of LNG is as given below²⁵: -



Figure 7: Hazard Pictogram LNG (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 141)

5.7.2. **General features relating to LNG**²⁶. LNG, or Liquefied Natural Gas, is increasingly used as a source of energy as its main advantages are to release significantly less carbon and lower pollutant emissions, including NO_x, SO_x and particulate matter. In the maritime shipping world, LNG can either be transported as cargo or used as bunkering fuel. For the latter, LNG can be used alone or with a dual fuel engine.

Type of LNG	Tank Volume	Type of Tank type
Cargo	10,000 - 45,000 m ³ per tank Maximum cargo 266,000 m ³ for Q-max vessel	

²⁵ Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 141

²⁶ Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 141

Type of LNG	Tank Volume	Type of Tank type
Bunker	20,000 m ³	Thermally insulated tank, pressure lower than 0.7 bar
	500 – 10,000 m ³	Type-C tank, pressure lower than 4 bars Temperature range: -162°C up to -121°C
	40 m ³	ISO tank (IMDG compliance), pressure lower than 10 bars

Table 9: Type of LNG (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 141)



Cargo



Storage tank for seaborne transport of LNG

Figure 8: LNG Tanks (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 141)



ISO tank (IMDG compliance)

Figure 9: LNG Tank ISO Type (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 141)

5.7.3. The physical and chemical properties of LNG are as given below: -

Boiling Point	-162 ⁰ C	LFL-UFL	5-15%
Flash point	-188 ⁰ C	Density of LNG	0.4
Auto Ignition temperature	595 ⁰ C	Density of Methane	0.6

Table 10: Physical and Chemical Properties of LNG(Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 142)

5.7.4. **Hazards and Behaviour**²⁷. LNG is mostly composed of methane (CH₄, CAS Number 74-82-8), representing about 90%, and a few other alkanes (such as ethane, propane and butane) with a total concentration of less than 10%. LNG is odourless, both in cargo or bunkers. No additive is present to detect a release by a characteristic odour. LNG is a colourless liquid when liquefied at -162°C. At this temperature cryogenic effects can be expected. Water in contact with LNG can form ice and block safety devices. A 1 m³ release of LNG will represent 600 m³ after evaporation into the atmosphere. The anoxia or asphyxia hazard may also be high, especially in a confined area. When released into surface waters it can form a pool that will evaporate rapidly and create a flammable cloud when mixed with air with the subsequent formation of a white cloud due to the condensation of water humidity in the air. If the vapour ignites it can create a jet (pressurised gas release) or pool fire, a flash fire or even a vapour cloud explosion when the surrounding environment creates overpressure and blast damage. For pressurised tanks, BLEVE may also occur in case of fire. Methane does not exhibit violent reactivity with products that are frequently used or transported on ships. However, it reacts violently with liquid oxygen.

5.7.5. Possible impacts on people, environment and amenities are as given below: -

		Effects on		
Type of incident	of	People	Environment	Amenities
Release of cryogenic liquid	of	Serious injuries due to cold burn or due to projections in case of Rapid Phase Transition	Can form ice in water. In absence of fire, no damage to aquatic life because LNG is not soluble in water and it will evaporate rapidly	Brittle fracture damage to steel structures

²⁷Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 142

Type of incident	Effects on		
	People	Environment	Amenities
		into the atmosphere.	
Evaporation of methane into the atmosphere	Anoxia/asphyxia	Extremely low solubility in water	
Ignition of LNG slick	Injuries or death	No major damage expected	Fire, temperature
Inflammation of Vapour Clouds	Injuries or death	No major damage expected	Fire, temperature
Explosion of gas in confined space (for instance engine room)	Injuries or death	Extreme low solubility in water	-Glass explosion - Building destruction
BLEVE following fire of tank containing LNG under pressure	Injuries or death	Possible physical damage due to explosion	-Glass explosion - Building destruction

Table 11: Possible Impact of LNG on People, Environment and Amenities (Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 142 & 143)

5.7.6. **Situation Assessment**²⁸. As with gaseous products, LNG has fast-moving kinetics. It is important to properly assess the situation using all the tools available to effectively protect the population and stakeholders but also to initiate a response on the ground. Following may be undertaken: -

- (a) Situation assessment on ground.
- (b) Response considerations of flammables and explosives to be considered.
- (c) HNS spill modelling has to be undertaken.

²⁸Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 143

- (d) Remote sensing technologies may be resorted to.
- (e) Portable gas detectors are to be utilised by first responders.

Depending on the situation, especially the type of release and whether LNG is pressurised or only refrigerated, the following decision tree can support risk assessment²⁹.

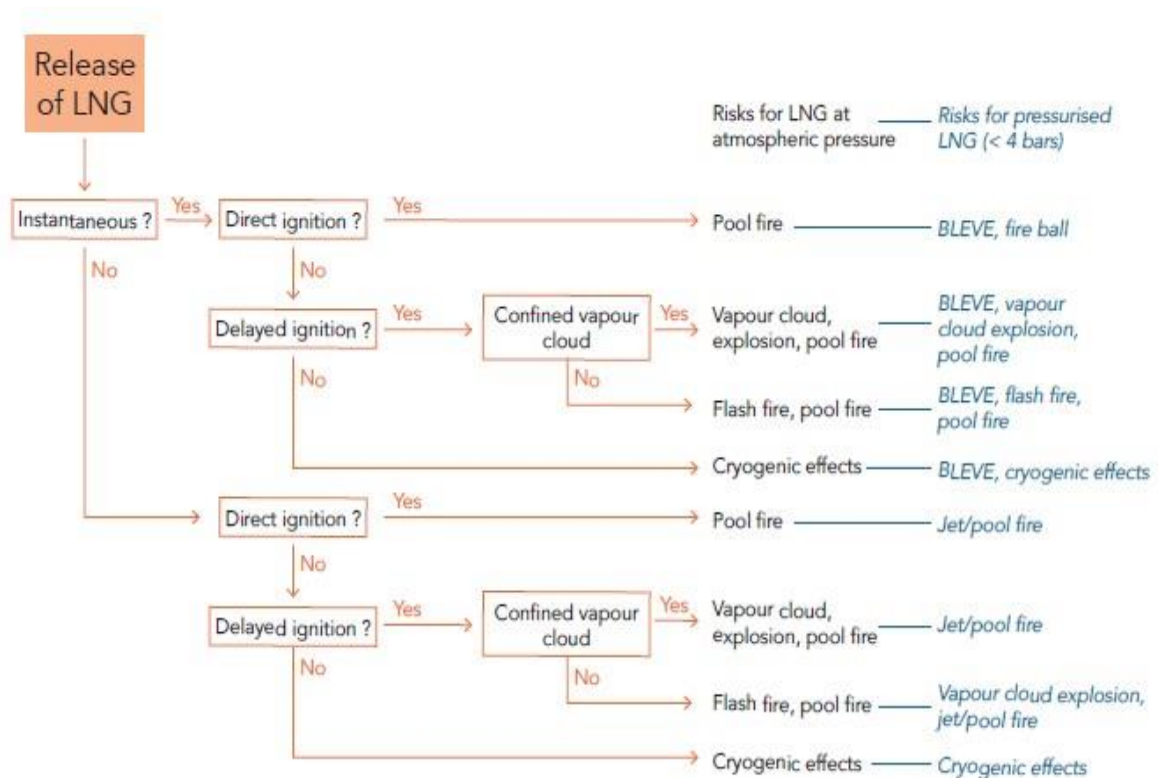


Figure 10: Decision Tree Regarding Release of LNG (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 143)

5.7.7. **Response**³⁰.

(a) **Protective Measures (Human, health, environment and Amenities).**

- (i) Zoning to be established and monitoring performed over time to assess the risk of flammability. In case of evacuation of the crew from a distressed vessel, the helicopter/rescue ship must approach from downwind;

²⁹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 143

³⁰Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 144

- (ii) PPE to be used.
 - (iii) HNS detection and analysis methods to be adopted.
 - (iv) Flammable ignition sources should be removed. Before responders plan to enter concentration below the LEL.
- (b) Response following a leak of LNG: -
- (i) All sources of ignition should be eliminated.
 - (ii) Nobody should walk on or touch the spilled LNG.
 - (iii) If the LNG is likely to leak, water can be sprayed on the vessel's hull to prevent brittle fracture on the steel structure due to cryogenic effect.
 - (iv) Water should not be sprayed directly onto LNG to avoid Rapid Phase Transition or RPT (no spray or run-off).
 - (v) Water curtains should be used, especially to reduce the concentration below the LEL.
 - (vi) If leakage cannot be stopped, the substance should preferentially be released in gaseous state rather than as cryogenic liquid.
 - (vii) Water can form ice when in contact with LNG, which can represent an advantage to temporarily block a leak.
- (c) Response in case of fire: -
- (i) A leak of burning gas should never be extinguished, unless the source of the leak can be stopped.
 - (ii) Water curtains should be used, especially to reduce radiation effects.
 - (iii) Fire should be fought from a maximum distance or with use of water cannons.

- (iv) Minor fire (bunker for instance): dry chemical powder or CO₂.
- (v) Major fire: water spray or fog.
- (vi) If possible, combustible products should be moved away from LNG on fire.

5.8. **Response Considerations Gases and Evaporators**

5.8.1. The SEBC behaviour of gases and evaporators are as given below³¹: -

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

Figure 11: Behaviour of Gases and Evaporators (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 150)

5.8.2. Response strategies need to consider the factors affecting the behaviour and fate of the released substances, taking into account that gases and evaporators mainly undergo short-term processes when spilled at sea, due to their physic state (for G) or high volatility (for E)³².

PROCESSES AND FACTORS AFFECTING BEHAVIOUR AND FATE OF GASES AND EVAPORATORS					
Physical State		Gaseous		Liquid	
SEBC Code		G	GD	E	ED
Behaviour and Fate	Processes when spilled at sea	Immediate evaporation/ Atmospheric partitioning		Rapid Evaporation	
			Dissolution		Dissolution
	Environmental factors influencing intensity of process	Sea state /wind intensity/air and water temperature/humidity (when on board)/solar irradiance/coastline morphology			
	Drift and spread of HNS	Atmospheric dispersion with potential production of dangerous air mixture. Potential violent reactions with smoke/gas/aerosol production, possibly toxic. Non-persistent.			
		Dispersion, diffusion,		Dispersion, diffusion,	

³¹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 150

³²Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 150

PROCESSES AND FACTORS AFFECTING BEHAVIOUR AND FATE OF GASES AND EVAPORATORS					
			dilution in sea surface waters		dilution in sea surfacewaters
	Other relevant HNS properties and hazards	Flash point, explosive range, reactivity, toxicity, corrosivity, gas/ vapour density			
	Impact on marine environment	Gas/evaporator substances tend to readily leave the water column by partitioning first in the sea surface layer and then in the atmosphere: time- andspace-limited impact (generally low) on pelagic ecosystem; risks could be more significant for avifauna and more sensitive pleust on organisms.			

Table 12: Processes and Factors Affecting fate and Behaviour of Gases and Evaporators (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 150)

5.8.3. **Response Considerations**³³. Response considerations shall be: -

- (a) Main risks for safety and/or human health (crew; population if source and cloud near to the coast).
- (b) Response considerations of flammable and explosive substances to be considered.
- (c) Response considerations of toxic substances to be considered.
- (d) Minor risks for the marine environment (non-persistent substances).
- (e) Response actions are conducted on board the ship.

5.8.4. **Situation Assessment and First Actions**³⁴.

- (a) **Information Gathering.**
 - (i) Immediately refer to SDS or chemical databases. In the case of an unknown substance, act as in the case of maximum risk.

³³Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 150

³⁴Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 151

(ii) Immediately refer to data related to the location of the incident and other relevant information;

(iii) Consider sea and weather forecast.

(iv) Incident notification, incident data gathering and information on resources are to be undertaken.

(b) **Situation Assessment.**

(i) On the basis of the information gathered on the incident and the risks identified during contingency planning, consider conducting.

(ii) Hazard identification has to be undertaken. While doing so following response consideration has to be born in mind:-

(aa) Response considerations of flammable and explosive substance.

(ab) Response considerations of toxic substances.

(ac) Response considerations of corrosive substances.

(ad) Response considerations of reactive substances.

(iii) Estimation of risk and vulnerability.

(iv) Evaluation of consequences.

(c) **First Actions.**

(i) Taking into account the first actions to guarantee safe conditions for the responders by identifying and reducing the hazards of explosion, fire, exposure to toxic clouds, etc. and then stop or reduce the source of the HNS spill. First actions with respect to casualty and responders are to be considered.

(ii) Consider public safety. Establish safety zones.

(iii) Equipment/logistics:-

(aa) Personal protective equipment.

(ab) Portable gas detectors for first responders.

(d) **Monitoring.**

(i) **Modelling.** Modelling of gas cloud in air; Input to be considered: chemical and physical parameters of the substance, weather condition and forecast, type of spill source. HNS spill modelling may be undertaken.

(ii) Monitoring using remote measuring instruments and search techniques: -

(aa) aerial surveillance: aircraft (not in case of explosive or unknown gas); drones.

(ab) Remote sensing technologies.

(ac) Use of markers (not in case of explosive or unknown gas) for safety and operational reasons.

(iii) Monitoring using in-situ measuring instruments and search techniques: -

(aa) Air sampling.

(ab) Trace gas sensors: explosimeter and gas detection to detect explosion or fire risks.

(ac) Detectors for toxic substances (on board and in environment).

(ac) Oxygen deficiency by electrochemical oxygen sensor.

(ad) Portable gas detectors are to be used by first responders while monitoring.

(iv) **Water Sampling.** Water sampling by "niskin" bottles and storage of samples for laboratory analysis (for not surface spill)/bottle sampling for surface water (for substances "DE" and "ED"). For GD substances (in particular with regard for VOC and semi-VOC), sampling techniques and protocols and HNS detection and analysis methods to be adopted.

(e) **Response Options.**

(i) Vessel-oriented actions:

(aa) Emergency boarding

(ab) Mark out the risk area onboard.

(ac) Stop the release of substance from its source by sealing and plugging.

(ad) Ventilate when possible (e.g. with ventilators) to reduce concentration but be careful if there is a very rich atmosphere ($> \text{UEL}$). In this case, ventilation could reduce the concentration below the UEL. Response considerations of flammable and explosive substances to be borne in mind.

(ae) For small spills, consider using techniques to prevent/control ignition or evaporation of the chemicals. Use foam.

(af) Recovery operation of the residual load - Cargo transfer.

(ag) Towing & boarding - Emergency towing and Places of refuge to be considered.

(ii) Pollutant-oriented actions: -

(aa) High pressure water spray jet - Using water curtains.

(ac) Re-condensation of spilled gas in liquid state: for small spillage.

(ad) Controlled release technique.

(ae) Natural attenuation and monitoring.

(af) Wildlife response focuses on toxic effects on avifauna or marine mammals (inhalation hazards).

(iii) Containment and recovery not practical. Only monitoring is required.

(iv) Natural attenuation and monitoring. Evaluate then on-intervention strategy in the case of high risks for human health. No risks of cloud advection towards the coast. Set up exclusion/ban areas, until natural processes have reduced pollutant concentrations.

(f) **Post-Spill**

(i) Environmental investigation.

(aa) Generally UNNECESSARY in the case of gaseous and highly volatile substances. To be considered in the case of damages following a release of gas/evaporator (e.g. fire and/or explosion).

(ac) For soluble substances (GD), detection of concentrations in water and evaluation of the effects on sensitive organisms.

(ad) Chemical and Eco toxicological analysis of samples of contaminated water.

(ae) Chemical analysis and studies on biomarkers of sedentary species.

(af) The same investigations must always be carried out in areas chosen as a reference. Not for explosive HNS.

(ag) HNS detection and analysis methods and environmental restoration and recovery methods may be adopted.

5.9. **Response Considerations Floaters**

5.9.1. The SEBC behaviour of gases and evaporators are as given below³⁵: -

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

³⁵Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 155

Table 13: Behaviour of Floaters (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 155)

5.9.2. For SEBC subgroups "FD" and "FED" see also response considerations of Dissolvers and for SEBC subgroup "FED" response considerations of Gases and evaporators are also to be considered³⁶.

5.9.3. Response strategies need to consider the factors affecting the behaviour and fate of the released substances as well as the short and long-term processes when spilled at sea³⁷.

PROCESSES AND FACTORS AFFECTING BEHAVIOUR AND FATE OF FLOATERS IN A MARINE ACCIDENT INCIDENT								
Physical state		Liquids				Solids		
SEBC Code		F	FD	FED	FE	F	FD	
BEHAVIOUR and FATE	Processes when spilled at sea	Spreading						
			Evaporation					
		Dissolution				Dissolution		
	Environmental factors influencing intensity of processes	Sea state, wind intensity, air and water temperature						
	Drift and spread of HNS	Drifting of the slick at sea surface (temporal continuity and persistence are variable). Possible impact on shoreline.				Drifting at sea surface		
		Possible emulsification, production of aggregates that could sink or affect shoreline (high viscosity substances)				Potential shoreline involvement	Dispersion, dilution	
		Evaluate potential violent reactions and aerosol production.						
Other relevant, HNS and properties	Viscosity			Vapour density		Buoyancy	Viscosity	

³⁶Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 155

³⁷Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 155

	Behaviour	Persistence		Persi stenc e	
	Impact on marine environment	Floaters mainly affect surface, pelagic and pleuston ecosystems, and their slicks (F-liquids) can alter atmospheric/sea-surface gas exchange, especially if the substance is persistent (F(p)). Shoreline ecosystems can also be affected by floating chemical spills. FE and FED substances can generate potentially dangerous vapours: the main social effects are related to navigational safety and strong limitation for legitimate uses of the sea.			

Table 14: Processes and factors Affecting Behaviours and Fate of Floaters in Marine Accident (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 155)

5.9.4. **Response Considerations**³⁸.

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

5.9.5. **Situation Assessment and First Actions.**

- (a) **Information Gathering.** Immediately refer to SDS or chemical databases. In the case of an unknown substance, act as in the case of maximum risk. Safety data sheet content to be examined for the same:-
 - (i) Immediately refer to data related to the location of the incident and other relevant information.
 - (ii) Consider sea and weather conditions.

³⁸ Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 155

(iii) Incident notification and incident data gathering to be resorted.

(b) **Situation Assessment:** -

(i) On the basis of the information gathered on the incident and the contingency planning risk, conduct hazard identification.

(ii) Response considerations to be considered are: -

(aa) Flammable and explosive substances.

(ab) Response considerations for toxic substances.

(ac) Response considerations for corrosive substances.

(ad) Response considerations reactive substances.

(iii) Estimation of risk and vulnerability.

(iv) Evaluation of consequences.

(c) **First actions.**

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

(ii) Both first actions (casualty) and first actions (responders) to be considered.

(iii) Consider public safety. Establish safety zones.

(iv) Equipment/logistics to include personal protective equipment and portable gas detectors for first responders.

5.9.6. **Monitoring**³⁹.

(a) **Modelling.**

³⁹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 157

- (i) Modelling of drifting floaters (solids and liquid slicks) at the sea surface. Input to be considered: chemical and physical parameters of the substance (e.g. viscosity), current sea and weather conditions and weather forecast, type of spill source. HNS spill modelling to be taken into consideration.
 - (ii) Modelling of gas cloud in air (for FE substances). Response considerations of gases and evaporators also to be considered.
- (b) Monitoring using remote measuring instruments and search techniques include: -
- (i) **Aerial surveillance**. Aircraft (not in case of dangerous situations) and drones.
 - (ii) Use of markers to make the substance visually detectable at the sea surface. Not applicable in the case of an explosion hazard or unknown substances.
 - (iii) Substance marking, remote sensing technologies and sampling techniques and protocols may be adopted for monitoring.
- (c) In situ monitoring using measuring instruments and research techniques involving: -
- (i) Trace gas sensors/explosimeter and gas detection (in case of explosion or fire risks or toxic vapours/aerosol formation or unknown substances).
 - (ii) Acquisition of physicochemical parameters of surface waters by multi-parametric probe (T, fluorescence, pH, conductivity, etc.). Specialised personnel could be required.
 - (iii) Portable gas detectors for first responders to be used and sampling techniques and protocols may be adopted.

5.9.7. **Water Sampling**⁴⁰.

⁴⁰Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 157

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

(b) Water sampling by "niskin" bottles (or other methods) and storage of samples for laboratory analysis or field measurements. In the case of a deep or subsurface spill, consider the use of a multi-parametric probe to locate the substances in the water column (specialised personnel could be required);

(c) Sampling of solid floaters in the surface and sub-surface layer of the water column (e.g. with specific nets, ROV, divers). Use of remotely operated vessels, Sampling techniques and methods and HNS detection and analysis method to be resorted to.

5.9.8. **Air sampling**⁴¹.

(a) Trace gas sensors: detectors for toxic substances (on board and in the environment); explosimeter and gas detection to detect explosion or fire risks.

(b) For analysing oxygen deficiency, electrochemical oxygen sensor may be used. Portable gas detectors for first responders to be used.

5.9.9. **Response Options**⁴².

(a) **Action on vessel.**

(i) Emergency boarding.

(ii) Stop the release of substance from its source. Sealing and plugging can be resorted.

(iii) Recovery operation of the residual load. Cargo transfer can be undertaken.

⁴¹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 158

⁴²Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 158

(iv) Onboard ship collect spillage, where practicable, using sorbent material for safe disposal if applicable.

(v) Towing & boarding. Procedures of emergency towing to be observed. Vessel may be towed to places of refuge.

(vi) Evacuate the downwind area and evaluate the need for a ban on navigation or other exploitation of marine resources (for FE, FED).

(vii) Prevent the formation of dangerous vapours (inject inert gas, ventilate and/or dehumidify the atmosphere).

(viii) Following considerations to be made:-

(aa) Response considerations for flammable and explosive substances.

(ab) Response considerations for toxic substances.

(ac) Response considerations for corrosive substances.

(ad) Response considerations for reactive substances.

(b) **Action on Pollutant**⁴³.

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

(aa) Using special barriers developed for solids and liquids, in shallow waters. Oil spill booms, often in association with sorbents (slicks or floating solids) can be used. Containment techniques using booms to be undertaken. For recovery techniques, pumps and skimmers may be used.

(ab) Contain by water barriers, in the presence of vapour or smoke; for FE/FED. Using of water curtain can be made.

(ii) **Recovery Techniques.**

⁴³Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 158

- (aa) Sorbents (booms, sheets, pillows...).
 - (ab) By pumping operations with various types of skimming.
 - (ac) Trawl nets or net bags towed by boats; for high viscosity chemicals or small floating solids.
 - (ad) Containment techniques using booms to be undertaken. For recovery techniques, pumps and skimmers may be used.
- (iii) **Cleaning Techniques**. Chemical dispersant; only for "dispersible" F substances (evaluation based on the value of kinematic viscosity) and only in very limited scenarios. HNS response in the water column to be considered.
- (iv) Standard intervention techniques on wildlife (avifauna, marine mammals, marine reptiles) affected by oil spills could be applied in the case of some floater spills, on the basis of physico-chemical characteristics and behaviour.
- (c) **Controlled Release Technique⁴⁴**. Controlled release of substances still stored on board (not advisable – evaluate for offshore, only implement after a rigorous evaluation).
- (d) **Natural Attenuation and Monitoring⁴⁵**. Evaluate the non-intervention strategy (not advisable – evaluate for offshore, only implement after a rigorous evaluation).
- (e) **Post-Spill⁴⁶**.
- (i) Chemical and ecotoxicological analysis of the sea surface layer and/or undiluted substance.
 - (ii) Chemical analysis (e.g. bioaccumulation) and biological analysis (e.g. biomarkers) of involved fauna to evaluate toxic effects (even on the coast, if involved).
 - (iii) Environmental restoration and recovery techniques can be adopted.

⁴⁴Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 159

⁴⁵Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 159

⁴⁶Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 159

5.10. Response Considerations of Dissolvers

5.10.1. The SEBC behaviour of dissolvers are as given below⁴⁷: -

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

Table 15: Behaviour of Dissolvers (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 161)

5.10.2. For SEBC subgroup "GD", "DE", "ED" response considerations of Gases and evaporators and for floaters and sinkers, response considerations of floaters and response considerations of sinkers to be considered. Response strategies need to consider the below mentioned factors affecting the behaviour and fate of the released substances as well as the short and long-term processes when spilled at sea.

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

⁴⁷ Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 161

Table 16: Processes and factors affecting behaviour and fate of dissolvers in a marine incident (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 161)

5.10.3. **Response Considerations**⁴⁸.

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

5.10.4. **Situation Assessment and First Actions**⁴⁹.

(a) **Information gathering.**

- (i) Immediately refer to SDS or chemical databases. In the case of an unknown substance, act as in the case of maximum risk.
- (ii) Immediately refer to data related to the location of the incident and other relevant information.
- (iii) Consider sea and weather conditions.

(b) **Situation Assessment.**

- (i) On the basis of the information gathered on the incident and the contingency planning risk, conduct hazard identification.
- (ii) Response considerations for flammable and explosive substances, toxic substances, corrosive substances, reactive substances are to be considered.
- (iii) Estimation of risk and vulnerability.
- (iv) Evaluation of consequences.

⁴⁸Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 161

⁴⁹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 162

(c) **First Actions.**

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

(ii) Identification of the main hazards. Response considerations for flammable and explosive substances, toxic substances, corrosive substances and reactive substances to be considered.

(iii) Consider public safety. Safety zones to be established.

(iv) Equipment/logistics including personal protective equipment and portable gas detectors for first responders to be available.

5.10.5. **Monitoring**⁵⁰.

(a) **Modelling.** Modelling dissolved plume in water column. Input to be considered are chemical and physical parameters of the substance, weather condition and forecast and type of spill source. HNS spill modelling to be considered.

(b) Monitoring using remote measuring instruments and search techniques: -

(i) Aerial surveillance: aircraft (not in case of dangerous situations), drones.

(ii) Remote sensing technologies may be used.

(iii) Use of markers to make the substance visually detectable in water column with ROV or specific sensor (e.g. fluorimeter): NOT applicable in the case of an explosive or unknown dissolver. Substance marking, remotely operated vehicles and Sampling techniques and protocols to be utilized.

(c) Monitoring using in situ measuring instruments and search techniques: -

⁵⁰Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 162-163

(i) Acquisition of chemical and physical parameters of the water column by multi-parametric probe and analytical determinations using field instruments (e.g. GC-MS, GC-FID, GC-PD, IR, etc.);

(ii) Trace gas sensors/explosimeter and gas detection (in case of explosion or fire risks or flammable/toxic vapours/aerosol formation or unknown substances.

(iii) Portable gas detectors for first responders and sampling techniques and protocols to be employed.

(d) **Water Sampling.**

(i) Water sampling by "niskin" bottles (for deep or sub-surface sampling) or by manual sampling (e.g. with a glass bottle for floating substances) and storage of samples for laboratory analysis. Use of multi-parametric probe to locate the plume. Very narrow time window. Specialised personnel could be required.

(ii) Sampling solid substances (if not completely dissolved) in surface and sub-surface seawaters with specific nets, etc. Very narrow time window.

(iii) Sampling techniques and protocols and HNS detection and analysis methods to be used.

(e) **Air Sampling.**

(i) Trace gas sensors. Detectors for toxic substances (on board and in the environment); explosimeter and gas detection to detect explosion or fire risks.

(ii) For detecting oxygen deficiency, electrochemical oxygen sensors could be used.

(iii) Portable gas detectors to be used for first responders.

5.10.6. **Response Options**⁵¹.

(a) **Vessel-oriented Actions.**

⁵¹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 164-165

- (i) Emergency boarding.
- (ii) Stop the release of substance from its source. Sealing and plugging may be undertaken.
- (iii) Recovery operation of the residual load. Cargo transfer may be an option.
- (iv) On board collect spillage, where practicable, using sorbent material for safe disposal.
- (v) Towing & boarding may be resorted to. Emergency towing may be undertaken to places of refuge.

(b) **Pollutant-oriented Actions.**

- (i) HNS response in the water column may be undertaken.
- (ii) Neutralising agent may be used in the case of accidents involving substances that induce strong pH variations. Applicable only for small spills, restricted areas and no current, consider dissolution kinetics.
- (iii) Suction of contaminated water and suitable purification treatment (e.g. adsorption on activated carbon; flocculating agents). Applicable only for shallow waters and calm waters;
- (iv) Physical barrier to stop or slow down the spread of the pollutant. In the presence of vapour or smoke, contain using bubble barriers. This technique is applicable for small spills and calm weather conditions.
- (v) Filtering flow to protect intakes.
- (vi) Recovery of solids suspended in the water column.
- (vii) Wildlife response will focus on avifauna and marine mammals exposed to toxic or corrosive substances.

(c) **Controlled Release Technique.** Controlled release of substance still stored on board (not advisable – evaluate for offshore, only implement after a rigorous evaluation).

(d) **Natural Attenuation and Monitoring.** Evaluate the non-intervention strategy (not advisable – evaluate for offshore only).

5.10.7. **Post-Spill.**

- (a) Environmental investigation:
- (i) Chemical and ecotoxicological analysis of contaminated seawater and/or undiluted substance.
 - (ii) Chemical and biological analysis of marine organisms (e.g. biomarkers) and involved wildlife.
 - (iii) HNS detection and analysis methods and environmental restoration and recovery could be employed.

5.11. **Response Considerations of Sinkers**

5.11.1. The SEBC behaviour of sinkers are as given below⁵²: -

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

Table 17: Behaviour of Sinkers (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 166)

5.11.2. For SEBC group SD, response considerations of dissolvers will be also applicable⁵³. Response strategies need to consider the factors affecting the behaviour and fate of the released substances as well as the short- and long-term processes when spilled at sea⁵⁴. The processes and factors affecting behaviour and fate of floaters are as given below⁵⁵:-

PROCESSES AND FACTORS AFFECTING BEHAVIOUR AND FATE OF FLOATERS IN A MARINE ACCIDENT INCIDENT		
Physical state	Liquids	Solids
SEBC Code	S	SD

⁵² Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 166

⁵³ Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 166

⁵⁴ Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 166

⁵⁵ Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 166

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

Table 18: Processes and factors affecting behaviour and fate of Sinkers in a marine incident (Source Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 166)

5.11.3. **Response Considerations**⁵⁶.

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

5.11.4. **Situation Assessment and First Actions**⁵⁷

⁵⁶Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 167

- (a) Information gathering: -
- (i) Immediately refer to SDS or chemical databases. In the case of an unknown substance, act as in the case of maximum risk.
 - (ii) Immediately refer to bathymetric and geomorphological data related to sea-bottom and to incident information.
 - (iii) Consider sea and weather conditions.
 - (iv) Incident notification and incident data gathering to be undertaken.
- (b) **Situation Assessment.** On the basis of the information gathered on the incident and the contingency planning risk, consider conducting:-
- (i) Hazard identification.
 - (ii) Response considerations of flammable and explosive substances, toxic substances, corrosive substances and reactive substances to be considered.
 - (iii) Estimation of risk and vulnerability.
 - (iv) Evaluation of consequences.
- (c) **First Actions.**
- (i) Take into account the first actions to guarantee safe conditions for the responders by identifying and reducing the hazards of explosion, fire, exposure to toxic clouds, etc. and then stop or reduce the source of the HNS spill.
 - (ii) First actions (casualty) and first actions (responders) to be considered.
 - (iii) Consider public safety. Establish safety zones.

(iv) Equipment/logistics. Personal protective equipment and portable gas detectors for first responders to be employed.

5.11.5. **Monitoring**⁵⁸.

(a) **Modelling.**

(i) Spill modelling: trajectories, drifting on seabed.

(ii) For sinkers, to be considered the type of release, environmental conditions during the incident. Evaluate prevailing weather and sea conditions to determine way and distribution of chemical on sea bottom. HNS spill modelling to be considered.

(b) Monitoring using in situ measuring instruments and search techniques: -

(i) Towing dredge (for solid substances) or absorbent material (for some liquid substances) along sea bottom.

(ii) Sonar systems: side scan sonar (solids) and multi beam echo sounder (seafloor depression or accumulation, bottom pool of sinking liquids), ROV investigations. Remote sensing technologies and remotely operated vehicles may be employed.

(c) **Sediment Sampling.** Sampling box corer, grabs/videos using ROV and/or professional divers.

(d) **Water Sampling.** Acquisition of chemical-physical parameters in (deep) water column by multi-parametric probe and analytical determinations using field instruments (e.g. GC-MS, GC-FID, GC-PD, IR, etc.). Only for SD or dissolved reaction products. Hazard of reactivity also to be considered.

(e) **Air sampling on board.**

(i) Some sinkers, such as calcium carbide, can react violently with water and can be ignited under almost all ambient temperature conditions, while others, such as naphthalene, are reactive to air and flammable.

⁵⁸Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 168

(ii) Trace gas sensors for explosion or fire risks. Explosimeter and gas detection to be utilised.

(iii) For oxygen deficiency electrochemical oxygen sensor may be employed.

(iv) Portable gas detectors for first responders, Sampling techniques and protocols and HNS detection and analysis methods may be used.

5.11.6. **Response Options**⁵⁹.

(a) **Vessel-oriented Actions.**

(i) Emergency boarding.

(ii) Stop the release of substance from its source. Sealing and plugging can be undertaken.

(iii) Transfer cargo or tow the ship to a place of refuge.

(iv) Retain all or part of the flow of the pollutant on board before it can reach marine environment.

(b) **Pollutant-oriented Actions.**

(i) Containment and recovery: dredging (mechanical, pneumatic or hydraulic) for solid sinkers; pumping systems for liquid sinkers (also operated with ROV or with underwater operators, depending on how dangerous the substance is and the depth of the seabed).

(ii) Wildlife response focuses on the seafloor to minimise the impact on benthic ecosystems.

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

⁵⁹Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC, pg 168 - 169

(d) **Natural Attenuation and Monitoring**. Evaluate the non-intervention strategy. Recovery of sunken substance is often not possible.

5.11.7. **Post-spill**

(a) Chemical and biological analysis (e.g. biomarkers) on pelagic and benthic organisms.

(b) Chemical analysis on sea bottom and in water column (for persistent substances).

(c) Post spill monitoring may be undertaken.

(d) HNS detection and analysis methods are to be adopted

(e) Environment restoration and recovery may be adopted.

5.12. **CEDRE Response Guide for Responding to HNS**

5.12.1. The response guide prepared by CEDRE with respect to commonly transported HNS by sea may be referred for responding to the spill scenario of the chemicals. The details of available response guides are as follow: -

Ser	HNS	CEDRE Response Guide
(a)	1,2-Dichloroethane	1,2-Dichloroethan Chemical Response Guide
(b)	Phosphoric Acid	Phosphoric Acid Chemical Response Guide
(c)	Sulphuric Acid	Sulphuric Acid Chemical Response Guide
(d)	Ethyl Acrylate	Ethyl Acrylate Chemical Response Guide
(e)	Ammonia	Ammonia Chemical Response Guide
(f)	Benzene	Benzene Chemical Response Guide
(g)	Chloroform	Chloroform Chemical Response Guide
(h)	Vinyl Chloride	Vinyl Chloride Chemical Response Guide
(j)	Condensates	Condensates Chemical Response Guide
(k)	Dimethyl Sulphide	Dimethyl Sulphide Chemical Response Guide
(l)	Unleaded Gasoline	Unleaded Gasoline Chemical Response

		Guide
(m)	Sodium Hydroxide 50% Solution	Sodium Hydroxide 50% Solution Chemical Response Guide
(n)	Stabilised Methyl Methacrylate	Stabilised Methyl Methacrylate Chemical Response Guide
(p)	Methyl Ethyl Ketone	2Methyl Ethyl Ketone Chemical Response Guide
(q)	Styrene	Styrene Chemical Response Guide
(r)	Xylene	Xylene Chemical Response Guide

Table 19: List of CEDRE Response Guides on HNS

5.12.2. The guides also provide following information of HNS with special reference to safety to be observed by the responders: -

- (a) First aid information.
- (b) Identity card denoting nomenclature and classifications.
- (c) Physical data.
- (d) Flammability data.
- (e) Toxicological data.
- (f) Ecotoxicological data.
- (g) Persistence in the environment.
- (h) Classification.
- (j) Particular risks.
- (k) Transportation, handling and storage.

Chapter-6: Stakeholder Engagement and Media Protocols

6.1. Media Protocols

6.1.1. **Media and Public Relations Coordinator.** The Media and Public Relations Coordinator shall ensure adequate liaison between the incident management team and the media. All queries received from the media should be directed to this person. Before releasing any information, the Media and Public Relations Coordinator's action should have the approval of either the relevant Coast Guard Commander or CIC, depending on the size of the spill.

6.1.2. **Communication Strategy.** 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:-

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

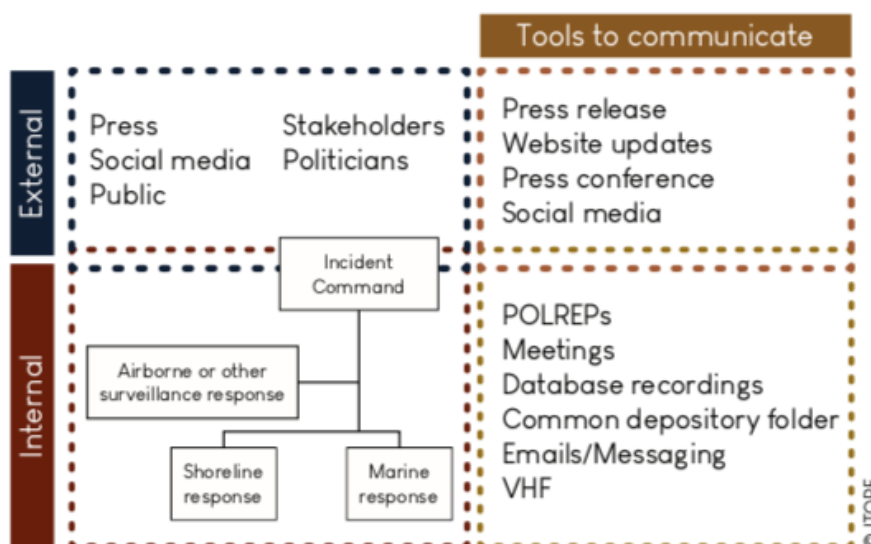


Figure 12: Flowchart of a Typical Communication Structure in a function-based structure

6.2. External communication

6.2.1. Information management is crucial to keep all external stakeholders

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

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



Figure 13: Communication Plan (Source Marine HNS Response Manual, Multi-Regional Bonn Agreement, HELCOM, REMPEC, Pg 95)

Important rules to note:

 <p>Appoint spokesperson</p> <p>A communication plan should appoint a single person to be the spokesperson during a response. This person should ideally undergo media training prior to an incident and be experienced in public speaking.</p> <p>All official enquiries should be directed to the spokesperson.</p>	 <p>Communicate early and often</p> <p>Rumours or fake news can spread fast in the absence of readily available, accurate information. Therefore, communicating early on in a response can reduce the spread of false information. Keeping all external stakeholders and the general public updated on the progress of the response will affect how response efforts are perceived.</p>	 <p>Keep it concise</p> <p>Information must be concise. This is particularly important in the age of social media where short snapshots of information are favoured. Indeed, most social media platforms encourage succinctness, limiting the lengths of statements or allowing only short videos. The key points of the message should be conveyed in easy to understand, non-specialist language as efficiently as possible.</p>	 <p>Stick to the facts</p> <p>Only true and verified information should be shared. However, it is important to keep in mind that whenever limited information is available, communication might still be necessary, to inform the public of the actions taken so far. Partial or incomplete information from verified sources can sometimes be preferable to no information at all. However, unverified information should never be released.</p>
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Figure 14: Key Issues Related to External Communications (Source (Luigi Alcaro2, 2021)(ITOPF), Pg 96)

6.3. Press Conferences

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

6.3.2. Drafting Press Release and Organising Press Conference. Aim of organising a press conference is to deliver a clear and managed message

to a target audience.

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

- (a) Answer the questions relating to the event: Who? What? Where? When? How?
- (b) Be concise, stick to the facts.
- (c) Use simple, straight-forward and non-specialist language.
- (d) Use a tone that reassures the end-user.
- (e) Provide contact details for all media and public enquires to allow your organisation to manage the incoming information efficiently.
- (f) Don't forget the time, date and reference number of the statement release.

6.3.4. Press Conferences. Press conferences should be organised by the communications team with the approval of the OSC. Media outlets need to be invited and a presentation or statement should be prepared ahead of time to provide an update on the situation and as many facts as is appropriate to give a clear understanding of the situation. A spokesperson, who has adequate media training, should be appointed to deliver the press conference. However, questions may arise that are best answered by experts/specialists, who should therefore be part of the speaker panel. If this is the case, a moderator for the panel should be appointed. As with all external communication, all parties must be briefed on the key points and on the facts that have been checked to be released to external parties. Keep the communication channels open with the public and the media but direct them through your approved channels to ensure your organisation has as much control as possible to sort and prioritise queries. Try to provide regular press conferences to give updates throughout the response and provide a platform for the public and the media to ask questions. Things to consider when planning a press conference:-

- (a) Make a clear and planned opening statement summarising the key facts.

- (b) Be clear and concise.
- (c) Direct any questions requiring expert knowledge to the appropriate person on the panel.
- (d) Allow a fixed number of questions or set a specific time frame for questions (e.g. 5 questions/20 min).
- (e) Prepare for challenging questions from the media, and keep answers factual.
- (f) Anticipate questions and prepare answers.
- (g) Do not speculate, or answer questions outside your competence.
- (h) Limit the whole conference to an hour/hour and a half at the most to ensure key messages are not lost.

6.4. Social media

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

6.5. Internal Communications

6.5.1. Internal communication will aim at:-

- (a) **Informing** all stakeholders of the current situation and the process for communication channels;
- (b) **Outlining** the roles and responsibilities of each team within the response, and what is expected of them;
- (c) **Advising** by providing reliable advice on how to act in different situations regarding communications.

6.6. On-site Communication

6.6.1. The transmission of information between responders and transmission to the On-Scene Commander (OSC) must be considered and prepared. Communication plays a key role in safety issues in the field throughout the various steps of the response. Indeed, clear transmission of information is required, especially in the case of HNS for which a single letter in the name of a chemical can change everything. The use of the international alphabet for transmission of key words is recommended as well as asking the receptor to repeat information to ensure it has been received correctly. During the response, responders should be able to communicate with team members. This might be possible for instance with all types of PPE suits equipped with bluetooth communication or by using agreed hand signals.

6.7. Incident Management Team Communication

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

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

6.8. Communication Plan

6.8.1. Information can be overwhelming for decision-makers during a crisis; a clear approach is required to allow information to be sifted through, organised and responded to in an appropriate and timely manner.

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

- (a) **Lack of Awareness of Responsibilities**. Having a developed and up-to-date communication plan prior to any crisis is essential to ensure roles and responsibilities are already defined. Each assigned

team member should be aware of their role and have received adequate training prior to an event to allow them to fulfil the role competently.

(b) **Overwhelming Incoming Requests for Information.**

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

(c) **Getting information to where it needs to go.**

A clear communication path is required to allow information to be delivered where needed across all internal teams efficiently. The communication plan should outline how updates and essential information is delivered to different teams so that a clear path of internal information transfer is outlined.

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

Appendix

(Refers to Para 10 of Chapter 20)

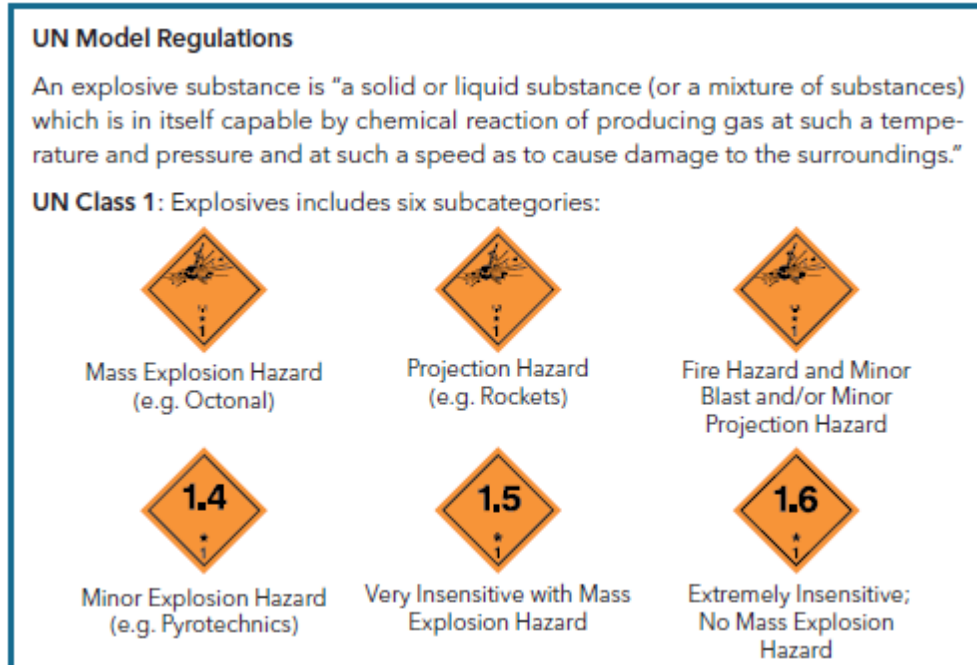
Symbology of HNS Substance

Figure 15: Hazard Explosivity (Source Marine HNS Manual, Multi-Regional Bonn Agreement, HELCOM, REMPEC, pg 19)

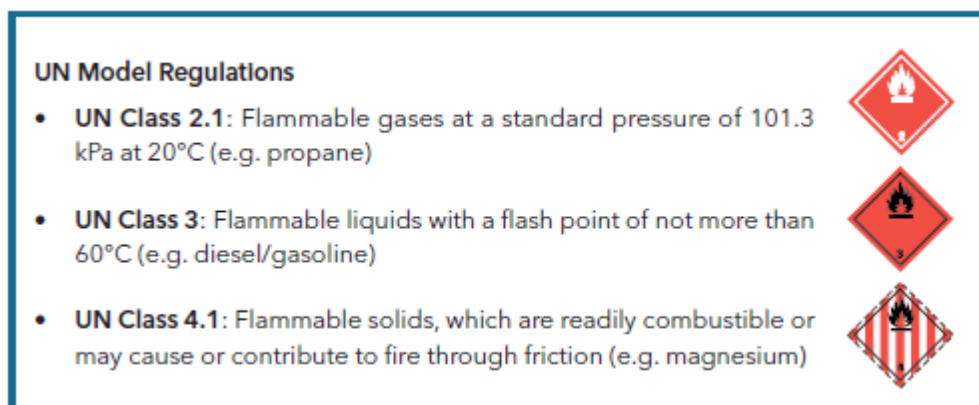


Figure 16: Hazard Flammability (Source Marine HNS Manual, Multi-Regional Bonn Agreement, HELCOM, REMPEC, pg 20)

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)




Figure 17: Hazard Oxidation (Source Marine HNS Manual, Multi-Regional Bonn Agreement, HELCOM, REMPEC, pg 21)

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".




Figure 18: Hazard Corrosion (Source Marine HNS Manual, Multi-Regional Bonn Agreement, HELCOM, REMPEC, pg 22)

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)




Figure 19: Hazard Reactivity (Source Marine HNS Manual, Multi-Regional Bonn Agreement, HELCOM, REMPEC, pg 23)

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).




Figure 20: Hazard Marine Pollutant (Source Marine HNS Manual, Multi-Regional Bonn Agreement, HELCOM, REMPEC, pg 24)

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- Luigi Alcaro², J. B.-K. (2021). *Marine HNS Response Manual Multi-regional Bonn Agreement, HELCOM, REMPEC*. Malta: REMPEC.
- ITOPF. (n.d.). *Technical Information Paper 17*. London: ITOPF.