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| **Title:** | **The Particularities of Heavy Oil Response** |
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## ABSTRACT

As a general rule the impacts associated with heavy fuel oil spills tend to be significantly greater than for "conventional" oil. A number of high profile incidents over the past few years have amply illustrated the challenges and impacts that can result from spills of heavy fuel oil.

The general characteristics of heavy fuel oil include high values of viscosity, density and pour point. They usually contain only a small percentage of light ends and so evaporative losses will not be significant following a spill. The high viscosity of the oil does limit the rate and extent of spreading, and emulsification may further increase the viscosity of what is already a highly viscous and persistent feedstock. These characteristics can provide a number of challenges in terms of the spill response and a careful choice of response equipment is required. The high viscosity and persistence of heavy fuel oil also means that it can have significant shoreline impacts.

However, a number of the issues defined for heavy fuel oil are not actually unique to this class of materials. Submerged oils (irrespective of whether from heavy fuel oil or not), emulsified fuels and other products all exhibit some similarities in behaviour, and challenges in terms of response. A more holistic view is useful for targeting some of the general key issues that still challenge the whole "industry". There is still valuable R&D that needs to be done, but sufficient emphasis also needs to be placed on planning and preparedness.

## INTRODUCTION

A number of high profile incidents over the past few years have amply illustrated the challenges and impacts that can result from spills of heavy fuel oil. According to the IMO earlier in this decade, the impacts and consequences of the Nakhodka (1997), Erika (1999) and Baltic Carrier (2001) "confirmed the urgent need for further development and dissemination of techniques to enable coastal States to respond rapidly and effectively to spills of high density oils". The Third R&D Forum on High Density Oil Spill Response was subsequently held in March 2002 in Brest, but was promptly followed at the end of that year by the *Prestige* spill. What was already a highly sensitive topic was made even more so despite various measures being adopted by the global shipping community to enhance maritime safety.

Given the volumes of heavy fuel oil shipped around the world, the possibility of further spills could not be ruled out. It has previously been estimated (*Lewis, 2002*) that around 600 million tonnes of residual fuel oil is consumed each year. A significant proportion of this is transported by sea from the refineries where it is produced to the power plants where it is used as a fuel. It was also conservatively estimated that approximately 140 million tonnes of marine bunker fuels are consumed each year, and the majority of this is heavy fuel oil.

There is an old adage that no two spills are ever the same. Whilst this maybe true, it is also true that as a general rule the impacts associated with heavy fuel oil spills tend to be significantly greater than for "conventional" oil. Accordingly the current session makes a distinction between *heavy fuel oil* and *crude oil,* but how do we define heavy fuel oil, how do they behave when spilled, how can we respond and what are the potential gaps in the spill response armoury? The current paper seeks to address these questions, but also advocates a more holistic view because many of the challenges posed by heavy fuel oil spills are not actually unique to this class of material.

## CHARACTERISTICS OF HEAVY FUEL OIL

In simple terms heavy fuel oils are produced by blending residues from distillation or cracking processes with a variety of lower viscosity distillates to produce a product having a particular grade/ viscosity. The origin, and processing of the heavy residue together with the type and quantity of diluent or cutter stock can all differ (*Lewis, 2002*). In short, heavy fuel oil can vary quite considerably.

The particular characteristics of concern from a spills perspective are those grades of heavy fuel that have a particularly high viscosity and density. At IOSC in 2001 ITOPF presented a paper entitled, "A Review of the Problems Posed by Spills of Heavy Fuel Oils" that provided a succinct summary of those properties that typically characterize heavy fuel oils:

- specific gravity of 0.92 - 1.02g/cm3
- high kinematic viscosity of 5,000 to 30,000 mPas
- high pour point

This is generally borne out if we look at some data from some recent major heavy fuel oil spills in Europe:

**Table 1 - Characteristics of Heavy Fuel Oils**

| Property | Vessel | | |
|---|---|---|---|
| | **Erika (1999)** | **Baltic Carrier (2001)** | **Prestige (2002)** |
| **Density @ 15°C, kg/m$^3$** | 1.0025 | 0.9753 | 0.993 |
| **Viscosity, cSt** | 555 @ 50°C<br>20,000 @ 10°C | 611 @50°C | 615 @50°C<br>30,000 @15°C |
| **Pour Point, °C** | +3 | +18 | +6 |

The specific gravity/ density is a measure of how readily an oil will float when spilled. However, prevailing environmental conditions such as currents, water salinity, temperature and sediment loading in the water column are also extremely important. This will be discussed in more detail below. In relative terms, the density of heavy fuel oil can be regarded as being high. Light distillate products such as kerosene have a much lower specific gravity,<0.8, and most crude oils would typically have values of <0.9 (*note: specific gravity is dimensionless, whereas density has SI units of kg/m$^3$*).

The viscosity of an oil is a measure of the resistance to flow. In simple terms it tells us how “thick” a liquid is, and how easy, or difficult, it is likely to be to pump and handle. At ambient temperature water has a viscosity of 1cSt. Most non-waxy crude oils are extremely fluid at ambient temperature and as a generalisation would typically have viscosities of <50 cSt. Waxy crude oils would also be fluid above their pour point (see below). Heavy fuel oils, depending on the grade in question, are much more viscous and would have viscosities at ambient temperature potentially up to 30,000 cSt, which helps to make heavy fuel oil a very persistent hydrocarbon when spilled. The very high viscosity leads to particular challenges in recovering and handling the oil, as well as contributing in a major way to potential shoreline impacts.

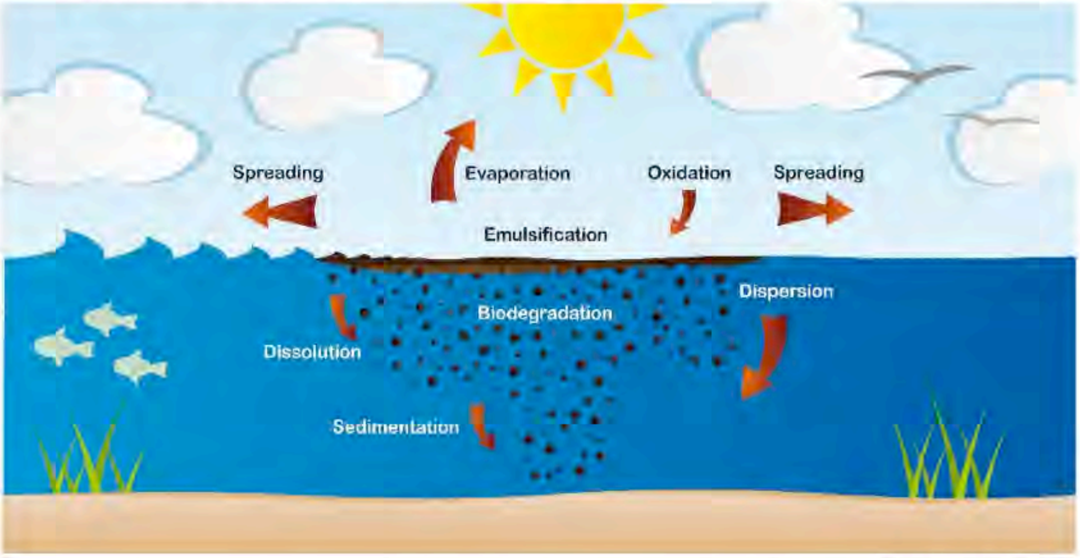
The pour point is defined as the temperature below which an oil will not flow and is an especially important concept for waxy oils (including some fuel oils). The significance of high pour point values is that if the oil gets below that temperature once it is spilled in the environment it could change from being very fluid and easy to handle into something that is essentially. This of course has implications in terms of subsequent behaviour and oil recovery. In the case of heavy fuel oil the pour point can be high (up to 30°C) although the pour point of the heavy fuel oil in the case of the *Erika* and *Prestige* was actually relatively low. It was higher for the *Baltic Carrier* spill, and in this case heated heavy fuel oil cargo spilled into the cold waters (approx. 5°C) of the Baltic Sea it quickly cooled to temperatures below the oil’s pour point (18°C), and took on a ‘chewing gum’ consistency.

## FATE AND BEHAVIOUR OF OIL SPILLS

When an oil reaches the sea surface after being spilled it is subject to a number of different physical and chemical processes, collectively known as weathering. Some of the key characteristics of heavy fuel oil from a spills perspective have been described above, and these have an influence on, and are influenced by, these weathering processes.

A diagram summarising these different processes is shown below:

**Figure 1 - A Schematic Summary of Oil Spill Weathering Processes**




*Courtesy of ITOPF*

The processes of spreading, evaporation, dispersion, emulsification and dissolution are most important during the early stages of a spill. Oxidation, sedimentation and biodegradation are more important longer-term processes that will help determine the ultimate fate of the oil. These processes are considered for a hypothetical heavy fuel oil spill.

### Spreading:

As soon as an oil is spilled it starts to spread over the surface of the water. Oil viscosity is an important parameter in this process. A light oil of low viscosity would spread much more rapidly and to a greater extent than heavier, more viscous oils. Spreading of a heavy fuel oil spill would be much restricted due to the high viscosity of the oil, especially as it cools down from its temperature of transport to ambient temperature. It may also fragment or break up into mats, whose thickness can vary quite considerably depending on the viscosity and quantity spilled as well as the temperature and wind, waves and currents.

### Evaporation:

In the case of so called "conventional oils" a significant proportion of a crude oil may evaporate leaving behind a much more viscous residue. The extent to which this will occur will depend on distillation profile of the oil and the environmental conditions.

For example, in the case of the relatively light Forties Crude that was spilled when the *Sea Empress* ran aground in Milford Haven in 1996, around 40% of the oil evaporated under the prevailing conditions. In the case of heavy fuel oil, there would likely be much less evaporation (as a generalisation <10%).

**Dispersion:**

Generally at least some proportion of an oil spill naturally disperses as small droplets into the upper part of the water column. If the droplets are small enough,< 70 microns (*Lunel, 1993*), they become essentially permanently entrained in the water column, and the oil dilutes and disperses. The extent to which natural dispersion occurs depends on the characteristics of the oil, and on the environmental conditions. Due to its high viscosity, heavy fuel oil can be regarded as unlikely to disperse naturally to any great extent, irrespective of sea state and conditions. In extreme weather conditions heavy fuel oil may break into smaller lumps, tar ball and fragments, but not micron sized droplets (a micron is one thousandth of a millimetre).

**Dissolution:**

As a rule of thumb, heavy fuel oil contains considerably less water soluble components than crude oils and light distillate products. In fact the prevailing logic for heavy fuel oil is that it is insoluble in water, which suggests no dissolution, but this is an over-simplification.

Although heavy fuel oil is largely composed of complex molecular species, there are some components that are potentially water soluble/ bioavailable. Lower molecular weight aliphatic hydrocarbons (e.g. alkanes and cycloalkanes) can contribute to toxicity in gasoline and other light products where they form a major portion of the fuel. However, heavy fuel would not be expected to contain significant quantities of these aliphatics. BTEX concentrations in heavy fuel oil are also very low (in the ppm concentration range), whereas Applied Science Associates, ASA, (*French McCay, 2008*) have found that the BTEX content of crude oil is normally 1 -2 % (BTEX rapidly volatilizes reducing exposure concentrations in any case).

Heavy fuel oil is however likely to contain at least some 2-4 ring PAHs (even higher molecular weight, multi-ring PAHs are insoluble and not bioavailable). ASA's experience of heavy fuel oil confirms how variable it is with a range from 1-24% PAH, with a mean of 8%. However, it should be noted that this higher figure is pretty exceptional and less than 10 percent is more usual (*see ASA, 2002*). In recent years the percentage has gone down even lower because the light ends are taken out more efficiently. In comparison crude oils normally contain around 1% PAH.

It is also interesting to note that CEDRE found that the heavy fuel from the *Erika* spill contained mono-aromatic (6.6%) and di-aromatic (5.9%) fractions that showed some solubility in water (*CEDRE, 2008*). Therefore, depending on the particular heavy fuel oil, there may well be some dissolution and it should not just be assumed that it is totally insoluble.

**Emulsification:**

Whereas all of the above processes cause a decrease in the volume of oil on the water's surface, emulsification can cause a significant increase. It also causes a very drastic increase in viscosity.

Depending on the oil chemical composition (asphaltene content), and environmental conditions, an oil may emulsify up to ~80% of water to form a highly viscous and (sometimes) stable water-in-oil emulsion or mousse. The high viscosity of heavy fuel oil can actually act as an impediment to the incorporation of water, but it is worth noting that in the case of the *Erika* spill, CEDRE conducted measurements that suggested that the oil had incorporated up to 50% water. Similar concentrations were found in heavy fuel oil samples analysed following the *Prestige* spill. The consequence of this is that an already highly viscous material is made even more viscous, and also increases the volume of pollutant.

**Oxidation:**

Hydrocarbons can react with oxygen to form an oxidised skin, or soluble products, although compared to the other weathering processes its effects are not that great. In the case of thicker patches or mats of heavy fuel oil an outer oxidised coating or layer can form which may further increase the persistence of something that is already highly viscous/ persistent. This oxidation process can make the oil less "sticky" or adhesive, although beneath the oxidised layer is likely to be stickier, less weathered oil.

**Sedimentation:**

The high density of heavy fuel oil means that whilst in the case of seawater (specific gravity 1.025) it can generally be expected to float, it may fail to do so in brackish or fresh water. However, whilst heavy fuel oil would not be expected to sink in the case of a marine spill in open water, it may "sit low in the water" and be especially susceptible to over-washing. The loss of any evaporative light ends (minimal) and incorporation of seawater through emulsification may further increase the density of the oil. In fresh or brackish water the heavy fuel oil may actually sink. In near shore marine environments a heavy fuel oil may incorporate sediment which could also cause it to sink.

**Biodegradation:**

Sea water contains a range of micro-organisms capable of degrading hydrocarbons. Their ability to do so is dependent on a range of variables including availability of oxygen, nutrients, temperature, the type of oil and the available surface area.

A significant proportion of some lighter oils might be biodegradable under the right circumstances, and naturally or chemically dispersed oils would be more amenable to biodegradation because of the large surface area associated with the oil droplets. As already mentioned heavy fuel oil can be regarded as a mixture of may molecular species, the majority of which are extremely large and complex.

Some of the smaller saturate and aromatic species are potentially biodegradable, but a significant proportion or larger, highly aromatic species, such as resins and asphaltenes, would not. In simple terms, biodegradation of heavy fuel oils is likely to occur over weeks- months – years, and even then is likely to be incomplete.

## SPILL RESPONSE

The characteristics of heavy fuel oil “as loaded”, and the subsequent weathering once spilled, have significant implications in terms of mounting an effective and efficient oil spill response. The response will not be assisted by evaporation because heavy fuel oil contains so few volatile components. On the other hand heavy oil spills will not pose the same explosion and fire danger in the first few hours after release. Unlike with some spills of lighter products, containment and recovery can therefore begin as soon as the equipment arrives. But what equipment and techniques are appropriate for spills of heavy fuel oil?

### Tracking and Surveillance:

Visual observation and the use of remote sensing systems are an essential element of effective response to marine oil spills. They are used to provide information relating to the at sea response and shoreline clean-up, and to verify predictions of the movement of oil by modelling techniques. However, it is often very difficult to track and monitor heavy oils either visually or using conventional tracking and surveillance technology. This can be problematic given the long distances that heavy fuel can travel from the spill location, and the fact that it can come ashore many days after the original incident. Due to their high density, heavy fuel may spend at least some time beneath the surface of the water and is subject to over-washing. They are generally difficult to track in rough weather. Depending on the composition of the heavy fuel oil there may well be less sheen formed than in the case of conventional oil. In extreme cases the oil maybe be fully, and permanently, submerged..

Predicting the drift of heavy fuel oil by modelling techniques maybe more difficult because it is less influenced by wind than conventional oil slicks.

### Containment and Recovery:

In a sense the challenges associated with heavy fuel oil containment and recovery may manifest themselves before the clean up even commences. As described above, if the oil is not easily visible then any subsequent attempt at containment and recovery is much more difficult. In the event that the heavy fuel oil actually sinks, then there are a whole different set of challenges associated with locating and recovering submerged oils.

For heavy fuel oil that resides at or close to the water surface, it can in theory be contained with conventional booms. However, the extremely high viscosity of spilled heavy fuel oil does have implications in terms of the subsequent recovery of the oil.

Not all skimmers that are available to responders in equipment stockpiles will work with heavy fuel oils. A range of mechanical feeder skimmers have shown themselves particularly well suited to the recovery of thick layers of extremely viscous oils (Hvidbak, 2001). Weir skimmers and many other types of skimmer that work well with light oils are not suited to thick, viscous layers or mats of oil. Manufacturers may claim that the pump associated with their skimmer is capable of pumping high viscosity oils, but often it is a case of actually getting the oil into the pump in the first place. In the case of weir skimmers it can be extremely challenging to get the oil to flow over the weir (granted, the level of the weir can be adjusted, but this increases the likelihood of recovering large volumes of water). In the case of oleophilic discs or mops, the skimmers simply become gummed up with heavy oil. In many cases it is not just the high viscosity of the heavy fuel oil that is an issue but often there is a "stickiness" associated with these oils. This is generally a negative attribute and if this proves to be the case then past experience has shown that it helps to keep surfaces water-wetted.

Because of the viscosity/ stickiness issue it is possible, and sometimes preferable, to use relatively simple equipment like crane-operated clamshells, buckets or other mechanical grabs, which are generally readily available pieces of equipment. Trawl nets or recovery socks can also be a simple and effective way of collecting floating heavy fuel oil, especially if the oil is in the form of scattered lumps or tar balls. There is, though, a question of cost and re-usability of these nets/ socks.

**Figure 2 – Heavy Oil Recovery Using Mechanical Grab**

Photograph from ACCIDENT OF THE OIL TANKER "BALTIC CARRIER" OFF THE DANISH COASTLINE FINAL REPORT European Task Force in Denmark from 1st to 5 April, 2001

However, to successfully remove heavy fuel oil from the surface of the water is only the first step. Once the oil has been recovered, then it still has to be transferred from the skimmer into temporary/ permanent storage.

Frictional losses in the transfer lines and in the skimmer itself can in effect render the heavy fuel oil non-transferable from an operational perspective. Increasing the efficiency of oil transfer through techniques such as steam/hot water injection to produce an outer water annulus and encourage core-annular flow have been successfully demonstrated previously (Hvidbak, 2003). The issue of transfer can be avoided if the skimmer can recover directly into disposable bags, but the subsequent handling of the bags does present an additional handling issue in itself.

**Figure 3 – Recovery of Heavy Oil with Mechanical Feeder Skimmer (lhs) and Disposable Bag Containing Recovered Heavy Oil (rhs)**

Use of the grab techniques described on the previous page also offers the potential to recover relatively large volumes (~ 0.5 tonne) directly into temporary storage. There is then a potential issue in getting the heavy oil out of the temporary storage vessel. If the storage container is not fitted with heating capability, or if an ad-hoc heating system cannot be arranged, then removing heavy fuel from temporary storage is a potential bottleneck waiting to happen.

**Chemical Dispersants:**

The use of chemical dispersants can be an extremely valuable option for reducing the environmental impacts of large oil spills. Conventional wisdom is that dispersants are not a suitable response option for heavy fuel oil because it is simply too viscous.

Even with conventional oil there is a "window of opportunity" where dispersants are considered to be effective. Fresh oil is much more amenable to dispersion than aged, weathered oil where the light ends have been lost to evaporation and emulsification has further increased the viscosity by orders of magnitude. The precise "cut-off" point (if indeed there can be one) where an oil is no longer amenable to dispersion has been the subject of considerable debate (*ExxonMobil, 2008*). An oft quoted rule of thumb is that once the oil viscosity exceeds 5,000 – 10,000 cSt it is no longer dispersible. In reality of course there are numerous other variables that are important in determining whether spraying dispersant is likely to be successful or not, and these include "mixing energy", temperature, dispersant type and concentration.

Recent studies have also suggested that oil composition (as opposed to viscosity alone) maybe an important factor, and advances in dispersant technology mean that in some circumstances it might be possible to disperse heavy fuel oils that have a viscosity > 10,000 cSt.

Whilst directionally the more viscous an oil becomes the harder it is likely to be to disperse it, it may still be worth conducting a small scale test spray to evaluate how a given heavy fuel oil might (or might not) disperse under a given set of conditions. Given the potential shoreline impacts associated with heavy fuel oils (see below), it is probably at least worth keeping in mind.

**In-situ Combustion:**

Heavy fuel oil contains significantly less light ends than conventional oil. Any light ends that were present will likely have evaporated/ dissolved by the time that a response is mounted. Even if combustion could be initiated/ supported then potential concerns about air emissions and the formation of tarry, intractable residues that would likely sink, make this an unlikely response option for heavy fuel oil.

**Shoreline Clean up:**

There is a considerable body of experience that has been developed from cleaning up shorelines following heavy fuel oil spills. The impacts of highly, viscous persistent heavy fuel oil have been all too evident in several high profile incidents over the past decade. If the oil does come ashore in significant quantities, then a long lasting, manually intensive clean up operation can be anticipated. The costs and impacts can of course vary significantly, but as a category heavy fuel oil spills are extremely expensive to clean-up as highlighted below:

- "The cost of cleaning up 14,500 tonnes of HFO spilled from the TANIO was almost as expensive as for the 223,000 tonnes of crude oil from the AMOCO CADIZ in 1978" - ITOPF 2002
- "In the USA, the average figure for heavy crude oil cleanup and disposal only is $20,000 per m3 " - Etkin, 2000
- "The oil {*from the Prestige spill*}, however, still reached the coast contaminating 1900km of Spanish, French and British shores. The cost of the manual clean up that ensued, involving 5000 military and volunteer workers, together with compensation claims, totalled €1 bn with a further cost of € 1m for removal of the remaining oil from the wreck. One hundred and forty-one thousand tonnes of oiled waste from the shoreline response still remained to be treated at the time this manual was prepared" – extract from Section 8 ExxonMobil Oil Spill Dispersant Guidelines, 2008

The final point above makes reference to the disposal issues, which must be considered at the contingency planning stage. In the case of the *Erika* spill around 20,000 tonnes of heavy fuel oil were spilled, and more than 180,000 tonnes of oily waste material were recovered.

## PREPAREDNESS AND A HOLISTIC APPROACH

There are certainly some aspects of heavy fuel oil response where further technological advances would be beneficial. That being said, a number of the challenges and issues described above are not unique to heavy fuel oil. This has been recognised previously (*ITOPF, 2001 and 2002*), where it was also stated that “grouping these different products together on the basis of their similar spill behaviour rather than the characteristics of their parent oils is useful because response strategies must be oriented towards the oil as it is found in the water, rather than in its commercial form”.

Tracking, detection and monitoring of heavy fuel oil was highlighted as potentially problematic, but there is certainly overlap here with “submerged oils” in general. Other types of material that would likely pose some of the same challenges include bunker fuels that are used to provide motive power for vessels, and other products such as bitumen, asphalt, carbon black and emulsified fuels (i.e. oil-in-water type emulsions like Orimulsion® or MSAR®, as opposed to water-in-oil). Relatively recent work for the US Coast Guard (*Michel, Research Planning, Inc and Cooper, SAIC – 2006*) provides a very useful encapsulation of the issues and the state of current knowledge regarding heavy/ submerged oils. Table 1 from *Michel* contains some very interesting examples of non-heavy fuel oil based materials that did not float. In some cases the whole weathering process and the environmental conditions can transform the characteristics of a particular hydrocarbon, such as a heavy crude oil, to drastically increase its viscosity/ persistence and density.

Care does need to be taken to ensure that products are not just “lumped together” for ease and convenience. The generic, single term “heavy fuel oil” can cover a multitude of differences (Lewis, 2002), yet these high viscosity, high density black oils are often grouped together as one class of marine pollutant. This generic description might be a convenient way to distinguish these oils from crude oils or refined products, but it can conceal variations that would be useful for contingency planning and spill response. Similar differences exist within other generic groupings. It has been reported that certain asphaltic materials, on contact with cold water, have been known to exhibit signs of colloidal instability resulting in the lighter components and the heavier components separating from one another. This could result in quite complex behaviour with one fraction sinking and another floating. In the case of emulsified fuels, future developments may see much heavier feedstock types used which the individual droplets can essentially be regarded as “solid spheres”. These spheres will not undergo coalescence like the droplets from “softer” feedstock types, which does have implications in terms of fate and behaviour and for spill response.

Being adequately prepared should not only involve doing some “homework” on the spill response issues surrounding the particular product being transported, but should also involve thinking holistically about some of the “indirect” issues. For example, the characteristics of a product can have implications in terms of any salvage operation involving transfer or removal of cargo. In the case of emulsified fuels or bituminous products it is essential to have the most appropriate equipment available should the need arise, as it is pretty rare that the whole cargo would be lost.

For those incidents involving bituminous products, there is also a potential issue regarding the temperature of carriage of the product. Because it is so viscous it is transported at elevated temperatures, which could have safety implications for spill responders actually contacting the product or when the hot product contacts water.

## CONCLUSIONS AND RECOMMENDATIONS

The general characteristics of heavy fuel oil include high values of viscosity, density and pour point. They usually contain only a small percentage of light ends and so evaporative losses will not be significant following a spill. The high viscosity of the oil does limit the rate and extent of spreading, and emulsification may further increase the viscosity of what is already a highly viscous and persistent feedstock.

These characteristics can provide a number of challenges in terms of the spill response. Tracking, monitoring and detection may be difficult because the oil may be at least temporarily beneath the surface of the water. The high viscosity of the oil also present challenges in terms of spill clean up because recovery and transfer operations can be adversely affected. A careful choice of response equipment is required. The viscosity and persistence also means that heavy fuel oil can have significant shoreline impacts. Conventional thinking suggests that dispersants have no role to play with heavy fuel oil, but in recognition of the potential impacts, and in light of recent technical studies and advances, there may be some situations where application of dispersants is at least worthy of consideration.

A number of the issues defined for heavy fuel oil are not actually unique to this class of materials. Submerged oils, emulsified fuels and other products all exhibit a number of similarities and challenges. A more holistic view is useful for targeting some of the general key issues that still challenge the whole “industry”. There is still valuable R&D that needs to be done, but sufficient emphasis also needs to be placed on planning and preparedness. In terms of R&D, the issue of detection and tracking is a good example. The US Coast Guard has made good recent progress in evaluating a number of different techniques for detecting submerged oil. However, further work no doubt needs to be done. In some cases the behaviour of oils can be quite complex (such as after the *Erika* spill). Problems of slick sinking in rough weather or at night, and surfacing in calm weather or in the morning, can cause real difficulty. Further effort in this area would enhance tracking and drift prediction, and greatly help the overall spill response.

Care needs to be taken to ensure that heavy fuel oil and other classes of product are not just all assumed to be all the same and one amorphous group. Within any given category there can be significant differences. For example, some heavy fuel oils contain more water soluble fractions than others. There may be some heavy oils where dispersants might be a viable response option. There may be emulsified fuels in development that are sufficiently different to those that have gone before. It should go without saying, but it is essential that the information and knowledge that continues to be generated, is actually disseminated throughout the industry and spill response community.

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