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Response to spills of alternative fuels and energy products

Characterisation of oil based products

INTRODUCTION

Ipieca has developed a series of fact sheets on preparedness and response to accidental releases of alternative fuels and energy products. To respond effectively to a spill of any product, it is important to understand its characteristics. This overview introduces the key properties that contingency planners and spill responders use, serving as a reference for the other fact sheets on alternative oil based fuels and energy products.

WHAT ARE ALTERNATIVE FUELS AND ENERGY PRODUCTS?

Traditional hydrocarbons (oils) and petrochemicals have had broad application and use throughout society. However, as we transition to renewable energies, alternative fuels and their associated products are becoming more prevalent in production, manufacturing, and use. Their safe handling and prevention of spills remains a priority. These fact sheets address products that could be released in high volumes to the environment. Such incidents are infrequent but could potentially result in impacts requiring response and/or monitoring and remediation. This fact sheet focuses on the characterisation of oil based alternative fuels and energy products (Table 1).

Table 1: Oil based alternative fuels and energy products covered by the series of fact sheets

0.5% S CAP VERY LOW SULPHUR FUEL OIL (VLSFO)	• Mandated under the International Maritime Organization's MARPOL Annex VI since 2020, VLSFOs contain a maximum of 0.5% sulphur and are increasingly being used as ship bunkers • Refiners and suppliers formulate VLSFOs in a variety of ways to encourage widespread availability • Possess widely variable physicochemical properties
0.1% S CAP ULTRA LOW SULPHUR FUEL OIL (ULSFO)	• MARPOL Annex VI also allows the designation of Sulphur Emission Control Areas (SECAs), where use of ULSFOs with a maximum of 0.1% sulphur is mandated
BIOMASS-BASED DIESEL FUEL	• Biofuels are produced from biomass including plants or used vegetable oils • They can range from ethanol that is blended into gasoline to biodiesels and renewable diesel products
CONDENSATE	• Condensates are light liquid hydrocarbons formed by the condensation of gases present in oil fields • They are typically formed at or near the wellhead • They are highly volatile, leading to fire and explosion hazards
NON-FLOATING OIL	• A diverse group of oils including crudes and heavy oils from refining, defined by their behaviour • Relatively high density with their sinking tendency dependent on the salinity of the receiving waters and/or attachment of sediment

KEY MESSAGES

- A product's physicochemical characteristics and the environmental conditions determine its fate and behaviour if spilled
- The fate and behaviour of spilled product affects potential impacts
- Safety data sheets typically contain insufficient information to respond to a major release
- It is therefore important to characterise and 'know the product' in the context of contingency planning and spill response

THE NEED FOR CHARACTERISATION

Oil type products can behave with marked differences if spilled, depending on their physicochemical characteristics and the prevailing environmental conditions. Laboratory analyses of a product can provide information to predict its fate and behaviour if spilled. Understanding these characteristics helps determine suitable response techniques and resources during contingency planning.

PROPERTIES USEFUL FOR PLANNERS AND RESPONDERS

The parameters used to predict an oil based product's fate and behaviour are listed in Table 2. There are standardised bench-scale laboratory methods for determining these parameters.

OIL GROUPS

Specific gravity and distillation can be used to group crude oils and oil products, as a quick reference to their possible behaviour if spilled. For example, oils with a low specific gravity tend to contain a high proportion of volatile components and be of lower viscosity. Denser oils tend to be more viscous, meaning they do not naturally disperse or evaporate to a significant degree and persist longer in the environment. If the temperature is more than a few degrees below the pour point, an oil behaves as if from a higher group. Table 3 gives the oil groups as defined in ISO 16165:2020.

Table 2: The parameters used to predict an oil based product's fate and behaviour if spilled

DENSITY	• Typically expressed as specific gravity, which is the density in relation to freshwater. Most oil products float on seawater which has a specific gravity of approximately 1.025 at 20 °C. • 'Heavy' or very dense oils may sink, partially or fully. • The °API may be used to describe the specific gravity of oil products; higher °API equates to lower specific gravity.
VISCOSITY	• A product's resistance to flow or 'runniness', providing an indication of spreading potential and whether dispersants or certain skimmers would be effective. • Products become more viscous as the temperature falls and as the volatile components evaporate during weathering. • Viscosity is given at a test temperature.
POUR POINT	• The lowest temperature at which an oil will continue to flow when cooled, determined by a laboratory test. • In dynamic water, the oil may remain liquid at a few degrees below the pour point. Pour point will increase with weathering as lighter product evaporates.
DISTILLATION OR BOILING POINT CURVE	• Distillation characteristics give an indication of anticipated evaporation; roughly the fraction that distils below 250 °C. • Viscosity will increase as evaporation occurs and the volatile components will evaporate within 24-48 hours if the oil is freely spreading on water, with higher temperature and rougher seas speeding up the process.
ASPHALTENES	• Complex molecules with properties that can play a significant role in the stabilisation of water-in-oil emulsions. • A rough rule-of-thumb is that emulsions can be formed when the asphaltene content is greater than 0.5%. • Resultant oil/water emulsions (sometimes referred to as 'chocolate mousse') can have high viscosities and can greatly increase pollutant volume due to this entrained water.
FLASH POINT	• The lowest temperature at which an ignitable vapour is generated. • Flash point <93 °C is considered potentially flammable and hazardous under the Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

Table 3: Definition of oil groups according to ISO 16165:2020

GROUP I	Consists of hydrocarbon fractions, at least 50% of which distil at 340 °C and at least 95% of which distil at 370 °C	Extra light	Non-persistent
GROUP II	Specific gravity of less than 0.85	Light	Increasing persistence
GROUP III	Specific gravity equal to or greater than 0.85 and less than 0.95	Medium	
GROUP IV	Specific gravity equal to or greater than 0.95 and less than 1.00	Heavy	
GROUP V	Specific gravity greater than 1.00	Extra heavy	

ENVIRONMENTAL CONDITIONS – THE WEATHERING PROCESS

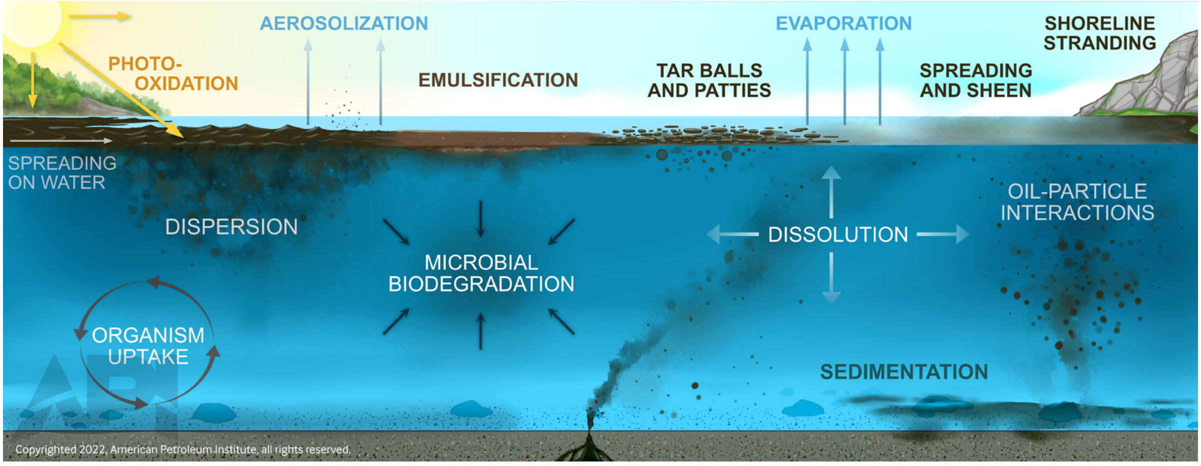


Figure 1: Overview of weathering processes affecting oil spilled into water (source: API, 2022)

Weathering encompasses physical, chemical, and biological processes that act on spilled oil and related products, causing its physical and chemical properties to change over time. The main weathering processes are shown in Figure 1. The extent of each weathering process relates to the initial oil characteristics, quantity of oil spilled, temperature, sea state, concentration and density of suspended sediment, amount of sunlight, the microbes present and whether the pollution remains at sea or is washed ashore.

Weathering tends to increase viscosity and reduce acute toxicity of the remaining oil. Emulsification can increase the pollutant volume (up to 4-fold) and its persistence, with significant clean-up and waste management implications.

The potential impacts of spilled oil, and the optimal response strategy, can be predicted with an understanding of how weathering processes change different oil types (Figure 2). For example, contingency planners can predict:

- Whether the product is likely to persist
- Whether dispersant application or controlled in-situ burning are feasible response options
- Which type of recovery devices (skimmers and pumps) might be effective
- Which shoreline clean-up techniques might be suitable

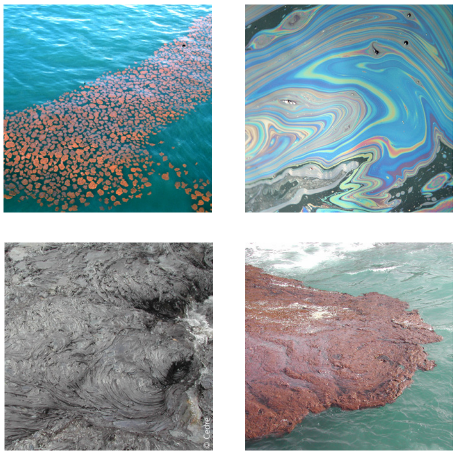
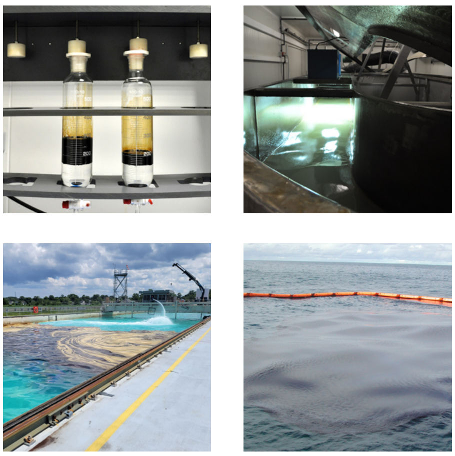


Figure 2: Oils can be dramatically different in their appearance and behaviour, depending on their properties and the state of weathering (source: Cedre)



ADDITIONAL CHARACTERISATION AND TESTING

The weathering processes can be simulated in controlled laboratory tests and field trials (Figure 3). Such studies rarely duplicate exact spill conditions but provide valuable insights to help predict behaviour. Oils can also be tested for chemical dispersibility and acute toxicity when fresh or at various stages of their laboratory weathering. Such studies have been undertaken for a variety of alternative fuels and oil products.

Figure 3: Valuable insights can be obtained from laboratory, flume, test-tank and field scale experiments (source: top-left, top-right, bottom-right = Cedre; bottom-left = Ohmsett)

SUPPORT TO DECISION MAKERS

Safety data sheets (SDS) typically do not provide sufficient information to respond to a major release. Obtaining the key properties described in this fact sheet can help predict the fate of spilled oil and products, and this can be supported by computer modelling. Oil spill model inputs include oil properties, ideally determined from laboratory and weathering studies, plus environmental parameters. Comprehensive and accurate data input leads to more reliable output. The output is predicted weathering over time, leading to improved decision making, response effectiveness, and enhanced situational awareness.

CONCLUSION - KNOW THE PRODUCT

Laboratory characterisation of an oil or related product's properties greatly assists planning and spill response. Predicting the likely fate and behaviour of spilled oil, and the most effective response as the product weathers, is invaluable for those involved in the clean-up operation.

RELEVANT RESOURCES

Ipieca-IOGP (2013). *Guidelines on oil characterization to inform spill response decisions.* www.ipieca.org/resources/guidelines-on-oil-characterization-to-inform-spill-response-decisions

ITOPF (2014). *Tip 02: fate of marine oil spills.* www.itopf.org/knowledge-resources/documents-guides/tip-02-fate-of-marine-oil-spills/

NOAA (2024). WebGNOME. https://gnome.orr.noaa.gov/
NOTE: WebGNOME is a publicly available oil spill trajectory and fate model that simulates oil movement and weathering due to winds and currents.

Sources of oil characterisation data

- Oil producers' or refiners' crude oil assay sheets, examples:
  - bp www.bp.com/en/global/bp-trading-and-shipping/documents-and-downloads/technical-downloads/crudes-assays.html
  - Equinor www.equinor.com/energy/crude-oil-assays
  - TotalEnergies https://ts.totalenergies.com/business-customers/crude-assays/
- Ship owners:
  - Bunker Delivery Note (BDN) for a marine fuel - mandated under MARPOL Annex VI
  - Certificate of Quality (CoQ) for a marine fuel - may be available and provide more than BDN
- Safety data sheet (SDS) for the oil or product

Ipieca is the global oil and gas association dedicated to advancing environmental and social performance across the energy transition. It brings together members and stakeholders to lead in integrating sustainability by advancing climate action, environmental responsibility and social performance across oil, gas and renewables activities.

Ipieca was founded at the request of the United Nations Environment Programme in 1974. Through its non-lobby and collaborative approach Ipieca remains the industry's principal channel of engagement with the UN.

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