International Oil Pollution Compensation Funds

Guide to Persistent and Contributing Oils

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Contents

This text was endorsed by the 24th session of the 1992 Fund Administrative Council, acting on behalf of the 28th extraordinary session of the 1992 Fund Assembly, and the 12th extraordinary session of the Supplementary Fund Assembly in April 2024.

1 Foreword

1.1 Compensation for pollution damage caused by spills from oil tankers is governed by an international regime developed under the auspices of the International Maritime Organization (IMO).

1.2 The framework for the regime was originally the 1969 International Convention on Civil Liability for Oil Pollution Damage (1969 Civil Liability Convention) and the 1971 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (1971 Fund Convention). This 'original' regime was amended in 1992 by two Protocols, and the amended Conventions are known as the 1992 Civil Liability Convention (CLC) and the 1992 Fund Convention. The 1992 Conventions entered into force on 30 May 1996. The Supplementary Fund Protocol entered into force on 3 March 2005 creating a third tier in the liability and compensation regime, which provides additional compensation over and above that available under the 1992 Fund Convention for pollution damage in the States that become Parties to the Supplementary Fund Protocol.

1.3 The 1992 Civil Liability Convention applies to oil pollution damage resulting from spills of persistent oil from tankers. It covers spills of cargo and/or bunker oil from laden, and in some cases unladen, seagoing vessels constructed or adapted to carry oil in bulk as cargo (but not to dry cargo ships).

1.4 Damage caused by non-persistent oil, such as gasoline, light diesel oil, kerosene etc., is not covered by the 1992 CLC.

1.5 Equally, damage caused by non-hydrocarbon substances carried in bulk by sea transport, such as chemicals, gases, vegetable oils etc., is not covered by the 1992 CLC.

1.6 A contributing oil is a persistent oil which is broadly covered by the terms 'crude oils' and 'fuel oils' but may include other hydrocarbon oils, such as heavy diesel oil and lubricating oil, that are deemed persistent by this guide. Such oils, when carried by sea and imported into a Member State, are deemed to be contributing oils with respect to financing under the 1992 Conventions.

1.7 This Guide to Persistent and Contributing Oils is intended to provide clarification around the differences between contributing, persistent oil and non-persistent oil, particularly as persistent oil is not defined in the governing Conventions. It is not intended to be an authoritative definition of all persistent and non-persistent oils. However, it is intended, through the identification of oils that are covered by the Conventions, to provide Member States and oil receivers with a clear understanding of the oils that should be included in their annual reporting of contributing oil.

2 Glossary of terms

2.1 Additives

2.1.1 Additives are chemicals that are added to refined products in very small volumes to improve product properties without adding volume. This is in contrast to blendstocks, which change average product properties but also contribute additional volume.

2.1.2 Additives are typically introduced downstream from the refinery, often as product is loaded onto tank trucks at the terminal rack for final delivery.

2.2 American Petroleum Institute (API)

The API is an organisation for the US oil industry. It lobbies for the industry on policy issues and sets some industry standards.

2.3 ASTM International (ASTM)

ASTM International, formerly known as American Society for Testing and Materials, is an international standards organisation that develops technical standards for a wide range of materials, products, systems and services. ASTM standards in the petroleum industry cover topics ranging from the extraction of crude oil to the production, distribution and usage of petroleum products. These standards are commonly used in the oil and gas industry to ensure quality control, facilitate regulatory compliance and promote safety.

2.4 Aniline point

The aniline point is a measure of the parafinicity of a stream and thus its ignition quality as a diesel blend stock. Aniline point is measured as the temperature at which equal volumes of the stream and aniline are completely miscible.

2.5 API gravity

2.5.1 API gravity is a commonly used index of the density of a crude oil or refined product originally devised by the API.

2.5.2 API gravity moves inversely to specific gravity and is obtained from specific gravity using the formula:

API = (141.5/Specific Gravity) – 131.5

2.6 Aromatics

Aromatics are hydrocarbons containing a benzene ring of six unsaturated carbon atoms and includes benzene (the smallest, most basic aromatic compound), toluene and xylene. Aromatics are an important element in gasoline blending as they are a key source of highly valued octane. However, some aromatics are also toxic to humans and a contributor to smog when released into the atmosphere. As a result, refiners typically try to maximise the aromatics content of gasoline, up to a limit which has been set to address environmental concerns.

2.7 Atmospheric distillation

Atmospheric distillation is the first and most fundamental step in the refining process. The primary purpose of atmospheric distillation is to separate crude oil into its components (or distillation cuts, distillation fractions) for further processing by other processing units.

2.8 Biofuels

2.8.1 Biofuels are nonoil-based fuels usually produced from agricultural products (e.g. bioethanol, vegetable oils). Biofuels are typically used as a blend stock in conjunction with conventional oil-based fuel blendstocks to make diesel and gasoline products.

2.8.2 Biofuels which have been identified as falling under the scope of the 2019 Guidelines for the carriage of blends of biofuels and MARPOL Annex I cargoes (MSC-MEPC.2/Circ.17) are recorded in Annex 11 of the annual MEPC.2/Circular issued by IMO.

2.9 Blend stock

A blend stock is any unfinished oil that is blended with other similar unfinished oils to make a final refined product.

2.10 Boiling range

2.10.1 The boiling range is a range of temperatures across which the components in a mixture of liquid hydrocarbons boil. In refining, a boiling range is used to define a distillation fraction for a crude oil grade.

2.10.2 The initial boiling point for a distillation fraction is the temperature at which the fraction just begins to evaporate when distilled. In practice, refiners usually use the term 'effective' initial boiling point; this is slightly higher than the true initial boiling point.

2.10.3 The mid-point is the temperature where 50% of the fraction has evaporated and the end point is the temperature at which 100% of the fraction has evaporated when distilled.

2.11 Catalyst

2.11.1 A catalyst is a substance that enhances a chemical reaction without being one of the reactants. Most refining conversion units employ some type of catalyst to expedite the chemical reactions taking place.

2.11.2 Common catalysts used in refining include:

- Hydrofluoric acid – alkylation
- Platinum – C4 isomerisation
- Sulfuric acid – alkylation

2.12 Catalytic cracker

The catalytic cracker is the unit where petroleum vapour passes through a catalyst bed which causes the heavier fractions to 'crack' producing lighter more valuable products.

2.13 Cracking

2.13.1 Cracking is a broad term that refers to any process that results in the breaking down of larger hydrocarbon molecules into smaller molecules.

2.13.2 Cracking can be achieved through the use of heat (thermal cracking) or hydrogen addition (hydrocracking) often in the presence of a catalyst (catalytic cracking/hydrocracking).

2.13.3 Cracking in its various forms is the primary means of improving the product yield of a refinery to include more of the high-value light products and less of the low-value heavy products.

2.14 Crude oil

2.14.1 Crude oil is a naturally occurring mixture of liquid hydrocarbons. In its natural state, crude oil has few direct uses.

2.14.2 The most common characteristics used to identify the quality of a crude are its API gravity and its sulphur content. The highest valued crude grades are typically those with high API gravity and low sulphur content.

2.15 Crude oil distillation unit (CDU)

A crude oil distillation unit, or crude unit, is usually the first unit in a refinery that processes crude oil. The CDU primarily uses heat to separate the crude oil into its fractions through distillation.

2.16 Cut point

In fractional distillation, a cut point is the temperature that defines the boundary between two crude oil fractions that are being separated.

2.17 Diesel index

A diesel index is an empirical measure of the ignition quality of a gas/diesel oil using the API gravity and aniline point of the fuel. The higher the number, the better the ignition quality. The diesel index is calculated using the following formula:

$$\text{Diesel Index} = \frac{\text{Aniline Point (°F)} \times \text{API Gravity}}{100}$$

2.18 Distillate

2.18.1 Distillate, also known as middle distillate, is a term used to refer both to the atmospheric gasoil cut from atmospheric distillation, and to a range of light products ranging from kerosene to diesel.

2.18.2 Generally, the distillate products are considered to include kerosene, jet fuel, diesel, heating oil, industrial gasoil (IGO) and marine gasoil (MGO).

2.19 Distillation curve

2.19.1 A distillation curve is a graph showing the cumulative volume of a crude oil (or other hydrocarbon stream) that boils off at different temperatures.

2.19.2 For a crude oil, the distillation curve effectively describes how much of the crude volume falls into the different distillation fractions such as naphtha, kerosene and atmospheric gas oil.

2.20 End point

2.20.1 The end point for a distillation fraction is the temperature at which 100% of the fraction has evaporated when distilled.

2.20.2 This means it is also, in theory, the cut point between the fraction and the next heavier fraction being distilled, and the initial boiling point of that heavier fraction.

2.20.3 However, in reality, the true end point of a fraction is typically higher than the true initial boiling point of the next highest fraction (i.e. they overlap) because they are complex mixtures of different hydrocarbons. Consequently, refiners in practice split the difference and define an 'effective' end point that is in between and therefore lower than the true end point.

2.21 Energy-rich fuels

2.21.1 Energy-rich fuels are wholly or partly derived from non-petroleum feedstock and they can be produced either without blending as such or by blending with petroleum products.

2.21.2 An energy-rich fuel is obtained from biological origin or non-petroleum sources (e.g. algae, vegetable oils) or is a blend of petroleum-based fuel and a product obtained from biological origin or non-petroleum sources (e.g. algae, gas-to-liquid (GTL) process, hydrotreated vegetable oil (HVO), co-processing).

2.21.3 An energy-rich fuel is comprised only of constituents that can be expressed as individual chemicals of the hydrocarbon family, for example alkanes with straight or branched chain and cycloalkanes etc.

2.21.4 An energy-rich fuel is a complex mixture which is formed of a relatively large amount of constituents. It cannot be represented by a simple chemical structure and has a composition that may vary from batch to batch.

2.21.5 Guidelines for the carriage of energy-rich fuels and their blends are contained in the IMO Circular MEPC.1/Circ.879.

2.22 Feedstock

Feedstock is any hydrocarbon input to a refinery process unit. This could be crude oil or any intermediate refining stream.

2.23 Fraction

A crude oil fraction is a component of crude oil, which has its own particular molecular composition, weight and boiling range. The refining process involves the separation of crude oil into various crude oil fractions through, initially, distillation.

2.24 Heavy and light

Heavy and light are terms used loosely to differentiate between crude oils, volatile and non-volatile products, and within products themselves to distinguish between lighter and denser material. The lighter material will have a lower boiling range and specific gravity. Within crude oils, light is indicative of crude oil that contains a greater proportion of volatile products when refined.

2.25 Hydrocarbon

Hydrocarbons are any substances made up of carbon and hydrogen. This includes crude oil and all petroleum products, as well as natural gas and coal.

2.26 Hydrotreater

The hydrotreater unit removes sulphur and other contaminants from intermediate streams before blending into a finished refined product or before being fed into another refinery process unit.

2.27 Initial boiling point

2.27.1 The initial boiling point for a distillation fraction is the temperature at which the fraction just begins to evaporate when distilled. In theory, it is the 'cut point' between the fraction and the next lighter fraction as crude oil is distilled.

2.27.2 In reality the true initial boiling point of a fraction is typically lower than the true end point of the next lightest fraction (they overlap) because they are complex mixtures of different hydrocarbons. Consequently, refiners in practice split the difference and define an 'effective' initial boiling point that is in between and therefore higher than the true initial boiling point.

2.28 Intermediate

An intermediate refers to any refinery hydrocarbon stream that is not a crude oil or one of the finished petroleum products.

2.29 Isomerisation

The isomerisation unit converts light naphtha into a higher-value gasoline blend stock. The primary product of isomerisation is called isomerate. The value from isomerisation is its ability to upgrade light naphtha into gasoline.

2.30 Low sulphur fuel oil

2.30.1 Low sulphur fuel oil (LSFO) is one of the products which may be obtained from the fractional distillation of crude oil. LSFO may be further categorised depending on the amount of sulphur contained in the finished product. The typical percentage limits are 0.50% (LSFO) or 0.10% for ultra-low sulphur fuel oil (ULSFO).

2.30.2 With respect to the status of LSFOs in terms of their persistency characteristics, a recent study of LSFO properties was undertaken and this concluded that these products would generally be considered to be contributing oils. The study generated true boiling point curves for a number of LSFO samples and compared these data with the accepted distillation criteria for non-contributing oil. None of the LSFOs tested met the criteria and the study accordingly confirmed that the low sulphur (residual) fuel oils tested in the project would show a high degree of persistence on the sea surface.

2.30.3 More information can be found on the ITOPF website, www.itopf.org.

2.31 Natural gas

2.31.1 Natural gas is a gas composed primarily of methane but typically with some ethane as well. Most natural gas comes directly from upstream oil and gas wells, i.e. not from refining.

2.31.2 In refining, natural gas is often purchased and used as a refinery fuel and as a feedstock to make hydrogen in hydrogen plants.

2.32 Natural gas liquids

Natural gas liquids (NGLs) are condensable hydrocarbons that are often associated with natural gas or crude oil production. Ethane, propane, butane, isobutane and pentane are all NGLs.

2.33 Octane

Octane or octane rating is an index of a fuel's ability to resist auto-ignition (known also as engine knock) during compression in an ignition engine. Octane is one of the most important product qualities for gasoline and can be enhanced by blending higher octane material, e.g. methyl tertiary-butyl ether (MTBE).

2.34 Petrochemicals

Petrochemicals generally refers to the petroleum-derived commodity chemicals used primarily in the production of plastics and fibres. Most of the feedstocks for petrochemicals come from refining and NGL processing, including ethane, propane, butane, naphtha and aromatics.

2.35 Petroleum

Petroleum is a hydrocarbon-based fossil fuel like coal or natural gas. Petroleum in its raw state is known as crude oil.

2.36 Pour point

Pour point is an important quality specification for diesel fuels. Specifically, it is a measure of the tendency of a fuel to become more viscous and resist flowing when cold.

2.37 Processing units

A refinery is a plant that includes a number of different processing units. Each of the processing units plays a role in the overall process of converting crude oil into finished petroleum products.

2.38 Refined products

Refined petroleum products are the outputs of a petroleum refinery. A typical refinery produces a wide variety of different products from every barrel of crude oil that it processes. Generally, refineries operate to make as much of the high-value light products (gasoline, jet fuel, and diesel) that they can, with the other products acting essentially as by-products.

2.39 Reformer

The reformer unit upgrades heavy naphtha into a high-value gasoline blend stock by raising its octane. The primary product of the reformer is reformate.

2.40 Residual

Residual is a broad term used to identify the products left over in the refining process and some finished products. Atmospheric residue and vacuum residue are examples of the former and residual fuel oil is an example of the latter.

2.41 Sulphur content

This is the amount of sulphur by weight present in a material, expressed as a percentage of the material in question. Most crude oils contain some sulphur, most of which must be removed during the refining process to meet strict sulphur content limits in refined products.

2.42 Tetraethyllead (TEL)

Tetraethyllead, also written as tetraethyl lead, is a gasoline additive that was once widely used to improve gasoline octane.

2.43 Treating

In a refinery, a number of process units focus on improving the quality of a hydrocarbon stream without changing the product mix of the refinery. A treating process typically removes contaminants by binding them with hydrogen, absorbing them in separate columns, or by adding acids to remove them.

2.44 Vacuum distillation unit (VDU)

Vacuum distillation occurs in the VDU, also known as the vacuum tower. It separates the atmospheric residual (resid) generated by the CDU into its component streams by further distilling the resid under a vacuum. The fractions produced by the VDU (vacuum gasoil (VGO) and vacuum resid) provide feedstock for other refinery units and can be used as a fuel oil blending component.

2.45 Vacuum gas oil (VGO)

As noted above, vacuum gas oil refers to products obtained by the vacuum distillation of heavy oil left over from the atmospheric distillation of crude oil. VGO can be further refined in a catalytic cracking unit, upgrading vacuum gas oil into products with greater value (gasoline and diesel) or, if not upgraded, it may be blended into residual fuel oil. It is an important intermediate feedstock and within the industry, it may be divided into heavy vacuum gas oil (HVGO) or light vacuum gas oil (LVGO) depending on boiling point range. Both VGO types are considered to be persistent oils. While VGO is not specifically cited in the guidance list of contributing oils found in the IOPC Funds' reporting form for oil receipts, it is nevertheless encapsulated by the entry for intermediate or process stocks (fuel oil blend stocks).

2.46 Viscosity

Viscosity is an important quality specification for residual fuel oil. Specifically, it is a measure of a liquid's resistance to flow. High-viscosity fuel oil is more difficult to pump and is therefore less desirable as a product.

3 Introduction to crude oil

3.1 Petroleum, in one form or another, has been used for many centuries but came to modern prominence initially as a replacement for whale oil used for lighting, and subsequently for transportation following the development of internal combustion and jet engines. Numerous other uses have been found for the petroleum products derived from crude oil. With the development of the petrochemical industry, crude oil with its constituent compounds is used as the feedstock to make many essentials of modern-day living, e.g. plastics, fertilisers solvents, adhesives and pesticides.

3.2 Petroleum in its raw state contains all liquid, gaseous and solid hydrocarbons in differing proportions depending on the oil field from which it is derived. At surface atmospheric temperatures and pressures, the lighter hydrocarbons, such as methane, ethane, propane and butane exist as gases, whereas heavier hydrocarbons, such as pentane and above, exist as liquids, i.e. crude oil or waxes.

3.3 Although some light crude oils can be used directly as burner fuel, crude oil is not usually consumed in its raw state. Instead, the constituent hydrocarbon molecules that make up crude oil are broken down into simpler petroleum products through fractional distillation in an oil refinery.

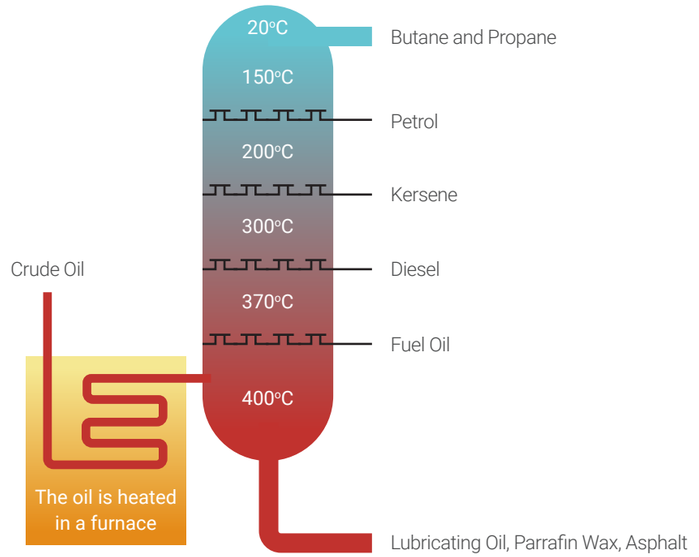
3.4 The first process in a petroleum refinery is usually the crude oil distillation unit (CDU). Heated crude oil passes into the CDU which distils the incoming crude oil into various fractions at different boiling ranges, each of which are then processed further in the other refinery processing units.

3.5 A modern refinery has several processing units after the CDU, e.g. vacuum distillation unit, hydrotreater, catalytic cracker, reformer, isomerisation and blending. Oils that are used as feedstocks for these units are referred to as process oils, intermediates and blend stocks. Non oil-based fuel from agricultural products can also be used as a blending component, usually into diesel and gasoline.

3.6 Resultant petroleum products can be grouped into four main categories: light distillates (LPG, naphtha and gasoline), middle distillates (aviation fuel, kerosene and diesel/gas oil), heavy distillates (light fuel oil, heavy gas oil) and residual fuel (heavy fuel oil, lubricating oil, waxes, bitumen, asphalt and ultimately coke).

3.7 In general terms, the heavier the crude oil or petroleum product, the more persistent it is when released into the marine environment and consequently, the more difficult and costly it is for oil spill response and clean-up operations.

3.8 It is for this reason that importers of crude oils and fuel oils are required by the 1992 Civil Liability and Fund Conventions to pay contributions to the IOPC Funds.



4 Fate of marine oil spills

4.1 Persistent and non-persistent oil

4.1.1 When oil is spilled into the sea it undergoes a number of physical and chemical changes, some of which lead to its removal from the sea surface, for example through evaporation, dispersion and sinking, whilst others cause it to persist. The fate of oil spilled in the marine environment depends upon factors such as the quantity spilled, the initial physical and chemical characteristics of the oil, the prevailing climate and sea conditions, and whether the oil remains at sea or is washed ashore.

4.1.2 The combined effect of the various natural processes acting on spilled oil is collectively known as 'weathering'. These processes, and how they interact to alter the composition, nature and behaviour of oil with time are fundamental to an oil's persistence in the marine environment and its definition as a persistent or non-persistent oil.

4.1.3 More detailed technical information on the fate of oil spilled in the marine environment can be found in the Technical Information Papers produced by ITOPF (www.itopf.org).

4.2 Properties of oil

4.2.1 Crude oils of different origin vary widely in their physical and chemical properties, whereas refined products tend to have well-defined properties irrespective of the crude oil from which they are derived. Intermediate and heavy fuel oils, which contain varying proportions of residues of the refining process blended with lighter refined products, also vary considerably in their properties.

4.2.2 The main physical properties that affect the behaviour and the persistence of an oil spilled at sea are specific gravity, distillation characteristics, vapour pressure, viscosity and pour point. All are dependent on chemical composition, such as the proportion of volatile components and the content of asphaltenes, resins and waxes.

4.3 Weathering

The individual processes described below act together to bring about the weathering of a spilled oil; the relative importance of each process varies with time.

4.4 Spreading

As soon as oil is spilled, it immediately starts to spread over the sea surface. In open water, the thickness of the slick changes with time and distance from the discharge point, varying from a thickness of a few centimetres to less than a micrometre. The speed at which this takes place depends to a great extent on the viscosity of the oil and the volume spilled. Fluid, low viscosity oil can spread rapidly extending over several square kilometres in a few hours and several hundreds of square kilometres in a few days. Such crude and fuel oils often spread as a coherent slick but can quickly break up into smaller slicks or patches. As the thickness of the slick reduces, its appearance changes from black/dark brown into iridescent patches. Semi-solid or highly viscous oil, particularly where the pour point is above the sea temperature, will fragment into patches which tend to move apart. Oil on the sea surface predominantly moves with currents and tides. Wind tends to cause spilled oil to form narrow bands or 'windrows' parallel to the wind direction. In open waters, spreading of spilled oil is not usually uniform.

4.5 Evaporation

The more volatile components of an oil will evaporate into the atmosphere at a rate dependent on the ambient temperature, wind speed and surface area of the slick; therefore, rough seas, high wind speeds and warm temperatures increase evaporation. The greater the proportion of components with low boiling points, as reflected in the oil's distillation characteristics, the greater the degree of evaporation. Those oils with a boiling point lower than 200oC may evaporate entirely over 24 hours. Kerosenes and gasolines may evaporate completely within a few hours. Light crude may lose up to 50% of its volume, with the residual oil increasing in both density and viscosity as a result. In contrast, heavier crude and fuel oils undergo little, if any, evaporation.

4.6 Dispersion

Dispersion involves the assimilation of oil molecules into the water column and is largely dependent upon the characteristics of the oil and the state of the sea. Dispersion increases with reducing viscosity when breaking waves are present. Turbulence at the sea surface can cause all or part of the slick to break up into droplets of varying sizes which become mixed in the upper layers of the water column. Smaller droplets remain in suspension while larger ones rise back to the surface where they may reform into a coherent slick or create a very thin film. The increased surface area presented by dispersed oil droplets promotes processes such as biodegradation, dissolution and sedimentation (see below).

4.7 Dissolution

The rate and extent to which an oil dissolves depends upon its composition, spreading, sea temperature, turbulence and degree of dispersion. The heavier components of crude oil are virtually insoluble in sea water whereas lighter compounds, particularly aromatic hydrocarbons such as benzene and toluene, are slightly soluble. However, these compounds are also the most volatile and are lost rapidly to evaporation. Dissolution does not make a significant contribution to the natural removal of oil from the sea surface.

4.8 Sedimentation and sinking

Very few oils have a specific gravity greater than sea water, which would cause them to sink once spilled. Most oils have a lighter specific gravity than water and remain afloat unless they interact with denser materials. Dispersed oil droplets can interact with sediment particles and organic matter suspended in the water column so that the resultant particles become dense enough to sink slowly to the sea bed. Shallow coastal areas and estuaries are often laden with suspended solids that can bind with dispersed oil droplets promoting favourable conditions for sedimentation, particularly in brackish waters where the water density is reduced. Sedimentation is one of the key long-term processes leading to the accumulation of spilled oil in the marine environment, however this is rarely observed other than in shallow waters or close to the shore, primarily as a result of shoreline interaction.

4.9 Emulsification

Many oils take up water and form a water-in-oil emulsion. This can increase the volume of pollutant by up to five times. Viscous oils, such as heavy fuel oils, tend to take up water more slowly than less viscous/fluid oils. Depending on the characteristics of the oil, as the emulsion develops with wave action, it can become progressively more viscous and very stable. Stable emulsions may contain as much as 70 to 80% water, are often semi-solid, highly persistent and can remain emulsified indefinitely.

4.10 Photo-oxidation

Hydrocarbons can react with oxygen, which may either lead to the formation of soluble products or persistent tars. Oxidation is promoted by sunlight and, although it occurs for the entire duration of the spill, its overall effect on dissipation is minor compared to that of other weathering processes. Thick layers of very viscous oil or water-in-oil emulsions tend to oxidise to persistent residues rather than degrade.

4.11 Biodegradation

4.11.1 Every crude oil is comprised of a variety of organic compounds which dictate the unique physical characteristics of the oil. The different compounds in crude oil have different abilities to be degraded, thereby dictating the oil's overall biodegradability. Simpler organic and saturated hydrocarbons will more readily biodegrade compared to the more complex aromatic hydrocarbons, resins and asphaltenes.

4.11.2 Biodegradation of oil occurs as the result of micro-organisms breaking-down and metabolising the components of oil. Sea water contains a range of marine micro-organisms, including bacteria, moulds, yeasts, fungi, unicellular algae and protozoa, all of which can utilise oil as a source of carbon and energy. Such organisms are distributed widely throughout the world's oceans although they are more abundant is areas of natural seeps of oil or chronically polluted coastal waters (typically those close to urban centres which receive industrial discharges and untreated sewage). The micro-organisms necessary for biodegradation are present in relatively small numbers away from coasts in the open sea but multiply rapidly when oil is available. Biodegradation will continue until the process is limited by nutrient or oxygen deficiency.

4.11.3 The main factors affecting the rate and extent of biodegradation are the characteristics of the oil, the availability of oxygen and nutrients (principally compounds of nitrogen and phosphorus) and temperature. Biodegradation can only take place at the oil/water interface and the eventual products of biodegradation are carbon dioxide and water. Biodegradation is one of the major long-term processes that removes oil from shorelines.

5 Persistent and contributing oils

5.1 Persistent and contributing oils are related terms under the 1992 Civil Liability and Fund Conventions; 'persistent' is used when referring to oils that are covered for compensation under the 1992 Civil Liability and Fund Conventions whereas 'contributing' is used to refer to oils that are liable to be counted for the purposes of calculating contributions to the 1992 Fund.

5.2 Persistent oils

5.2.1 Persistent oil is defined in Article I(5) of the 1992 CLC as 'any persistent hydrocarbon mineral oil such as crude oil, fuel oil, heavy diesel oil and lubricating oil, whether carried on board a ship as cargo or in the bunkers of such a ship'. There is no technical definition.

5.2.2 In the absence of a technical definition of persistent oil in the 1992 CLC, the following definition of non-persistent oil was approved at the 4th session of the 1971 Fund Assembly in 1981 (see document 71Fund/A.4/11, Annex and 71Fund/A.4/16, paragraph 14): 'an oil is considered non-persistent if, at the time of shipment, at least 50% of the hydrocarbon fractions (by volume) distil at 340 oC (645 oF) and at least 95% distil at 370 oC (700 oF).'

5.2.3 For the 1992 Fund Convention to apply to an oil spill incident, the ship must therefore have on board a cargo of persistent oil, or the residues of such a cargo, or persistent oil in the bunkers of such a ship. The incident must have occurred within the waters of a Member State.

5.2.4 For consistency, testing of an oil to determine its persistence should be made in accordance with the ASTM International (ASTM) method D86, D2887, D7344 and D7345 as best suits the material under test. If D2887, D7344 and D7345 methods are used, results should be reported as a 'predicted' D86 result by following the conversion guidance presented in these documents.

5.2.5 It is recognised that other organisations and testing methods exist, e.g. the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN). In preparing this guide it was considered whether any equivalent testing methods could be applied to determine if an oil falls within the definition above. It was concluded that the ASTM methods above remain the most relevant and globally accepted standards to determine whether an oil is persistent or not as measured using the above technical definition.

5.3 Contributing oils

5.3.1 The IOPC Funds are financed by contributions levied on any person who has received in one calendar year more than 150 000 tonnes of crude oil and/or heavy fuel oil (contributing oil) in a State party to the 1992 Fund Convention or the Supplementary Fund Protocol.

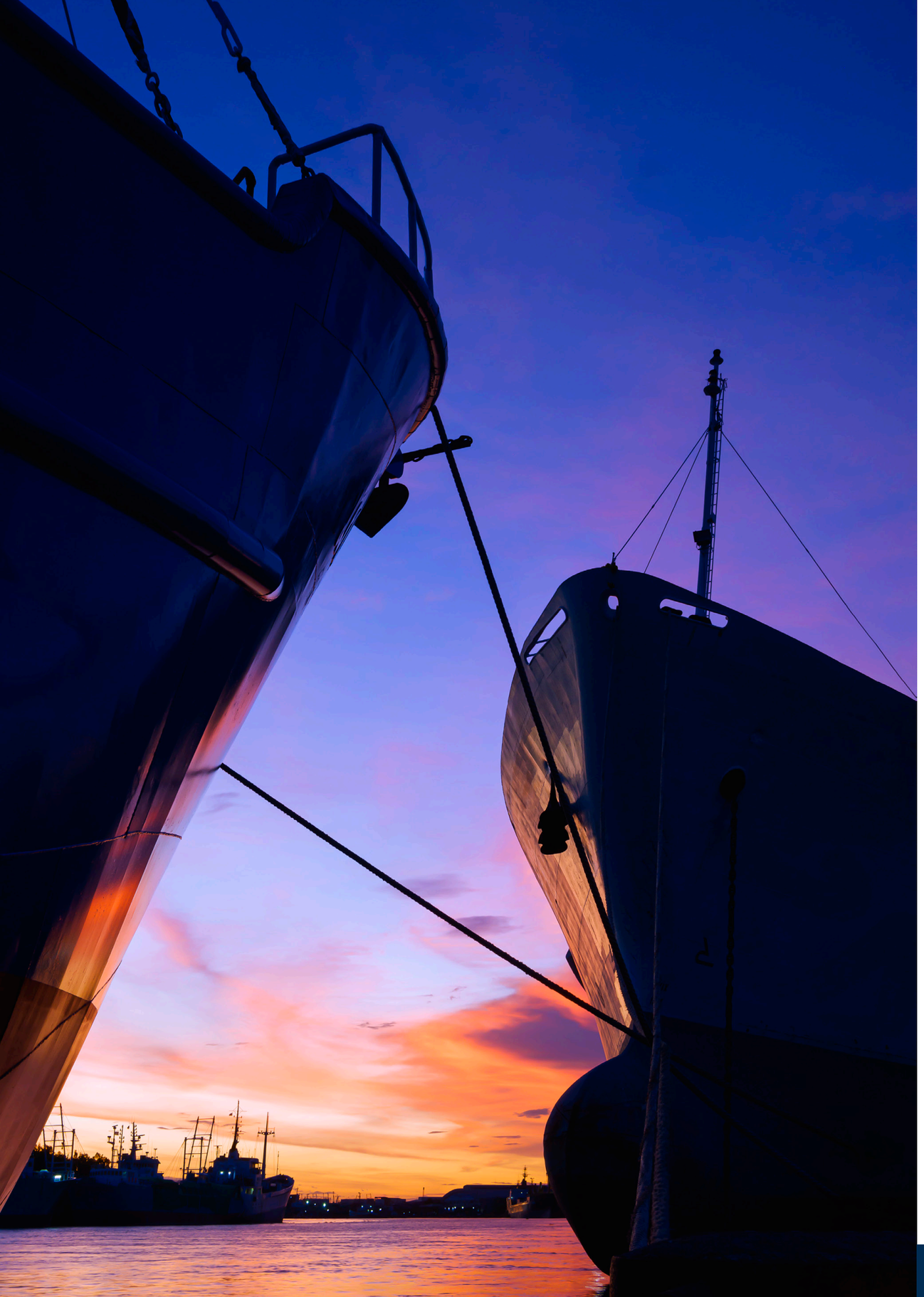
5.3.2 Article 1.3 of the 1992 Fund Convention defines 'contributing oil', meaning crude oil and fuel oil, as follows:

(a) 'Crude Oil' means any liquid hydrocarbon mixture occurring naturally in the earth whether or not treated to render it suitable for transportation. It also includes crude oils from which certain distillate fractions have been removed (sometimes referred to as 'topped crudes') or to which certain distillate fractions have been added (sometimes referred to as 'spiked' or 'reconstituted' crudes).

(b) 'Fuel Oil' means heavy distillates or residues from crude oil or blends of such materials intended for use as a fuel for the production of heat or power of a quality equivalent to the 'American Society for Testing and Materials' Specification for Number Four Fuel Oil (Designation D 396-69)', or heavier.

5.3.3 Note that although ASTM D 396-69 is mentioned above (69 indicating 1969 as the issue year), all ASTM standards are regularly revised, reissued or withdrawn and consequently, there have been a number of revisions made to the D 396 standard over time. The version currently listed as being active for this standard is ASTM D 396-21.

5.3.4 'Contributing oils' comprise crude and fuel oils as defined in the 1992 Fund Convention. However, contracting States have clarified this definition at several sessions of the IOPC Funds' governing bodies, such that crude oils classed as non-persistent and marine diesel oils classed similarly as persistent are not contributing oils (see documents 92FUND/A.3/26 and 92FUND/A.4/13 for more information). Furthermore, various persistent residual oil products that are not used for heat and power are also not contributing oils. These exclusions provide simplification of the process for oil receivers when completing the annual reporting of receipt of contributing oil to the IOPC Funds' Secretariat. A list of contributing and non-contributing oil, intended as a guide for reporting receipts of contributing oil products, is maintained on the IOPC Funds' website and this can also be found at Annex I.



6 Petroleum cargoes moved by sea

6.1 The table of petroleum products moved by sea describes the major petroleum products and other processed hydrocarbons transported by sea (see Annex I).

6.2 Crude oils

Natural gas liquids (NGLs) and condensates

6.2.1 Natural gas liquids and condensates are components of natural gas that are separated from the gas state in the form of liquids. There are several types of natural gas liquids and many different applications for NGL products. NGLs and condensates are usually non-persistent but this should be determined by analysis.

Natural gasoline

6.2.2 Natural gasoline is a liquid hydrocarbon mixture condensed from natural gas. Natural gasoline is volatile and unstable with a low octane rating. It is a blending component for motor gasolines and can be used as a solvent in the extraction of oil from oil shale.

Non-persistent crude oils

6.2.3 As a general rule, all crude oils are considered to be persistent oil. On rare occasions, a crude oil contains a sufficiently low amount of residual hydrocarbon (by definition) that is considered non-persistent. An example of such a crude oil was the Canadian Cohasset-Panuke crude oil which was in production between 1992 and 1999.

6.3 Refined products

Methane and ethane

6.3.1 Methane and ethane are simple hydrocarbon gases which are often left as a natural gas and cooled to a liquid state at atmospheric temperature for transportation by sea in specialist liquified natural gas (LNG) ships.

Propane

6.3.2 Propane is the lightest liquid stream produced in a refinery and is transported by sea in specialised ships which may be refrigerated or semi or fully pressurised. In refining, propane is typically blended into finished products (LPG and propane for petrochemical feed) to make ethylene or propylene. It is also sometimes used as refinery fuel but this is typically its lowest value end use.

Butane

6.3.3 Butane is one of the lightest liquid streams typically produced in a refinery and is transported by sea in specialised ships which may be refrigerated, or semi or fully pressurised. Butane is typically either blended into gasoline or LPG (in small volumes) or sold directly as a finished product. When blending into gasoline, butane is favoured for its high octane rating but limited by its high vapour pressure.

6.3.4 Butane is also frequently converted into isobutane for use as an alkylation feedstock. It is sometimes used as a refinery fuel, but this is typically its lowest-value end use and avoided where possible.

Aviation gasoline (AvGas)

6.3.5 AvGas is also known as aviation spirit and is a fuel used in spark ignition plane engines. Generally, AvGas uses tetraethylenelead (TEL) to prevent engine knock (premature detonation).

Motor gasoline (Mogas)

6.3.6 Mogas, also known as motor spirit and gasoline, is one of the major petroleum products produced from processing crude oil.

6.3.7 Gasoline is one of the higher-valued light products (along with jet fuel and diesel). It is used almost exclusively in the transportation sector, mostly as a fuel in motor cars and other light-duty vehicles. Demand for gasoline varies seasonally with the highest demand during the northern hemisphere summer. Summer is also when gasoline quality specifications (especially vapour pressure) tend to be tightest, resulting in generally higher prices in these months. Different grades of Mogas are differentiated by their octane rating.

White spirit

6.3.8 White spirit is also known as turpentine, turpentine substitute, solvent naphtha or mineral spirit, and a number of other trade names. It is a specialty refined product in the naphtha boiling range. It has a variety of uses including as an extraction solvent, a cleaner (paint thinner) or a degreaser. It is a common solvent in paints, lacquers, varnishes, aerosols and asphalts.

Kerosene

6.3.9 Kerosene is produced in various grades under a variety of names depending on its intended use and, in some cases, its sulphur content.

6.3.10 Premium and regular use kerosene (also known as paraffin) is a lower quality aviation turbine kerosene specification and is sold for non-aircraft uses. Premium kerosene is used for lighting, heating, cooking purposes and sometimes for small engines (outboard/motorcycles) whilst regular kerosene is used for domestic heating.

6.3.11 Aviation turbine kerosene (ATK) is also known as jet fuel, jet A1, avtur, JP5 (AvCat) and JP8 (military grades) and No. 1 fuel (ASTM). These grades of kerosene are used in both domestic and military aeroplanes.

6.3.12 ATK is one of the higher-valued light products derived from crude oil refining. It is used primarily in the transportation sector and is the primary fuel used in jet aircrafts and other jet turbine applications.

Gasoil

6.3.13 Gasoil is a broad term that can refer to a range of intermediates and finished petroleum products, generally in the diesel or vacuum gasoil (VGO) range.

6.3.14 Intermediates sometimes referred to as gasoil include:

- Light atmospheric gasoil (LAGO) – diesel range straight run material from the atmospheric distillation tower;
- Heavy atmospheric gasoil (HAGO) – straight run material in between the diesel and VGO range from the atmospheric distillation tower;
- Vacuum gasoil (VGO) – the lighter resid fraction from the vacuum distillation tower;
- Coker gasoil – VGO range product from the coker; and
- Hydrocracked gasoil – VGO range material from the hydrocracker.

6.3.15 Finished petroleum products sometimes referred to as gasoil include:

- Diesel, which is a high-quality fuel used in diesel engine cars and trucks;
- Heating oil or industrial gasoil (No. 2 Fuel – ASTM, Furnace fuel) used as furnace fuels in homes and commercial buildings; and
- Marine gasoil (marine diesel/MDO) which is a blend of gasoil and heavy fuel oil used in marine diesel engines.

Base oil

6.3.16 Base oils are not fuels. They are blend stocks used to formulate a variety of lubricating oils for use in engines and other machinery. Base oil is persistent when spilled on water.

Lubricating oil

6.3.17 Lubricating oil (lube oil or lubes) has a multitude of purposes each often requiring its own speciality blend to produce the specific performance requirement for its task. Each speciality lube oil is a base oil with the addition of chemical additives specific to its end purpose. The resultant product is usually high value.

6.3.18 Most lube oils transported in bulk by sea are base oils and blend stocks which are subsequently blended in a refinery or purpose-built lube oil blending plant to create the finished grade which is packaged for onward transportation. Lube oil is persistent when spilled on water.

Fuel oil

6.3.19 Fuel oil is a broad term that could refer to a number of different refined products ranging in density from kerosene to residual fuel oil.

6.3.20 In general terms, fuel oil is any liquid fuel that is burned in a furnace or boiler for the generation of heat or used in an engine for the generation of power.

6.3.21 ASTM grades of fuel oil used in US markets are:

- **No. 1** – A fuel oil consisting of kerosene range material. Also called stove oil or range oil;
- **No. 2** – A fuel oil consisting of light atmospheric gasoil material. This is the fuel oil used as a home heating oil. It is very similar to diesel but of lower quality. Typically, it has a lower cetane and higher sulphur content. Also called Bunker A;
- **No. 3** – This is a now obsolete light gasoil range fuel oil, that has been combined with No. .2;
- **No. 4** – A fuel oil consisting of VGO range material, intended for commercial heating furnaces lacking a preheater;
- **No. 5** – A fuel oil consisting of vacuum residual range material with a low viscosity, allowing it to be pumped without preheating. Also called Bunker B; and
- **No. 6** – A fuel oil consisting of vacuum residual range material with a high viscosity, requiring preheating before pumping. Also called residual fuel oil or Bunker C.

Residual fuel oil

6.3.22 Residual fuel oil is one of the lowest-value petroleum products from a refinery and is a by-product of distillation process which produces the lighter products.

6.3.23 The primary end use for residual fuel oil is as a fuel in simple furnaces such as power plants and industrial boilers. It is also the primary fuel used on ocean-going ships, where it is called bunker fuel.

6.3.24 Residual fuel oil has some quality specifications that it must meet, for performance and environmental reasons. The most important are:

- Viscosity – This is a measure of a fluid's tendency to resist flow. Lower viscosity is more desirable; and
- Sulphur content – Fuel oil has a maximum sulphur content determined by environmental concerns. This typically sets a limit on the maximum sulphur content allowed, expressed as a percentage by weight (wt %).

6.3.25 Residual fuel oil is the heaviest among a range of different fuel oil grades and is often carried heated. If spilled onto the sea surface it is highly persistent.

6.3.26 Residual fuel oil comes in many grades but can broadly be categorised as:

- Light fuel oil (LFO)/No. 5 fuel oil (light) – a low viscosity grade which can be transported without heating;
- Medium fuel oil (MFO)/No. 5 fuel oil (heavy) – a medium viscosity grade that requires moderate heating to transport; and
- Heavy fuel oil (HFO)/No. 6 fuel oil – the heaviest grade of fuel oil being the residue after lighter materials have been removed by distillation.

6.3.27 Fuel oils that come straight from the distillation tower are referred to as straight-run fuel oils. They are produced solely from atmospheric distillation and are generally used as an intermediate feedstock for further processing.

6.3.28 Fuel oils can be blended with a variety of other products to meet defined final product specifications, e.g. viscosities, sulphur etc. Fuel oil used in the marine environment which is required to have a reduced sulphur content to limit environmental pollution is known as low sulphur fuel oil (LSFO) or ultra low sulphur fuel oil (ULSFO).

6.3.29 Low sulphur waxy residue (LSWR) is a fuel oil blend stock for heavy fuel oil.

Bitumen

6.3.30 This is also known as asphalt and is the densest liquid refined product produced by a refinery. It only stays liquid if stored and transported at a high temperature. It becomes a solid if allowed to cool to normal atmospheric temperatures. As a result, bitumen is usually carried by sea in specialist ships.

6.3.31 Bitumen can be cut or blended with a lighter product depending on its end use requirements.

6.3.32 Bitumen is very persistent if spilled into the marine environment and, as some bitumen has a density greater than one, spilled bitumen may sometimes sink.

Bitumous emulsions and fuel oil emulsions

6.3.33 Emulsified fuels have been developed to enable the easier transportation and commercialisation of natural bitumen reserves, or to develop heavy residual oils into usable fuel for large industrial boilers.

6.3.34 Emulsified fuels are composed of an emulsion of bitumen or fuel oil and water (8 to 30%) with a chemical surfactant (1%). These products are traded under individual trade names.

6.4 Process oils, intermediate and blend stocks

6.4.1 Process oils and intermediate oils refer to any refinery hydrocarbon stream that is not a crude oil or a finished petroleum product and includes all of the outputs from distillation and conversion units. These oils are used as feeds to other units.

6.4.2 A blend stock is any unfinished oil that is blended with other similar unfinished oils to make a finished product. Commonly, lube oils and fuels oil are transported by sea to a location close to a usage market where blending to market specifications then takes place.

6.4.3 Typically, process oils, intermediate oils and blend stocks are produced and consumed within the same refinery but it is not uncommon for these to be traded and transported by sea between refineries.

6.4.4 Process oils, intermediate oils and blend stocks are referred to by a multiplicity of names and specifications. This depends on the crude oil from which they are derived, the refinery, and area of the world in which they are being traded.

6.5 Related cargoes

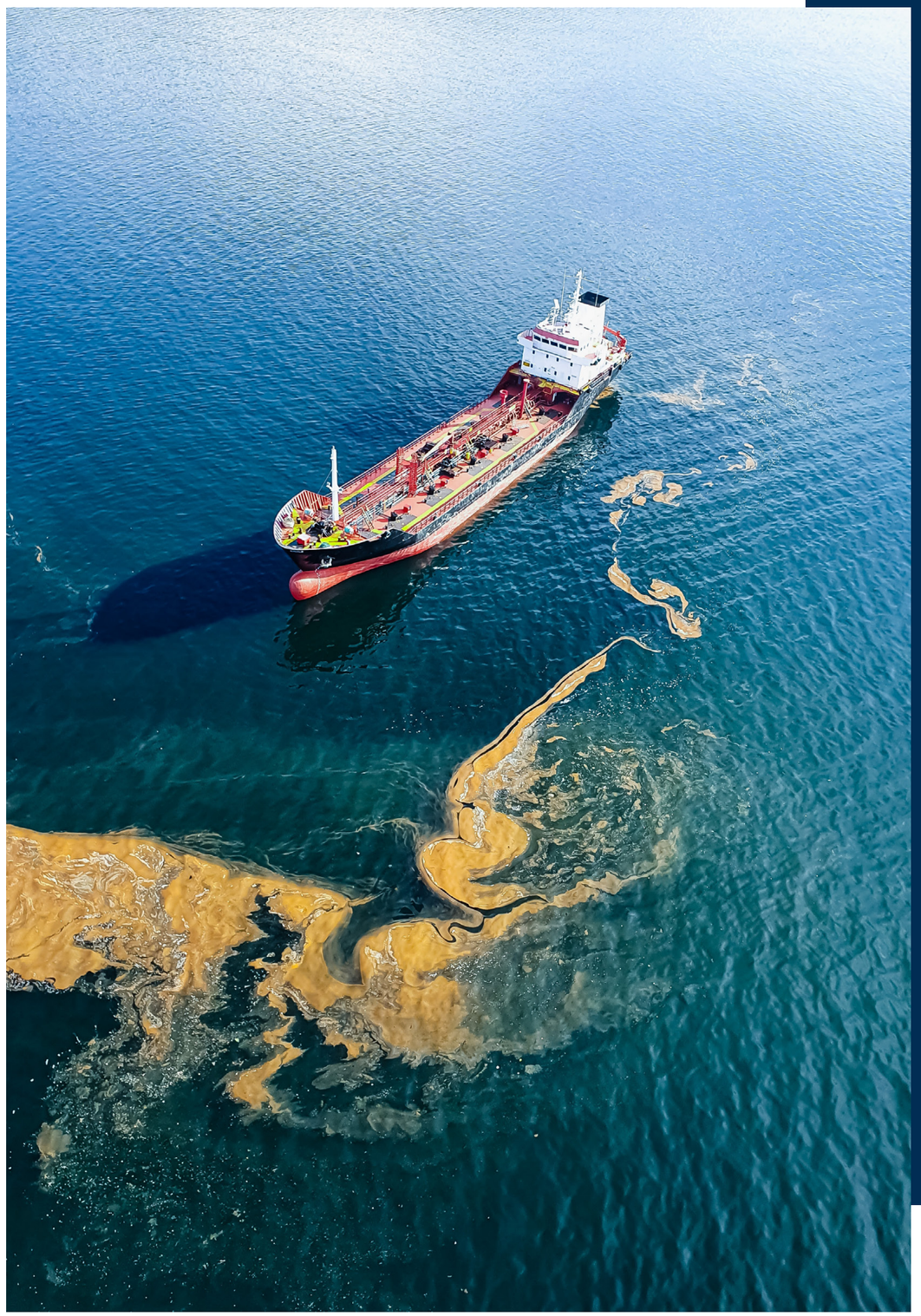
6.5.1 In addition to the range of conventional petroleum products noted above, in recent years two further types of cargo have now been routinely transported by sea, biofuels and energy-rich fuels.

6.5.2 As noted under the Glossary of Terms, biofuels are typically used as a blend in conjunction with conventional oil-based fuel blendstocks to make diesel and gasoline products.

6.5.3 Energy-rich fuels which are wholly or partly derived from non-petroleum feedstock may be produced either without blending or by blending with petroleum based products.

6.5.4 These products/blends are non-contributing cargoes with respect to the IOPC Funds' reporting requirements for the receipt of contributing oils.

6.5.5 They are listed by IMO in the annual MEPC.2/Circular which addresses the Provisional Categorization of Liquid Substances in accordance with MARPOL Annex II and the IBC Code. Products listed in MEPC.2/Circ.29 under Annexes 11 and 12 for Biofuels and Energy-rich fuels respectively can be found at Annex II.



ANNEX I

Contributing and non-contributing oils (taken from the form for reporting receipts of contributing oil which can be found on the IOPC Funds' website)

Contributing oil

Crude oils

- All naturally occurring crude oils*
- Condensate
- Topped crudes
- Spiked crudes
- Reconstituted crudes

Finished products

- No. 4 fuel (ASTM)
- Navy special fuel
- Light fuel oil
- No. 5 fuel (ASTM) (light)
- Medium fuel oil
- No. 5 fuel (ASTM) (heavy)
- Bunker C fuel oil
- Heavy fuel oil
- No. 6 fuel oil (ASTM)
- Blended fuel oils by viscosity or sulphur content
- Bituminous emulsions and fuel oil emulsions**

Intermediate or process stocks

- Fuel oil blend stocks

Non-contributing oil

Crude oils

- Natural gas liquids
- Condensate*
- Casinghead naphtha
- Natural gasoline
- Cohasset-panuke

Finished products

- LNG and LPG
- Aviation gasolines – motor gasoline (petrol, essence)
- White spirit
- Kerosene
- Aviation kerosene – jet 1 A and No. 1 fuel (ASTM)
- Gas oil
- Heating oil
- No. 2 fuel (ASTM) (lubricating oil)
- Marine diesel
- Fuel blends containing biofuels
- Energy-rich fuels and their blends

Intermediate or process stocks

- Straight run naphtha
- Light cracked naphtha
- Heavy cracked naphtha
- Platformate
- Reformate
- Steam-cracked naphtha
- Polymers
- Isomers
- Alkylates
- Catalytic cycle oil
- Reformer feed
- Steam cracker feed
- Gas oil blend stocks
- Catalytic cracker feedstock
- Visbreaker feedstock
- Aromatic tar

* To be considered as 'non-contributing oil' if more than 50% by volume distils at a temperature of 340°C and at least 95% by volume distils at a temperature of 370°C, when tested by the ASTM method D86/78 or any subsequent revision thereof.

** Quantity of emulsion received should be reported with no allowance for its water content.

ANNEX II

Biofuels and energy-rich fuels listed in MEPC.2/Circ.29, Provisional categorization of liquid substances in accordance with MARPOL Annex II and the IBC Code (issued 1 December 2023)

Biofuels

Recognized biofuels in accordance with the 2019 Guidelines for the carriage of blends of biofuels and MARPOL Annex I cargoes (MSC-MEPC.2/Circ.17) as listed under Annex 11 are,

1. tert-Amyl ethyl ether*
2. Ethyl alcohol
3. Fatty acid methyl esters (FAME) † (m)
4. Vegetable fatty acid distillates (m)

* With regard to the shipment of blends of petroleum oil and tert-Amyl ethyl ether under MARPOL Annex II controls, it is necessary to initiate or refer to tripartite agreements for such blends indicating the carriage requirements as appropriate.

† This entry is intended to include any specific FAMEs set out in chapter 17 of the IBC Code or the MEPC.2/Circular.

(m) indicates that these products must be made from vegetable oils, animal fats and fish oils specified in the IBC Code.

Energy-rich fuels

Recognised energy-rich fuels subject to Annex I of MARPOL in accordance with the Guidelines for the carriage of energy-rich fuels and their blends (MEPC.1/Circ.879) as listed under Annex 12 are,

1. Alkanes (C4-C12) linear, branched and cyclic (containing benzene up to 1%)
2. Alkanes (C5-C7), linear and branched
3. Alkanes (C9-C24) linear, branched and cyclic with a flashpoint ≤60°C
4. Alkanes (C9-C24) linear, branched and cyclic with a flashpoint >60°C
5. Alkanes (C10-C17), linear and branched.
6. Alkanes (C10-C26), linear and branched with a flashpoint ≤60°C
7. Alkanes (C10-C26), linear and branched with a flashpoint >60°C

Note: These products or their blends are non-contributing cargoes with respect to IOPC Funds' reporting requirements for the receipt of contributing oils.

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