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WP 2. Oil Spill Response at Sea

T 2.4 USE of DISPERSANTS

State of the Art

Rev1

Authors

Rapporteur: François Xavier Merlin; Cedre
WP Leader: Georges Peigné; Cedre

Contributing organisations
1. Cedre
2. Sintef

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Short description of the issue, and of the limitations of the present state of the art

Used and studied for more than 30 years, chemical dispersion has been highly developed both in terms of basic knowledge (physico-chemical and toxicological aspects) as well as in terms of practical considerations (application equipment, operational recommendations).

Nevertheless, many items remain uncertain, such as the dispersibility of oil which cannot be accurately predicted and the short and long term impacts of the dispersed oil which is still far from being known. Therefore, this technique remains difficult to apply and decision-making often remains controversial.

Scope and limitations

There is scope for improvement to reduce the dispersion efficiency limitations especially when dealing with waxy or viscous oil, with low mixing wave energy, with low salinity water, or using dispersants in more coastal or sensitive environments through a better knowledge of their environmental impacts.

Extension/coverage

Dispersion is used all over the world while most of the studies and development on chemical dispersion take place in Europe and America.

Impact on OSR operations and socio-economic impact

Dispersion is, along with mechanical recovery, one of the main response options available for OSR. Any possibility to improve this technique must be considered tested and brought into force.

Expertise of the rapporteur

See Annex 1

List and titles of the annexes (to be defined in agreement with the WG leader)

Annex 1 Expertise of the rapporteur

Annex 2 Expertise of contributing organisations related to dispersant issues

Annex 3 Research programs conducted currently in North America

Executive summary

Introduction / Background

"Chemical dispersion" is one of the main at sea response options, as recognised in IMO oil spill counter measures manual, available in the oil spill responder's tool box.

The use of dispersants remains a public concern, due to the observed toxic effects of the old dispersants used during the *Torrey Canyon* incident.

Considering the practical viewpoint of responders, chemical dispersion is often considered easier to use than mechanical recovery. However, this technique faces other limitations in terms of efficiency.

The dispersion process has several consequences, notably that the oil dispersed in the water column is no longer subject to wind influence. Dispersion can be a good technique for protecting shorelines or sensitive resources located downwind of the spill. Furthermore, the formation of myriads of tiny droplets improves oil biodegradation. However, distribution of oil into the water column is promoted locally which could temporarily increase the exposure of underwater marine life to oil.

Description of best practices

Policies for the use of dispersant have been developed and involve the following items:

a) An approval process to select the best dispersant products to choose the most efficient and least toxic products. To be approved, a product must meet the selection criteria threshold values especially for its efficiency and toxicity.

b) Oil dispersibility predictions to define which oil and/or how long an oil is dispersible taking into account its rheological properties (e.g. viscosity, elasticity, pour point…) and its chemical composition. So far, general recommendations have been produced taking into account only the oil's viscosity. Therefore uncertainties remain on the dispersibility of the oil. - see hand written comment

Studying the weathering kinetics and dispersibility through laboratory testing remains the best approach. The data generated can be used to supply the weathering models and to improve the reliability of the predictions

c) Pre-studies on the potential environmental impact of dispersed oil to define where and to what extend the oil can be dispersed safely. A comparative rationale has been developed ("NEBA" process) which consists of comparing the impact of the pollution when treated and when left untreated. By preparing this NEBA process in advance for different areas, geographical limits can be defined where dispersion can or cannot be undertaken.

d) Development of specific application equipment for aircrafts and ships. Aerial application is often preferable as it can be mobilised quickly and cover large surface areas, whereas ships can be appropriate for treating medium size pollutions.

Dispersant should be applied to oil slicks using appropriate spraying equipment, which should be tested in advance with dispersant in field trials.

e) Development of procedures for dispersant application to conduct spraying operations.

f) Development of stockpiles of dispersants properly located and sized. The quality of the dispersants in the stockpiles should be checked periodically.

g) Monitoring dispersant treatment to check the efficacy of the treatment (visual observation, remote sensing techniques, water sampling or SFUV measurements) and to assess the environmental impact of dispersed oil.

h) Contingency planning to gather the information needed during the decision making process.
i) A decision making scheme based on 3 basic questions: *Is dispersion possible? Is dispersion acceptable from an environmental viewpoint? Is treatment logistically feasible?*
j) Use of dispersant on the shoreline:
Dispersants have been used on the shoreline as a shoreline cleaning agent but as they lead to transferring the oil and dispersant to the sea, the use of dispersant on the shoreline is very rarely considered by responders.

Gap between best practices and current use

Current uses often differ from the ideal situation described above.

European countries, having brought approval procedures into force, use their own testing methods and selection criteria: there is therefore a lack of standardisation.

The efficiency of dispersants still needs to be improved for specific situations (e.g. waxy crudes, emulsions…). The dispersibility of crude and heavy fuel oils cannot yet be determined according to their chemical composition. The kinetics of the weathering of oils, the surface mixing energy, the conditions for contact between dispersant and the formation of fine oil mineral aggregates need to be studied.

To tackle all these issues, experimental works should be undertaken in the laboratory, through pilot scale studies and through sea trials.

The toxicity of dispersed oil on living species, its impacts on different environment and its long term fate and behaviour are still not well known, which leads to controversial discussions observed on the topic of dispersants. The development of a common approach to conduct the NEBA is needed.

As concerns application equipment, we are still missing test data on their capability, and developments are needed to cope with low energy or cold environments and to better adjust the dispersant dosage versus the oil to be treated.

There is scope to improve the application procedures and develop innovative equipment to detect, locate and target what has to be treated even in adverse circumstances.

There are no real established and accepted testing procedures for carrying out quality controls.

The development of innovative and easy monitoring techniques would help to conduct such monitoring during real spills. A systematic and common approach for conducting post spill monitoring would be useful to understand what happened and to improve, in light of the past experience, recommendations on the use of dispersant.

The development of a common approach to set the contingency plan for the use of dispersant would be useful.

As a general comment, there is a real need for harmonisation of research methodologies and practical procedures.

Most of the work conducted on dispersants outside of Europe is carried out first in North America and also in Central and South America.

Progress expected over the next 5 years

In the coming years, progress can be expected on different issues:

- A better understanding of the dispersion process according to the oil and the environmental conditions

- Some improvement in dispersant formulations to treat more weathered oils, waxy oils, in low temperature conditions, with low mixing energy or in low salinity water.
- An improvement of the predictions of the window of opportunity according to the oil type (crude oils and refined products, including heavy fuel oils) and the environmental conditions (representative for various European waters -i.e. Baltic, North Sea, Arctic, Mediterranean) based on experimental data which should be used to improve weathering dispersibility models.
- Better knowledge of the potential impact of dispersed oil according to the habitat leading to better recommendations on when and where dispersant can be used.
- From the above items, better recommendations for the use of dispersants in coastal areas, and in close seas.
- Harmonisation of testing procedures on oil dispersibility and toxicity as well as on dispersant approval and selection and more generally the development of methodologies based on common approach to carry out the Environmental Benefit Analysis expected for the use of dispersant. This should lead to developments of computerised operational model tools for doing better quantitative scenario-based NEBA analysis of relevant spill scenarios
- New easy-to-use application devices (spraying apparatus) which are more efficient even in adverse conditions; these devices integrate detection means in order to treat without visibility.

1. Background

"Chemical dispersion" is one of the main at sea response options, as recognised in IMO oil spill counter measures manual, available in the oil spill responder tool box with "mechanical recovery", "in situ burning" and "decision to do nothing except monitoring the oil behaviour and trajectory". Among these, mechanical recovery and dispersion remain the main ones as, for safety reasons, in situ burning can be used only in very few situations (mainly arctic), and "do nothing and monitor" is the last option when none of the others are applicable.

This response technique has been used for more than 40 years, on many incidents from the historical *Torrey Canyon*" (1967) to more recent spillages such as the "*Solar I*" (2006 – Philippines).

Since the *Torrey Canyon* for which highly toxic dispersant products were used, causing great damage to the environment, the quality of dispersant products as well as the application equipment and procedures have been improved.

1967 the Torrey Canyon incident

Current products are far less toxic than initially, the scope for dispersant use is better understood and specialised equipment has been developed.

However, the use of dispersants keeps some fear in public mind, due to the observed toxic effects of the old dispersants used during the *Torrey Canyon* incident.

Considering the practical viewpoint of responders, the chemical dispersion is often considered easier to use than mechanical recovery, (usually faster to be deployed, still acceptable in mediocre sea conditions and producing no wastes to be disposed of afterward).

However, this technique faces other limitations in terms of efficiency, as not all oils are dispersible according to their type and weathering stage, and in terms of ecological impact, as in some circumstances, the dispersion of oil can lead to more damages to the environment than the pollution left untreated would do.

According to these limitations, the role of dispersion in comparison to mechanical recovery in the overall response strategy can vary widely from one country to another (from dispersion considered as a primary option, to the total rejection of the dispersion). Moreover, as uncertainties remain on the real efficiency and potential environmental impact of dispersion, in many cases the decision for to use dispersant remains a difficult one for the responders and can be controversial.

2. Introduction to dispersants

The dispersion process changes the surface oil slick into a cloud of oil droplets in suspension in the water column.

The natural mixing energy of the waves tends to produce droplets of oil in the water column. The stability of these droplets is related to their size; small enough, they may remain in suspension in the water column under natural turbulence; when large, they refloat more or less quickly to reform the surface oil slick.

Dispersants are chemical agents that reduce the interfacial tension between oil and water in order to enhance the natural process of dispersion by generating larger numbers of smaller droplets of oil that, when small enough, can be entrained permanently into the water column by wave mixing energy.

Plume of dispersed oil behind the dispersant spraying booms of a ship

A second effect of dispersants consists in reducing the water in oil emulsion formation (reverse emulsion) which would lead to thick and persistent floating oil patches.

Dispersion involves 2 phases: droplet formation in the water column, the primary dispersion (or "plume formation"), and their dissemination into a large volume of sea water by ambient turbulences and secondary dispersion, which acts as an infinite "dilution" process.

The dispersion process has several consequences:
As the oil dispersed in the water column is not subject any longer to wind influence (wind drifting), dispersion can be a good technique for protecting shorelines or sensitive resources located downwind of the spill. This is considered as the main objective of dispersant use.

Removing oil from the surface of the sea is beneficial for organisms, such as seabirds and marine mammals, and habitats at risk from contamination by floating oil.
Furthermore, the formation of myriads of tiny droplets improves oil biodegradation by increasing the oil surface area and therefore increasing exposure to bacteria, oxygen and nutrients.
Finally these oil droplets meeting natural mineral particles suspended in the water column can form oil mineral aggregates; this formation contributes to stabilizing the oil dispersion giving more time for oil to disseminate or "dilute" which is favourable to oil biodegradation.

However, distribution of oil into the water column is promoted locally which could temporarily increase the exposure of underwater marine life to oil.

Dispersant product formulations have evolved over the last 40 years; products have become less and less toxic and more and more efficient. This evolution was encouraged by the approval procedures which have been brought into force in different countries (UK, F, US….); products have to satisfy more and more severe criteria related to their efficiency and their toxicity : from the 1st generation, toxic products used in the 1970th , evolved the 2nd generation (*conventional dispersants*), products far less toxic but containing a relatively small proportion of surfactants, and then the 3rd generation, (*concentrate dispersants*) efficient products (high proportion of surfactants) but with low intrinsic toxicity.

3. Experience and data from past events

Over the last 25 years dispersants have been used during many incidents, on a large or minor scale.
Some examples are mentioned below:
In 1979-1980 the *Ixtoc 1* blow out, in the Gulf of Mexico released between 6 and 2 000 t of crude oil a day for 10 months; quite a large dispersant application was engaged with 450 flights of spraying aircrafts;

In 1983, for the *Sivand* incident, in an estuary on the east coast of England, between one sixth and a third of the spill was chemically dispersed, the remaining oil reaching the coast before being treated.

In 1989 for the *Phillips Oklaoma,* East England, 800 tonnes of crude oil spilled about 7 miles offshore have been treated by aerial application for 2 days. No oil reached the shoreline and chemical dispersion played an important role among the other processes such as evaporation and burning.

In 1990 for the *Rosebay* in the South-West of England, 75% of the 1100 t of spilled oil was removed from the sea surface by the evaporation and natural and chemical dispersion. Although the contribution of the chemical dispersion could not be specifically assessed, it is considered as having played a major role especially in reducing the amount of emulsified oil which polluted the shore.

In 1996 the *Sea Empress* incident in Wales which is the major case story for dispersants use.
The *Sea Empress* ran aground in the entrance to Milford Haven bay; the ship lay on the bed rock with her hull punctured underneath for about one week and released, with each tidal movement, a new fresh spill of light crude oil (North Sea –Forties). A total of 72 000 t of crude oil and 480 tons of heavy fuel oil were released which impacted an area 200 Km wide. The British authorities had time to organize a large operation to apply dispersant to these slicks by aerial means: 7 DC3 and a C 130 Hercules were involved in this operation for 9 days, spraying a total of 446 t of dispersants. The global budget of the pollution was: of the 72 000 t released, 40% was lost by evaporation, 3% mechanically recovered at sea, 7% stranded on the shore, and the remaining 50% naturally and chemically dispersed (36 000 t).
The oil concentrations of dispersed oil in the water column below the surface was monitored: recording showed 10 ppm just after dispersant spraying, dropping to 1 ppm two days later, then 0.5 ppm one week later, 0.2 ppm one month after and back to the background level 3 months later.
The environmental impact observed was far less than feared and localised on certain areas of the shore.

Aerial application of dispersant by a DC3 during the Sea Empress incident [MPCU]

As a general conclusion it was considered that without the use of dispersant a further18 000 t would have beached in addition to the 3 700 - 5 300 t estimated to have stranded.
As this oil would have emulsified, it would have represented between 54 000 and 72 000 t of emulsion complicating the shoreline cleanup and waste disposal.
The cost per tonne of dispersed oil was estimated at £40 - 60 in comparison with the cost per tonne of oil recovered, offshore, £2 000 and on shore, £9 000 (through the shoreline cleanup process).
In 1999, the *Blue Master* in the Gulf of Mexico spilled 45 t of IFO 180 which were treated successfully with 2.3 t of concentrate dispersants.
More recently, 2003 the *Tasman Spirit* in Pakistan, carrying 67 500 t of Iranian heavy crude oil, ran aground at the entrance to the channel of Karachi harbour. As the ship was stuck on the sea bed, lightering operations were planned to recover the cargo.
However due to the swell, the hull broke two weeks later and she released 20 000 t of oil.

The dispersant response option was chosen using the C 130 Hercules aircraft from EARL (Singapore) response and 100 t of dispersant were shipped from England to Pakistan by air cargo.

Dispersant spraying operation with the C130 Hercules during the Tasman Spirit incident in Pakistan- [picture from http://www.spillcon.com/2004/papers/O'BRIEN.pdf]

"The aim of the operation was to prevent the spread of the slick along the coast towards the Indus Delta, an ecological sensitive area of global significance and vital sustainability of regions fishing resources. The operational area for the aircraft was extremely challenging due to the vessel proximity to the shoreline, small islands with in the target area and the need to work close to a shoreline lined with high rise buildings. By utilising spotter helicopters with trained observers to direct the aircraft's spray runs. The operation was highly successful and as it ensured the spread of the oil was limited to a predetermined area. In total 7 spraying missions were conducted with 87 spray runs being completed, but only 39 tons of dispersant were used, showing a highly topical application and controlled use of dispersant chemical. On completion of spaying operation the aircraft remained on stand by until the lightering operation was complete" *– from "SPILLCON 2004 - Tasman Spirit – A case of study by Wayne O'Brian, Team Leader in Oil Spill Response Limited"*

4. Description of best practices

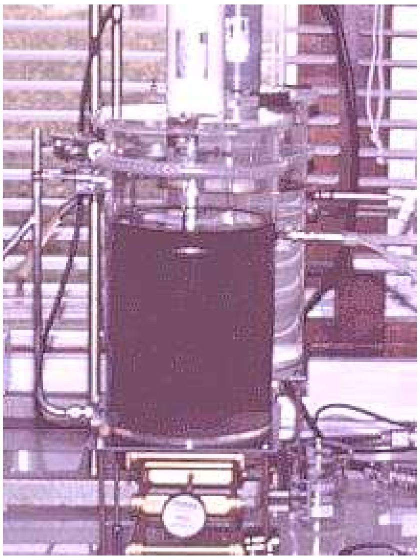
Policies for the use of dispersant have been developed and involve the following items:

4-1: <u>An approval process to select the best dispersants products</u>.

In order to choose the most efficient and least toxic products some countries have brought into force different approval procedures to test and select the products.

All procedures involve at least tests on efficiency and toxicity. Sometimes, for other purposes (environment, spraying possibility, safety…), other criteria are also considered such as the biodegradability, the viscosity or the flash point of the dispersant…..

To be approved, a product must meet the selection criteria threshold values especially for its efficiency and toxicity.

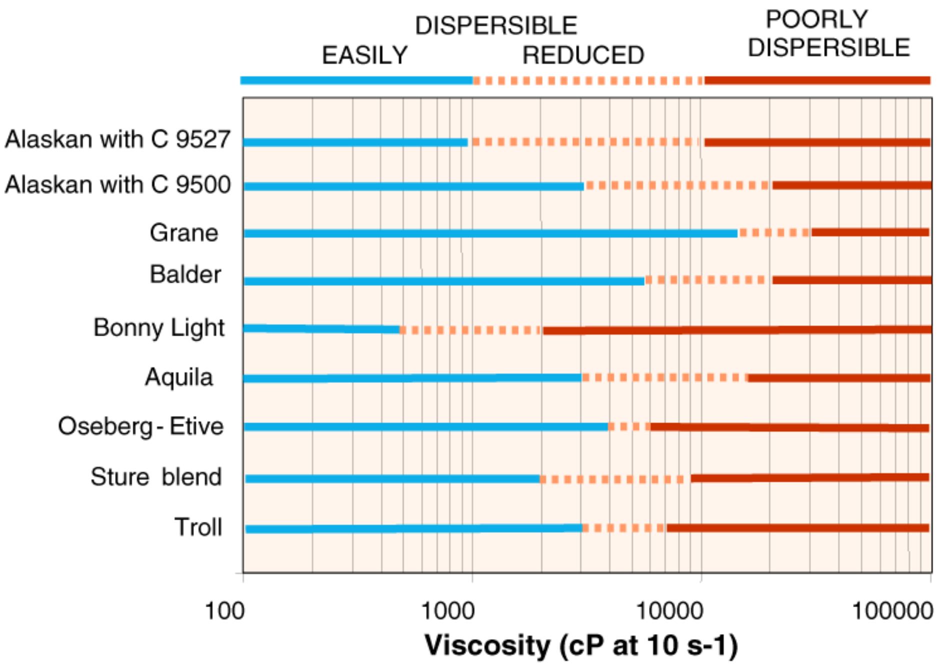


The French dispersant efficiency laboratory test apparatus [Cedre]

4-2: Oil dispersibility predictions

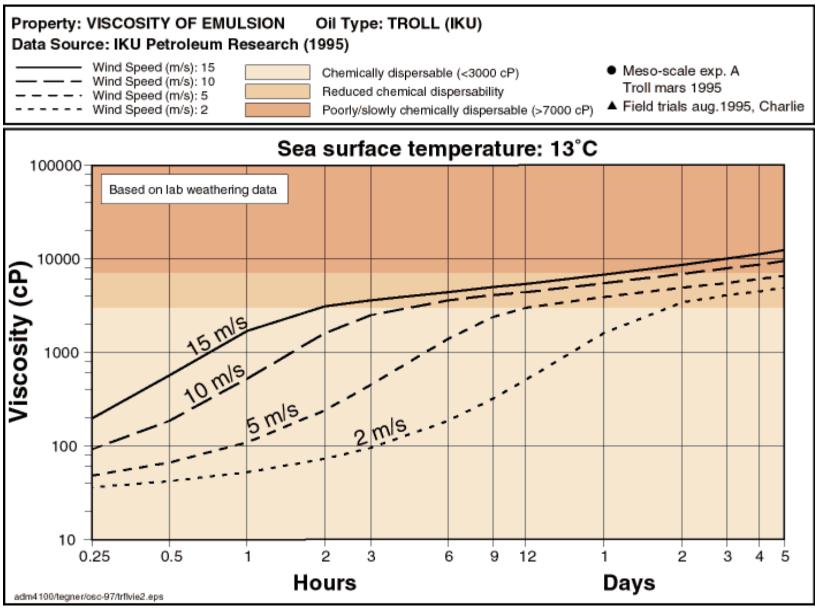
Not all oils are dispersible, and moreover, when oil is dispersible, it remains dispersible only for a rather short period of time due to the natural weathering process which changes its characteristics and composition. The time during which a specific oil remains dispersible in a given situation is known as "the window of opportunity for dispersion".

The dispersibility of oil depends on its viscosity at ambient temperature, and on its chemical composition.



Samples of different categories of dispersibility for different oils; (easily dispersible, reduced dispersibility, non dispersible); [Sintef]

In addition, the dispersibility of a given oil depends also of the dispersant used, all the dispersant formulations no having the same effectiveness.
General recommendations in terms of oil viscosity limits have been produced to give a general idea of the dispersibility of oil.
However, as these recommendations do not take into account the composition of oil and, as, in a given situation, the weathering stage of the oil is generally unknown, and some uncertainties remain on the dispersibility of the oil.
Predictions can be improved by taking into account the weathering kinetic assessed by computation (weathering models –e.g. Adios, Oscar).



example of weathering predictions using the SINTEF Oil weathering Model [Sintef]

The best approach remains, when possible, to assess for each oil the weathering kinetics and dispersibility through laboratory testing. The data generated can be used to supply the weathering models and to improve the reliability of the predictions of the window of opportunity for dispersion.

4-3: Pre-studies to define where it is possible to disperse oil in term of environmental sensitivity.

Dispersing oil causes the oil to be distributed into the water column and to increase locally and temporary the oil's toxicity for underwater life. However, dispersion can be favourable for surface species such as birds by reducing their exposure and as mentioned above, dispersion can prevent the surface slick from being wind drifted towards more sensitive areas such as the coastline.

Clearly according to the circumstances, especially the geographic location, dispersion can be a good or bad option.

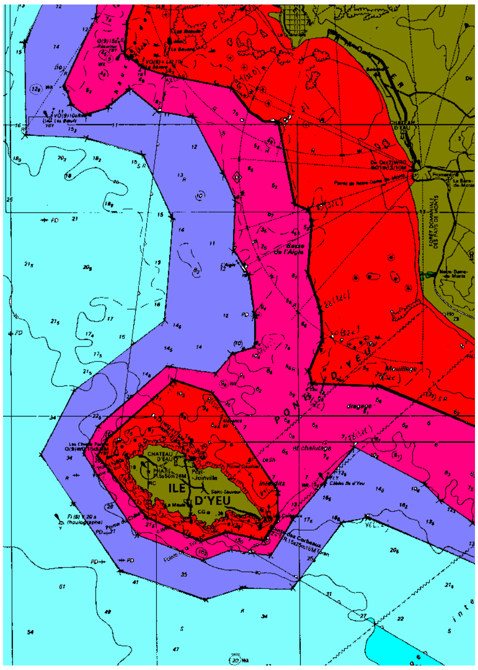
In order to help the decision maker, a comparative rationale has been developed call the "NEBA" process (Net Environmental Benefit Analysis) which consists of comparing the impact of the pollution when treated and when left alone untreated.

However this process, which should be undertaken before deciding to use dispersants, takes time and the answer to the question is likely to be obtained when the window of opportunity for dispersion is over.

In order to avoid this difficulty, it is possible to prepare this Neba process in advance for different areas considering different spillage scenarios and the local sensitive particularities.

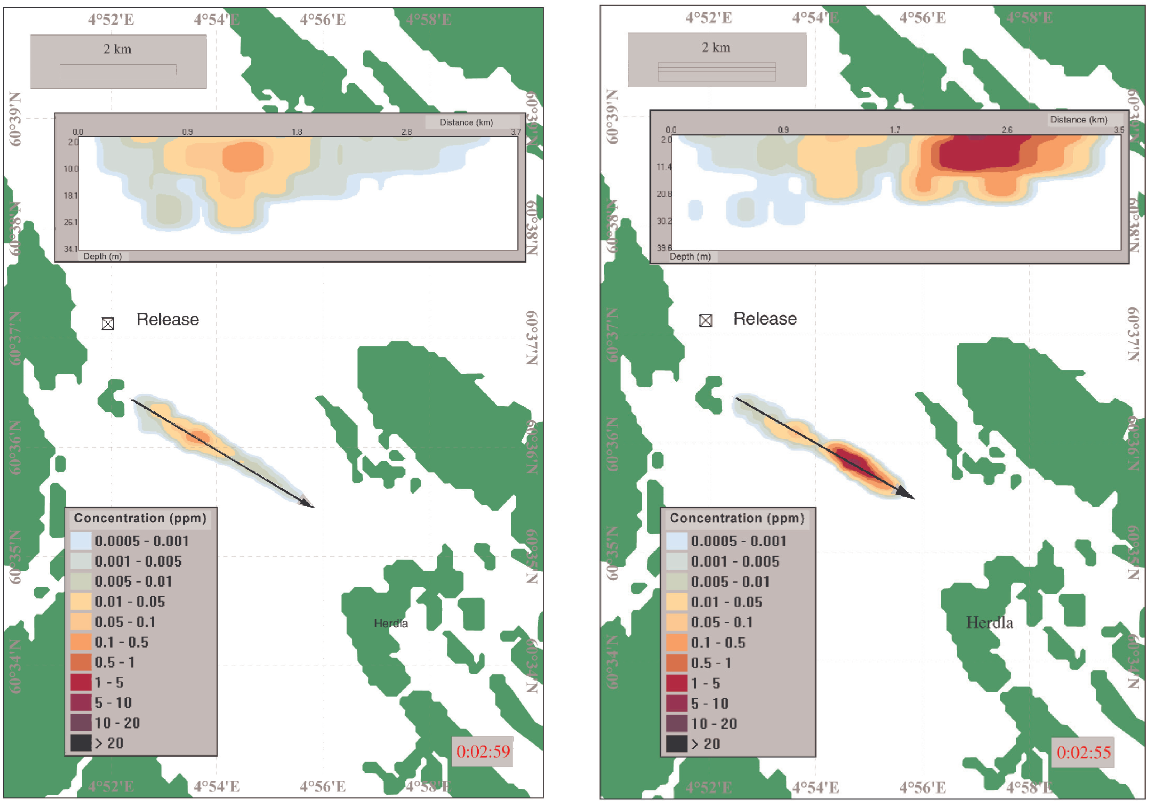
Important elements, among others, are the characteristics of the oil, its persistence, seasonal variations in distribution and life cycles of important species (e.g. birds or fish migration periods…), local sensitivity and vulnerability, the duration of the exposure, importance of possible impact on neighbouring compartments and the possibility of replenishment of populations from neighbouring compartments. Other considerations may include recreational areas, amenity beaches, industrial installations etc. Thus co-ordination with tourist, industrial and environmental interests is necessary.

Based on such pre-studies, geographical limits can be defined where dispersion can or cannot be undertaken. Such limits may take into consideration different spill size scenarios. This information is gathered in the contingency plan (see figure below).



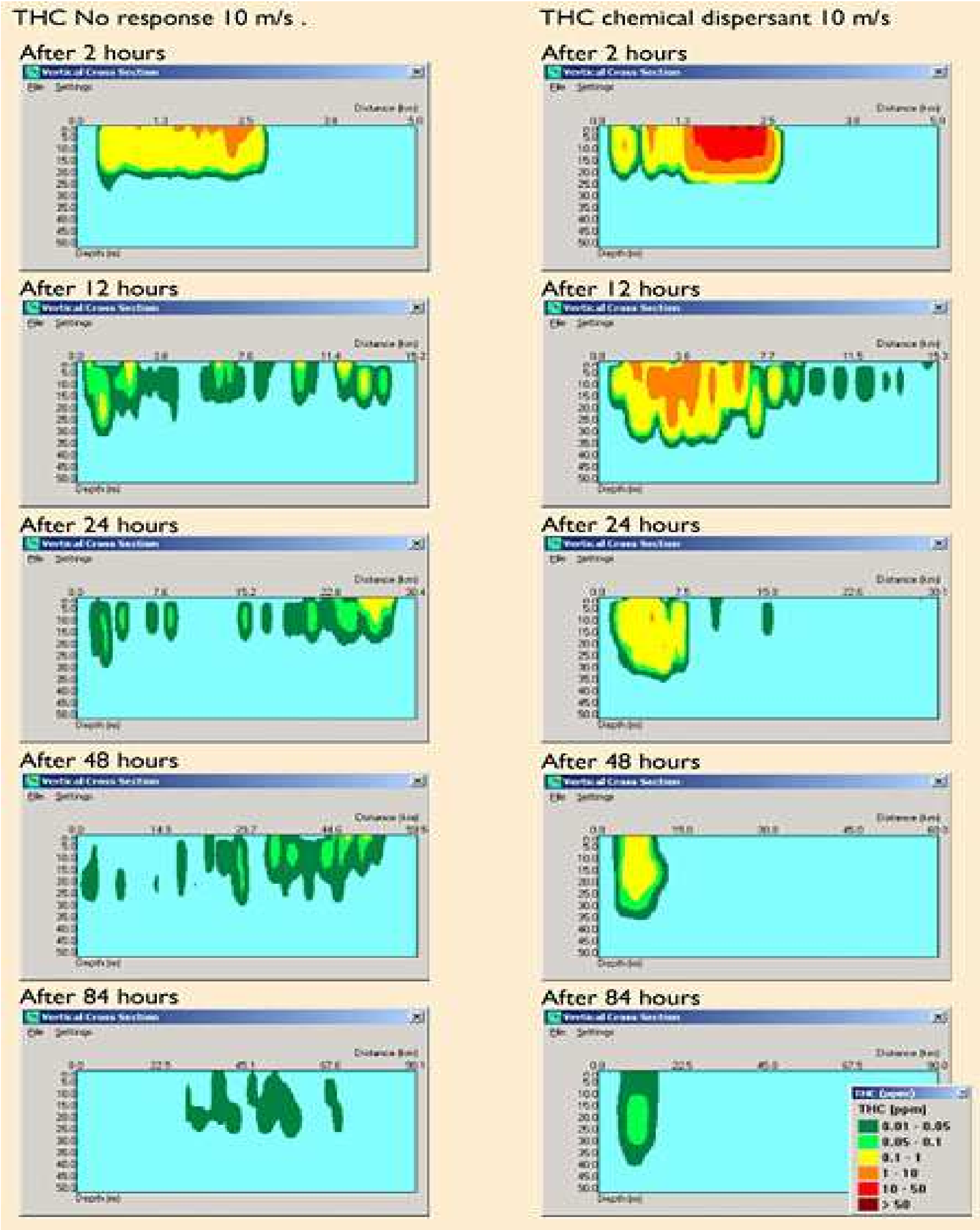
Example of geographical limits for dispersant use according to the spill size (brown: land; red: coastal area, no dispersion; pink: dispersion possible for up to 10 t of oil; dark blue: dispersion possible for to 100 t of oil; light blue: offshore area, dispersion possible for up to 1000 t of oil) [Cedre]

As another way to precise where dispersion is acceptable environmentally is carrying out case by case scenarios studies. These scenarios studies can be carried out using computerised modelling tool involving 3D model coupled with NEBA process (see figure below).



Comparison of spill scenarios with and without dispersant application :

The figure indicate the total simulated hydrocarbon concentrations (THC) in the water column 3 hours after release of a North Sea crude at 5 m/s wind from an oil terminal in Norway; Left: No response Right: Dispersant application from helicopter carried out 1.5 h. after release [Sintef]

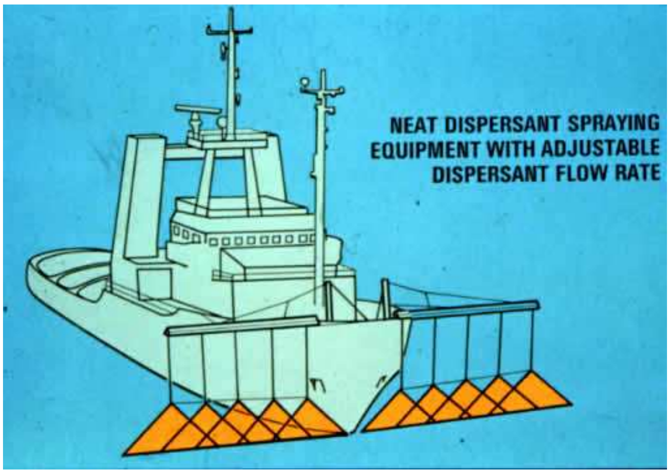


Development and dilution of oil plume in water column after dispersant treatment versus a non-treated slick. OSCAR-simulation of a release of 100 m^3 crude oil at 10 m/s wind speed. Dispersant application from one vessel start 1 hour after release. [Sintef]

4-4: <u>Development of specific application equipment</u>

Application can be carried out from an aircraft (helicopter or fixed wing) or from a ship.

Aerial application is often preferable as it can be mobilised quickly and cover large surface areas. However, in some cases, especially when already on site, ships can be appropriate for treating medium size pollutions.

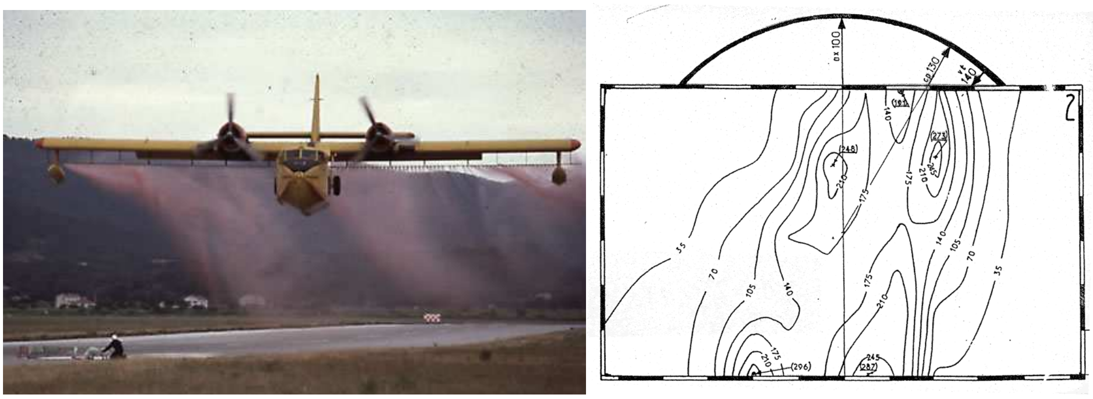


Example of shipborne spraying equipment [Cedre]

Dispersant should be applied to oil slicks using appropriate spraying equipment. Dispersant droplets size is very important (large enough to avoid wind-drifting out of the target, small enough to avoid crossing the oil surface film to be lost in the water underneath).

Up-to-date devices are designed to apply neat dispersant which is more efficient especially when the pollutant is weathered and become less dispersible. The usual dispersant dosage is 5% (or dispersant oil ratio 1/20), but, for ships and helicopters, the most advanced equipment is designed to offer several treatment dosages in order to cope with a variety of slick thickness.


Examples of advanced shipboard application equipment developed in France and Norway:
Left: Supply ship equipped for dispersant treatment [Sintef];
Right French Navy vessel applying dispersant during a sea trail [Cedre].



Field tests for assessing the spraying capability of an aircraft: map of the dispersant deposition [Cedre]

For aerial application, equipment can be purpose-built or converted from agricultural apparatus.
To ensure good spray pattern, shipborne equipment should be located ahead of the bow wave which mixing action can enhance the dispersion process.
All application devices should be tested in advance with dispersant in field trials in order to assess their capability (dispersant droplet diameter and real dispersant application rate, effective swathe width) and to determine the optimum conditions of use.
During the past decades, large helicopter buckets up to 300 Kg capacity has been developed in France and Norway (see Figures below)

Examples of large helicopter buckets dispersant application system :
Left: a SuperFrelon helicopter carrying an underslunder SOKAAF 3000 bucket treating a slick during field trials [Cedre]
Right: a Sikorski 61N helicopter reloading a RESPONSE 3000 dispersant spray bucket from dispersant stored onboard a support vessel [Sintef]

4-5: Development of treatment procedures for dispersant application

Spraying operation must be conducted according to specific procedures: spraying should begin the treatment at the edge of the slicks to the border of medium thicknesses in parallel and contiguous runs, following the axis of the wind (and preferably against the wind for a ship as long as she is moving slower that the wind) to guarantee optimum spraying conditions.

Aircrafts and ships need to be guided on the slick by a dedicated aircraft flying at higher altitude. As an additional possibility, this spotter aircraft can be equipped with oil sensing techniques (e.g. IR) which allows to treat at any times, even with poor visibility (e.g. at night).

Cessna from OSRL equipped with a spraying POD applying dispersant during Depol 04 sea trial [Cedre]

In, addition, when dealing with significant pollution, there are considerations for the global strategy:

- it is necessary to decide which part of the pollution should be treated first, according to the situation and the possibility of drift to sensitive areas.
- when the whole pollution cannot be treated due to a lack of dispersant or of spraying capability, it is important to decide which part of the pollution will be treated according to the situation and in order to reduce the final impact of pollution (e.g.: possibly the tail area, usually the thinnest part of the slick, to leave the thickest part to mechanical recovery; or the edges of the pollution to reduce the length of coastline likely to be polluted…)
- for a large incident, mechanical recovery can be conducted simultaneously to dispersion provided it is conducted separately on parts of the pollution different from those devoted to dispersion.

4-6: Development of stockpiles of dispersants

Sufficient stockpiles of dispersants should be set. These stockpiles should be properly located where dispersants are likely to be needed (close to the spraying means). The size of the stockpiles should be optimized: large enough to avoid lacking of product during the intervention, but not too large in order to reduce the capital assets.

The quality of the dispersants in the stockpiles should be checked periodically to guarantee that they remain efficient at all times.

4-7: Monitoring dispersant treatment

When used, the effects of dispersant should be monitored during and after treatment.

During the treatment, it is necessary to assess the direct effect of the treatment to check the oil remains dispersible (still in the window of opportunity). This is often done by a simple visual observation, but the use of remote sensing techniques such as IR can give a good overall idea of the treatment by assessing the oil which remains on the sea surface. In addition, water sampling, or better SFUV measurements can give an accurate evaluation of the dispersed oil concentration in the water column.

Remote sensing aircraft of the Swedish Coast Guard [Cedre]

After treatment, it is advisable to assess the impact of the pollutant to check for possible damage to the environment. Ideally, this requires good long-term baseline studies. In the absence of such studies, comparison can be made with ecologically similar areas that are not affected by oil or dispersed oil from the spill in question.

4-8: Contingency planning

Due to "the window of opportunity for dispersion", there is often a limited time frame for using dispersant. Therefore, to avoid loosing time, all the information and the logistics needed for deciding on the use of dispersants should be prepared and listed in the contingency plan:

- Recommendations and information on the dispersibility of oils preferably according to their weathering,
- Geographical limits where dispersants can be used safely for the environment,
- List of the application devices available, with mention of their operating limits
- List of stockpiles of products,

- All procedures for: selecting dispersants,
  checking dispersant stockpiles,
  maintaining application devices,
  mobilising equipment and products,
  supplying dispersants to the application means,
  applying dispersant on site,
  monitoring efficiency and impact of the treatment.

4-9: A decision making scheme based on 3 basic questions:
At the time of the spill, decision making on the use of dispersant should be considered in terms of 3 main questions.

4-9-1: *Is dispersion possible? or is the oil dispersible?*
This question can be addressed by comparing the characteristics of the oil at the time of the spill (evaluated with the assistance of an oil weathering model) with the recommendations in the contingency plan.

4-9-2: *Is dispersion acceptable from an environmental viewpoint? Or does it generate more damages than advantages?*
This question can be addressed by comparing the location of the incident and the possible wind drifting of the oil with the geographical limit for dispersant use in the contingency plan

4-9-3: *is treatment logistically feasible? Are there sufficient products and equipment to conduct the treatment?*
This question can be addressed by comparing the size and extend of the incident, the current conditions on location, with the listing of available means and their capability in the contingency plan.

As a general comment there are many documents written for the oil spill responder which described how to use dispersants (see references).

4-10: Use of dispersant on the shoreline
Dispersant have been used on the shoreline more or less as a shoreline cleaning agent.
Dispersant application onshore leads to transferring the oil and dispersant to the sea, either by tidal action or hosing with sea-water involving a possible impact on the near-shore ecosystems which can be exposed to significant dispersed oil concentration.
Therefore the use of dispersant on shoreline is very rarely considered, mechanical removal of oil and oily debris generally being preferred by responders.

5. Gap between best practices and current use

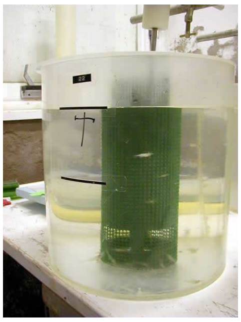
Current uses often differ from the ideal situation described above.

5-1: Approval process to select the best dispersant products.

All European countries have not brought into force an approval procedure for selecting the dispersants to be used in their water.

Moreover, each country set its own approval procedure using its own testing methods:

Efficiency measurements: the WSL test in UK, the IFP test in France and Norway;
Toxicity: assessments, the situation is even worse, as the test philosophy differs from one country to another: while France and Norway consider the intrinsic toxicity of the dispersant, the UK controls the toxicity of chemically dispersed oil, ensuring that it is lower than the toxicity of mechanically dispersed oil.



Approval procedure for dispersant: toxicity testing on white shrimp

In the current situation there is no standardisation either of the test methods or the threshold value criteria for dispersants selection.

As a consequence, the market for dispersant products is not open Europe wide, and the use of dispersant from the national stockpile of other countries is restricted unless specific regional agreements have been made previously (e.g. agreement between neighbouring countries).

In addition, if the efficiency of dispersants has improved over the two last decades, there are still limitations when dealing with paraffinic oils, weathered and emulsified oils, or when considering special situations such as low salinity water (e.g. estuary situation), low mixing energy and/or low temperature (these three conditions being found simultaneously in the Arctic situation).

The efficiency of dispersants still needs to be improved for these situations: is it possible to develop dispersant formulations which would be more adapted to waxy crudes? Is it possible to treat water-in-oil emulsion by developing specific dispersants able to break emulsions or by combining demulsifiers and dispersants?

Dispersant which is not dependant on the water salinity would be useful especially in coastal and estuarine environments and possibly in the Arctic zone.

5-2: Oil dispersibility predictions

It is not yet possible to link crude oil dispersibility to its chemical composition and this is particularly true for paraffinic oil. The dispersibility of heavy fuel oils which are increasingly transported in European waters is still unknown; some are dispersible while other are not, and so far, we are unable to explain these differences based on the composition of the heavy fuel oils themselves

Oil slick during the Depol 04 sea trials 2004- [Cedre]

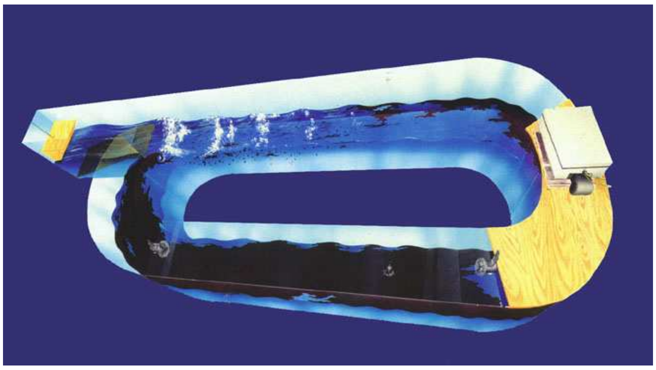
The kinetics of the weathering of oils remains difficult to predict accurately according the all the environmental conditions (wind, temperature, agitation…). There are therefore still uncertainties in the prediction of oil dispersibility and the assessment of the window of opportunity for dispersion is still an approximation.

The surface mixing energy is a key factor in the dispersion process: according to the oil type, there is a minimum level of energy requested to get the dispersion process initiated. The energy quantification of this energy remains very uncertain, and consequently leads to uncertainties in dispersion predictions.

Furthermore, although dispersion is usually a rapid process, it can sometimes take time, possibly several hours, especially when the mixing energy level is low. So far, the study on dispersion has only considered the short term process. It would be beneficial to obtain a better understanding of dispersion on a longer period of time.

Moreover, the condition for contact between dispersant and oil is very important for the dispersion process itself; some of these aspects are already being studied as the influence of the contact time between dispersant and oil to check if dispersant keeps with oil or may dissolve with time in the water underneath –PERF study-; investigations on this topic should be continued.

To tackle all these issues, experimental works should be undertaken at different stages; intensive laboratory study in which all the parameters can be modified with validation at larger scales, in doors at pilot scale (as conducted in flume test in Sintef and polludrome in Cedre), out door in floating cells as conducted by Cedre) and in real conditions, in sea trials such those carried out by Sintef or Cedre.

Pictures of the of the Flume tests in Cedre (Left) [Cedre] and at Sintef facility (Right) [Sintef]

Considering specific environments (e.g. the Arctic) there is lack of knowledge on the environmental conditions themselves (e.g. Arctic: mixing energy, ice regime, water salinity).

In coastal and estuarine environment where there are a lot of mineral particles, dispersed oil droplets can link with these particles to form aggregates whose fate and behaviour could differ from those of the oil (in terms of buoyancy and possibly in terms or of biodegradation). This aggregate formation still needs to be investigated further.

As generally, the different institutes which work on these issues use different methodologies which leads to results which are no always comparable. Harmonisation of research methodologies is therefore advisable.

Generally speaking, current dispersion predictions provide more of an overall indication than on accurate representation.

Experiment in floating cells equipped with meteorological monitoring [Cedre]

5-3: Pre-studies to define where it is possible to disperse oil in terms of environmental sensitivity

The toxicity of dispersed oil for the living species, and its potential impact on the different compartments of the environment are not yet well known.

So far, it is mainly the acute effect of some oils on a small number of species which has been studied. Questions remain when considering long term or sub-lethal effects or when dealing with complex environment (when taking into account interaction between species).

We need to diversify the bio-assay to a larger number of species, appropriately chosen either for their role in the ecosystem or for socio-economic reasons. Apart from laboratory bio-assays, experimental assessments in the field or at least in mesocosms, taking into account complex environments, are needed to obtain a clear view of the potential impact of dispersed oil especially in shallow waters.

Once again, among the data which are available today, a good part is not comparable as the institutes working on these issues do not use similar methodology. Harmonisation is needed in order to pool the results from the different institutes.

Moreover, the long term fate and behaviour of the dispersed oil remains unknown; it is assumed that part of the oil is biodegraded, and the remainder probably sedimented on the sea bottom, but, so far, there are few clear experimental data and observation to support this assumption.

Therefore the recommendations on the use of dispersant which are designed to protect the environment remain insufficiently accurate and cannot pretend to avoid any harmful effect resulting from the dispersion of the oil. This is especially true for coastal areas for which responders are still questioning whether dispersion is advisable. The definition of geographical limits for the use dispersants should be improved in light of this information.

The approaches adopted to define these geographical limits differ from one country to another and the criteria taken into account can be different, (minimum depth, strength of currents, bird migrations, amount of pollutant to be dispersed…); therefore the limits, when they exist, are not similar. Once more, there is a need for harmonisation.

In addition to eco-toxicological data, it is be necessary to take sea movement more carefully into consideration (tidal current, regular stream) in the definition of these geographical limits to obtain a better idea of the local dilution processes at sea, to assess more accurately, for each location how fast a dispersed oil plume will reach safe low concentration, and therefore, how much oil can safely be dispersed.

As a general comment on the environmental concerns, dispersant policies are based, so far, on empirical observations, either from past incident (which are often poorly documented) or from a few bio-assays (which cannot give a full overview). The lack of clear and indisputable data and information on the possible impact of dispersants in the short and long term is the source of the controversial discussions observed on the topic of dispersants.

The development of computerised models to conduct the Net Environmental Benefit Analysis (NEBA) on dispersant use, based on common and accepted approaches should be encouraged, and developed in order to equip oil spill responders with practical tools to decide when, where and to what extent dispersant can be applied.

5-4: Specific application equipment

Among the devices which are used for dispersant application, very few, if any, have actually been tested with real dispersant. The capability of these devices is often guessed from rough observations or from simple tests carried out with water. The real coverage rate, the swath width, and the droplet diameter are unknown. Therefore the use of the application devices is generally not optimised (e.g. for aircrafts best spraying altitude…)

French Navy ships applying dispersant during a drill

In addition, we are still missing devices designed specifically for particular environmental conditions such as ice infested waters, for example, application devices to treat and target oil patches trapped between ice blocks.

Development should be considered to improve our capability of treating oil in low energy environments; is it possible to artificially create some mixing energy (e.g. the use of ice breaker propellers in the Arctic situation)?

So far, the adjustment of the dispersant dosage versus the oil is manual and approximate; there is scope for improvement such as linking the dispersant dosage to an oil detecting device (e.g. IR camera).

Although this is no longer a research topic, it should be mentioned that application means, such as aircrafts, could be mutualised between European countries in order to optimise their use

So far, the aerial spraying capability in Europe is mainly located in the United Kingdom represented by 3 large aircrafts (2 four engines Electra and 2 Cessna equipped with a POD system and a C130 Hercules equipped with an ADDS Pack system.

5-5: <u>Treatment procedures to apply the dispersant</u>
Properly targeting a slick when applying dispersant remains a very difficult task. Quite often, some parts of the slick are left untreated, while other parts can receive dispersant twice even with the best guidance from a spotter aircraft to command the ships or spraying aircraft on location.

Picture of an oil slick treated in the best possible conditions (spotter aircraft guiding the spraying aircraft) during Depol 04 experiment showing stripes of treated and untreated oil

So far, in poor visibility or dark environments it becomes impossible to conduct treatment; it may be necessary to wait for proper day light to start an operation with the risk of the oil becoming no longer dispersible (as the window of opportunity for dispersion is over). However, night operations will be soon considered by using IR oil detection equipment as such a treatment has been recently carried out, once, in Norwegian water, to treat a 100t oil release : the use of real-time down link transfer of FLIR-pictures from Helicopter to the spraying vessel as illustrated in figures below was useful to guide the vessel on the thicker area of the slicks during the application in order to optimise the treatment (see examples of FLIR images during the spray operation in figures below).

Real-time down-link FLIR images from spot-helicopter to the bridge of the spraying vessel during application.
Left : Response vessel entering the thick part of the slick and start dispersant application.
Right: Response vessel entering going out of the slick after treatment

There is scope to improve the application procedures and develop innovative equipment to detect, locate and target what has to be treated even in adverse circumstances (poor visibility). As examples of ongoing researches are projects to develop the use of aerial detection system to drive the treating ships on slicks: use of IR camera from a aircraft with direct transmission of the slick image to the ship or development of an autonomous flying device equipped with a camera and operated from a ship to act as the "eye" of the ship to treat the slicks (Rapace project).
Finally, in case of a lack of mixing energy, there are questions on the possibility of associating an application of mineral powder (e.g. chalk), on dispersed oil in order to stabilize the flume of dispersed oil by forming oil mineral aggregates and to avoid oil recoalescence.

5-6: Stockpiles of dispersants

Stockpiles are not always properly suited (in terms of location and size), and periodic dispersant quality controls are not necessarily carried out; in the past, it occurred that responders, at the time of a spill, discovered their stockpiles corrupted. There are no real established and accepted testing procedures for carrying out quality controls. Due to the absence of a consensus on the approval procedure, the stockpiles of dispersant cannot be mutalised at European level.
In Europe, the amounts of dispersants in the national stockpiles are very different from a country to another according to the policy of the country towards dispersant use and the country itself. As an example, France owns a large stockpile involving around 900 t of dispersant dispatched on some harbours along its coastline.

5-7: Monitoring of the dispersant treatment

Treatment efficiency is often not monitored during real operation. This is due to the fact that many responders tend to consider monitoring as scientific work, not part of their task and also because there are few handy methods available to carry out such monitoring.
When considering the measurement of dispersed oil in the water column, water sampling is not very convenient while the use of SFUV is not easy. On real incidents, remote sensing tools when available are often used for other priorities.
The development of easier monitoring techniques would help to assess the actual dispersion during an incident and therefore to justify the choice of the dispersion option.

Longer term monitoring for possible effects of dispersed oil on living organisms is generally not conducted either, due to insufficient baseline data, and also to the lack of recognized assessment methods, as each laboratory uses different methods which therefore do not give comparable results.
A systematic and common approach for conducting post spill monitoring would be useful to understand what happened and to improve in light of the past experience, recommendations on the use of dispersant.

5-8: Contingency planning

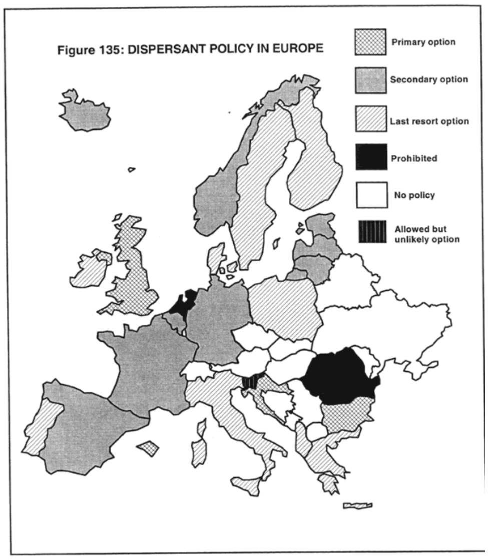
Specific chapters on dispersant use do not exist in all European national contingency plans, and the levels of pertinence of the existing plans are very variable. Development of a common approach to set the contingency plan for the use of dispersant would be useful.

6. Relevant regulations and standards

Any existing national regulations concerning dispersant are very different from one country to another. As an example, in the UK the use of dispersant is ruled by law while in France it is only a recommendation. The global approach can be very different too: for instance, France and UK have drawn up a list of approved dispersants while Norway requests the relevant actors, such as the operating oil companies to test and select the most appropriate dispersants for their own produced oil….).

As concerns the policy for the use of dispersants, the most advanced country is the UK (this was successfully applied during the *Sea Empress* incident); however, since this event, the UK national organisation has been revised (dissolution of the MPCU, reduction of the spraying aerial fleet from 7 DC3 to 2 Electra…), and research and development efforts reduced.

In terms of research and development, Norway is quite well advanced, with a lot of on going studies (on oil dispersibility and operational application procedures). Only two countries in Europe, France and Norway, still run sea trials on dispersants (and other techniques).



Dispersant policy in Europe

In Europe, only the UK considers chemical dispersion as the 1st response option while France considers chemical dispersion as an option among others, and Belgium, Cyprus, Greece, Ireland, Italy and Malta consider chemical dispersion as 2nd response option after mechanical recovery the other countries are very restrictive on the use of dispersants while the Netherlands and Slovenia reject the use of dispersants.

In Europe only 6 countries claim to have an approval procedure (2 with efficiency, toxicity and biodegradability tests, 4 having only efficiency and toxicity tests); 6 countries which do not have their own approval procedure recognize dispersants approved elsewhere (4 accept what is accepted by the Bonn Agreement, 1 what is accepted in France or the UK, 1 what is accepted only in the UK). Some countries are setting up their approval procedure for dispersants notably Spain an Italy.

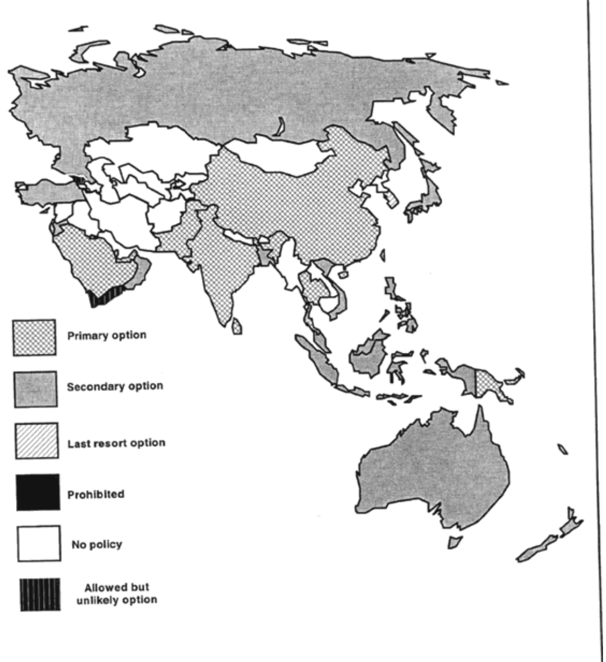
A global view of the European situation can be found at <http://www.emsa.eu.int/Docs/opr/dispersants%20inventory%202005.pdf> *on pages 49 to 53 of the Emsa document "inventory of national policies regarding the use of dispersants in the EU member states" [Nov 2005]).*

As an important issue in Europe is chemical dispersion in close sea (e.g. Baltic sea): to what extend can dispersants be used in areas where sea water is renewed so slowly?
The use of chemical dispersant in the Arctic situation is also a key issue, also currently being studied.

7. Current initiatives and other non-European regulations

The situation outside Europe is quite similar, as most of the countries consider the chemical dispersion as a secondary option. However, some countries, mainly in Asia (Saudi Arabia, China, Emirate, India, Malaysia, Pakistan and the Philippines), as well as in South America (Brazil and Ecuador) consider dispersion as a primary option.

Figure 137: DISPERSANT POLICY IN ASIA



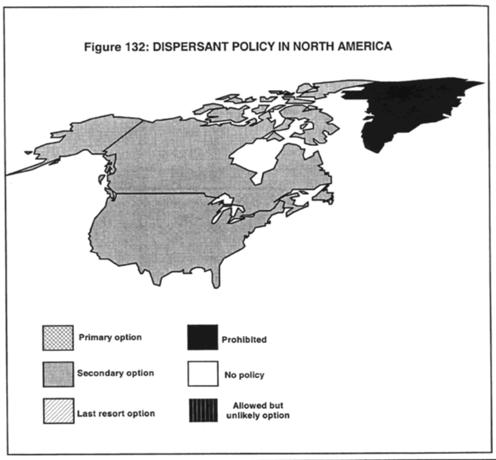


Figure 132: DISPERSANT POLICY IN NORTH AMERICA

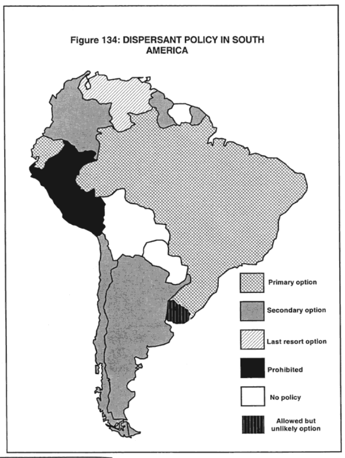


Figure 134: DISPERSANT POLICY IN SOUTH AMERICA

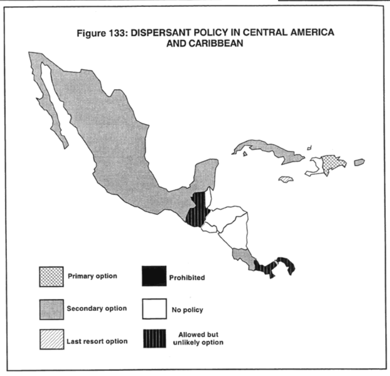


Figure 133: DISPERSANT POLICY IN CENTRAL AMERICA AND CARIBBEAN

Very few countries reject the use of dispersants (Peru, Uruguay, Panama, Guatemala).
Few countries put in force their own approval procedure. Generally, countries recognize dispersants which are approved by other developed countries, mainly, the UK, France and the USA. The same approach is taken by regional international bodies such as the Ropme in the Arabic Gulf which accept dispersant which are approved in 2 countries out of the UK, France and the USA.
As for research and development initiatives, most of the work conducted on dispersants outside of Europe is carried out first in North America and also in Central and South America.
The topics which are currently being studied are

1) On the physical aspects:

- the dispersibility of oil according to its physico-chemical composition
- the role of mixing energy in the dispersion process (modelling the hydrodynamic processes)
- the fate and long term behaviour of dispersed oil in the water column
- computerised simulation of dispersed oil.

2) On the environmental effect:

- the toxicity and impact of dispersed oils,
- the testing methods for simulating realistic exposure to dispersed oil,
- the long term and sub-lethal effect of dispersed oil on marine life, with the objective of being able to make predictions.

3) On the logistic and practical aspects:

- the use of dispersant in ice-infested waters, (what is the possibility for chemical dispersion in iced water and how to use it there) is studied in a joint industry project gathering mainly American, Canadian and Norwegian and Russia.

Field testing is highly restricted in North America; therefore the North American research community use experimental simulation to study oil dispersibility and toxicity of the dispersed oil:

Experiment on dispersibility in a normal situation and with presence of ice conducted in the wave canal of DFO (Canada), in the wave tank of Ross Canada or, on a large scale, in the huge wave basin of Ohmsett (USA).

As for toxicity studies, for similar reasons work is mainly carried out in the laboratory or in mesocosms, which can be very large like the COSS in Texas in which the impact of dispersed oil on coastal eco-compartments has been studied.

Two major field programs have been conducted in the past on the impact of oil and dispersed oil: one in Arctic conditions (Baffin Island), and more recently a field test in tropical conditions, on mangroves (Tropics).

8. Progress expected over the next 5 years

In the coming years, progress can be expected on different issues:

- A better understanding of the dispersion process according to the oil and the environmental conditions, which should contribute to better use of dispersants, especially in calm conditions (or also in the Arctic).
- Some improvement in dispersant formulations to treat more weathered oils, waxy oils, in low temperature conditions, with low mixing energy or in low salinity water.
- An improvement of the predictions of the window of opportunity according to the oil type and the environmental conditions.
- Better knowledge of the potential impact of dispersed oil according to the habitat leading to better recommendation when and where dispersant can be used.
- From the above items, better recommendations for the use of dispersants in coastal or shallow areas, and in close seas or in low salinity waters.
- Harmonisation in testing procedures on oil dispersibility and toxicity as well as on dispersant approval and selection.
- Development of easier monitoring techniques to assess the actual dispersion during an incident and therefore to justify the choice of the dispersion option.
- New easy-to-use application devices (spraying apparatus), more efficient even in adverse conditions; these devices integrate detection means in order to treat without visibility.

9. Workshops, conferences and reports

A number of workshops on dispersants have been organised.

In the USA, the Coastal Research Response Centre has elected chemical dispersion as one of its priorities and organises workshops (the last one held in Feb 2007) – *information to be found on www.crrc.unh.edu*

In Europe EMSA has led workshops on the use of dispersants in European waters (in Dec 2005 and Nov 2006) - – *information to be found on www.emsa.eu.int*

In Europe a publication from ITOPF and CEFAS: The use of chemical dispersant to combat oil spills at sea: A review of practice and research needs in Europe to be published this year. (cf bibliography)

In addition, the HELCOM committee held a workshop entitled "analysis of opportunities for usage of dispersant in the Baltic sea" in Latvia (Apr 2005) *http://sea.helcom.fi/dps/docs/folders/Response%20Group/Workshop%20on%20dispersants,%202005.html*

10. Rapporteur´s view on the state of the art and progress up to 2015

A lot of work has been and is still being carried out on dispersants worldwide.
The first issue for the coming years should be harmonising the methods used in order to obtain comparative results between the different research teams.
This should be applied to the studies on dispersant and also to those on oil weathering which are used to assess the window of opportunity for dispersant.
European standards should be developed on dispersant testing (efficiency test and toxicity tests bearing in mind that, for toxicity, the philosophy of the tests should be harmonised first), as well as standards for application equipment (in terms of spraying capacity assessment, on the equipment specification, on the fixation of the equipment on the ships…).
The second issue is to better assess the potential impact of dispersed oil, through similar and comparable experimental approaches, in order to harmonise recommendations on the use of dispersant based on the NEBA scheme, and to open it to coastal waters. As a continuation, a common methodology to define the area where dispersant can be used safely for the environment (geographical limits for dispersants) should be defined.

11. Socio-economic environmental impact

A common approach on dispersant approval would open up the market for dispersant suppliers, as a dispersant would be approved in a large number of countries. Moreover, the stockpile of dispersants could be mutualised, in order to facilitate the oil spill responders' job.
The adoption of common approaches to application devices in order to obtain similar and comparable assessment results would open up the market for application devices, and would offer the possibility of exchanging of equipment between European stakeholders.

The final objective of such developments should be the definition of a common policy on dispersants use in European water between Members States.

12. Conclusions

Despite the large amount of work which has been carried out on the dispersion technique, and which have caused this technique to become one of the major ones, there are still a lot of aspects which remain unclear and on which research work should be carried out.
This include either the physicochemical aspects, either the ecotoxicological aspects, without excluding the practical sides, such as the application, the strategy through the development of tools for the responders, such as developments of application equipment and decision models based on a comparative analysis (NEBA).
Dispersion is a complex process, rendering decision making difficult and often controversial. The approaches are quite different according the countries concerned, and the rationales based on different arguments.
So far, the research works already conducted by the different scientific teams, have been carried out often independently, sometimes in collaboration but each stakeholder keeping in own conclusions.
It is time to adopt a real cooperation with the will to come to accepted conclusions on the different issues related to dispersant and in the future to arrive to a common strategy on the use of dispersants at least at the European level.
This evolution should begin by a real effort to harmonise the research method in order to come to comparative results. This should be a major criterion in the selection of the future research projects on dispersants.

13. Abbreviations

CEFAS	Centre for Environment, Fisheries & Aquaculture Science
DFO	Department Fisheries and Ocean
EMSA	European Maritime Agency
HELCOM	Helsinki Commission
IFP	Institut Français du Pétrole
IMO	International Maritime Organisation
ITOPF	International Tanker Owners Pollution Federation
NEBA	Net Environmental Benefits Analysis
OSRL	Oil Spill Response Limited
SINTEF	Norwegian laboratory of Sintef Applied Chemistry
SFUV	SpectroFluorimetry Ultra Violet
WSL	Warren Spring Laboratory

14. References

14 – 1 Guidelines and Manuals on dispersants

- 1995 -IMO / UNEP Guidelines on Oil Spill Dispersant Application including Environmental Considerations 1995
- 2001 - Dispersant and their role in oil spill response – second edition - IPIECA report series –vol 5
- 2005 -Using dispersant to treat oil slicks – airborne and shipborne treatment – Response Manual – Cedre
- 2007 – H Chapman, K Purnell, R Law & M Kirby; The use of chemical dispersant to combat oil spills at sea: A review of practice and research needs in Europe to be published this year. Marine Pollution Bulletin 2007- being published.

14-2 Other documents

- IMO Counter Measures Manual
- 2005 - Oil Spill Dispersant – Efficacy and Effect – National Research Council of National Academies
- 2005 - EMSA : Inventory of national policies regarding the use of oil spill dispersants in the member states- nov 2005 (to be loaded from http://www.emsa.eu/end645.html)

15. Specialist organisations

Cedre **(France)**
SINTEF (Norway)
Oil Spill Response Limited (UK)
ITOPF (UK)

Annexes

ANNEX 1
Expertise of the rapporteur

Main studies and publications related to dispersant issues
Research and Development:
1979 – 1986: Participation to the field test program PROTECMAR to assess the efficiency of dispersants.
1980 - 1982: Field test to assess the dispersant spraying capability of the Canadair airplane of the French Civil Security.
1980 – 1981: Definition and assessment of the dispersant spraying bucket SOKAF 3000 to equip the heavy helicopters of the French Navy.
1985: Definition of the shipboard spaying system to equip the French Navy ships.
Since 1986: Person in charge of the approval procedure for dispersant in France.
1990: Study to define the general principles for the use of dispersants in inland waters.
1992: Field test to assess the spraying capability of the C130 Hercules aeroplane; (study carried out for the MSRC (Texas – USA)
1994 – 1999: Definition of geographical limits along the French coast for the use of dispersants.
1995 - 2000: Development of pilot scale experimental tests to assess the behaviour and the dispersibility of various oils
2003: Participation at the UK 2003 dispersant sea trials
2004: Organisation of the sea trial DEPOL 04 on dispersants
2005: Organization of the sea trail on dispersant DEPOL 05.

Revision of official documents and workshops organisation
1987 – 1988: Participation to seminars on dispersant; work carried out for ROPME (Qatar & Abu Dabi)
1987 – 1988: Animation of training courses specialised on dispersants and other treating agents; work carried out for EC and REMPEC (Marseilles France)
1991: Co-ordinator for drafting the position paper on dispersant for the Bonn Agrement (North Sea surrounding countries).
1995 – 1999: Chairman of the standardisation committee on treating agents (committee AFNOR T 71A); drafting standards on measurement methods on dispersant (efficiency T90-345, toxicity T90 348 and biodegradability T90 346), on shipboard spraying equipment (T71 400) .
1995: Animator of the IMO – UNEP workshop in charge of drafting guidelines on dispersant, (IMO/UNEP Guidelines on Oil Spill Dispersant Application).
1999: Reviewing the chapter related to dispersants of the combating manual of the Bonn Agreement.
2000: Animator of a workshop on dispersant organised by REMPEC for the Mediterranean East region
2000 - 2001: Revision of the chapter related to dispersant in the section IV of the IMO manual on Oil Pollution.

2001: Revision of the IPIECA report on dispersant (Dispersants and their Role in Oil Spill Response).
2005: participation to the study: Development of an Operational Manual on the Applicability of Oil Spill Dispersants for EMSA
2006: part of the reference group for dispersant in the ice infested water JIP (N)
2007: part of the reference group on dispersant in the Coastal Research Response Center (US)

Main publications
As secondary author:
1985: C Bocard et al.: recent advances in dispersant effectiveness evaluation and field aspects; IOSC 1985
1987: JP Desmarquest er al. Protecmar : the French experience from a seven-years dispersant offshore triels program ; IOSC 1985
1999: J Guyomarch et al.; dispersants and demulsifiers studies in the laboratory, harbor and polludrome; IOSC 1999
2001: J Guyomarch er al.; experimental oil weathering studies in hydraulic canal and open pool to predict oils behaviour in case of casual spillage; IOSC 2001
As first or co-author
1987: C Bocard & F Merlin : manuel Cedre / IFP sur l'utilisation des dispersants à partir de navires.
1989: F Merlin et C Bocard: manuel Cedre / IFP sur l'utilisation de dispersants par voie aérienne.
1989: F Merlin et al.: optimisation of dispersant application especially by ship; IOSC 1989
1991: F Merlin et al.: toward a French approval procedure for the use of dispersant in inland waters; IOSC 1991
1995: F Merlin et al.: the use of dispersants at sea: defining geographical limits for the French coastline; Forum R&D de l'OMI Londres)
1999: J Guyomarch & F Merlin: study of the feasibility of chemical dispersion of viscous oils and water-in-oil emulsion; AMOP 1999
1999: J Guyomarch & F Merlin: methodology for assessing oil weathering in a dedicated hydraulic canal: evolution of the physical-chemical properties and dispersibility of various crudes; IOSC 2000
2002: J Guyomarch & F Merlin: oil weathering and dispersibility studies: laboratory, flume, mesocosms and field experiments; IMO, 3rd R & D Forum.
2006: F. Merlin: Depol 04; Sea trials in the French waters; Interspill conference; London

ANNEX 2

Expertise of contributing organisations *related to dispersant issues***;**

SINTEF

Department of Marine Environmental Technology at SINTEF has 35 employees. Main activities are: experimental, monitoring and modelling studies and response methodologies connected to releases of oil and chemicals to the marine and terrestrial environment. Personnel employed at the department of Marine Environmental Technology have during the last 25 years been working with topics related to oil spills and oil spill counter-measurements. (see also http://www.sintef.no/marine_environment)

Examples of Research and Development programs / projects at SINTEF related to dispersant issues:

1984-91: Dispersion of Oil On Sea (DOOS- program)
1986-94: Application of dispersants on weathered oils - DIWO 1+2)
1991-94: Properties, behaviour and dispersibility of oils in Arctic and ice infested waters (ONA-program)
1991-96: ESSO/SINTEF Coastal Oil Spill Treatment – ESCOST-program
1991-95: Weathering properties of crude oils transported in U.S. waters (MSRC-project)
1993-98: Evaluation of regulations for use of dispersants in Norway
1998-00: Advanced Management of Oil Spills (AMOS- program)
1998-00: Dispersant testing of heavy bunker fuel oils (Exxon program)
1999-00: Operational Effectiveness of Oil Spill Dispersants (OSRL-project: SINTEF/AEA/CEDRE-cooperation)
2001: Oil Spill Dispersants – State of the art (SINTEF / Alun Lewis cooperation)
2004-05: Extension of "time window" for effective use of dispersants
2005-06: Operational Manual / Support Tool on Applicability of Oil Spill Dispersants (EMSA-project,: SINTEF / Alun Lewis/ CEDRE cooperation)
2006-09: Oil in Ice: Use of Dispersants in arctic conditions (JIP)
2006-09: Oil Spill in coastal and shallow water / Oil on shore (JIP)

Weathering and dispersibility of oils at sea

A methodology for studying and predicting the weathering behaviour and chemical dispersibility of oils at sea has been developed and improved at SINTEF over a period of 20 years. SINTEF has over this periode of time performed dispersibility testing on regular basis in combination with weathering studies of about 100 crude oils in addition to some heavy fuel oils and other refined products.

Full-scale field trials with experimental oil slicks in the North Sea with application of dispersants: 1982, 1983, 1984, 1989, 1994 1995, 1996 and 2006.

ANNEX 3

Research programs conducted currently in North America

- Field Verification of SIMAP Oil Spill Fate and Transport Modelling and Linking CODAR Observation Systems Data with SIMAP Predictions (James Payne, Payne Environmental Consultants, Inc)
- Dispersant Effectiveness as a Function of Energy Dissipation Rate and Particle Size Distribution (Kenneth Lee, Bedford Institute of Oceanography)
- Effects of Dispersants on Oil-SPM Aggregation and Fate in US Coastal Waters (Ali Khelifa, Environment Canada)
- Establishing Performance Metrics for Oil Spill Response, Recovery and Restoration (Seth Tuler, Social & Environmental Research Institute)
- Monetary Values and Restoration Equivalents for Lost Recreational Services on the Gulf Coast of Texas Due to Oil Spills and Other Environmental Disruptions (George Parsons
- University of Delaware)
- A Convergent Validity Test of the Parameter Updating Method (Christine Poulos, Research Triangle Institute)
- Acute and Chronic Effects of Oil, Dispersant and Dispersed Oil to Symbiotic Cnidarian Species (Carys Mitchelmore, University of Maryland, Chesapeake Biological Laboratory)
- Studies Using an Estuarine Turtle (the Diamondback Terrapin) to Assess the Potential Long-Term Effects of Oiling of Nests During Early Embryonic Development (Christopher Rowe, University of Maryland, Chesapeake Biological Laboratory)
- Survival Time Models Quantitatively Predict Lethal Effects of Pulsed, Short- and Long-Term Exposure to Water-Soluble Oil Spill Fractions (Michael Unger, College of William & Mary, Virginia Institute of Marine Science)
- Integrating Demographic and Physiological Parameters in NRDA (Victor Apanius, Wake Forest University)
- Relationship between Acute and Population Level Effects of Exposure to Dispersed Oil, and the Influence of Exposure Conditions Using Multiple Life History Stages of an Estuarine Copepod, Eurytemora affinis, as Model Planktonic Organisms (Gina Coelho, Ecosystem Management & Associates, Inc.)
- Delivery and Quality Assurance of Short-Term Trajectory Forecasts from HF Radar Observations (Newell Garfield, San Francisco State University)
- Measurements and Modelling of Size Distributions, Settling and Dispersions (Turbulent Diffusion) Rates of Oil Droplets in Turbulent Flows (Joseph Katz, The Johns Hopkins University)
- Ecology and Economics of Restoration Scaling (Charles Peterson, University of North Carolina)
- Development of a Numerical Algorithm to Compute the Effects of Breaking Waves on Surface Oil Spilled at Sea: Dispersion and Submergence/Over-Washing as Extremes of a Theoretical Continuum (Mark Reed, SINTEF Materials and Chemistry)