ARE HNS SPILLS MORE DANGEROUS THAN OIL SPILLS?

A White Paper for the

Interspill Conference & the 4th IMO R&D Forum

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'FU SHAN HAI' sinking with a cargo of Potash in the Western Baltic Sea, 2003.
[Image courtesy of the Swedish Coastguard]

PREFACE

The joint Steering Committee of the Marseille 2009 Interspill Conference and Exhibition, and the IMO 4th R&D Forum, recognised that the growth in marine transportation of chemicals, together with State and industry obligations arising from the recent entry into force of the OPRC-HNS Protocol,[1] have focussed professional and public attention on the potential dangers of Hazardous and Noxious Substances (HNS) spills at sea. The Committee further observed that knowledge about the fate and effects of HNS in the marine environment is not as extensive as it is for oil spills. A potential outcome of this attention and uncertainty is concern that spills of HNS may have devastating consequences for both human health and the environment.

To consider whether such concern is well founded or the result of over-rating the risks associated with a spill of HNS the Committee agreed to prepare a White Paper that would ask the question 'Are HNS spills more dangerous than oil spills?.' The goal of the White Paper is to present the key issues and concerns associated with a spill of HNS into the marine environment, as compared with a spill of oil, and to provide a platform to stimulate open discussion.

The White Paper has been prepared by Dr. Karen Purnell (ITOPF) with contributions from a consortium comprising the IMO, EMSA and CEDRE.

Chapter 1

INTRODUCTION

The framework for preparedness and response to oil spills from tankers has evolved over some 40 years or more to provide a regime that has stood the test of time. Initiatives implemented by both the oil/shipping industry and governments during this period to improve safety or preparedness have contributed to an overall decline in oil spills from tankers to a level that is now one fifth of that observed during the 1970s, despite a steady increase in oil transported by sea.

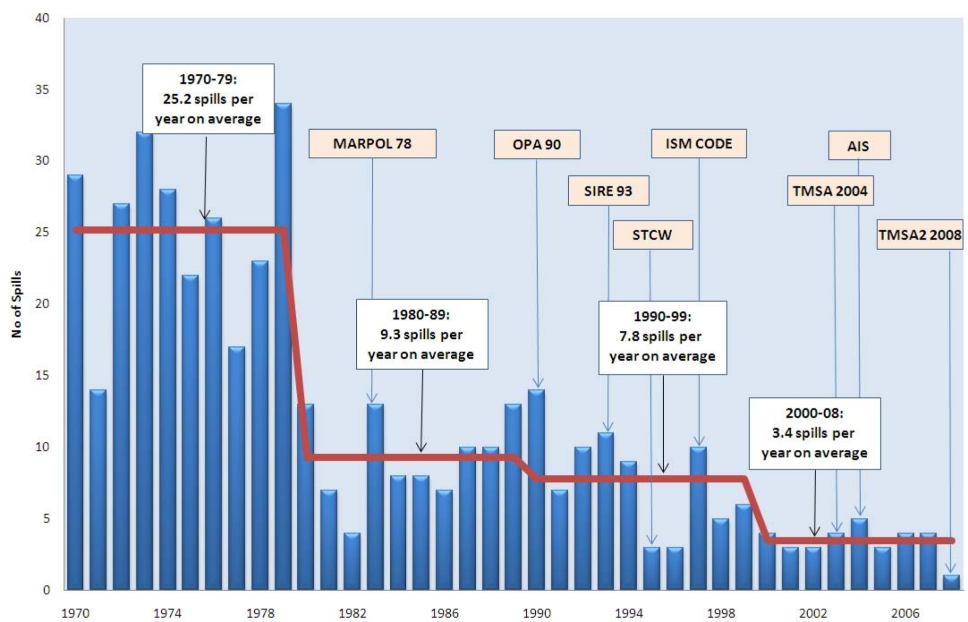

Figure 1: Trends in the number of oil spills from tankers[2]

During the same period, transport of chemicals by sea has also increased but without a comparable regime of preparedness or response. It is therefore no surprise that the template that has served well for oil spills is being applied now to address spills of Hazardous and Noxious Substances (HNS). However, in preparing for and responding to spills of HNS the similarities and differences between oil and HNS need to be considered in order to assess the suitability of existing arrangements for incidents involving HNS. The comparison should be carried out against a background of probability and consequences of HNS spills from ships so that the conclusion reached is realistic and not based on sensationalism.

While the hazards and consequences of oil spills are well known, little information exists for chemical spills. Words such as 'carcinogenic', 'mutagenic', and 'neurotoxic', which appear on shipping documents, are readily misinterpreted and extrapolated to worst-case scenarios causing public apprehension and mistrust. This paper attempts to answer the question 'Are HNS Spills More Dangerous Than Oil Spills?' by reviewing the current arrangements for prevention, preparedness and response and evaluating these against the potential for serious harm from HNS and lessons learned from past incidents, including knowledge from studies of chemical spills at sea.

Chapter 2

PREVENTION

2.1 Hazard evaluation

Not all chemicals transported by sea are considered hazardous but those that are have been variously defined in different international instruments addressing marine pollution; many definitions being similar but largely dependent on the intent of the legal instrument. The definition provided by the OPRC-HNS Protocol is quite broad but is appropriate for consideration of the question posed in this paper. Here, HNS is defined as:

"any substance other than oil which, if introduced into the marine environment is likely to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea."

The 'hazard' associated with a particular chemical is dictated by its inherent properties. HNS may thus present one or any combination of the following hazards: flammability, explosivity, toxicity, infection, reactivity, corrosivity, and radioactivity. Manufacturers provide information on the chemicals they produce in the form of Material Safety Data Sheets (MSDS); soon to be replaced by Safety Data Sheets (SDS) under the UN Globally Harmonized System of Classification and Labeling of Chemicals, (GHS). These, and other internationally recognized guidance standards, provide comprehensive information such as the chemical and proper shipping name, hazard identification, physical and chemical properties, emergency response information, and toxicological and ecological information.[3]

The behaviour of chemicals spilt or released at sea needs to be known in order to assess human health and safety implications, the effects on the environment, and the most effective response strategy. There is, among others, a European Behaviour Classification System of chemicals spilt into the sea,[4] which establishes that substances behave in certain ways depending on their physical properties (physical state, density, vapour pressure, solubility) and on the environmental conditions. For example, a chemical once spilt can evaporate more or less rapidly, dissolve wholly, partly or not at all, float or sink. Table 1 provides the behavioural groups for chemicals spilt on water, with examples, and this is shown schematically in Figure 2.

Fate	Group	Properties	Examples of Behaviour Groups
Evaporate Immediately (Gases)	G	Evaporate immediately	propane, butane, vinyl chloride
	GD	evaporate immediately, dissolve	ammonia
Evaporate Rapidly	E	float, evaporate rapidly	benzene, hexane cyclohexane
	ED	evaporate rapidly, dissolve	methyl-t-butyl ether vinyl acetate
Float	FE	float, evaporate	heptane, turpentine toluene, xylene
	FED	float, evaporate, dissolve	butyl acetate isobutanol ethyl acrylate
	F	float	phthalates, vegetable oils, animal oils dipentene, isodecanol
	FD	float, dissolve	butanol butyl acrylate
Dissolve	DE	dissolve rapidly, evaporate	acetone, monoethylamine propylene oxide
	D	dissolve rapidly	some acids and bases, some alcohols, glycols, some amines, methyl ethyl ketone
Sink	SD	sink, dissolve	dichloromethane 1,2-dichloroethane
	S	sink	butyl benzyl phthalate, chlorobenzene creosote, coal tar, tetraethyl lead, tetramethyl lead

Table 1: Behaviour of chemicals spilt on water

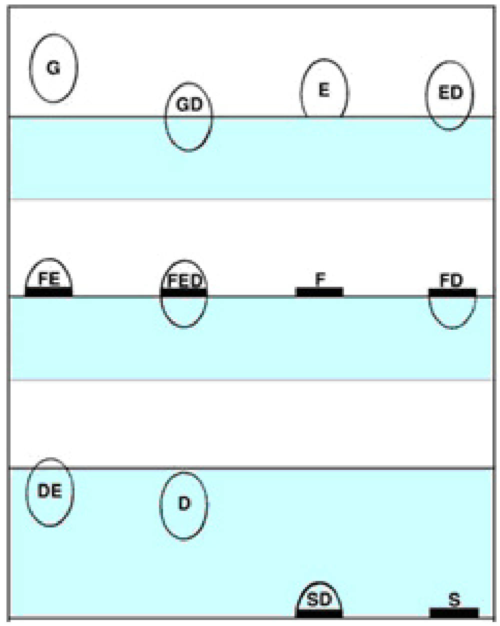

Figure 2: Schematic of the main behaviour of chemicals when spilt in the marine environment [5]

In addition, a UN advisory body known as GESAMP[6] provides a hazard profile for chemicals based on an independent and peer-reviewed Hazard Evaluation Procedure in order to define the safe transport of these chemicals in bulk. Hazards for marine life, human health and interference effects (e.g. taint, physical effects, and interference with coastal amenities) are evaluated and the information presented in the form of a 'hazard profile' for each substance. The hazard profile is used to assign a pollution category (i.e. X, Y, Z or OS), the ship type (i.e. 1, 2 or 3) and carriage conditions for each chemical substance. This information may also be employed to evaluate the impact of these chemical substances should they enter the marine environment through abnormal operational discharges, accidental spillage, or loss overboard.

2.2 Transportation by Sea

It is estimated that of about 37 million different chemicals used by man some 2,000 are transported regularly by sea, either in bulk or in packaged form. Reliable data on the actual number and volume of chemicals transported around the world are often difficult to obtain but, a Chemical and Product Tankers Conference held in March 2009[7] heard that the chemical tanker trade currently totals approximately 165 million tonnes, of which methanol and liquid chemicals account for some 46% and palm/vegetable oils account for a further 29%. The UK-based independent research company, Ocean Shipping Consultants Ltd[8], forecast that the chemical seaborne trade will increase to 215 million tonnes by 2015.

Chemicals may be transported in bulk, i.e. in liquid gas carriers for gaseous substances, in chemical carriers for liquids, and in bulk carriers for solids. In these cases, there is no protective packaging as such and a breach in the tank or hold can result in a release to the environment. However, only a few hundred chemicals are transported in bulk even though they make up most of the volume of the chemical sea-borne trade. The remainder, which account for a very large number of chemicals but in smaller volume, is transported in packaged form primarily in container vessels.

The specific properties of chemicals as described in section 2.1 above are used to classify the chemicals and provide guidance for their packaging and transportation in order to minimize the risk of a hazard arising from their carriage by sea. The two most important international conventions governing the transportation of HNS in bulk and in packaged form are SOLAS[9] and MARPOL[10]. Various other IMO Conventions and Codes apply dependent upon the physical form and quantity of the chemical transported, and the ship type. For example, the IBC Code[11] provides an International standard for the safe carriage by sea of dangerous and noxious liquids in bulk; the ICG code[12] applies to gaseous cargoes; the BC Code[13] applies to bulk solid cargoes, and the IMDG Code[14] applies to packaged dangerous goods. Before a major pollution emergency, the flag State has a major role to play for it is the flag State which is responsible for enacting and enforcing all the various maritime international rules and regulations.

Shippers of packaged dangerous goods are required to declare the proper shipping name, UN number, quantity and weight of any HNS to be carried by sea and to ensure that it is correctly packaged and labeled for carriage. Ship owners and managers use this information to produce stowage plans for the cargo, which take into account the particular hazards of the HNS and assigns a position on the ship where it may be stowed safely. Correct declaration of the cargo is thus very important, especially for packaged goods, and some of the HNS incidents in recent times are thought to have occurred because of inappropriate stowage due to mis-declaration of cargo. In 2006, off the Gulf of Aden, an explosion in the aft section of the container ship 'HYUNDAI FORTUNE' caused a fire that destroyed most of the containers in the area and caused massive structural damage. The reason was widely thought to be an undeclared consignment of fireworks[15]. Similarly, according to the cargo manifest for the 'SEA ELEGANCE', no dangerous goods were listed when the ship exploded off the coast of Durban, South Africa in October 2003 killing one of the crew. Fire scene investigators believed that the fire was caused by the self-ignition of a container-load of calcium hypochlorite that was mis-declared and stowed next to the engine room bulkhead where the elevated temperatures could have caused the chemical to decompose[16]. Following several large fires on ships carrying calcium hypochlorite, a study undertaken for the IMO[17] found that consignments of this chemical are sometimes loaded onboard vessels under different names and, as a result, shipments are occasionally not declared as dangerous cargo.

The importance of declaring the correct weight of cargo and containers should also not be underestimated as highlighted by the recent UK Marine Accident Investigation Branch (MAIB) report[18] following the 'MSC NAPOLI' incident in 2007. Investigators found that around one-fifth of all the containers were either badly packed, inaccurately labelled or the wrong weight. Others have gone on to suggest that 'this cavalier approach to the declaration of accurate weights' could have been one of the factors contributing to the loss of the 'MSC NAPOLI'[19]. MAIB noted that discrepancies with declared weights is widespread within the container ship industry and is due to many packers and shippers 'not having the facilities to weigh containers on their premises, coupled with shippers deliberately under-declaring cargo weights to minimize import taxes, to permit the overloading of containers, and to keep the declared weight within limits imposed by road or rail transport'.

To assist port and harbour authorities with their planning to ensure the safe handling of HNS, it is standard practice for ships to notify the authorities in good time, but not less than 24 hours in advance of entry into the port area, and to provide details of the HNS on board[20]. This information can be used to assign the appropriate level of protection and escort to the ship as well as to specify the conditions under which the HNS may be discharged.

2.3 Risk Assessment

Risk assessment provides a valuable process for addressing hazards in a structured way and reducing the risk to an acceptable level. The risk process considers the potential consequences and the probability of a hazardous event occurring. To a large extent the consequences of an event will depend on the specific circumstances of the incident, the preparedness of the country involved and the hazards associated with the HNS cargo. However, the combination of these factors is important because the consequences may not necessarily be assumed merely by people having knowledge of the hazard associated with the HNS cargo. A good example is Liquid Natural Gas (LNG) where heightened public concern over a possible terrorist attack on a LNG carrier has generated rather alarmist accounts of LNG exploding with the force of '50 Hiroshimas'[21]. The likelihood (as shown by several credible studies[22]) is that, if released unintentionally, LNG would not change from its liquid to gaseous state at a rate sufficient to cause a massive explosion, especially in view of the safety features inherent onboard LNG carriers.

The probability of an event occurring requires a closer examination of the practices associated with the voyages made. For example, the volumes transported, navigational issues, the ship-type, the stowage, packaging and labeling, the number of voyages made etc. Information on past incidents has been particularly helpful when assessing the risk of oil spills occurring and similar information on HNS incidents has been compiled by the IMO[23] and EMSA.[24] EMSA's review of past incidents involving HNS in European waters is particularly interesting as it shows that for the majority of incidents (or potential incidents) a single HNS cargo was involved and this was usually carried in bulk. Furthermore, most of the incidents arose as the result of foundering or bad weather, with fire or explosion, collision and grounding making up the secondary causes. Using the earlier example, history shows that LNG carriers have an exemplary safety record and it follows that when combining consequences and probability the risk of a serious incident involving LNG is low.

Attempts to carry out a risk assessment for HNS in a meaningful way are often frustrated by the lack of reliable information when compared with the same information for oil. In the EMSA report referred to earlier the researchers found flaws in the sources of information and studies relating to the lack of data, misidentification of chemicals, redundant chemical names or errors in translation. Whilst this is understandable (given the wide variety of HNS and the complex naming system for chemicals) improvements in the quality and standardization of reporting and recording information could be made to enable more reliable risk assessments to be undertaken.

Chapter 3

PREPAREDNESS

3.1 Framework for International Co-operation and Compensation

The key international convention addressing preparedness and response to HNS incidents is the OPRC-HNS Protocol, which entered into force on 14 June 2007. This Protocol provides a framework for international co-operation in the event of major incidents or threats of marine pollution from HNS and is intended to ensure that ships carrying HNS are covered by preparedness and response regimes similar to those already in existence for oil. The OPRC-HNS Protocol follows the same principles as the OPRC Convention[25] and calls for contracting States to develop and maintain adequate capability to deal with pollution emergencies from HNS; more specifically, ensuring that national and regional systems for preparedness and response are in place, ensuring that ships carrying hazardous and noxious liquid cargoes have shipboard emergency plans (SMPEPs)[26] and enhancing international co-operation in pollution response. As of the beginning of 2009, 23 countries had ratified the OPRC-HNS Protocol compared with 97 countries that had ratified the OPRC Convention. The slow ratification of the Protocol is thought to be due to the lack of available information and expertise to prepare for and respond to HNS incidents when compared with that available for incidents involving oil coupled with very few working national models (that demonstrate effective implementation of the Protocol) in place anywhere in the world.

To assist countries with *inter alia* their preparation for ratification of the OPRC-HNS Protocol, the IMO has established a Technical Group comprising IMO Member States and Observers who report to its Marine Environment Protection Committee (MEPC) and whose responsibility it is to oversee the delivery of the Technical Group’s work plan. Much of the work of the Group is focussed on developing guidance and resources to assist countries with ratifying and implementing the provisions of the Protocol; in particular training and information for oil and HNS preparedness and response, with particular attention to the needs of developing countries. A number of regional and bilateral agreements exist worldwide to provide a mechanism for co-operation and mutual assistance in responding to marine pollution incidents. The IMO maintains and ‘backstops’ regional centres such as REMPEC (Mediterranean), REMPEITC (Caribbean) and other centres such as the ROPME/MEMAC (Persian Gulf) and NOWPAP/MERRAC (Northwest Pacific) whose primary aim it is to service the commitments of the countries in a particular region (that belong to such agreements) by providing assistance to the countries on preparedness and response to spills of oil and HNS. The IMO also works with the oil industry and others through its Global Initiative (GI) to encourage and facilitate the implementation of oil spill contingency plans and ratification of the relevant conventions. A flagship of this programme is the one for West and Central Africa.

These regional and bilateral agreements have been put to the test from time to time for HNS incidents. For example, the 'IEVOLI SUN' (2000), 'ECE' (2006) and 'MSC NAPOLI' (2007) incidents occurred in the English Channel and necessitated close co-ordination between the French and British governments in order to decide the safest and most appropriate course of action to minimize damage due to the fuel oil and HNS cargoes on board. That co-ordination was given through the bilateral 'Manche Plan' which provides a framework for joint response to maritime emergencies. Similarly, parties to the Helsinki Convention were able to assist each other when two incidents involving potash carried in bulk occurred in the Baltic Sea within 4 years of each other; one of these was the 'FU SHAN HAI', illustrated on the cover of this paper.

The HNS Convention was established to provide compensation to victims of damage caused by HNS cargoes but is not yet in force. It is a single Convention based on the two-tier system of compensation for oil spills from tankers that is provided for by the CLC[27] and Fund Convention[28]. Similarly, the Bunker Convention[29] (which entered into force on 21st November 2008) follows the well-established liability and insurance provisions that apply to oil tankers under the CLC. The two-tier system of compensation for oil pollution damage from tankers has worked extremely well over the 30 years that it has been in existence and the extension of the same principles to spills of HNS is logical. However, as a single Convention, ratification of the HNS Convention has been delayed by complications caused by the negotiations on the exclusion of packaged HNS as a contributing cargo in exchange for higher limits of liability for the shipowner, the definition of 'receiver', and determining LNG contributions where the title holder is not a Member State. Furthermore, States must submit contributing cargo reports in order to assess contributions to the HNS Fund. Of the 13 States that have deposited instruments of ratification, only 2 have submitted cargo reports. A draft Protocol to the HNS Convention addressing some of these difficulties has been prepared and a Diplomatic Conference will be convened to consider the Protocol in 2010. In the interim, compensation payable to victims of damage caused by HNS is dependent upon whatever regime is in force in the jurisdiction affected, usually LLMC '76[30], which is likely to provide only a fraction of compensation that would be available under the HNS Convention.

3.2 Contingency Planning

Contingency planning is essential if countries are to respond to spills of oil and HNS promptly and effectively. A contingency plan should reflect a government's policy towards oil or HNS incidents and clarify the roles and responsibilities of the different players involved; it should also identify the capabilities that are in place to prepare for these events and the strategy to be followed. Where bilateral or regional agreements are in place, or where arrangements are in place to pool government and industry resources, the mechanism to put these arrangements into effect should be described.

For many countries, particularly in Northern Europe, governments are responsible for responding to spills of oil or HNS. This tried and tested approach recognises the duty of care that governments have for their citizens and the obligation they have for implementing the strategies identified in their national contingency plan. This approach also builds on the intent that is embodied in the text of the international preparedness and compensations conventions described earlier. The 'polluter pays' principle is realised insofar as the shipowner and his insurer is expected to 'pick up the bill'. However, that is not to say that the shipowner should not contribute in a more active sense to the response and salvage/wreck removal issues. Indeed, their expertise during an incident is actively sought. Nevertheless, a government-led response is more likely to be prompt and effective and will avoid the delay and confusion that can easily result from imposing a shipowner-led response, especially in cases where the ship was in transit and not destined for a port in the country. This will be particularly important for incidents involving HNS where rapid assessment and response to a situation could be essential to avoid potentially life-threatening consequences and where time delays are unacceptable.

The OPRC-HNS Protocol places an obligation on Member States to ensure that ships flying their flag have onboard a pollution emergency plan to deal specifically with incidents involving HNS. In general it appears that flag States are accepting the Shipboard Marine Pollution Emergency Plans (SMPEP) as required under MARPOL for ships of 150 gross tons or greater certified to carry oil and noxious liquid substances. But it should be remembered that the SMPEPs are primarily intended to enable the crew to take practical measures to control and minimise a spill from the ship under different scenarios. It would be unrealistic to expect the crew to be in a position to do anything more than is required of them to minimize the risk of a release as their focus will be on their safety and not on responding to any release away from the confines of the ship. However, in a few countries, such as Canada, Japan and the USA, shipboard emergency plans are more extensive and include requirements to provide specific response capabilities beyond the required shipboard equipment through local spill response contractors.

The tiered approach to responding to spills of oil has proven to be an effective and flexible mechanism for scaling the response according to the need. The concept of a local response using local resources (Tier 1) escalating to involve neighbouring government or industry-shared resources for spills beyond local capabilities (Tier 2), through to the mobilization of resources beyond Tier 2 capability to respond to a spill of national significance (Tier 3) is one that many countries have extended to address spills of HNS. This approach is likely to be appropriate provided that the unique characteristics of a spill of HNS are properly considered. A risk assessment is often the first step when considering the location and content of equipment stockpiles. For oil, Tier 3 regional stockpiles are mostly located in high risk areas or consumer countries; with good reason as oil spill statistics reveal that significantly more oil spills occur close to the port of discharge rather than the port of loading.[31] It is unclear whether such a trend is apparent worldwide for HNS incidents as these have been comparatively few. However, in practice it is likely that existing stockpiles will be augmented to provide capability for HNS response rather than entirely new stockpiles created. It is also likely that the factors that result in the trends observed for oil spills will apply similarly to HNS, such as weather patterns, congested waterways, operational malfunctions in ports and harbours etc. In which case, augmenting existing stockpiles would be sensible.

EMSA has undertaken a review of the capacity of EU Member States to respond to a spill of HNS in the marine environment.[32] It was found that the level of preparedness and response capability for HNS varied but that many countries were incorporating HNS into their established national contingency plans for oil and intending to apply the tiered response mechanism for HNS emergency response. Importantly, many countries did not consider themselves operationally prepared to respond to HNS incidents and admitted to lacking the experience or knowledge of the behaviour of HNS in the marine environment to respond to significant and/or complex (multiple cargo) HNS incidents. Of the 12 EU Member States that had ratified the OPRC-HNS Protocol, only 3 reported having 'specialised' capability to respond to HNS incidents whereas 6 reported 'very limited' capability.

For those countries that have made preparations for responding to HNS incidents, or are in the process of doing so, the majority are augmenting national response arrangements already in place for oil with specific expertise available from civil defence units, the military, specially trained fire brigades, salvage experts and other private contractors. The UK Maritime and Coastguard Agency (MCA) has, for example, trained 15 regional fire fighting teams to deal with HNS incidents while a ship is offshore and where access by other trained responders is impractical. Cascading the arrangements from the national level to the local and individual port or harbour level requires a clear understanding of their obligations under the OPRC-HNS Protocol and of the roles and responsibilities of the different players involved. As with contingency plans for oil spill response, the key to making contingency plans effective for dealing with HNS incidents is to provide for training and regular exercises involving the various stakeholders. Particular attention will be needed to check that emergency communication between parties is established and tested frequently as time delays in the case of HNS spills could have fatal consequences, an outcome less likely with oil spills. A clear example is in the case of a large release of toxic gas where emergency communication and response will need to be automatic to ensure that inhabitants downwind of the toxic cloud are given information on how to 'shelter in place' in a timely manner.

While there is a wide array of training available for responding to land-based chemical spills, there are comparatively fewer training courses that are focused specifically on the response to maritime incidents involving HNS. However, as interest is growing, more companies and organisations are beginning to offer such training. The Technical Group referred to in section 3.1 has recently developed two model courses on preparedness and response to HNS incidents in the marine environment: an introductory course for operational/first responders and an introductory course for incident managers; both intended to provide awareness of the issues that a responder or incident manager may be faced with during a HNS response rather than training them to a level of competency to actually respond. This recognises the fact that competency in responding to HNS spills is a skill that will be attained only after investment in response equipment and personnel training, including practical exercises.

3.3 Industry Responsibilities

In considering the role and responsibilities of the industry in the context of the OPRC-HNS Protocol, 'industry' is taken to include the shipping community (represented by the shipowners and operators, including many of the major oil companies) and other private and public organisations involved in the manufacture and distribution of HNS. Apart from the obligations placed on shippers as discussed in section 2.2, many countries require chemical manufacturers to provide copies of MSDS information to ‘centres’ providing 24/7 emergency support in the event of a spillage of their product. This service is provided by CHEMTREC[33] in the USA, by CANUTEC[34] in Canada and by the Marine Intervention in Chemical Emergencies (MAR-ICE) Network[35] in Europe. Beginning in January 2009, the new MAR-ICE Network (created through a trilateral agreement between EMSA, CEFIC and CEDRE) provides, upon request by EU Member States, information on chemicals in cases of marine incidents involving HNS and is accessible through a single MAR-ICE Focal Point. Clearly, to enable these services to work effectively in an emergency, the cargo manifest must be made available to those needing the information as quickly as possible. Delays in obtaining the cargo manifest have occurred in past incidents. Furthermore, on occasion, when the manifest had been provided, it was found to be too general to be useful. These are issues that some government agencies have highlighted for particular attention.

The tiered response to HNS incidents that is foreseen by many governments in their contingency plans generally encapsulates the support of industry. Oil companies are already familiar with their role in national contingency plans for oil spill response and, as they will be among the largest shippers of bulk petrochemicals, their role will probably be similar in the case of HNS responses. However, the level of expertise available generally for dealing with HNS incidents is likely to be less than for oil and greater reliance on the oil industry for advice and support is possible. Other chemical manufacturers and distributors are likely to be less familiar with their role in the event of a spill of one of their chemicals at sea and here there is potential for expectations to be misaligned. In most cases, all that might be required of the manufacturer is confirmation of the MSDS information and other remote advice as might be needed to deal with a spillage. However, larger manufacturers such as BASF, routinely respond to road and rail incidents involving their products and have specially trained personnel to deal such spillages. Consequently, manufacturers may be able to extend their expertise relatively easily to provide technical support and advice if one of their products is involved in an incident at sea. Indeed, some frustration has been expressed by chemical manufacturers and responders alike when opportunities for involving their expertise have been missed. These situations emphasise again the importance of effective communication between the shipper, shipowner, and the response agencies.

The important role that industry, and specifically the oil industry, can play in supporting governments in oil spill response has long been recognised and utilized to the benefit of both parties. As the number of HNS incidents has been proportionally less, the support that the oil industry can, and has, played in HNS incidents, particularly where they have been the charterer or cargo owner, is perhaps less obvious. For example, in the ‘IEVOLI SUN’ the two charterers, Shell and Exxon Chemicals, were able to provide precise information about the chemicals onboard, including information on the polymerisation inhibitor mixed with the styrene. However, understandably perhaps, they had little knowledge of the fate of styrene released into seawater at a temperature of 10 degrees Celsius and at a depth generating several atmospheres of pressure. An added complication of marine pollution emergencies is that the owner of the cargo at the time may not necessarily be either the shipper or the consignee, for the ownership may have changed hands once or more during the voyage. Initially, therefore, it may not be easy to establish who owns the cargo. This situation is more likely to arise with oil rather than with bulk chemicals although packaged HNS can be owned by a greater number and variety of entities.

The salvage industry is perhaps the best (and often under-utilised) source of support in many HNS incidents where expertise is lacking locally as they have specially trained personnel to deal with HNS response on board ships as well as specialists able to provide, for example, monitoring support, advice on specific cargoes, re-packing and disposal expertise. Following the grounding of the LPG carrier, 'KEW BRIDGE', in India in 2006, the salvors appointed by the owners of the ship and an expert to the Indian government provided advice on the behaviour of LPG in the circumstances of the incident and highlighted precautions that could be taken to minimize any risks in order to reassure the local authorities and population who were concerned about the possibility of a release and explosion.

Referring again to the example of industry's support in response to oil spills, many of the Tier 2 or Tier 3 stockpiles of oil spill response equipment (that are in existence worldwide to supplement government and local industry stockpiles) are entirely, or in part, funded by the oil industry in recognition of their part in the chain of responsibility. Similarly, the shipowner or operator may be required to contribute to the maintenance and replenishment of equipment stockpiles by paying 'dues' or 'transit fees' when entering certain ports or harbours; otherwise, their responsibility is to pay for the cost of the response in accordance with the relevant legislation. Ideally, the same approach for supplementing and maintaining these equipment stockpiles to prepare for HNS response would be followed.

Clearly, there exists a wealth of information among the chemical manufacturing and distribution sector, particularly in the case of land-based HNS spills, that might be tapped into more effectively to provide awareness, training and perhaps on-site support in the event of ship-source HNS incidents. Some of the initiatives currently being undertaken by, for example, the IMO and EMSA, are intended to identify and consolidate existing information to assist Member States and to avoid duplication of effort.

Chapter 4

RESPONSE

4.1 Initial Assessment

When dealing with an HNS incident, one of the priorities is the identification of the hazard and an assessment of the risk posed by a stricken vessel and its cargo to the public and responder safety, the environment and socio-economic assets that a State or coastal community depend upon. The primary factors which determine the severity and extent of any impact relate to the chemical and physical properties of the HNS and its physical fate in the environment. Basic information can be found from the MSDS available from the manufacturer, the internet and/or centres established specifically to provide such assistance as discussed in Section 3.3.

Hazards to human health are generally considered low in cases of oil spills. The more toxic, lighter fractions (BTEX) often evaporate before responders reach the scene. Therefore, the focus of an oil spill response differs from that of an HNS release. Following an oil spill the initial assessment is typically focused on determining the trajectory of the oil for protection of sensitive resources and evaluation of the most appropriate response techniques. However, this is not always the case; the 'TASMAN SPIRIT' incident which occurred in Pakistan in 2003 was a case in point. When the tanker broke up spilling about 27,000 tonnes of her cargo of Iranian light crude oil, the proximity of the tanker to the Karachi seafront and the prevailing wind direction caused alarm about potentially high levels of hydrocarbon vapours. Consequently, air monitoring and medical facilities were put in place to evaluate the risk to citizens and clean-up crews. Spills of non-persistent oils can generate similar anxiety as well as concern about potentially flammable vapours near the source. Therefore, monitoring of explosive limits, oxygen concentration, benzene and hydrogen sulphide may be undertaken during oil spill response to ensure a safe working environment. Nevertheless, for most oil spill response situations at sea and on the shoreline neither air quality nor the risk of explosion has been a concern.

Although vegetable oils are regarded as HNS they generally do not pose an immediate threat to human health and safety because they are not volatile or acutely toxic. However, vegetable oils can affect sea birds, which lose thermal insulation in a similar way to spills of petroleum oils, as documented by a spill of canola oil in Vancouver harbour in 1989.[36] They can also be highly persistent and disruptive to amenities as demonstrated by the incident in which 900 tonnes of palm kernel oil was spilt from the product tanker, 'ALLEGRA', following a collision in the English Channel in 1997[37]. This oil was originally heated but spread and solidified when it came into contact with seawater and eventually contaminated the beaches of the Channel Islands some 100km away. The persistence of vegetable oils and therefore, their impact, is very much dependent upon the type of oil as demonstrated by the studies carried out after the 'KIMYA' incident off the coast of North Wales.[38]

For the majority of HNS, undertaking an initial assessment and monitoring of potential hazards is a priority before any strategy for response can be considered. The initial assessment ought to be approached in a step-wise, logical order such that the identity of the HNS involved is first confirmed, then the primary hazard and behaviour in the marine environment is evaluated (i.e. what will it do? and where will it go?). This will allow informed decisions to be made about whether it is safe to respond at all and, if so, how to respond (assuming a response is needed). As explained in section 2.1 the hazards associated with a particular substance are dependent on its inherent properties and its fate in the marine environment. The monitoring techniques employed during the initial assessment need to be designed to measure the key properties that could give rise to a hazard. Sometimes the 'do-nothing' approach, where the situation is kept under observation as it evolves, is the most appropriate one. Assuming that the identity of the

HNS can be found from the cargo manifest (and verified through contact with the cargo owner), the MSDS will provide information on the hazards and physical/chemical properties of the substance/s involved as well as indicate possible incompatibilities or reactivity with water or other substances if more than one is involved. The challenge for responders is to focus on the most important health and safety hazards (especially in complex incidents involving more than one chemical) and to ensure that they are using appropriate monitoring techniques.

A further complication can arise when attempting to predict the fate and behaviour of individually packaged HNS goods that are subsequently loaded into containers. When the barge 'COSEL-L43' listed under tow from Port Moresby to a gold mine in Kiunga, Papua New Guinea, in June 1984[39], containers loaded with drums of sodium cyanide and tanks of hydrogen peroxide were lost overboard. Initially, the containers sank but several hours later they floated to the surface due to the reaction of seawater with hydrogen peroxide, which generated oxygen and increased the buoyancy.

Usually gases and 'evaporators' cause the most concern for human health and safety as they could explode, catch fire, or generate a toxic vapour cloud. Several monitoring devices are available to detect a dangerous atmosphere and most measure the ease with which the substance ionizes to obtain a concentration or percentage in air. Some marine pollution response vessels are equipped with sampling and gas detection systems with data logging that perform the task of providing information on the air quality around a casualty, thus limiting potential exposure of response personnel. If 'floaters' are coloured, they may be monitored visually; otherwise techniques that rely on 'interference' or 'wave dampening' of optical properties may indicate the presence of a pollutant and aerial/remote sensing devices, such as UV, radar, infra-red or laser techniques can be useful. The ability to monitor a 'dissolver' depends to a large extent on how the substance behaves in the water column. If it disassociates or reacts, electrochemical methods, such as conductivity, pH, or oxygen meters can be used. Alternatively, optical methods are useful if the substance creates turbidity or interacts with light. 'Sinkers' are usually very difficult to monitor although some acoustic techniques are being evaluated.'

Recognising that most concern for health and safety lies with gases and evaporators, several air dispersion models have been developed to aid decision-making and provide conservative estimates of safe distances for protection of the population and responders. After the chemical tanker, SAMHO BROTHER', sank off the coast of Taiwan in 2005 with a cargo of some 2,760 tonnes of benzene and 85 tonnes of bunker oil the shipowner and insurer engaged international experts to provide modelling and air/water monitoring to support the local authorities in determining the hazards. A conservative exclusion zone was established around the sinking site and warnings issued to fishermen and other seafarers to avoid the area. Modelling showed that the oil would move towards the coastline with the currents but the benzene vapour would travel offshore driven by the wind. The modelling output was also useful to provide reassurance regarding the effect of benzene on water column resources. To verify the model output, air monitoring was carried out by moving from the outer edge of the exclusion zone towards the sinking site. No benzene was detected either in the air or water column but the exclusion zone was maintained because the stability of the ship and the possibility of further leakage were unknown.

The models that are used for emergency response tend to be fairly basic as the intention is not to attempt to mimic multiple scenarios with accuracy but to provide a rapid means of delineating potentially dangerous zones and assessing appropriate levels of personal protective equipment (PPE). Trajectory models have been used for many years to monitor the movement of oil slicks and can be used in the same way to monitor floating HNS, provided that there is sufficient information on the speed and direction of the wind and currents. More sophisticated models exist for predicting the movement of substances in the water column but these are very dependent upon knowledge of the sub-surface water movement, which does not exist in most areas of the world and tend not to be used in emergency situations. Reliable modelling for 'sinkers' in a dynamic marine environment is still in its infancy.

The importance of an initial assessment has been demonstrated on many occasions following HNS incidents at sea as can be seen from the list of case studies provide in the supporting paper accompanying this White Paper.[37] The key difference when undertaking an initial assessment for HNS incidents, as compared with oil, is the timing. The initial evaluation for HNS incidents needs to be rapid because the consequences could be very severe. However, the time elapsed between when the incident first occurred and any response to the incident may be longer than for an oil spill because of the need to establish safe conditions and a strategy that is appropriate for the circumstances of the incident.

4.2 Response Techniques

Actions that can be taken by the crew as part of their on-board emergency plans (SOPEPs/SMPEPs) are critical for reducing the potential consequences of an incident. Closing valves, transferring cargo, changing the position of the ship to take explosive/toxic vapours away, moving to less vulnerable areas away from population centres or sensitive environmental resources etc., are all response options that can be considered by the crew provided that there is time and it is safe to do so. The actions taken by the crew onboard the chemical tanker 'MULTITANK ASCANIA' to prevent an explosion from the 1,800 tonnes of vinyl acetate monomer on board following a fire in the machinery spaces were commended by the UK MAIB. The crew extinguished the fire using portable extinguishers and then flooded the machinery spaces with the fixed CO_2 systems before abandoning the ship.

Apart from the initial evaluation and assessment described above, opportunities to respond to HNS once released into the environment are limited when compared with spills of oil, unless the chemical can be safely contained and/or physically removed. This is because the range of behaviour for HNS is extensive, especially when more than one chemical is present or there is the potential for reaction and the formation of reaction products to consider. In contrast, oil behaves primarily as a floater and can be dealt with using a range of response techniques specifically designed to deal with the different viscosities of oil spilt and the sea conditions. It may be possible to extend the application of these techniques to spills of floating HNS provided that they are not reactive, potentially explosive or toxic. For example, booms have been used to contain spills of vegetable/animal oil, floating beads and contaminated debris. Also if the HNS has been lost as a package and, depending on the density of the HNS in the package, it may float making it possible to recover using booms, nets, cranes or towing devices.

Manuals have been prepared to provide advice on the different techniques that can be used to respond to HNS incidents. Examples of such are the chemical response guides prepared by CEDRE and provided on their website[40] and the IMO Manual on Chemical Pollution[41]. The response techniques are grouped according to the behaviour of the HNS in the environment, whether still packaged or released. In general, risks associated with gases and evaporators (e.g. ammonia, vinyl chloride and LPG) can be reduced using controlled release/dilution methods or 'knock-down' sprinkler systems. In their report[24], EMSA provides a synopsis of case studies grouped according to the behaviour of the HNS involved and uses the example of the 'VAL ROSANDRA' (Italy, 1990) to illustrate the controlled rupture of the cargo tanks and burning off the propylene cargo. A similar approach was taken when 51 steel containers of chlorine were lost from the 'SINBAD' off the Dutch Coast in 1979.[42] Water sprays may also be used to cool hot surfaces and reduce the risk of fire and explosion in flammable gas clouds as happened with the container ship, 'EVER DECENT', following a collision with a cruise vessel in the English Channel in 1999. However, attention needs to be given to the consequences of using water sprays on the stability of the casualty and the potential to cause environmental damage by contaminated run-off.

Techniques applicable to oil spill response may be suitable for some floating substances as discussed earlier, provided that the response takes into consideration any hazards identified from the initial assessment. This is particularly the case for floating substances that also evaporate and create potentially explosive vapour clouds and where spark/static-free equipment should be used, for example, diesel, xylene or styrene. Foam sprays or sorbent material may also be useful for treating spills near the source.

Treating spills of HNS that dissolve or distribute in the water column (such as acids, bases and alcohols) is difficult, more so if the water body is large and constantly moving. The HNS will form a growing plume, which if invisible, could be difficult to track. In shallow water where the HNS may be confined, treating agents such as neutralizers, activated carbon, oxidising or reducing agents, complexing agents or ion exchangers could be considered. By way of example, ferrosulphate was added to the wreck area prior to the salvage of the 'VIGGO HINRICHSEN', which sank off the Swedish island of Oland in September 1973[43]. The ship was carrying chromium compounds among its cargo and had begun to leak and chromium was detected in the water around the wreck. The effectiveness of these treating agents will depend on the ability of the product and the HNS to interact together and it is rarely the case that pouring one chemical in after another in flowing water could effectively neutralise or treat the spilt HNS. In many cases, particularly where ships have sunk, HNS that dissolve into the water column and dilute rapidly may be 'bled' into the sea such that the concentration remains low and of minimal threat to the surrounding environment. This was done with the cargo of methyl ethyl ketone (MEK) and isopropyl alcohol (IPA) which were on board the chemical tanker, 'IEVOLI SUN', when it sank in the English Channel in October 2000. It was also advised following the sinking of the chemical tanker, 'ECE', in 2006 carrying 10,000 tonnes of phosphoric acid.

Unconfined HNS that are heavier than seawater have the potential to contaminate large areas of the seabed making recovery difficult, time-consuming and expensive. Methods that have been used include various forms of dredges, such as mechanical, hydraulic or pneumatic. However, dredging is likely to generate large quantities of potentially contaminated dredged material and care needs to be taken to ensure proper containment and disposal of this. Capping of contaminated sediment *in-situ* is another response option that can be considered in some circumstances. For example, heavier clean sediment can be dumped on top of the contaminated sediment to prevent the HNS from being spread further in the environment. HNS contained in packages (or in a ship) may be recovered, released or pumped into other containers and this has been achieved primarily with the assistance of Remotely Operated Vehicles (ROVs). In the case of the 'IEVOLI SUN' mentioned earlier, the cargo of some 4,000 tonnes styrene was assessed as being a threat to the environment and, as such, could not be deliberately released in the same way as the other two cargoes onboard. Consequently, the diver-less Remote Offloading System (ROLS) was used to penetrate the double hull of the tanker at a depth of 90 metres and allow the styrene to be pumped into a reception vessel. ROVs have also been used in operations to pump oil out of sunken wrecks such as the 'PRESTIGE', in Spain, and the 'SOLAR 1' in the Philippines. In the case of the 'PRESTIGE', oil removal was achieved at a depth of more than 3,500 metres.

If, after a full assessment of the risks posed by an HNS incident a response is considered necessary, various actions may be taken to reduce the risks to the surrounding population and the environment during the operation. Local authorities may decide to evacuate some areas, prevent recreational activities, close amenity beaches or impose fishing restrictions to protect fishermen and/or consumer health. Throughout the operation and until its completion, close coordination and cooperation with stakeholders and parties involved in the response is essential to reduce the possibility of harm.

Chapter 5

ENVIRONMENTAL CONSIDERATIONS

The GESAMP hazard profiles referred to in section 2.1 are generated after evaluation of data provided by the producer or user of the chemical, including for example, LC_{50} values for different exposure routes, testing for irritation, corrosion and long-term effects, measurements of bioaccumulation, biodegradation and tainting (although the latter is not a requirement). Therefore, if a hazard profile exists for the HNS spilt into the environment following an incident it is possible to gauge the severity of potential environmental effects in areas where the concentrations are identified as likely to cause harm. Similarly, the MSDS information provided by the manufacturer also contains a section on ecological toxicology and this can be used to indicate the risk of harm to the environment if certain concentrations are exceeded. However, the toxicity data are, for the most part, obtained from laboratory studies in which test organisms are exposed to a fixed concentration of the chemical in freshwater (rather than salt or brackish water) for a period of 96 hours. The laboratory setting is not representative of the environment in which HNS may be spilt following an incident at sea and neither does it account for rapid dilution of the HNS due to tidal movement in the sea. Consequently, the values provided in the GESAMP hazard profile and the MSDS are more precautionary than those which may be applicable in reality.

The effects of oil on the marine environment have been studied extensively and reported[44,45]. However the same cannot be said of HNS where there have been relatively few studies of specific HNS on marine fauna and flora. Whilst not necessarily toxic, vegetable or animal oils are likely to pose similar problems for marine birds and mammals relying on fur and feathers for insulation. As a result, they could be just as harmful as petroleum oil spills because of their potential to physically coat the animal or bird and cause heat loss. These oils may also smother coastal fauna and flora and interfere with their biological activity, much like viscous or emulsified petroleum oils. Other cargoes may at first appear benign and of no risk to the environment. However, as illustrated by the grounding of the bulk carrier, 'FENES', in France in 1996 even cereals can generate a toxic environment if they ferment *in-situ.* In this incident some of the 2,900 tonnes of wheat cargo were dumped on the seabed causing localised smothering of the seabed fauna and flora, eventually fermenting and generated hydrogen sulphide, which created a hazardous environment for response personnel.

Because it is difficult to identify a direct correlation between exposure and effect for many HNS, monitoring programmes undertaken after an incident need to be specific and designed to produce meaningful results that will aid decision-makers in their strategy. For example, following an oil spill the hydrocarbon content in the water column is often monitored and compared with control sites or background levels to enable local authorities to consider the merit and the duration of fishing restrictions that protect human health and the consumer market. Similar issues are likely to arise following a spill of HNS and monitoring for the presence or absence of the substance in the water column may be helpful, especially if the HNS could bio-accumulate or cause taint. This was the case following the incident described earlier involving the 'SAMHO BROTHER' whereby fishermen were concerned about the effect of benzene on the fisheries. The combination of modelling and monitoring for benzene in the water column enabled responders to demonstrate that benzene would not reside in the water column in sufficient concentration to affect the fisheries.

Monitoring programmes can also provide some guidance regarding the pros and cons of leaving a wreck and its cargo in place. If studies demonstrate that the effect of the cargo is localised, transient or likely to cause minimal environmental harm, decision-makers may be reassured about the consequences of the cargo and able to focus solely on the consequences of the wreck. Conversely, if studies show that the cargo is hazardous, they are then able to provide the rationale for removal of the cargo. Resource, or habitat-specific, studies may also be useful where there has been evidence of significant mortality and there is concern about the ability of the resource or habitat to recover naturally.

Chapter 6

DISCUSSION

In answering the question 'Are HNS spills more dangerous than oil spills?' it is clear that consideration of more than just the hazardous nature of the substance/s involved is necessary. If 'dangerous' means 'ready to do harm or injury' the issue then becomes one of considering whether HNS spills have the potential to cause greater harm or injury than oil spills and, if so, why.

Oil spills could be considered dangerous if the volatile vapours from the oil are of sufficient concentration to be toxic to human health or to create a risk of fire or explosion. They may also be considered dangerous if the concentration of oil in the environment is sufficient to cause harm to sensitive environmental resources and habitats. If a spill of HNS generates a more toxic or explosive or environmentally harmful situation than oil then it is logical to conclude that it will be more dangerous than an oil spill. The incident involving the 'CASON', off the coast of Spain in December 1987 is a case in point. This ship was loaded with 1,100 tonnes of packaged HNS identified as toxic, flammable and corrosive. A fire broke out onboard after containers of sodium came into contact with seawater and killed 23 out of the 31 crew members. Subsequent explosions destroyed the ship and resulted in the evacuation of some 15,000 people within a 5 mile radius.

Incidents involving multiple cargoes of packaged HNS, such as the 'CASON', are fortunately rare. However, the circumstances that could result in an incident involving packaged goods are more likely to be associated with the chain of responsibility linking the shipper to the receiver. Mis-declaration of HNS, poor packaging, labelling, weighing, incorrect stowage etc. are all links in this chain any one of which, if broken, may directly or indirectly lead to a casualty. The sheer number of potential shippers and receivers involved in the transport of packaged goods, together with the inevitable variation in knowledge and application of the IMDG code, increases the potential for HNS to be inadvertently or deliberately mis-recorded. Although the quantities of HNS involved will probably be significantly less compared to HNS carried in bulk, the consequences of a spillage could be more severe if the HNS is considerably more dangerous. The passenger ferry, 'PRINCESS OF THE STARS', which capsized during a typhoon off the coast of the Philippines in June 2008 illustrates this point. Tragically, fewer than 60 of the 850 passengers onboard survived when the ferry capsized but it was also discovered that the ferry was loaded with containers holding five highly toxic pesticides (endosulfan, carbofuran, propineb, metamidophos nicolosamide), other HNS and 100 tonnes of fuel oil. No leakage of either pesticide or fuel oil has been reported so far and recommendations made by the Joint UN/EU Mission to the Philippines include installation of a complete system for recovery, storage and elimination or disposal of chemicals prior to the start of salvage operations.[46] Clearly, if the pesticides enter the marine environment, the consequences for the near-shore fauna and flora, and subsequently the people dependent on these resources, could be severe. Because of the persistence of the pesticides, the extent of harm to the environment and its duration is likely to be considerably greater than for most other HNS or for oil.

The findings from various risk assessments and information on actual incidents or 'near misses' help to highlight the HNS most likely to be involved in an incident and, hence, the potential for a more dangerous situation than for oil. According to these sources, it is most likely that an incident will involve HNS carried in bulk. Given that the volumes of hydrocarbon oil transported by sea are considerably more than for other HNS, it is no surprise that oil spills make up the greatest proportion of incidents. If oil is excluded, data compiled by the International Parcel Tankers Association (IPTA) for 2000 indicate that the most commonly transported HNS in bulk are petrochemicals (such as xylene, benzene and toluene), petrochemical products (such as MTBE, methanol, styrene, ethyl dichloride and ethylene glycol) and acids or bases (such as phosphoric acid, sulphuric acid and sodium hydroxide). To compare information on the volumes of HNS moved by sea with the reported incidents or 'near misses', it is interesting to note that a US Coast Guard statistical analysis of spills of hazardous substances for the period 1992-1996 identified sulphuric acid as the most commonly spilt HNS, with other dissolvers such as phosphoric acid and sodium hydroxide being prominent. Evaporator/dissolvers such as acrylonitrile and vinyl acetate, and floater/evaporators such as benzene, toluene, xylene and styrene, were also among the HNS most commonly spilt in US waters. The same HNS featured in a number of other incidents that occurred internationally as can be seen from the case studies in the supporting paper[37] and the EMSA HNS Action Plan[24].

Thus, there is reason to suggest that the most commonly transported chemicals are the ones most likely to be involved in an incident. Also, the risk of an HNS incident occurring will almost certainly vary according to the location. Logically the risk will be higher along the shipping routes where most chemicals are transported, where there is congestion, and where poor weather conditions exist, as well as at the ship-shore interface in ports where loading and discharge take place. It would seem sensible to invest in efforts to better understand the risk of HNS spills occurring in different regions of the world and to look for ways of improving the quality of data gathered on the movement of HNS. Having an awareness of these factors will facilitate improvements in preparedness for dealing with casualties involving the 'high-risk' chemicals and provide the opportunity to take measures to reduce the potential for harm or injury.

As bulk HNS are transported in chemical carriers or gas carriers, which are highly specialised ships where carriage of these products is heavily regulated, it would be unusual for mis-declaration of cargo or poorly stowed cargo to be a contributing factor to a dangerous situation involving HNS onboard these ships. It is more likely that other factors such as a foundering, fire/explosion, collision, or grounding would be the cause of an incident. The 'human factor' as a contributory cause in a number of fire/explosions on board chemical and product tankers was highlighted in a study carried out by an Inter-Industry Working Group (IIWG) on behalf of the

IMO Maritime Safety Committee[47] and illustrated the importance of following established guidelines and practices. The IIWG found among their conclusions that the majority of incidents involved MARPOL Annex II substances (rather than oil) and were caused by tank cleaning, venting or gas freeing. Recognising the importance of the 'human factor' as a contributing cause, the industry has subsequently established a task group to address procedural compliance on board chemical and product tankers.

A controlled release of volatile HNS from a ship (where the dangers are known and precautions are put in place), and an uncontrolled release where precautions are not followed, highlights the progression from a non-threatening situation to a potentially dangerous situation, even when the circumstances of the incident are the same. Many of the HNS involved in past incidents could certainly be regarded as more dangerous than oil on the basis of their hazards to human health but, in several cases, their chemical and physical properties (and subsequent fate in the marine environment), together with careful evaluation, planning and response, have combined to make the situation less dangerous than for oil. Good examples are those where the HNS has been diluted into the surrounding sea (e.g. sulphuric acid), or released into the atmosphere and have enabled the situation to remain in control with little or no harm to response personnel, the public or the environment.

An important difference in the dangers between oil and other HNS arises when considering the response to a spill. Early in the paper it was explained that air quality and the risk of explosion are not usually of concern for response personnel following an oil spill because the oil was likely to have lost the more dangerous, volatile components by the time a response is put into effect; this is particularly the case for shoreline clean-up. Consequently, it is not unusual for fishermen or unskilled labour to be engaged to assist in the clean-up. In contrast, risk assessments and information on actual incidents have demonstrated that clean-up of a spill of HNS is unlikely to be feasible and response will be limited, in most cases, to initial evaluation, establishing exclusions zones, modelling and monitoring, followed by planning for controlled release, recovery or leaving in-situ; a process which may endure for many weeks or even months. It is, therefore, more usual for specialists to be involved in these stages of the response, such as salvors, especially as transfer of cargo, securing cargo holds and/or containers, and making the situation safe are not tasks that can be undertaken without the necessary expertise, equipment and PPE. This approach limits the potential for dangerous situations to arise and ensures that only qualified personnel are in direct contact with the HNS.

Although it is important to have an awareness of the 'potential' for a particular substance to be dangerous, the possibility of the dangers actually being realised are subject to the specific circumstances of the incident and its handling. For oil spills, experience has shown that where a country has fully implemented the requirements of the OPRC Convention and has contingency plans in place with a complementary programme of training and exercises, a pragmatic and confident approach to the handling of a casualty is more likely. Many countries ratify Conventions without a proper understanding or application of their inherent obligations. Consequently, when an incident occurs they are unprepared, often without the infrastructure or equipment necessary to mount a prompt or effective response. As discussed in chapter 3.1, the OPRC-HNS Protocol follows the same principles as the OPRC Convention and, as such, requires member States to dedicate resources to ensuring an adequate level of preparedness for HNS incidents. Fulfilment of the obligations of this Protocol will be especially important because of the specific dangers associated with the HNS, which may be fundamentally different from those associated with oil.

Chapter 7

RESEARCH & DEVELOPMENT

Very large oil spills like the 'TORREY CANYON' (UK, 1967), the 'EXXON VALDEZ' (USA, 1989), the 'ERIKA' (France, 1999), the 'PRESTIGE' (Spain, 2001) and the 'HEIBEI SPIRIT' (Korea, 2007) have prompted investment in research and development (R&D) with the intention of understanding the fate and effects of oil in the marine environment better and to identify innovative, more effective response techniques. Indeed, much of the early development in chemical dispersants was initiated following lessons learnt from the response to the 'TORREY CANYON' incident. The continuing demand for oil and the high volumes moved by sea has ensured that oil spills and associated R&D remain on the agenda. Recent spills involving heavy oils (such as the 'DBL 152' which occurred in Louisiana, USA in 2005), coupled with the possibility of a spill involving one of the heavy oils coming from Russia, has prompted investment in R&D to improve monitoring and recovery of sunken oils. Similarly, transport of oil through ice-infested waters has prompted R&D in techniques that could improve response to oil spills in ice. Dispersant effectiveness, the fate of chemically dispersed oil, deep water oil recovery techniques, fast water booming and skimming are also topics that attract interest and funding as different countries seek to improve their response capability.

In contrast, there has been much less investment in R&D for HNS spills, primarily because there are so many more substances potentially involved each with widely differing properties and the frequency of incidents is relatively low. Nevertheless, the opportunity has been taken to study the behaviour of some chemicals following actual incidents. For example, the behaviour of styrene, MEK and IPA was studied to provide information to decision makers following the incident involving the 'IEVOLI SUN'[40] and studies were carried out on the behaviour of phosphoric acid after the 'ECE' incident and on cocoa beans after the stranding of the ROKIA DELMAS. Similarly, Environment Canada carried out some research to investigate the behaviour of benzene in cold seawater following the grounding of the 'SICHEM ANELINE' off the coast of Montréal, Canada in 2007 [48]. The information from these studies and others will be helpful for future incidents, provided of course that a mechanism for effectively collating and disseminating the information can be found.

The entry into force of the OPRC-HNS Protocol and the efforts taken to bring the HNS Convention into force have prompted interest in understanding the fate and effects of chemicals in the marine environment and have raised questions about the effectiveness of existing response techniques. As a consequence some flag States are supporting R&D specifically to prepare themselves for ratification of these Conventions as well as to gain a better understanding of the advantages and limitations of evaluation and response techniques that are currently available. In recognition of the growing need for more information to assist member States with ratification of the OPRC-HNS Protocol, the Technical Group referred to in chapter 3.1 has developed a work programme that focuses on projects encompassing both oil and HNS but with particular emphasis on HNS awareness and information. One such project is to provide a summary of HNS incidents and lessons learnt that can be made available to all member States. Another is the organisation by the IMO of the 4th R&D Forum on HNS in the Marine Environment.

From the perspective of the authors of this paper investment in R&D specifically for HNS spills would be worthwhile in areas such as:

- Developing an electronic means of rapidly identifying the HNS and its location on board container ships. The data should be capable of being manipulated such that HNS of greatest concern can be identified and prioritised quickly. The usefulness of such a system could extend beyond HNS.
- Identifying practical models for the extension of the Tiered oil spill response concept to HNS spills.
- Extending land-based modelling capability to water-borne spills.
- Developing real-time monitoring capability for many HNS currently not measurable without laboratory analysis, in particular for those chemicals that are transported most frequently, in significant quantities.
- Developing aerial observation and/ or monitoring technologies suitable for some colourless HNS.
- Identifying the extent to which current oil spill response technologies or salvage capabilities could be transferable to HNS incidents.
- Collaboration with industry and chemical manufacturers to determine the extent to which their expertise can assist with the development of new response or monitoring techniques, and extending techniques used for land-based or inland waterway spills to the marine environment.
- Evaluation of techniques for tracking lost packages and containers on the seabed or suspended under water, with particular focus on the development of techniques traditionally used in the defence industry, where possible.
- Analyses of HNS transport statistics and determination of risks.
- Studies of the fate, behaviour and toxicity of HNS most commonly transported in different marine environments.
- Review of waste disposal methods for HNS-contaminated liquids and solids.
- Development of a R&D database and a mechanism for maintaining it to enable dissemination of existing work and avoid duplication of effort.

Nevertheless, if R&D for HNS spills is to be sustainable, mechanisms need to be found to engender a greater degree of international interest, funding and cooperation. Many administrations and institutions are experiencing financial 'cut-backs' and often R&D is among the first activities to be cut. Previously it has been noted that investment in oil spill R&D, training and exercises tends to follow after an incident when interest and concern is still high and administrations are more likely to have funding available. Interest, and with it funding, tend to wane as time progresses until the next incident. Whilst this might be inevitable, there may be a greater possibility of R&D programmes being immune to such 'feasts and famines' if R&D could become more 'centralized', perhaps through supporting established R&D institutions worldwide with funding and collaborative projects of relevance to the greater spill community. This may have the added advantage of protecting funding agencies from accusations of bias, as well as generating larger funding reserves to support more worthwhile R&D projects, as opposed to a proliferation of reviews spawned because of limited resources to support larger projects. To encourage companies to develop the products and technologies needed for HNS evaluation and response it will also be necessary to consider how to provide commercial and confidentiality agreements within the collaborative funding arrangements. It is interesting to note that some techniques used in oil and HNS response today have their origin in defence, for example, remote sensing devices. It could be that providing an opportunity for the defence sector and related industries to appreciate the needs of the response community, and then identifying a mechanism to encourage 'free thinking,' backed up with funding and incentives to properly recognise and reward collaborative effort, could encourage more manufacturers to invest in R&D. This is likely to be more fruitful than R&D effort originating primarily from academia.

Chapter 8

CONCLUSIONS

Even if HNS cargoes have the potential to be more dangerous than oil, incidents involving spills of HNS are statistically less likely to occur. From a risk assessment perspective there are more spills of oil than HNS. This creates a higher frequency of oil spills but, more often than not, the risks to life are low. On the other hand, HNS spills are fortunately rarer but when they occur the risk of a life-threatening situation is greater. Thus, in the equation:

$$\text{Risk} = \text{Frequency} \times \text{Consequence}$$

oil and HNS spills may come out even. However, attempting to compare the dangers is problematic because of the different hazards and different circumstances associated with individual incidents. Nevertheless, with projections of increased transport of chemicals on ships, some increase in the number of HNS incidents may be expected. In addition, a single incident in which HNS is spilt or threatened is sufficient to generate alarm, often accompanied by demands for more stringent restrictions and/or legislation. A 'fear' of chemicals tends to be instinctive, particularly among the public, and especially when information is lacking and a situation appears to be out of control. Consequently, the potential to alleviate anxiety and fear exists through ensuring adequate preparedness for HNS incidents. Preparedness ought to extend throughout the chain of responsibility; from reviewing the systems in place for proper declaration of chemicals, identifying mechanisms to ensure that information on the cargoes is provided quickly in the event of an incident, through to updating and exercising contingency plans regularly so as to generate familiarity and confidence with the issues that can arise.

Whilst knowledge of the hazardous nature of the cargo provides only some indication of the seriousness of the situation, it is clear that other factors (some beyond human control) can turn a potentially dangerous situation into a reality. There is also the dichotomy of needing to react quickly and yet respond cautiously or only monitor. These dilemmas highlight the importance and value of planning and preparedness, especially if competency and control are to be conveyed to politicians, the press and the public and reduce the chances of a situation worsening.

Even today, lessons from oil spills are sometimes disappointingly slow to be learnt and the level of preparedness and experience throughout the world varies significantly. Given that spills of HNS are relatively rare, the opportunities to learn lessons are less frequent. Arguably, the most effective way to facilitate preparedness among countries is to ensure that information on HNS incidents is made accessible and to provide opportunities to benefit from the experiences of others.

The papers being presented during the complementary oil and HNS sessions at the Interspill conference allow knowledge and experience to be shared. The IMO R&D Forum takes this theme further and provides a chance for participants to express their priorities for R&D projects as well as to inform them of projects already planned or taking place. Joint government/industry funded projects combined with more effective dissemination of information from incidents and R&D projects are surely the way forward.

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