IPIECA

International Association of Oil & Gas Producers

Regulatory approval of dispersant products and authorization for their use

Oil Spill Response Joint Industry Project

IPIECA

The global oil and gas industry association for environmental and social issues

14th Floor, City Tower, 40 Basinghall Street, London EC2V 5DE, United Kingdom
Telephone: +44 (0)20 7633 2388   Facsimile: +44 (0)20 7633 2389
E-mail: info@ipieca.org   Internet: www.ipieca.org

International Association of Oil & Gas Producers

London office
14th Floor, City Tower, 40 Basinghall Street, London EC2V 5DE, United Kingdom
Telephone: +44 (0)20 3763 9700   Facsimile: +44 (0)20 3763 9701
E-mail: reception@iogp.org   Internet: www.iogp.org

Brussels office
Boulevard du Souverain 165, 4th Floor, B-1160 Brussels, Belgium
Telephone: +32 (0)2 566 9150   Facsimile: +32 (0)2 566 9159
E-mail: reception@iogp.org   Internet: www.iogp.org

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About this report

In response to the Deepwater Horizon incident at the Macondo Prospect off the Gulf of Mexico in April 2010, the International Association of Oil and Gas Producers (IOGP) formed the Global Industry Response Group (GIRG). This Group was tasked with identifying ways to prevent the recurrence of such an incident and to identify learning opportunities both with respect to the cause of, and response to, the incident. Part of this effort involved the formation of a subgroup on Oil Spill Response (OSR). This group was comprised of nominees from IOGP member companies, from the IPIECA Oil Spill Working Group (OSWG), from Oil Spill Response Limited (OSRL), and from other industry organizations, associations and spill response cooperatives, as appropriate.

The IOGP GIRG-OSR task force reported on its findings to both the IOGP Management Committee and the IPIECA Executive Committee at a joint session in February 2011. While certain actions recommended by the GIRG-OSR report fell within the remit of existing organizations, it was recognized that the most efficient way to execute the resultant work was for the industry to establish a limited duration Joint Industry Project (JIP), governed by the funding companies.

This report addresses Finding 2 of the IOGP Global Industry Response Group (GIRG) report which outlines the principles of regulations concerning dispersants and their use. It is aimed at national regulators and their advisors, and at oil industry personnel. Its purpose is to establish a common understanding of what is required for the effective regulation of dispersants and their use, and to provide guidance on how this may be accomplished.

Purpose of this document

Development of dispersant regulations by competent national authorities or appropriate government regulators forms a critical part of national oil spill contingency planning processes, in alignment with the International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC Convention) and published IMO guidance (IMO, 2011).

This report has been produced by the IPIECA-IOGP Oil Spill Response Joint Industry Project (JIP) to provide an overview of the principles of regulations concerning dispersants. Dispersant regulations have been divided into the following two categories:

1. **Dispersant product approval regulations** that describe *which* dispersants would be approved for use in national waters.
2. **Dispersant use authorization regulations** that define *where and when* approved dispersant products may be authorized for use on spilled oil in national waters.

The basis of the primary legislation, of which dispersant regulations are subsidiary instruments, varies from country to country and therefore no specific recommendations or requirements about the legal implementation of dispersant regulations is given. It is the right and responsibility of national authorities to introduce regulations about dispersants as they see fit. This report provides a background, and the relevant information and good practice, to assist countries that are currently without dispersant regulations to develop them, should they wish to do so.

This report is aimed at national regulators and their advisors, and oil industry personnel involved with oil spill response who may interact with these national regulators and advisors. The purpose of the report is to establish a common understanding of what is required for effective regulation of dispersants, and to provide guidance on how this may be accomplished.

Boxes are included throughout the document to provide additional information to support the text, and notes in the margin serve to emphasize the key points.

Introduction

Dispersant regulations are critical to ensuring the most effective response to many spill scenarios.

Oil spill dispersants are an important part of the 'toolbox' for responding to offshore oil spills, particularly larger spills, around the world. Regulation of dispersants ensures that this response option can be made available in a timely manner, and that suitable dispersants are available for use if required. Such regulation is essential to minimize the potential environmental damage from oil pollution in those situations where dispersant use is appropriate. Without regulation, the opportunity to use dispersants may be lost, potentially resulting in widespread and avoidable damage from oil pollution due to the inability of other response options to combat a large oil spill effectively in the offshore environment. More than 75 countries have recognized the benefit of dispersants and put in place regulatory approval and authorization for their use.

Dispersed oil rapidly dilutes and degrades.

Undispersed oil can cause long-term damage to coastal habitats.

Depending on the oil properties and environmental conditions, a proportion of spilled oil will disperse naturally in the water column as variously-sized droplets due to the mixing energy from wave action (NRC, 1989) or the turbulent mixing associated with subsea releases. The larger droplets will surface and the smaller ones remain dispersed. The addition of dispersants greatly enhances the formation of very small droplets (<0.1 mm) that remain dispersed. Very small droplets create a large increase in the surface area of oil available for biodegradation. Biodegradation of dispersed oil has been measured to have a half-life of days to weeks (Brakstad *et al.,* 2014). In contrast, undispersed oil remains on the water surface and weathers, retarding biodegradation. Furthermore, if oil comes into contact with the shoreline it may persist for years. Past experience has shown that spilled oil causes most damage when it drifts into oil-sensitive nearshore and shoreline habitats, including mangroves, mudflats and saltmarshes, where it may persist and continue to cause damage long after the incident. It is difficult to clean up oil in such habitats without causing additional damage.

Responding to an oil spill is often a 'race against time' to recover, burn or disperse the spilled oil before it has an impact on an oil-sensitive resource. All response actions undertaken should have a net environmental benefit compared with taking no action. If it is clear that a response is required, the most rapid way of dealing with large offshore releases is to apply a dispersant to the spilled oil using a suitably equipped aircraft. Enhancing the removal of surface oil through the use of dispersants can also be of benefit to the health and safety of on-scene responders and the general public, by reducing or preventing their direct contact with hydrocarbons and their exposure to the volatile components of the oil.

The role of dispersant regulations

It is necessary for dispersant regulations to cover two separate issues. This report is divided into two parts to address each issue:

Part 1: **Dispersant product approval**: describes *which* dispersants are approved for use and how dispersants can be added to an approved dispersant list by meeting the requirements of specified testing.

Part 2: **Dispersant use authorization**: describes *where and when* approved dispersant products may be authorized for use on spilled oil in national waters.

Box 1 A note on terminology

- This document uses the term *'dispersant product approval'* to describe the testing process that identifies the products that can be used as dispersants. Countries may use synonymous terms, such as 'listed' or 'licensed' dispersants to describe approved products.
- The term *'dispersant use authorization'* means those circumstances under which approved products may be used as a response option to combat oil pollution. In many situations it can be appropriate to *'pre-authorize'* dispersant use. This means identifying certain locations and scenarios under which authorization is granted in advance of a potential incident, as part of contingency planning.

As spilled oil 'weathers' it becomes more viscous as it loses volatile components by evaporation and incorporates water to form water-in-oil emulsions. This increase in viscosity means that the use of dispersants may become less effective (Belore, 2012; Pond *et al.,* 1997). It is therefore imperative that dispersants are used as soon as possible after a spill has occurred. For dispersant use to be one of the options considered for reducing the environmental impact of a spill, it is essential to have in place:

- approved dispersants listed in advance; and ideally
- pre-authorization for use in appropriate areas (based on the principles of NEBA—see Annex 2).

Granting pre-authorizations also allows for contingency planning covering suitable equipment, logistics, dispersant stockpiles and trained personnel necessary to enable the rapid application of the dispersant.

The safety of responders and the public is a paramount concern during oil spills. The storage, handling and use of dispersants with respect to human health are not normally addressed by specific dispersant regulations. Rather, they are covered by national regulations and guidance concerning the safe handling and use of chemicals. Further information on human health considerations is provided in Annex 1.

Part 1: Dispersant product approval

Governments should consider, in advance, developing a list of approved dispersants (EMSA, 2010; US EPA, 2014) to ensure that only suitable products can be used during an oil spill response. Once a spill has occurred, there is rarely sufficient time to consider obtaining approval for the use of dispersants to minimize the impact of the spill. When considering a candidate dispersant for approval, the following factors should be considered:

Approved dispersants should be reasonably effective at dispersing oil, and have relatively low toxicity to marine life.

- **A dispersant should meet or exceed a threshold for effectiveness** (or 'efficacy'). It is necessary for a dispersant to be of appropriate effectiveness to enhance the rate of natural dispersion when applied at sea.

- **A dispersant should not exceed a maximum toxicity threshold to marine life.** Care needs to be taken when considering dispersant toxicity versus the toxicity of the dispersed oil (dispersant plus oil). When approving a dispersant for use, the maximum toxicity threshold of a candidate dispersant is usually set at either:
  a) a level where the oil and dispersant mixture is no more toxic than the oil alone at the same exposure levels; or
  b) if the dispersant is tested alone, at a level which is significantly less toxic than a reference oil.

  Note: concerns over the toxicity of dispersed oil should be considered during dispersant use authorization (i.e. when and where dispersant use may be allowed). This is discussed in more detail in Part 2 of this document.

- **A dispersant should be readily biodegradable and not contain persistent harmful constituents.** This may require additional information to be provided as part of the product approval process.

Options

Countries may choose to adapt existing dispersant testing regimes or accept the approval process used in another country.

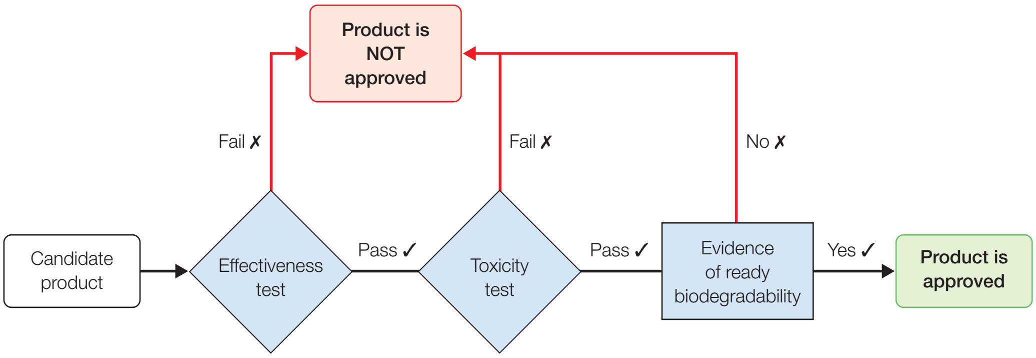
Countries that do not currently have a list of approved dispersants or dispersant product approval regulations, and whose relevant regulatory authority wishes to develop such an approved dispersant list, have the following options:

- Adapt one of the existing internationally recognized test methods to be more relevant to the locally prevailing conditions. It is not necessary to consider developing unique effectiveness and toxicity testing regimes for dispersant product approval, as a wide variety of well-developed methods already exist.
- Accept dispersants that have been approved in another country (or selected countries) utilizing published testing protocols, for inclusion on their own approved dispersant list. This approach avoids the need to conduct any further testing and greatly simplifies the approval process.

Overview of the approval process

A recommended process for dispersant product approval is illustrated in Figure 1. The threshold or pass mark for approval using existing effectiveness and toxicity tests should be set at a level with which a regulator is comfortable. The thresholds should be suitable for approving dispersants that are reasonably effective and lower in toxicity than the oils they will be used to treat.

Figure 1 Example dispersant product approval process



Several countries have developed standard laboratory tests of varying complexity for both effectiveness and toxicity. These tests can only evaluate the relative performance and toxicity of different candidate dispersants on the test oil under laboratory conditions, and will not accurately predict dispersant efficiency or environmental impacts during an actual oil spill response. The recent development of subsea dispersant injection does not have major implications for the rationale behind dispersant product approval, and additional testing for such approval is unlikely to be required.

Laboratory tests do not predict real-world dispersant efficiency or the potential for environmental damage.

For each product, a Safety Data Sheet (SDS) including Chemical Abstracts Service (CAS) numbers for components of the dispersant should be available in order to allow a first pass on potential toxicity, prior to either reviewing existing test results or undertaking new toxicity testing of the product.

The same product approval testing is applicable, irrespective of surface or subsea use considerations.

When considering dispersant product approval, it is important to consider the potential need to access large volumes of the dispersant very quickly for some spill scenarios. Many countries, and companies (Carter-Groves, 2014), have developed the framework to access ‘shared stockpiles’ across international boundaries. These frameworks include multilateral and bilateral agreements encouraged by the OPRC Convention, and are manifest in a number of regional conventions and protocols based on the Regional Seas Programme. Having these agreements or memorandums is critical for response planning since they can facilitate access to large quantities of dispersant. They also avoid the unnecessary duplication of dispersant stockpiles in each country, taking into account that dispersant stocks can have a shelf life of many years, if correctly stored and periodically checked (Clark *et al.,* 2008). This means that consideration should be given to ensuring that the products in the shared stockpiles have been submitted for approval and are therefore authorized for possible use. If only one or two dispersants are approved in a country, there is potential that available stockpiles of these products may be exhausted, compromising the response to some oil spill scenarios.

Effectiveness testing for product approval

As part of the dispersant product approval process, a candidate dispersant should be tested to demonstrate at least a minimum level of effectiveness. Different effectiveness (or 'efficacy') test methods have been developed and used by different national authorities (Clark *et al.,* 2008).

All the effectiveness tests use laboratory apparatus to apply a degree of mixing energy to sample quantities of a reference oil, dispersant and water within an enclosed vessel, aiming for repeatability. The purpose of the test is to identify those products which have, as a minimum, appropriate effectiveness at dispersing oil, thereby avoiding the approval of poorly performing products.

Effectiveness tests do not simulate real-world conditions.

None of the laboratory test methods can simulate the complex mixing scenarios and energies encountered in the marine environment. Prevailing wave conditions at sea can vary over a wide range from flat calm to very rough. One laboratory test method may superficially resemble a particular sea state more than another, but an accurate simulation of oceanic conditions is not possible for reasons of scale.

For this reason, the results from laboratory tests, typically expressed as 'percentage effectiveness', should not be extrapolated to the amount of oil likely to be dispersed in real world incidents. It may be that a dispersant that produces a laboratory test result of '55% effectiveness' may have close to 100% effectiveness when used during an incident in appropriate environmental conditions. The tests will, however, provide data on the relative effectiveness of different dispersants within the parameters of that test.

It is important to recognize that the same laboratory test can be used to identify whether a product has appropriate effectiveness, regardless of whether the product is considered for use in surface application or subsea injection scenarios. The laboratory test simply indicates that the product is capable of dispersing the test oil with the applied mixing energy. The mixing energy in the real world can be supplied from surface waves or subsea turbulence generated by an oil and gas release. As part of dispersant use authorization (which is separate from the product approval process) the availability of suitable mixing energy therefore becomes an operational consideration, coupled with the dilution potential of the dispersed oil.

The relevant considerations concerning which laboratory effectiveness test to incorporate into a product approval process are as follows:

- A dispersant product approval authority may choose to rely on the effectiveness testing results from other countries. Such testing should have been carried out at certified laboratories, utilizing known and published effectiveness testing protocols. If a product is listed in the other country as having been approved, it must have passed the test that ensures the product meets or exceeds a threshold for effectiveness. If this approach is adopted, a candidate dispersant that has not been tested in the other country will need to undergo suitable effectiveness testing at a certified laboratory using that country's published protocols, prior to approval.
- If an authority wishes to adapt one or another of the existing effectiveness test methods to be more relevant to the locally prevailing conditions:
  - A simple, low-cost and repeatable effectiveness test will allow laboratories to undertake testing without significant investment and should not require a high level of technical expertise. A trained laboratory technician should be competent to carry out the test using readily available apparatus. The Warren Spring Laboratory LR448 rotating flask test (WSL, 2007) and the baffled flask test (Sorial *et al.,* 2001) meet these criteria reasonably well.
  - The choice of a reference (or 'test') oil should focus on obtaining an oil that is reasonably challenging to disperse, to provide measurable differences between tested products. Availability and relevance of oil to be used in the testing is clearly a practical factor and therefore locally-produced or traded crude oils are the best initial candidates. It may be necessary to 'top' (i.e. either distil or agitate in a nitrogen atmosphere) the crude oil to increase the viscosity to a level providing the necessary conditions to discriminate between poor and good dispersing products. This may require some preliminary testing with a crude oil topped at different temperatures before choosing the most suitable test oil. Topping also has the advantage of partially simulating the 'weathering' of oil due to evaporation. When a suitable test oil has been identified, its key physical parameters should be defined—including its dynamic viscosity, specific gravity (at the stipulated temperature) and pour point—and included in the test protocol.
  - The temperature and salinity of the test water should be adjusted to reflect local conditions. Note that the majority of scenarios where dispersant use will be considered will involve offshore oceanic conditions (with typical salinity of 35 parts per thousand of salt). However, some water bodies or sea areas may have significantly higher or lower salinity. This may need to be taken into account at the product approval stage, as salinity influences the effectiveness of dispersants. Dispersants are not recommended for rivers, freshwater lakes or ponds but they may be considered for use in some brackish water or estuarine situations.

Emphasis is placed on choosing a simple, low-cost and repeatable effectiveness test

It is recommended that the amount of dispersant used during the test, compared to the amount of oil, reflects a typical dispersant-to-oil ratio (DOR) used during surface operations—for example 1:20.

A relevant pass mark indicating the acceptable minimum level of effectiveness in the test then needs to be defined. Most combinations of test methodology and reference oil, that are able to discriminate poor products from good ones, will lead to a pass-mark being set around the middle-range (i.e. around 50%). However, a relevant pass mark may be higher or lower than this.

The pass mark for approval varies between different test methods

It is important to recognize that the use of different test methods and variations in parameters such as the test oil means that there is no standard or universal pass mark for dispersant approval. It is recommended that initial testing includes one or two widely available commercial dispersants, known to be effective at the salinity of the test. This will provide a reference or benchmark against which the pass mark can be proposed, discussed and ascribed by the relevant regulating body. This means that it is likely, and acceptable, that there will be different effectiveness pass marks in different countries or regions, due to variations in the testing apparatus, test oil and method used.

Box 2 How much effectiveness testing is needed?

Effectiveness testing is a laboratory methodology to ensure that only reasonably effective dispersants are approved. To achieve this, it is only necessary to test a candidate dispersant with one suitable reference (or 'test') oil.

It should be emphasized that laboratory tests are not designed to predict dispersant effectiveness in real-world conditions, and the results of such testing can only provide approximate guidance for contingency planning. It is therefore recommended that additional testing is not included in regulations and remains optional on a case-by-case basis. Furthermore, the limitations of laboratory methods means that it is neither necessary nor constructive to test all oils traded or produced in a country against a range of approved dispersants, in an attempt to find the 'best' dispersant for each oil. Generally, a reasonably effective dispersant will disperse all crude oils and emulsions, as long as their viscosity is not too high and suitable environmental conditions prevail. Dispersants are likely to be effective on oils with viscosities below 5,000 cSt. Chemical dispersion of oils with viscosity between 5,000 and 10,000 cSt may be reduced (see IMO, 2011), though dispersion of oils with viscosities above 20,000 cSt is reported.

There may be occasions where some additional effectiveness testing of a specific oil could be incorporated into contingency planning for dispersant use authorization. An example is the production of crude oil having properties at the borderline of normal expectations regarding dispersability—for instance oils or emulsions with viscosities above the range 5,000-10,000 cSt, according to the IMO. In this case, laboratory testing and weathering studies of the oil may provide indicative information to support advance decisions on whether the dispersant option is feasible for this oil.

Toxicity testing for product approval

Approval of dispersant products by the regulating agency usually requires that the dispersant should not exceed a given aquatic acute toxicity threshold. Testing should ensure that approved dispersants are of significantly less toxicity than the oils they are designed to treat. Studies have shown that a commonly stockpiled dispersant displays acute toxicity to marine organisms similar to, or less than, that of household cleaning agents (Word, *et al.,* 2014). Current toxicity testing of dispersant for product approval purposes has been carried out in two different ways around the world:

i. Toxicity testing of 'dispersant alone'

Some countries specify a dispersant should not exceed a maximum toxicity threshold to be approved. For example:

- In France, the toxicity of the dispersant to shrimp must be at least ten times lower than the toxicity of a reference toxicant (*Noramium DA50*).
- In Norway, a standard toxicity test is used to determine the acute toxicity of the dispersant alone, by testing it on a planktonic alga (*Skeletonema costatum* test, ISO/DIS 10253). This is one of the standardized internationally accepted ecotoxicity tests used by the OSPAR Convention. The use of dispersants with EC_{50} values < 10 mg/l is prohibited.

This approach uses the concept that any dispersant to be used in national waters must express a relatively low toxicity to marine life. It is a straightforward 'gate-keeper' concept.

ii. Toxicity testing of 'dispersant plus oil'

Some countries test for product approval toxicity by using a combination of dispersant and test oil. For example:

- In the UK, the currently used 'Sea Test' toxicity test procedure exposes shrimps to a mixture of oil (i.e. a lightly weathered Kuwait crude oil) and dispersant. The mixture is 1 part of dispersant to 10 parts of oil. The dispersant will be approved based on nominal concentrations if the dispersant and oil mixture causes no more mortality than that caused by mechanically dispersed oil alone.
- In the USA, the current toxicity test for dispersants and other products involves testing with two US EPA standard species—inland silverside fish (*Menidia beryllina*) and mysid shrimp (*Americamysis bahia*)—five concentrations of the test product and No. 2 fuel oil alone, and in a 1:10 mixture of dispersant to oil. To aid comparisons of test results from assays performed by different laboratories, reference toxicity tests are conducted using sodium lauryl sulphate[1] as a reference toxicant. The test length is 96 hours for *Menidia* and 48 hours for *Americamysis*. LC_{50} values are calculated. The exposure regime used in an LC50 test procedure is that required to kill 50% of the test organisms.

This approach recognizes that any toxicity of the dispersant is likely to be eclipsed by that which could be caused by the dispersed oil.

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1 Also called dodecyl sodium sulphate (DSS)

Box 3 Understanding toxicity

Toxicity is defined as the 'inherent potential or capacity of a material to cause adverse effects in a living organism', and **aquatic toxicity** is the adverse effect of chemicals, materials and activities on aquatic organisms. The range of these effects is considered from the subcellular level, to whole organisms and even to individual communities and whole ecosystems.

Adverse effects from a toxicant can include changes to behaviour, physiology (such as slowed movements), reproduction (such as reduced fertility), or possibly death when in the presence of certain concentrations of the test materials. Observed biological effects are a function of both the **duration of exposure** to the chemical and the **concentration** of the chemical during the test. In the actual aquatic environment, the length of exposure varies with tides and currents and the mobility of the potentially affected organism, while the concentration of a chemical is heavily influenced by the:

- physical, chemical and biological properties of the ecosystem, such as salinity, temperature, water depth, waves and currents, which will influence vertical and horizontal mixing in the water column;
- sources and rate of input of the chemical into the environment; and
- physical (e.g. boiling point, solubility, viscosity) and chemical (e.g. elemental composition) properties of the chemical.

Observed effects can be produced by short-term (acute) or long-term (chronic) exposure. In the case of oil spills, the smaller more volatile molecules in the oil are quickly lost by evaporation but can also dissolve into the underlying water creating the potential for acute aquatic toxicity before being diluted and degraded naturally. Effective dispersion of oil may increase the acute impacts on marine life residing in the top few metres of the sea in the vicinity of the spill. These impacts are limited because of the rapid dilution of the dispersed oil. Chronic exposure generally involves the larger compounds found in oil, as these are more persistent. When considering oil spills, long-term risks are primarily associated with persistent or weathered undispersed oil stranding on low energy (sheltered) shorelines and becoming a potential source of chronic exposure.

Box 4 provides further information on 'dispersant plus oil' testing; the use of this testing approach has several issues, for example:

- 'dispersant plus oil' toxicity testing does **not** simulate actual dispersant use on spilled oil in the marine environment; and
- 'dispersant plus oil' toxicity testing inevitably discriminates against highly effective dispersant and towards less effective dispersants since the test organisms will be exposed to higher concentrations of dispersed oil (Bratbak *et al.,* 1982).

It is recommended that 'dispersant alone' toxicity testing is used for product approval.

For those countries where a dispersant approval process is not yet in place it is recommended that 'dispersant alone' toxicity testing is used for product approval.

Box 4 'Dispersant plus oil' toxicity testing

It might seem reasonable to assume that toxicity testing with 'dispersant plus oil' would be more relevant than testing with 'dispersant alone' because:

- dispersant would not be used if no spilled oil was present; and
- the potential for toxic effects when modern dispersants are used on spilled oil at sea is caused by the dispersed oil, not by the dispersant.

However, this is to misunderstand the purpose of toxicity testing for dispersant product approval purposes, which is to select dispersants that do not exceed a given aquatic acute toxicity threshold.

The potential toxic effects on marine organisms assessed in the 'dispersant plus oil' approach are those caused by the dispersed oil. The use of a high toxicity test oil will result in greater measured toxicity independent of the dispersant being tested. The dispersion of oil is a consequence of dispersant use, and is addressed by dispersed oil toxicity studies that have been carried out in support of dispersant use authorization (see Box 5). The 'dispersant plus oil' toxicity test approach appears to be a reasonable simulation of dispersant use at sea because dispersed oil is present in the test. But the presence of dispersed oil in a toxicity test procedure is not the relevant point. The basis of all toxicology is that '*the severity of negative effects caused by a substance on an organism is related to the exposure of the organism to the substance.*' Exposure is a function of the concentration of the substance that the organism is exposed to and the time for which it is exposed.

The exposure regimes used in the UK and USA 'dispersant plus oil' toxicity tests for dispersant approval are much more severe than would ever be encountered during real-world dispersant use on spilled oil at sea, presuming dispersants were used in accordance with typical dispersant use regulations:

- The UK 'Sea Test' toxicity test procedure exposes shrimps to a mixture of lightly weathered Kuwait crude oil and dispersant at 1,000 ppm in water for 100 minutes.
- The US toxicity test procedure exposes fish for 4 days (96 hours) and shrimp for 2 days (48 hours) to sufficiently high constant concentrations of dispersed No. 2 fuel oil to kill 50% of the test organisms; it is an LC_{50} test procedure.

The purpose of conducting this type of toxicity testing is to cause measurable negative effects on the test organisms. The exposure regime used in an LC_{50} test procedure is that required to kill 50% of the test organisms. However, the exposure to dispersed oil experienced by marine organisms during at-sea dispersant use is much less severe. The concentrations of dispersed oil in the water column, following surface application under typical conditions, may approach 30–50 ppm in the upper 10 metres of the water column, but those concentrations usually diminish to below 10 ppm within the first hour. Thus, for surface dispersant application, exposures to organisms are of relatively short duration and occur only in relatively shallow portions of the water column. This is different from test protocols which typically use a constant concentration over a fixed amount of time.

The toxic effects of the dispersed oil measured in these tests are related to the quantity of oil dispersed into the water. A more effective dispersant will disperse more oil than a less effective dispersant. 'Dispersant plus oil' toxicity tests for dispersant product approval purposes therefore inevitably discriminate against effective dispersants. They do not necessarily allow a reliable comparison to be made between the toxicities of different dispersants, as the impacts will be driven by the composition of the oil itself. These tests are more suitable for evaluating the relative toxicity of various petroleum products, although they may still not be representative of the actual exposure regimes for dispersed oil in the field.

The successful application of dispersants in response to an oil spill will transfer greater amounts of oil into the water column, increasing the exposure of aquatic organisms to oil components. Generally, this increased exposure is short term, often lasting for a few hours due to natural mixing and dilution; it is also limited to the upper few metres of the water column. During a spill, the toxicity consideration therefore focuses on whether enhancing the dispersion of oil with a dispersant will bring an overall environmental benefit (see Annex 2). This consideration relates to dispersant use authorization, not product approval, and is covered in Part 2 of this document.

Toxicity testing of local species

Concerns may be raised about the toxicity of dispersants to local species. This gives rise to consideration of the need for toxicity testing of representative local species for product approval, as an alternative to using existing international data.

There is little evidence to support the need for toxicity testing of local species.

Some species are more sensitive to dispersants than other species, and some life-stages, such as eggs or larvae, are more sensitive to dispersant than adult organisms (NRC, 2005). Comparisons of the toxicity of numerous species have confirmed that the relative sensitivities of different species and at corresponding life stages are similar, irrespective of the habitat locations around the world (ranging from the Arctic to the Tropics) (Bejarano, 2014). There seems to be no habitat where a specific species is much more sensitive to dispersant than in other habitats. There is, therefore, little evidence to support the need for toxicity testing of local species for dispersant approval in different geographic regions.

Use of toxicity tests from other countries

Toxicity testing methods are complicated and expensive to undertake, requiring certified laboratories staffed with knowledgeable and skilled managers and technicians. Such laboratories may not be available in every country. The purpose of the testing is to ensure that candidate dispersants do not exceed a given aquatic acute toxicity threshold.

A dispersant product approval authority in one country may therefore choose to rely on the results of testing carried out in other countries, using non-native species. Those countries must have known and published toxicity testing protocols using certified laboratories. Examples of such countries include France and Australia, where listed products must have passed a toxicity test to ensure that they do not exceed a maximum threshold.

If this approach is adopted, a candidate dispersant that has not been tested in the other country will need to undergo suitable toxicity testing at a certified laboratory using published protocols, prior to approval.

Suggested additional information required for product approval

Some dispersant product approval regulators require additional information about a candidate dispersant before approval can be obtained. This is to address issues other than dispersant effectiveness or dispersant toxicity. These issues are summarized below.

Dispersant biodegradability

Any dispersant that is to be approved should be readily biodegradable so that it does not persist in the marine environment. The French dispersant product approval regulator requires a biodegradability test of the dispersant alone as part of the product approval process. Commercial dispersants most commonly stockpiled around the world are readily biodegradable and pass this French test. If a dispersant is approved in France, it must have passed the biodegradation test (AFNOR standard NF T90-346).

It is recommended that product approval includes the requirement to demonstrate that the dispersant, or all of its constituent parts, have passed a biodegradation test such as the French method or similar (e.g. OECD 306, OECD 301A-301F, OECD 310, ISO 10708:1997). Approval in France would be adequate evidence for this. Furthermore, within the European Union, all surfactants must meet the biodegradability requirements of Regulation (EC) No 648/2004 (the Detergents Regulation). All dispersants manufactured in the EU must conform to this Regulation. For approval purposes, the dispersant manufacturer could be required to state that the surfactants and solvents used are biodegradable and provide supporting evidence.

In some parts of the world, the use of a particular type of surfactant (alkyl phenol ethoxylates or APE) has caused concern because it biodegrades to a persistent chemical compound that is toxic to fish and can cause other effects such as endocrine disruption. The European Union has effectively eliminated the use of APE in most industrial and product sectors through Regulation (EC) No. 648/2004. Other areas of the world may follow this example. A national dispersant product approval regulator should coordinate with national or other regulations regarding APE, and should consider adding APE as a prohibited ingredient (see below).

Permitted and prohibited ingredients

The UK dispersant product approval regulator states the following requirements in their *Specification for Oil Spill Dispersants* (Appendix A to WSL Report LR 448 (OP), revised February 2007):

> *The oil spill dispersant shall consist of suitable ionic, non-ionic or a blend of such surfactants dissolved in a suitable solvent. It shall not contain compounds which could expose the user to an unacceptable toxicological hazard during the normal spraying or handling operations when wearing a closely fitting face visor …*
>
> *… In addition, the following ingredients are prohibited: benzene, chlorinated hydrocarbons, phenols, caustic alkali and free mineral acid.*

The UK regulations sit within the requirements of the European Union's REACH (Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals) (EC, 2014). This ensures that all chemicals used in the manufacture or blending of dispersants must have passed the stringent requirements of REACH.

Dispersant product approval regulators in other parts of the world might consider a requirement within their dispersant product approval regulations that all chemicals contained in a dispersant comply with REACH (or an equivalent).

Required dispersant properties

The UK dispersant approval regulator requires that any modern type of dispersant should have a maximum viscosity of 250 cP at 0°C, a flash point above 60°C and a cloud point of above -10°C, before it can be approved. These requirements ensure that the dispersant can be sprayed using existing equipment, meets insurance classification for shipboard use and will not separate when stored in cold temperatures. There may be additional requirements relating to the application of dispersants from aircraft.

These might also be relevant considerations for dispersant approval regulators in other countries. However, a specialized higher viscosity dispersant has been developed, which has demonstrated effectiveness and overcomes some of the limitations described above; regulators may not wish to impose conditions that prevent its approval.

Required labelling

A dispersant product approval regulator may wish to specify labelling requirements for the dispersant to be approved. This could follow the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) (UNECE, 2014) and should include any risk symbols, storage instructions and information required to conform to local regulations regarding chemicals.

Part 2: Dispersant use authorization

Dispersant use authorization addresses the question of when and where approved dispersants may be used. In many countries there will be existing legislation on environmental protection that prohibits the release of chemicals to the marine environment. The first consideration is therefore to ensure that an exemption in such legislation exists, or is developed, to allow the authorized use of dispersants, without criminal or financial penalty under a marine environmental protection law.

A primary justification for using dispersants is to reduce the overall environmental damage caused by the oil spill and facilitate faster recovery of the ecosystem.

The benefits and drawbacks of dispersant use, compared with other feasible response options and no intervention should be taken into account when deciding whether dispersants should be authorized. This is the basis of net environmental benefit analysis (NEBA) (see Annex 2).

Use of NEBA

Dispersant use authorization must take into account the pros and cons (trade-offs) of treating, and not treating, spilled oil with dispersant. The key factors that should be taken into account when conducting a NEBA are described below.

Dispersant effectiveness under prevailing conditions

The first task is to assess whether dispersant use would be effective under prevailing conditions, i.e. would adding dispersant to the oil be likely to cause a much greater proportion of the oil to be dispersed into the water?

The dispersant effectiveness results generated during the dispersant approval process will not be useful as a predictive measure of effectiveness in the field because they would have been determined using a specified test oil and laboratory test method that is unable to replicate an open water environment.

The properties of the spilled oil and how the oil is likely to 'weather' under the prevailing conditions should be considered. The viscosity of the oil (and how this will change with 'weathering') at the prevailing sea temperature and pour point (ASTM-D97) will influence the probable effectiveness of dispersant use.

Table 1 Generally accepted ranges of the effect of oil viscosity on dispersant effectiveness

Light distillate fuels (petrol, kerosene, diesel oil)	Dispersant use is not advised
Oils with viscosity up to 5,000 cSt	Dispersant use is likely to be effective
Oils with viscosity between 5,000 and 10,000 cSt	Dispersant use might be effective
Oils with viscosity above 10,000 cSt	Dispersant use is unlikely to be effective[2]

2 Note that dispersion of oils with viscosities above 20,000 cP (~23,000 cSt) is reported—see Lessard and DeMarco, 2000.

The viscosity of an oil will increase progressively with time on the sea surface due to weathering (evaporation, emulsification), and the probable effectiveness of dispersant use will decline with time. This presents what is often known as the 'window of opportunity' for dispersant use.

Dispersant use on oils with a pour point that is significantly higher than the prevailing sea temperature is unlikely to be effective.

Specific information about the oil may be available if weathering studies (and possibly dispersibility studies) have been undertaken. These may have been combined with computer modelling to produce predictions of likely spilled oil movement and progressive change in the oil's properties under a range of prevailing conditions.

In the event of an incident, operational procedures should incorporate the use of a pilot or test spray to verify that the dispersant is working. Observation/monitoring should continue to ensure that application ceases if the dispersant is not working, though such procedures should not delay the response

Potential environmental and safety considerations of dispersant use

i. The successful use of dispersant is independent of whether it is used on surface oil slicks or injected underwater to treat a subsea release. In both cases, the primary environmental benefit of using dispersants is to minimize the long-term damage to sensitive wildlife and coastal habitats:
   a. **Surface oil slicks:** the dispersant enhances the transfer of spilled oil from the sea surface into the upper part of the water column as very small droplets. The dispersed oil is rapidly diluted into the water column and degrades over time. Dispersed oil is unlikely to be detectable deeper than 10 m. In some circumstances, dispersing freshly released oil into the water column also reduces the amount of volatile organic compounds (i.e. BTEX compounds) reaching the air, thereby reducing the explosion risk and the potential inhalation hazard to responders working in the spill area. This alone could be a justification for using dispersants.
   b. **Subsea releases:** the dispersant enhances the creation of very small droplets of oil, forming a dispersed oil plume; the large majority of droplets are diluted and biodegrade in the water column before being able to reach the surface. As with surface applications, this reduces the concentration of volatile organic compounds (i.e. BTEX compounds) reaching the air, thereby reducing the explosion risk and the potential inhalation hazard to responders working on the surface to cap the well.

ii. The potential disadvantages of dispersant use are as follows:
   a. **Surface use:** marine organisms inhabiting the upper water column (approximately 10 m depth) will be briefly exposed to potentially harmful, diffuse clouds of dispersed oil droplets and partially water-soluble oil compounds in the water column, compared to the situation if dispersants were not used.

b. **Subsea use:** the dispersed oil plume of very small oil droplets will expose marine life in its path to elevated, localized and potentially harmful concentrations of oil droplets and partially water-soluble oil compounds. In some circumstances the oil concentrations will be elevated prior to any dispersant injection, due to the mixing energy of the release.

Past experience at several major oil spill incidents has shown that negative effects on marine organisms caused by the elevated dispersed oil concentrations in relatively deep water due to dispersant use were localized and of short duration (Lunel *et al.,* 1999; Henry, 2005). Ecological studies and monitoring following major oil spills have repeatedly shown that the populations and communities of organisms in the water column (e.g. algae and zooplankton) recover much more quickly from brief exposure to dispersed oil in the water than the populations and communities of birds, mammals, seagrasses, saltmarshes or mangroves that may be exposed to oil that stays afloat as a slick or which comes ashore.

The NEBA process should be approached from a holistic ecosystem perspective, to ensure that the chosen response options achieve the best environmental outcomes under the prevailing circumstances of the spill. It is inadvisable to require toxicity tests on individual species as part of the NEBA process during an incident. Such an approach is not only likely to suffer from the significant problems of extrapolating laboratory test results (see Box 5 on pages 18–19) to real-world conditions, but also risks diverting the focus of decision makers away from the broader perspective of the response.

It can take years to decades for some shoreline communities to recover from oiling, whereas many water-column communities recover in weeks to months. The open water marine environment is, in general, more resilient than the coastal environment and natural recovery takes far less time. Furthermore, the coastal and near-shore environments tend to have higher population densities and primary biological productivity compared to offshore waters. The adult fish in the water column are able to sense the dispersed oil and actively avoid it (Weber *et al.,* 1981).

As a consequence, any consideration of the 'trade-offs' of dispersant use should take account of the amount of severe and long-lasting damage to oil-sensitive coastal habitats and resources that may be prevented by dispersant use, compared with highly localized and short-lived effects that dispersants might have on the marine environment.

The advantages of dispersant use can significantly outweigh the disadvantages.

Box 5 Dispersed oil toxicity studies in support of dispersant use authorization

The rate and extent of natural dispersion varies depending on the prevailing environmental conditions and oil type. Successful dispersant use will cause more oil to be transferred into the water column. Marine organisms will therefore be exposed to elevated concentrations of dispersed oil, and of partially water-soluble compounds from the oil, compared to the situation if dispersants are not used. This raises concerns about the potential of dispersant use to increase the toxic effects of dispersed oil on some marine organisms. To address these concerns, the potential toxic effects caused by exposure to dispersed oil need to be considered as part of the NEBA process (see Annex 2).

The simplest general-case application of the NEBA process is to consider using a defined minimum water depth and distance from shore that ensure that dispersed oil concentrations and exposure duration will be sufficiently low. This approach reduces to a very low level the risk of significant toxic effects to the marine organisms that may be present. The validity of this approach has been underpinned by past studies of dispersed oil toxicity, as referenced below. This principle is incorporated into the dispersant use authorization regulations in many countries, including France and the UK, and in different Regional Response Teams in the USA. It results in the identification of offshore areas where dispersants use is pre-authorized.

Where there is risk of spilled oil entering shallow waters (typically less than 10 or 20 metres deep) close to the shore and in bays, there could be a desire to examine the suitability of dispersant use. This would most likely be the case where the adjacent shoreline is of very high sensitivity to long-term damage from undispersed stranding oil (such as biologically productive wetlands). Here, the general-case approach may be rendered insufficient, due to the reduced dilution potential. In such cases, more specific information on dispersed oil toxicity may be required as part of the NEBA considerations.

In the majority of cases, the existing body of studies on the toxicity of dispersed oil can be utilized for this purpose. The science that underlies the consideration of dispersed oil toxicity is contained in the reports of a large number of studies that have been conducted over the years on the toxicological effects of dispersed oil. These studies have considered a range of potential toxic effects on a wide variety of marine organisms by exposure to a range of crude oils. Two highly reputable sources of information are:

- the National Research Council's (NRC's) 1989 publication, *Using Oil Spill Dispersants on the Sea,* which summarizes the results of dispersed oil toxicity studies conducted up to that date; and
- the NRC's 2005 publication, *Oil Spill Dispersants; Efficacy and Effects* (specifically Chapter 5, 'Toxicological Effects of Dispersants and Dispersed Oil', pp. 193–275) which summarizes and discusses the results of further dispersed oil toxicity studies performed from 1989 to 2005. This report concentrates on the consequences of using dispersants in shallow water

Further studies and reviews have been conducted more recently.

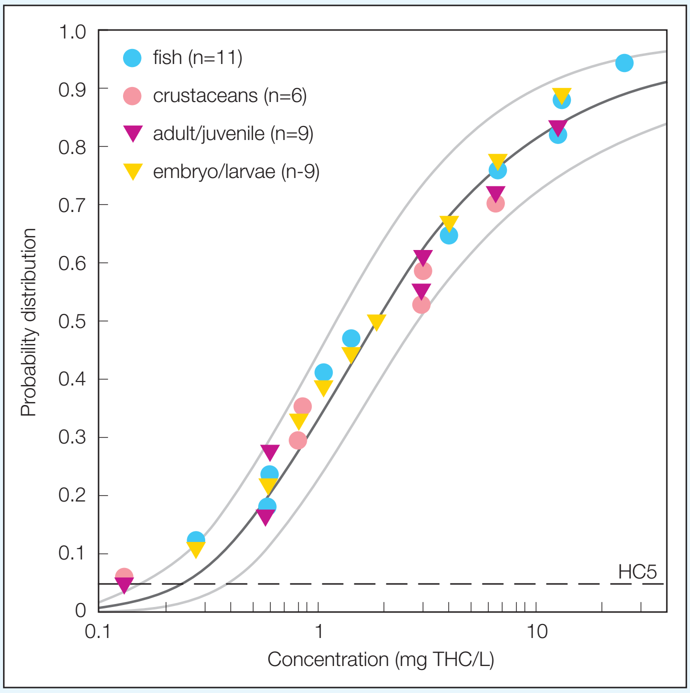
It has been found that some species of marine organism are more sensitive to dispersed oil than other species, and that some life stages, such as eggs or larvae, are more sensitive to dispersed oil than adult organisms. Small crustaceans (amphipods) are known to be amongst the most sensitive organisms to dispersed oil.

Comparisons of the dispersed oil toxicity to numerous species have confirmed that the relative sensitivities of different species and at corresponding life stages are similar, irrespective of the habitat locations around the world (ranging from the Arctic to the Tropics).

Species sensitivity distributions (SSDs) can be used to display cumulative distributions of laboratory-derived toxicological end points (e.g. LC_{50} events typically from the same exposure duration) for species used in testing programmes, thereby allowing for comparisons of the relative sensitivities of several species to the same chemical. Assumptions can then be made concerning the sensitivity of untested species, i.e. falling within the range of tested species.

However, the results of the toxicity studies of dispersed oil are often difficult to interpret and apply. This can cause confusion among the public, policy makers and environmental management authorities. Most of the currently available toxicity data on dispersed oils have been generated under controlled laboratory test conditions. The majority of these tests used exposure

Box 5 Dispersed oil toxicity studies in support of dispersant use authorization (continued)



Bejarano *et al.*, 2014

Example of a Species Sensitivity Distribution (SSD) based on data from chemically and mechanically dispersed toxicity tests (96-hour median lethal concentration (LC_{50}) and median effective concentration (EC_{50}); measured total hydrocarbon content (THC) concentrations) from constant exposures comparing taxonomic groups (circles) and life stages (triangles).

The curved lines represent the mean estimated SSD (black) and its 95% confidence interval (grey), and the horizontal dashed line represents the 5th percentile of the probability curve (HC5).

regimens that are not representative of dynamic field conditions with respect to dilution. Constant exposure regimes over a number of days are typically used. The results are primarily of value for comparative purposes, not for extrapolation to predict the real-world impacts of dispersant use. The lack of correspondence between exposure and toxic response makes the application of laboratory test data challenging for decision making during oil spill incidents. Some studies have used a spiked exposure as a closer representation of real-world dispersant use conditions (see Aurand and Coelho, 2005). Most oil spill response decisions regarding dispersant use have been made with the understanding that laboratory data represent an unrealistic, worst-case exposure, and provide conservative estimates of effects at sea.

The way that the toxicity of dispersed oil is measured and reported can be confusing for non-toxicologists. Measured toxicity should be reported in terms of the actual concentration of petroleum hydrocarbons in the water, rather than as nominal concentrations or oil loadings (e.g. mg oil/l water) because the nominal loading approach leads to the erroneous perception that enhanced dispersion by the use of dispersants causes the oil to be more acutely toxic than physically dispersed oil. Consequently, nominal toxicity data should not be used because these data are not sufficiently detailed or accurate to support decision making regarding the potential toxic effects of dispersed oil.

From this brief description, it can be seen that using results from dispersed oil toxicity studies will not be directly transferable to the prevailing circumstances of an actual oil spill. Incorrect interpretation may lead to misleading conclusions. Interested readers are guided towards the references contained in this section for further detailed discussion of the numerous issues involved. Nevertheless, results from past studies—when interpreted correctly by a competent authority—can provide useful insights during oil spill contingency planning for decision making on the use of dispersants in response to oil spills in shallow waters or in waters that contain especially sensitive resources.

Oil spill risk and dispersant use authorization

In the case of vessel transport of oil, the specific location and type of potential oil spills may be difficult to determine in advance, depending on the maritime trade and shipments in an area. This is in contrast to fixed offshore installations, where both the location and type of oil that may be spilled is known in advance. In the latter case, more thorough contingency planning based on possible spill scenarios is usually feasible. This includes the likelihood of a particular oil being dispersed under prevailing environmental conditions.

It is extremely beneficial to pre-authorize dispersant use in suitable sea areas.

However in both cases, it is possible to delineate 'pre-authorized' sea areas or zones where dispersant use is permitted, based on the following general restrictions:

i. a minimum water depth (for example, 10 m);
ii. a minimum distance from shore (for example 1 km); and
iii. avoiding ecological or socio-economic features, such as coral reefs, industrial seawater intakes and fish farms, identified as being particularly vulnerable to dispersed oil.

The use of minimum water depth and distance from shore underpins the NEBA process.

The use of a minimum water depth and a minimum distance from shore is to ensure that there is a sufficient volume of water to allow the dispersed oil to be diluted to concentrations in the water that are below those that could have significant negative effects on marine organisms. Unless there are specific reasons to favour other response options, pre-authorization of dispersants could use these criteria (i.e. water depth and distance from shore) as the underlying basis of a simple but suitable NEBA.

Pre-authorization is beneficial because it encourages and facilitates incorporation of the dispersant option into the response toolkit. It helps organizations that may be required to combat oil pollution to be able to plan the required capability to rapidly apply dispersants. If dispersant use authorization is left until after an incident has occurred, this creates the potential for delay while an authority considers whether the use of dispersants is allowed. Such delays can lead to the window of opportunity for dispersant use being lost, and can compromise the opportunity to reduce the environmental and socio-economic damages that may result from the incident.

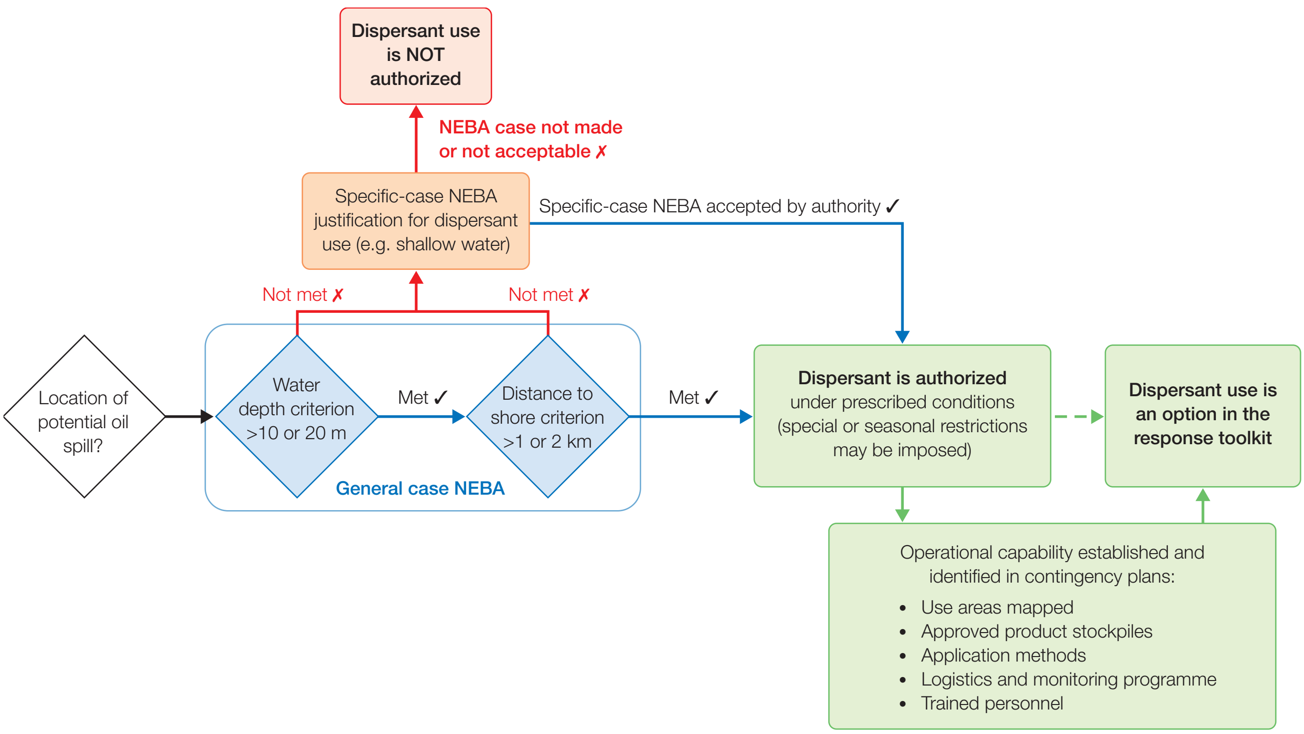
In all cases, the regulations underpinning dispersant use authorization should stipulate that:

- oil pollution must be present before dispersant is applied;
- an exemption can be granted to permit the use of dispersant under the regulation, i.e. preventing prosecution or fines under existing environmental law(s) for use of dispersants;
- applying dispersant in non-conformity to the regulation may lead to prosecution, with stipulated penalties;
- observation/monitoring should be established during application to verify that the dispersant is working and requiring that application must cease if the dispersant is not working—though this should not delay the response;
- dispersant is applied using suitable application equipment and conforming to manufacturer's instruction; and
- operational guidance for dispersant application is followed (e.g. published IMO guidelines (IMO, 2011; IMO/UNEP, 1995)).

Use of dispersant may be a justifiable strategy in waters shallower than a pre-authorized minimum depth (Le Floch *et al.,* 2014) or closer to shore than the minimum distance stipulated, provided it can be demonstrated that this will result in less environmental damage overall and that other response strategies cannot achieve the same result. The process and authority by which special case approvals are issued should be identified in the regulation. In this case, the onus falls on the organization that is applying for special case dispersant use to undertake the associated specific NEBA and present the justification to the relevant authority for their consideration, before the latter may, or may not, authorize dispersant use.

In all cases where a private entity wishes to consider using a dispersant as part of its response strategy, this should be included in its oil spill contingency plan. This plan should address, in advance, the operational practicalities and logistics of potential dispersant use. This ensures that authorized dispersant use becomes a viable, integrated option within the response toolkit. Figure 2 illustrates the elements of a framework for authorizing the use of dispersants.

Figure 2 A framework for dispersant use authorization



Annex 1: Human health considerations[3]

The primary human health concern from oil spill response is exposure to crude oil. Crude oil is made up of many different chemical compounds, some of which have the potential for toxic effects on humans exposed to these compounds. The nature and types of these constituents vary according to the source. The components of crude oil that can potentially present hazards to human health include: hydrogen sulphide and volatile organic compounds (VOCs) such as hexane, toluene, benzene and xylene.

Hydrogen sulphide is the most acutely hazardous, but is rarely present in an uncontrolled well release. As crude oil weathers on the sea surface, the lighter constituents (VOCs) rapidly evaporate or dissipate. The heavier components, if not dispersed into the water column, may eventually form tar balls or mousse, and are typically deposited on land or in sediment. Such 'weathered' oil is considered less acutely toxic compared to fresh oil, but may still cause health problems in the unlikely event of chronic direct skin contact. These heavier weathered fractions can still have significant environmental and amenity effects through smothering.

The safety and health of the general public and responders is assigned the highest priority during spill response operations and a properly managed dispersant operation will not harm the health of either responders or the community. An incident management system, with safety and health at its core, starts from the top and penetrates to all levels within the organizations participating in response activities. The management team will appoint an individual with a supporting team that has the skills to undertake responsibility for safety and health management of all oil spill response operations. The responsible individual will consider issues such as monitoring and maintaining awareness of active and developing situations, assessing hazardous and unsafe situations and developing measures to assure the safety of personnel and the public. These measures include:

- An initial site assessment with documented processes for:
  - hazard identification;
  - risk assessment;
  - selection and protection of responders, including local labour;
  - provision of control zones (including supply of specialized equipment and personal protective equipment (PPE) required in those zones);
  - exclusion of shipping, fishing and recreational vessels from the spill response area;
  - assessment of training needs; and
  - identification of decontamination areas.

  Competent personnel, i.e. those appropriately trained and experienced in oil spill safety issues, will manage and supervise the response.
- Developing and implementing a Site Safety and Health Plan (SSHP): information to develop the Plan can be obtained from competent health and safety professionals, the risk assessment process and environmental monitoring. The Plan should be reviewed regularly with regard to the safety and health implications of the activities proposed or in progress.

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3 For a review of potential human health consequences following the Macondo Well release, see Goldstein *et al.,* 2011.

The primary risk assessment is typically conducted in the emergency planning stage and includes a review of potential health hazards, for community and responders, presented by the dispersants that may be used. In the event of an emergency, the details of the pre-plan are further developed in the site safety and health plan that is prepared for each area of operations (community, onshore, nearshore, offshore, air operations, etc.) to address all health and safety hazards, including dispersant handling and application.

When assessing the risk for dispersant operations two questions must be taken into consideration:

1. Is there any potential for exposure?
2. If there is potential for exposure, what protective measures should be put into place to eliminate that exposure?

Dispersants are comprised of two primary constituents: a solvent and surfactants. The solvents in modern dispersants are selected for performance and low toxicity, and are primarily used as a carrier to deliver the surfactant to the oil. Many of the surfactants found in dispersants are also found in household cleaners, shampoos, detergents, dish soaps and foodstuffs. Each dispersant will have a Safety Data Sheet (SDS) identifying potential hazards, including human health hazards and exposure controls, and the required personal protection. The SDS should be consulted and appropriate measures put in place to minimize any risk to human health.

The key to managing the potential health risks associated with dispersants is to ensure that possible exposure routes are assessed and then either removed or minimized. For dispersant operations, this is achieved by suitable controls during storage, handling and spraying operations and wearing of appropriate PPE to prevent any skin or eye contact (IPIECA, 2012). For persons handling dispersants, risk-awareness training that emphasizes the importance of these controls is essential.

When spraying from vessels or aircraft, exclusion zones must be established around other response vessels and vessels involved with transportation, fishing or recreation. These zones ensure low-flying aircraft remain safe when spraying, but in both cases the exclusion zones will also take into account the potential wind drift of the droplets and any aerosols produced when spraying. This will eliminate the potential exposure of other responders as well as the general public. In general, the public is unlikely to be exposed to dispersed oil since the dispersed oil will be mixed into the water column and be diluted far from shore and away from the public. In the unlikely event that exposure of the public to dispersed oil was to occur, short-term exposures to dispersed oils would be expected to have effects similar to those of being exposed to the oil itself.

When used with suitable precautions, there is no dispersant exposure route for responders or the wider community.

Annex 2: Net environmental benefit analysis

Net environmental benefit analysis (NEBA) is a process used by the response community for making the best choices to minimize impacts of oil spills on people and the environment. It involves consideration and judgement to compare the likely outcomes of using different oil spill response methods, and recommendations as to the preferred tactics from experienced response/NEBA practitioners. It should be used in preference to making simple 'trade-off' decisions about dispersant use (ASTM, 2013). NEBA typically involves the following steps:

NEBA is the tool used to ensure the best response options are chosen for a given spill scenario.

1. The first stage of NEBA during oil spill contingency planning is to consider where the spilled oil is and to where it will drift under the influence of currents and wind; various oil spill computer models exist to support this. It is also useful to know how an oil will 'weather' as it drifts.
2. The next stage is to assess what is likely to be affected by the spilled oil. This may include ecological resources offshore, nearshore and on shorelines, alongside socio-economic resources. The detail of this step includes the identification of selected environmental receptors (e.g. key species or habitats) and an assessment of the temporal and spatial extent of potential consequences and recovery rates.
3. The efficiency and feasibility of the response toolkit should be reviewed. This covers the response techniques, the practicalities of their utilization and how much oil they can recover or treat. If areas under threat include oil-sensitive coastal habitats, the role of oil spill response at sea is to try to prevent the spilled oil from reaching these habitats. Previous experience can help to assess which oil spill response methods are likely to be effective. Pragmatic, operational considerations should form an important part of the NEBA process applied to all feasible response methods. A simplified decision matrix as to the suitability of all response methods is shown in Table 2.

Table 2 Simplified decision matrix relating to the suitability of response methods

Response method	Response effective in prevailing conditions?	Capability of response to significantly affect the outcome in the time available?	Availability of sufficient equipment and personnel?
Booms and skimmers used at sea	Yes / No	Yes / No	Yes / No
Protective booming	Yes / No	Yes / No	Yes / No
Controlled, or in-situ, burning	Yes / No	Yes / No	Yes / No
Dispersant use	Yes / No	Yes / No	Yes / No

The apparent 'luxury of choice' between different response methods can lead to confusion and unnecessary debate, but often a realistic choice does not exist because the type of oil spilled or the prevailing conditions will dictate the response method that should be used:

- If the sea is cold and a very high viscosity oil such as Mazut M-100 (a heavy fuel oil for power station use) has been spilled, such as happened at the *Prestige* spill off the Spanish coast in November 2002, the use of dispersants is not likely to be effective and all efforts should be devoted to recovery at sea and to protection of the shoreline.

- If the spill is of a crude oil and the sea is too rough for the effective use of booms and skimmers, then dispersant use—together with it's potential consequences—should be considered. Protective booming of especially oil-sensitive areas should also be considered as a 'back-up', since no at-sea oil spill response method is likely to be 100% effective.

All feasible response options should be compared, and their advantages and disadvantages weighed against each other, and against that of no intervention and allowing natural recovery. It is important to realize that various response tools can, and should, be used in concert where possible.

4. The process concludes with the adoption of response technique(s) within contingency plans that minimize the impacts of potential spills on the environment, and promote the most rapid recovery and restoration of the affected area.

Further information concerning NEBA is provided in IPIECA-IOGP, 2014.

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IPIECA

IPIECA is the global oil and gas industry association for environmental and social issues. It develops, shares and promotes good practices and knowledge to help the industry improve its environmental and social performance; and is the industry's principal channel of communication with the United Nations. Through its member led working groups and executive leadership, IPIECA brings together the collective expertise of oil and gas companies and associations. Its unique position within the industry enables its members to respond effectively to key environmental and social issues.

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IOGP International Association of Oil & Gas Producers

IOGP represents the upstream oil and gas industry before international organizations including the International Maritime Organization, the United Nations Environment Programme (UNEP) Regional Seas Conventions and other groups under the UN umbrella. At the regional level, IOGP is the industry representative to the European Commission and Parliament and the OSPAR Commission for the North East Atlantic. Equally important is IOGP's role in promulgating best practices, particularly in the areas of health, safety, the environment and social responsibility.

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