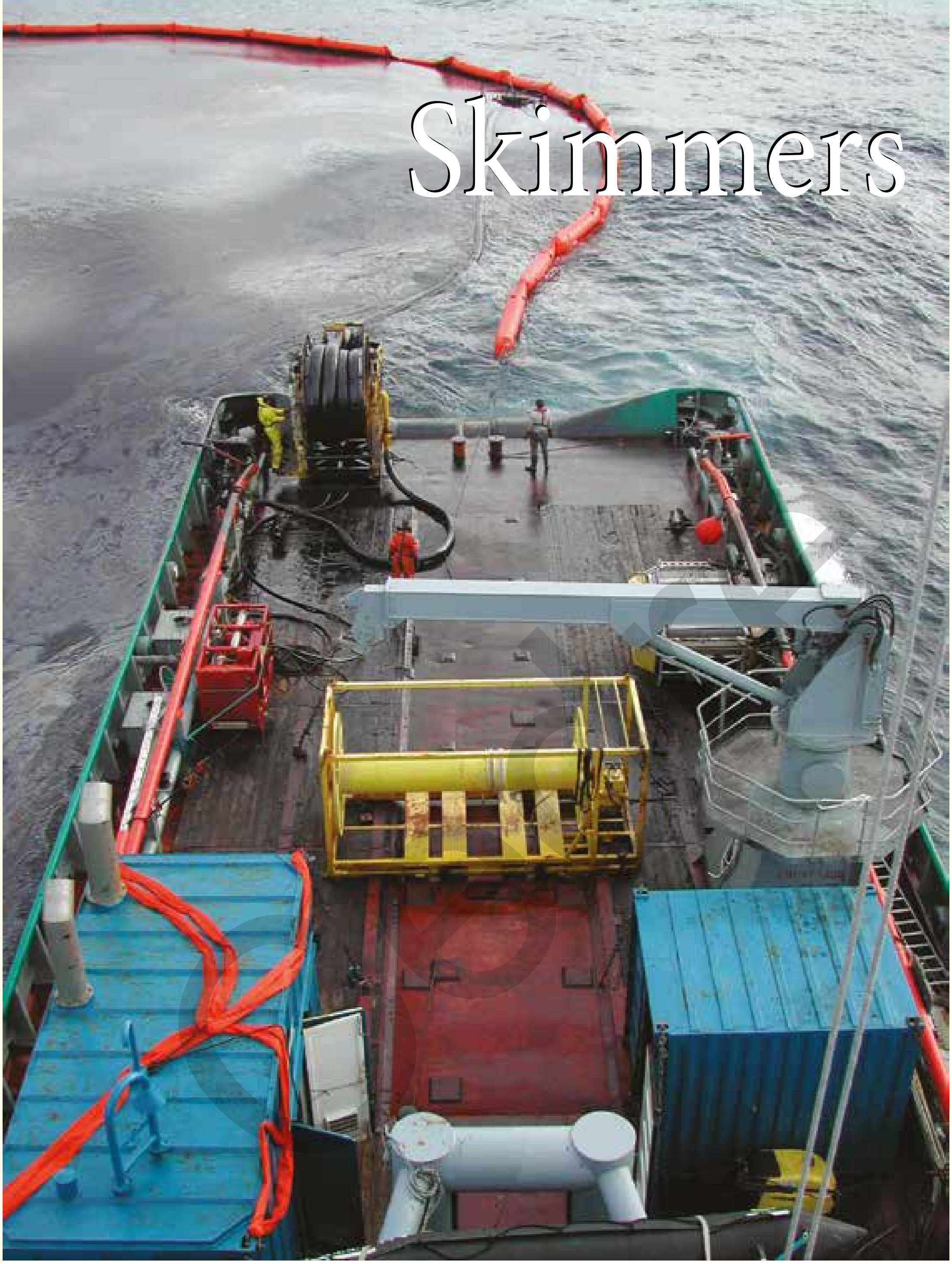

Skimmers

OPERATIONAL GUIDE

Cedre

Skimmers

OPERATIONAL GUIDE

Information
Decision-making
Response

Guide produced by Cedre with financial support from Total and the French Ministry of the Environment, Energy and the Sea

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Containing and recovering an oil slick,
Prestige spill in 2002
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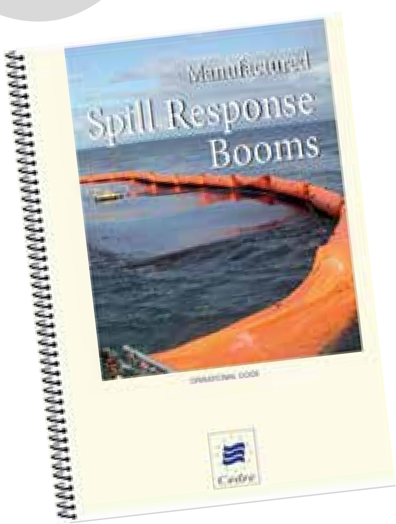
Purpose and structure of this guide

Whether the aim is to rapidly remove all or some of a substance spilt at sea, inshore, in an estuary, a harbour or in continental waters, or to collect pollutant which has been remobilised following clean-up operations on the shoreline (rocks, infrastructures, etc.), the use of skimmers is extremely common practice in spill response operations. It is therefore important to have equipment which has been selected, purchased, tried and tested in advance, as part of a response planning and preparedness effort, in order to determine the performances of these skimmers and the relevant ancillary equipment, in terms of deployment and expected efficiency.

This guide is one of a collection of operational guides produced by Cedre. It is devoted to skimmers designed and marketed specifically for response to spills of floating pollutants and strives to provide an overview of the main types of equipment available in spill response stockpiles and on the market. It also covers the related ancillary means, in particular pumping and storage equipment, which is required to ensure efficient recovery. Among this ancillary equipment, containment booms are of primary importance in operations often referred to as 'containment and recovery' operations, hence the many references to the guide published by Cedre in 2013 on "Manufactured Spill Response Booms".

This guide presents Cedre's knowledge in this field, both in terms of equipment and its use. Based on the information provided and the many illustrations, readers will be able to make informed decisions on the most appropriate equipment and systems for the situation with which they are liable to be confronted, as well as to assess their relevance during exercises or training courses.

This guide mainly targets oil site personnel, rescue and protection services, fire fighters, personnel from local authorities' technical services and, more generally, all personnel liable to be involved in the response to a spill in surface waters (offshore, inshore, rivers, lakes, etc.).



Cover of the guide "Manufactured Spill Response Booms"

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Preparedness - Response plan

A

A1

Why use skimmers?

Expected benefits of the recovery strategy

When a pollutant is released into a water body, whether accidentally or deliberately, various response strategies may be considered:

- **Leaving nature to do the job:** it can sometimes be preferable to let the natural environment break down the pollutant for various reasons (site layout, adverse weather conditions, highly volatile pollutant...)
- **Recovering the pollutant** while it is at the water surface
- **Chemically dispersing the spill** when all factors allow it from a technical, environmental and logistical point of view (product characteristics, geographical situation, weather conditions – NEBA approach, see. Cedre operational guide on "Using Dispersant to Treat Oil Slicks at Sea" published in 2005)
- **Burning the slicks**, preferably following prior containment operations
- **Leaving the pollutant to strand** on the shores or banks and subsequently recovering it.

Unlike natural clean-up or in situ treatment options (chemical dispersion or burning) which all involve the pollutant being broken down in the natural environment, recovery on the water aims to physically remove the pollutant from the environment. When feasible, this option should, in principle, result in the least impact on the environment. Finally, in relation to collection on land, this option significantly reduces the volume of waste to be treated and means that it can more easily be reprocessed. Furthermore, it helps to reduce the extent of shoreline clean-up operations –which can be long, complex and costly – and minimise the potential impacts of a spill on coastal habitats which are often sensitive in various respects (ecologically, economically, socially, culturally, etc.).

Products suitable for recovery

Provided appropriate equipment is used, recovery operations can be carried out on the water on all types of persistent floating pollutants, i.e. mainly crude oils and refined products other than those showing a high degree of evaporation, but also vegetable oils and a few chemicals. They can also be implemented on various types of floating solid debris, possibly contaminated by liquid pollutants.

Recovering oil, the Atlantic coast

Oiled debris, Lebanon

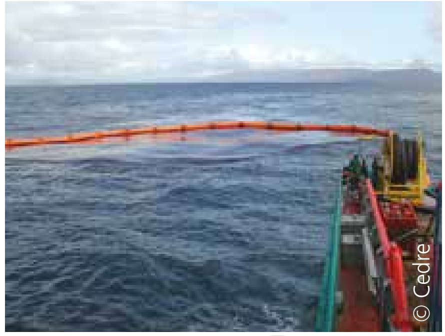
Recovering soybean oil, Brest port

When/where in relation to the spill?

Recovery at the water surface is more efficient when slicks are thick and unfragmented. It is therefore always best to recover the spill on the water as early and as close to the source as possible, provided it is safe to do so, and to concentrate the slick prior to recovery, either by promoting natural containment or by using containment booms (see Cedre operational guides entitled "Manufactured Spill Response Booms" published in 2013 and "Custom-Made Spill Response Barriers" published in 2012).

In what type of environment?

In the open sea, recovery operations on the water can only be carried out when weather conditions allow and when all the necessary logistics are in place, in particular when suitable support boats have been mobilised. The conditions may be more favourable in coastal waters, or even immediately in front of and from the shoreline, and generally tend to be even more conducive in sheltered or partially sheltered areas, such as ports, where spills, although fortunately usually small-scale, often occur. Finally, these operations are not only carried out in marine waters but can also be implemented in inland surface waters (rivers, lakes, etc.), or even in the groundwater table.



Offshore recovery

Recovery in front of and from the shoreline

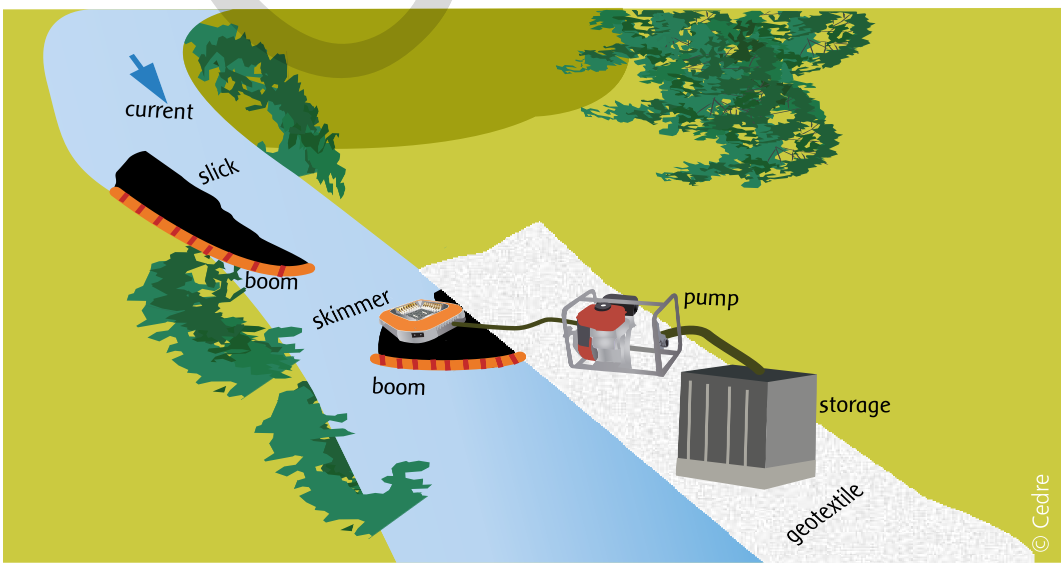
Recovery in port areas

Recovery in rivers

Links in the recovery chain

A2

Recovery of a spill at the water surface comprises a chain of operations and equipment. Skimmers are specially designed to remove the pollutant from the water as selectively as possible and, generally, transfer it to a storage capacity using appropriate hoses. Skimmers should therefore be considered as one element in a broader set-up and are therefore generally used in association with a pump system, which may be part of the skimmer, as well as a concentration and containment system, generally in the form of a manufactured floating boom. Such systems can be integrated on board a recovery vessel or port cleaning boat, which may or may not comprise its own storage capacity.



Overview of the recovery chain

Skimming means pumping

Although the transfer pump is sometimes incorporated within the skimmer, in most cases it is separate. Unlike skimmers, which are a type of specialised equipment, the pumps which may be used in spill response are not always designed to be oil, abrasion or corrosion resistant. It is therefore very important, when selecting the pump, to consider its technical specifications, taking into account the context and operational constraints foreseen by the operator.

The explosion risk must be taken into consideration if the recovered substance is a light oil. This hazard will not only influence the choice of pump, but also the drive arrangement and its position at a distance from the oil slicks and vapours.

Another delicate issue to be resolved is how to pump highly viscous products: heavy fuel oil or water-in-oil emulsions A5. Few pumps are capable of taking in and discharging such substances over distances of a few dozen metres, and those which are are generally sensitive to the presence of debris and litter. It is therefore important to keep the presence of solid waste in the product to be pumped to a minimum.

Managing and optimising the quantities recovered

Another piece of equipment which is often very useful is a settling device. Skimming is rarely perfect, except perhaps by oleophilic skimmers working in ideal environmental and operating conditions. Skimmers tend to take in a certain amount – often a large proportion – of water, which should ideally be separated from the oil to make best use of the available storage capacities. This requires a separator. The simplest such device could be a tank fitted with a drainage valve in the lower section to purge the water following settling.

Integrated transfer pump in a weir skimmer

Separate transfer pump beside a storage and settling tank

Skimmer classification

A3

Uses and dimensions

Skimmers are often classified according to their area of use: offshore, sheltered waters or calm waters. Skimmers integrated in large specialised recovery vessels are of course designed for operating offshore, while small skimmers deployed manually will only be used in calm waters. However between these two extremes, there is a wide array of equipment which may be suitable for different environments. Their classification in a given category is therefore mainly based on size and weight criteria, as well as in some cases considerations relating to their behaviour in the marine environment.

Operating principles

Generally speaking, skimmers are made up of different components designed to perform some or all of the four main functions below:

- Movement on the water
- Buoyancy
- Collection of the pollutant at the water surface
- Transfer of the pollutant to a storage capacity.

In addition to these four basic functions, skimming operations often involve an additional task: containment and concentration of the pollutant prior to collection. This task may be performed by a component of the skimmer itself or by an associated containment boom.

Recovery vessel

Small skimmer (on the right in the photo)

Self-propelled skimmer

Buoyancy

Most skimmers are self-buoyant, with the exception of those integrated into or operated by vessels which therefore ensure that the collection device remains at the water surface and position it on the slick.

Propulsion

In terms of their movement on the water, skimmers can be divided into the following categories:

- **Self-propelled**: driven by a remote controlled propulsion system in order to position them on the thickest part of the slick
- **Dynamic**: generally deployed at, or integrated into, the front or side of a vessel. They are positioned by the vessel in relation to the slicks, to promote their encounter and recovery. Most such skimmers can also be used in a stationary position, facing into the current.
- **Static**: positioned in the centre of the slick, they are generally held in place and moved using ropes.

Self-propelled recovery barge

Dynamic recovery system (alongside vessel)

Static skimmer (C)

Collection

There are two main methods of collecting the pollutant at the water surface:

- **Mechanical recovery**, which is based on the fluid properties of the water and pollutant mixtures and the differences in density between the pollutant and the water
- **Oleophilic recovery**, which is based on the adhesive properties of the pollutant on materials placed in contact with the water and the pollutant.

Generally speaking, oleophilic skimmers are far more selective (over 90% oil in the mixture recovered in optimised operating conditions) due to their operating principle (affinity with oil but not water). They generally however offer lower recovery rates of pure pollutant than those of certain mechanical skimmers.

Transfer to a storage capacity

The collected pollutant is generally transferred to a storage capacity using a pump which, together with the storage capacity itself, may be:

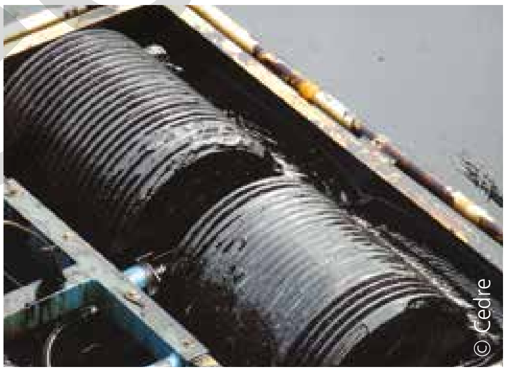
- Integral pump
- Separate from the skimmer.

Different types of skimmers

There are 5 main types of skimmers and recovery systems:

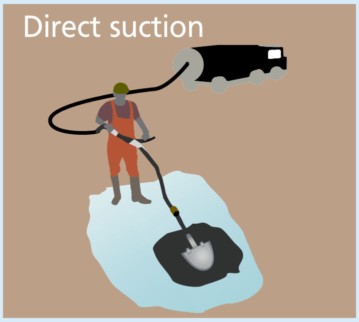
- Mechanical
- Oleophilic
- Recovery boom systems
- Surface nets and trawls
- Port cleaning boats.

Mechanical skimmer (weir)

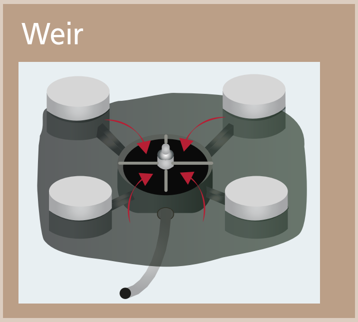


Oleophilic skimmer (grooved drum)

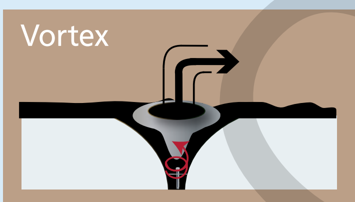
Mechanical skimmers



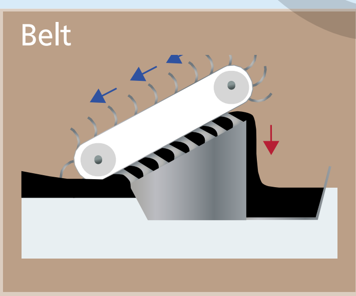
A skimmer head connected to a suction system removes the surface layer. These systems are very simple to operate and are very convenient when working in shallow waters and at the water's edge, used in conjunction with a vaccum system. Although this method has low selectivity, it is commonly used, especially on small spills.



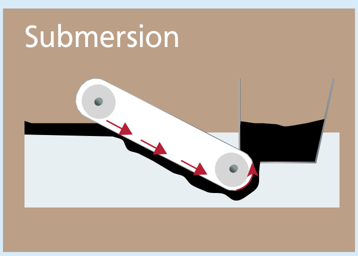
By placing a weir below the surface, only the layer of pollutant which flows into the sump is collected and recovered using a pump. In the case of most weir skimmers, the weir floats on top of the contents of the sump, meaning that its height can be adjusted according to the thickness of the slick, by adapting the pump rate.
These devices are also simple to operate, although they are more elaborate and more selective than the previous category. Their efficiency is directly dependent on the type of integrated or associated pump, with an integrated pump being preferable to recover viscous products.
Many such skimmers exist and are suitable for responding to thick slicks (or slicks thickened by containment) preferably in calm waters. However several models have also be developed for use offshore and have been proven to operate in rough seas, although with lower selectivity.



The pollutant, less dense than water, becomes concentrated at the centre of a spiral motion, thus allowing selective pumping.
These devices are mainly suitable for use on fluid products in calm waters.

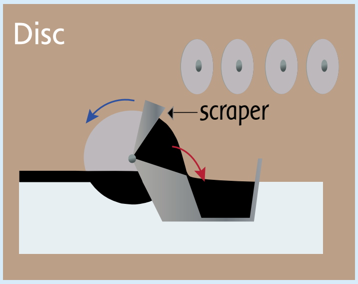


A belt or drum fitted with paddles lifts the pollutant up a ramp and into a storage and settling tank.
These skimmers are particularly suitable for recovering highly viscous products. They can be used in static mode, with a light current pushing the pollutant towards the skimmer, usually installed on a small port workboat, or in dynamic mode, at the apex of a towed boom.

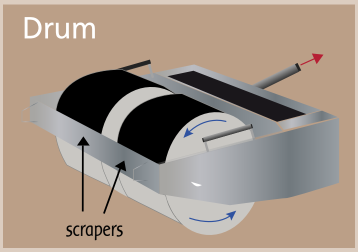


The pollutant is pulled under the water by a sloping ramp or chain as far as a collection sump where it gathers at the surface and is recovered by pumping. These devices are more effective on substances with low to moderate viscosity and show good selectivity. To function efficiently they require a light current, possibly generated by the skimmer itself (dynamic mode). At fast flow rates or in the presence of waves, there is a risk of leakage due to entrainment under the collection sump.

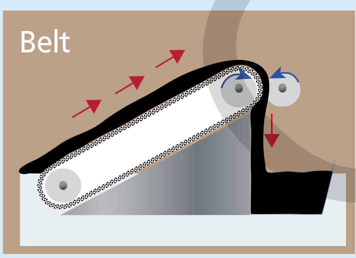
Oleophilic skimmers



Oleophilic discs rotate around a horizontal axis in the liquid then in the air where scrapers remove the pollutant from the discs. The rotation speed can be adjusted to optimise the operation according to the characteristics of the pollutant and the slick thickness, bearing in mind that an increased rotation speed often means reduced selectivity.
These skimmers are highly selective yet generally have a low throughput.
Many such skimmers exist in varying degrees of sophistication and are of particular interest for selectively recovering small spills of fluid to moderately viscous pollutants, in static mode. Grooved disc skimmers have been developed to increase the recovery rate. Tooth disc skimmers have been developed to recover highly viscous pollutants, but are mainly based on a mechanical recovery principle.

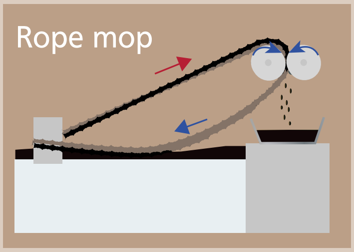


When the skimmer is placed in contact with the slick, the pollutant adheres to the oleophilic fabric on the outside of the drum and is subsequently scraped off the emerged part of the drum. Like for disc skimmers, the rotation speed can be adjusted according to the viscosity of the pollutant and the thickness of the slick.
These devices are very selective and their performance (recovery rate and efficiency) increases with the viscosity of the pollutant.
Their performances can be increased by operating in dynamic mode.
Grooved drum skimmers have been developed to increase the recovery rate.

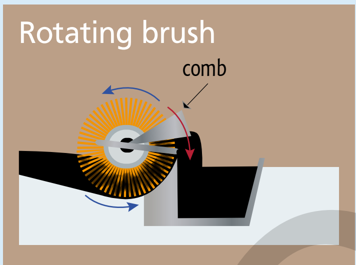


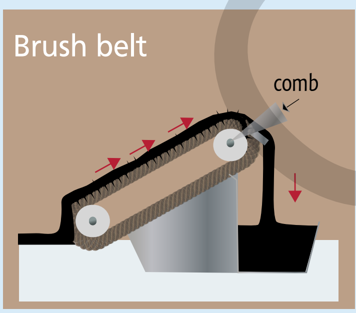
A permeable belt works like a conveyor belt while draining off the water before squeezing out the pollutant.
These skimmers are highly selective and debris tolerant and are particularly efficient in the case of viscous products.
They should ideally be used in dynamic mode to promote contact between the pollutant and the belt, whether vessel-mounted or deployed at the apex of a boom alongside a vessel of opportunity.

Diagrams © Cedre



The oleophilic rope rotates continuously between a drive pulley and a return pulley. The drive pulley is combined with squeeze rollers which express the pollutant which is then collected and removed by pumping.
These highly selective skimmers are the least affected by choppy waters. Their use is limited by their low mobility however they are appropriate for use in inland waters. The rope rotation speed can be adjusted according to the slick thickness and the viscosity of the pollutant. In the case of highly viscous pollutants, the throughput is lower due to the difficulty in wringing out the rope.
Vertically suspended models have been developed for use at sea from a vessel. They are of particular interest in Arctic environments as they are able to recover oil from ice-infested waters. They are relatively debris-tolerant.
When vessel-mounted onboard a catamaran, they can be operated dynamically, based on a zero relative velocity (ZRV) design.





The pollutant adheres to the surface of the brushes and/or is trapped between their bristles, and is then removed by a comb. Most models comprise several brushes which rotate in parallel around a central structure such as a conveyor belt or a drum.
Various configurations exist, from small static skimmers to dynamic systems mounted at the bow or side of a workboat or vessel. Dynamic operation is preferable, especially if the brushes are rotating clockwise.
These skimmers are generally efficient on viscous to extremely viscous substances and are relatively debris-tolerant. The greater the number of rows of brushes, the higher the recovery rate will be.

Diagrams © Cedre

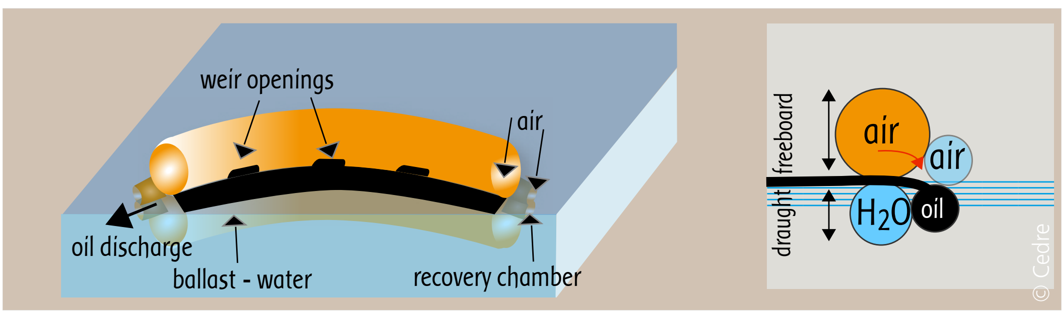
Recovery boom systems

Various mechanical recovery boom systems have been developed for spill response. These systems include a containment boom designed to concentrate the spill before it is recovered at the surface by an integrated device. Such systems necessarily operate dynamically, even if simply moored facing into the current. They offer many advantages:

- A high encounter rate
- A certain flexibility, meaning that they remain efficient in waves
- Their compatibility with powerful pump systems resulting in recovery rates of several hundred m^3/h.

A few limitations on their use and their performance should nevertheless be taken into consideration:

- They all require a speed of 1 to 2 knots relative to the water flow to reduce oil leakage, which implies the use of vessels able to work at low speeds
- Their selectivity is generally moderate to poor, meaning that large storage and settling capacities are required downstream of the skimmer
- Given that they rely heavily on the capacity of the pollutant to flow into the recovery system and to be gradually evacuated, they are most appropriate for recovering fluid to moderately viscous substances.



Recovery boom systems

Surface nets and trawls

These systems have been specially developed to recover solid, or at least extremely viscous, products, or oil slicks to which powdered sorbents have been applied.

Several systems exist based on a trawl design consisting of two parts:

- The first section is a concentration device designed to contain and thicken slicks; strictly speaking this is the "trawl" component.
- The second section, generally referred to as the cod-end, collects the oil and, when full, can be removed from the trawl and closed in order to be either hauled aboard a storage vessel or towed to land to be unloaded.

The first section can be made either of netting or of boom sections, or of a combination of the two. The cod-end, usually designed to be disposed of after use, is made of a very fine mesh net (1 to a few mm) and can have a capacity in the range of a few m^3 to a few dozen m^3, but generally around the 10 m^3 mark.

These trawls have been designed for several reasons:

- Compared to fabrics conventionally used for containment booms, the use of mesh materials to collect the pollutant provides less water resistance.
- These systems are easy to deploy and relatively compact.
- They also cope well in swell.

These three characteristics mean that these systems can be operated by small fishing boats which, especially in the case of trawlers, are suitable for handling this type of equipment.

Over and above the difficult on-site management of cod-ends filled with pollutant, the main drawback of such systems is their discontinuous operating mode, which results in relatively modest global performances which are not sufficient to respond to a major oil spill.

Surface trawls

Port cleaning boats

These workboats are mainly designed for collecting solid floating debris and are generally self-propelled. They are primarily designed to deal with the problem of chronic pollution, which is the main pollution issue in ports. They can however be used to recover highly viscous or practically solid oil. Furthermore, certain models can be fitted with an optional device for selective oil collection.

Port cleaning boat

Standardisation

Recovery vessels

Various standards have been developed to support operators in their choice of spill response equipment. In the field of recovery, certain certificates exist which attest to a vessel's capacity to implement oil recovery operations at sea and to store the recovered oil onboard:

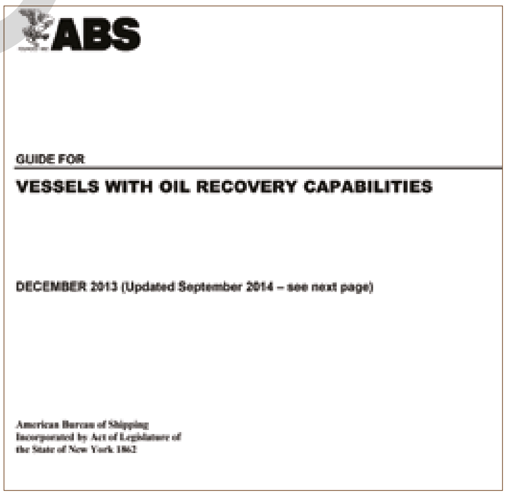
Det Norske Veritas (DNV) OILREC notation for oil recovery vessels

Since 1993, the Norwegian classification society Det Norske Veritas (DNV) has been offering an OILREC notation for vessels capable of implementing oil recovery operations at sea E5.

ABS Guide "Vessels with Oil Recovery Capabilities"

In 2006, the American Bureau of Shipping (ABS) developed this guide with the aim of promoting the safety of vessels and personnel by providing specific requirements for tugboats, supply vessels, and other vessels which are intended for service in the event of oil spills and are equipped for the storage of recovered oil floating on the sea. A version updated in 2013 and amended in September 2014 differentiates two classes of vessels, according to their capacity to recover oil with an unknown flash point or only oil with a flash point exceeding 60°C.

The Far Spica*, a Norwegian recovery vessel*


ABS

GUIDE FOR

VESSELS WITH OIL RECOVERY CAPABILITIES

DECEMBER 2013 (Updated September 2014 – see next page)

American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862

Cover of the ABS Guide

Individual skimmers

Several standards have also been established, in particular in Europe (France, Norway) and in the United States, to facilitate the comparison of skimmers and pumps through a descriptive vocabulary for this equipment and standardised test and characterisation protocols for the equipment and products used for these assessments:

AFNOR (*Association Française de Normalisation*) standards

In France in 1995, a commission comprising around 20 members including Cedre, AFNOR, SYCOPOL (French union of spill response equipment manufacturers and service providers) and port managers was set up.

Based on this group's work, several standards (NF T71) were established, including one aimed at ensuring consistency in the terminology and presentation of the performances of skimmers. With this standard, spill response managers and manufacturers benefit from a single frame of reference.

Other standards have been developed by AFNOR and the International Organization for Standardization (ISO), in particular standardised test procedures for skimmers and pumps, to facilitate equipment comparisons (in the conditions provided by the test facilities) E2.

ASTM (American Society for Testing and Materials) standards

The ASTM has developed several standards specific to spill response, a few of which deal with skimmers. They are listed in the appendices to this guide E3.

Standard F1778-97 defines a classification for skimmers, which is used and developed in the World Catalog of Oil Spill Response Products.

Standard F631-99 defines 5 reference classes of oil for comparative performance tests on skimmers.

Standard F2709-08 provides a standardised protocol for establishing skimmer performances.

DNV skimmer certification

DNV has developed three main standards or procedures relating to skimmer assessment, based on which this equipment classification society can provide certification, upon request by manufacturers or suppliers E4.

Nordtest standards

The Finnish body Nordtest has also issued standards in this field, in particular standard NT CHEM 002 (Performance testing of oil spill skimmers), which is heavily inspired by DNV and ASTM (F631-99) standards.

Booms, sorbents, pumps and other ancillary equipment

Booms

When recovering a spill at the water surface, the use of containment booms to concentrate and thicken the slicks around or in front of the skimmer is almost always required. Likewise, the deployment of containment booms to protect a site or contain a spill generally calls for the use of skimmers to recover the oil. For information relating to the choice of booms and the optimisation of their use, please see the Cedre operational guide released in 2013 on "Manufactured Spill Response Booms". We draw readers' attention to the need to ensure consistency between the size of boom and of skimmer chosen.

Sorbents

At the end of recovery operations, floating sorbents (loose or conditioned) are often used to recover the remaining oil left by the skimmer (see Cedre operational guide published in 2009 on the "Use of Sorbents for Spill Response"). When saturated, loose sorbents can be recovered either using a conventional skimmer capable of recovering such products, or using specific tools (e.g. scoop nets). In all cases, oiled sorbents must be stored separately from the liquid substances collected previously by the skimmers, as their treatment and disposal methods will differ.

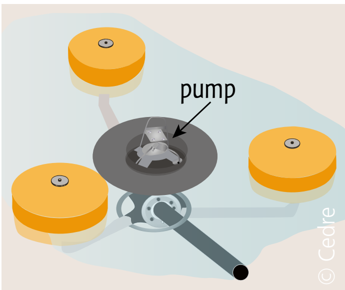
Containment boom used with a skimmer

Collecting contaminated loose sorbent using a scoop net

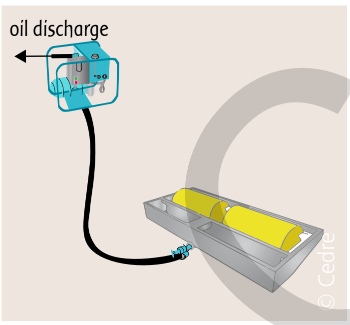
Pumps

The pumping equipment used in conjunction with the skimmer, whether required only to transfer the recovered pollutant to an ancillary storage capacity or also to channel the pollutant towards the skimmer, is a crucial element in the skimmer's performance. The pump may be incorporated within the skimmer (integral pump) or be separate. Integral pumps virtually only provide a discharge function and are often submersible pumps, while separate pumps provide both suction and discharge functions.

Few pumps have been developed specifically for spill response, apart from a few submersible pumps intended primarily to be integrated within the sump of a skimmer, in particular weir skimmers, and designed to perform well on viscous pollutants and to tolerate small debris.



Skimmer with integrated transfer pump



Transfer pump connected to a skimmer

Skimmers with separate pumps

The selection of pumps suitable for recovering and transferring oil is often based on the oil's viscosity, whether intrinsic (e.g. heavy fuel oils) or due to weathering (e.g. evaporation of the light fraction) or emulsification at sea. However the risk of explosion should also be taken into account when recovering light products, in particular most freshly spilt crude oils. Yet rather than affecting the choice of pump itself, this risk will influence the choice or location of the power source, which will preferably be located remotely in relation to the spill and the emanating vapours. The most problematic, and certainly the most common, issue in terms of response at sea is that of pumping viscous substances, heavy fuel oils and water-in-oil emulsions. Few pumps can take in and discharge such products over distances of a few dozen metres, and those that can are rarely debris-tolerant (plants, solid waste: pieces of netting, plastic packaging, etc.).

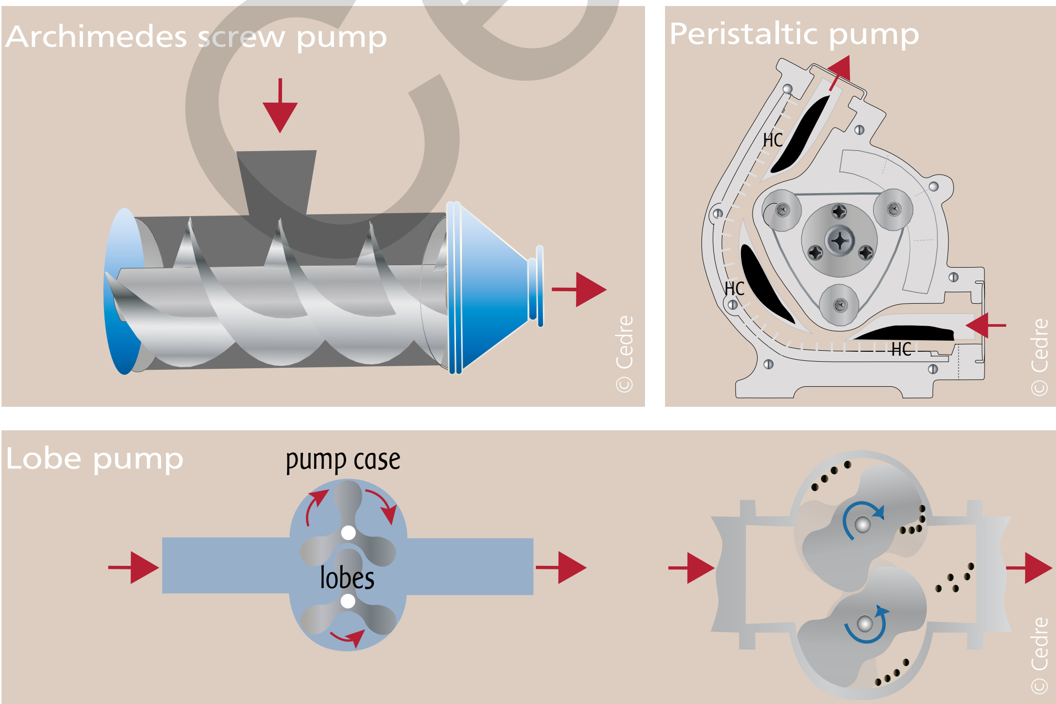
Generally speaking, **displacement pumps** are most suitable for recovering and transferring non-aggressive, viscous pollutants. They have the advantage of being relatively debris-tolerant.

The most efficient displacement pumps for recovering highly viscous products are Archimedes screw pumps, integrated within skimmers. In terms of remote displacement pumps, peristaltic or lobe pumps can also perform well, and have the advantage of relatively easy maintenance and being self-priming, but have lower flow rates.

Centrifugal pumps, unlike displacement pumps, are rapidly limited by viscosity. This limitation is aggravated by the tendency of centrifugal models to promote the formation of water-in-oil emulsions. To support recovery operations, they are often used to pump water rather than the pollutant itself, to facilitate containment (concentration of the pollutant by water jets, water curtains, etc.).

Diaphragm pumps can also be used, mainly on fluid substances which must be exempt from debris, to which they are particularly sensitive. Their use therefore requires a certain number of considerations in relation to the spill context (e.g. port waters with floating litter) and possible adaptations (e.g. use of a strainer on the skimmer with which the pump is being used, preferably used with oleophilic skimmers).

Trolley-mounted ATEX lobe pump with electric motor



Archimedes screw pump, peristaltic pump and lobe pump

Vacuum systems are often used in conjunction with a suction head for direct recovery. They have the advantage of performing pumping and recovery, storage, settling and, in some cases, transport operations. They are relatively tolerant to small solid debris, as long as it can then be easily removed from the tank. This tank may be simply a drum or a slurry or vacuum tanker. For safety reasons, such systems must only be used with pollutants with a high flash point.

Slurry tankers

Portable vacuum system

Backpack vacuum system

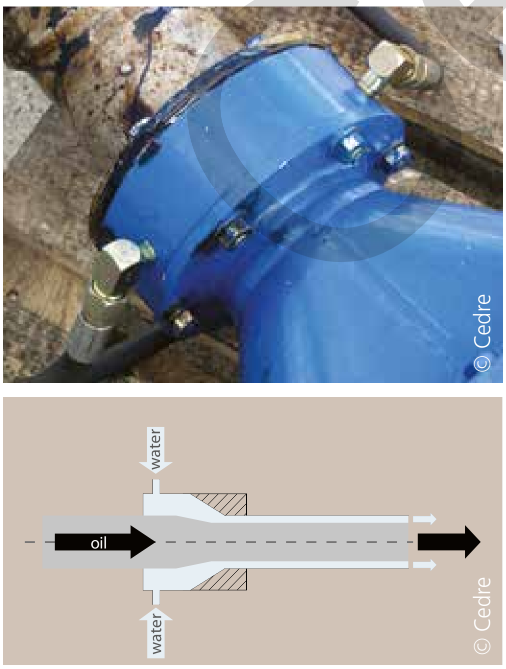
Vacuum truck

Vacuum truck

Annular water injection

To minimise head loss in the hoses when pumping highly viscous substances, it can be beneficial to include water with the pollutant, and thus to accept being less selective than is usually recommended. This concept is optimised by an annular water injection system, which is generally set up at the pump outfall where it creates a ring of water between the walls of the discharge hose and the substance being transported. In this way, the pollutant is transported almost as if it were water, by injecting water at a flow rate representing only a small percentage of the pollutant flow rate. Several suppliers of skimmers or pumps designed for spill response now offer such systems (annular injection flange and pump).

Instead of or in addition to this technique, the use of wider and/or shorter hoses will also reduce head loss and therefore improve the pumping of viscous substances.



Annular water injection system

During the *Erika* spill, the crew onboard the Dutch recovery vessel *ARCA* injected hot water (or steam) at the pump intake to fluidify the highly viscous fuel oil.

Hoses and fittings

Suction or discharge

Only direct suction systems and skimmers with a remote pump require suction hoses, which must be semi-rigid to prevent collapse due to the pressure exerted on them.

However, almost all skimmers and transfer pumps require the use of discharge hoses, preferably very flexible (similar to fire hoses) to facilitate handling and repacking, and made of a material compatible with the pollutant to be pumped.

Compatibility of fittings

The hoses are connected to the skimmer and/or its pump, as well as to other hoses, using different types and sizes of fittings. As no international standards currently exist in this respect, it is important to always:

- Ensure the compatibility of these fittings, or
- Use intermediate parts to connect components of different diameters or types and ensure their compatibility (e.g. ensure that the connections on the hoses provided match: male/female).

The same issue of compatibility can be encountered with hydraulic connections between the power pack and the pump, or even the skimmer when it comprises moving parts (discs, drums, etc.).

Preventing hindrance to skimmer operation

Transfer hoses and hydraulic hoses should, wherever possible, be fitted with floats to prevent them from affecting the skimmer's position on the water.

Fitting on a hydraulic hose

Fittings on hydraulic and transfer hoses

Drive assemblies

Most skimmers and/or pumps available on the market come with a suitable drive assembly, providing the power required to drive the rotating parts of skimmers and pumps (transfer or annular injection pumps), and even, in some cases, propulsion equipment.

They are generally hydraulic power packs driven by a diesel engine. For operations at industrials sites, they must comply with the applicable standards in terms of fire and explosion risks. For response in the open sea, this is less of an issue, as operations rarely involve a fresh spill, except at oil exploration and production sites. However, as a general rule, it is important to watch out for signs of excess pressure and overheating and to follow the recommendations made by the manufacturer.

Small drive assembly

Hydraulic power pack

Pollutant storage

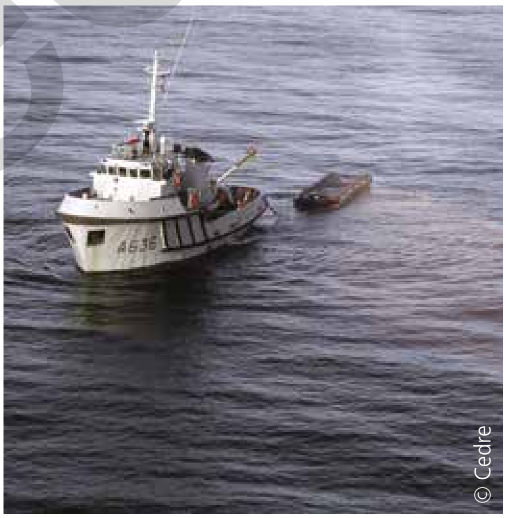
At sea

Primary storage of recovered substances is often a limiting factor during recovery operations at sea.

For the temporary storage of products recovered offshore, the best solution is to use the support vessel's onboard tanks. If this is not possible, the use of towable bladders or barges may be a solution which is generally easy to implement. However:

- Flexible tanks generally have low capacities and therefore require a greater number of transfers to secondary storage facilities.
- Closed tanks are often difficult to empty when the pollutant is viscous. The use of tanks with a removable cover can resolve this problem.
- When contemplating storing recovered products in the tanks of vessels or barges, it is important to consider the need to empty and wash out these tanks, which can prove complicated if the pollutant is highly viscous. In this case, tanks equipped with reheating systems (e.g. cargo tanks of bitumen tankers) can be used or portable heating elements can be placed in the tanks (heating rods or coils) together with a mobile heating system. It is also possible to use an annular water injection system if a submersible pump is used to empty the tank.

Flexible floating tank



Storage bladder towed by a support vessel

Inshore

In the calmer and moderately deep, or even shallow, waters of harbours and sheltered inshore areas, low draught vessels can, in addition to being suitable platforms from which skimmers can be deployed, be used to carry tanks (open-top tanks or cubitainers) or portable storage capacities. Nevertheless, it is important to ensure that these tanks, together with the other equipment taken onboard for the operation, do not jeopardise the vessel's stability (notably due to the free surface effect of liquid cargoes).

From land

For operations conducted from land, locally available equipment such as tanker trucks, agricultural tanks, slurry tankers or watertight skips can be used.

Flexible self-supporting or frame tanks can also be used and should preferably be open-topped (but with a removable cover to protect them against weather conditions) so as to empty and clean them more easily. In all cases, models with a drainage valve at the base of the tank should be used in order to remove as much of the settled water as possible (by letting it flow into the contaminated water body, in the containment area where the skimmer is operating) before removing the pollutant and transporting it to a treatment facility.

Offshore storage barge in dock

Offshore storage barge in operation

Tanker truck

Slurry tanker

Flexible framed storage tanks

Self-supporting storage tank

Flexible framed storage tank

Flexible framed storage tank

Separators

Over and above the simple gravity settling technique which can be implemented in storage tanks and which remains the simplest way to separate the large proportion of water inevitably recovered with the pollutant (except in the case of optimised use of oleophilic skimmers), a separator can be used. Separators are generally placed directly at the skimmer outlet, to concentrate the pollutant recovered and optimise the use of the available storage capacities.

However, most of the separators available on the market are relatively poorly suited to the specificities of spill response, in particular as the pollutants can have a density close to that of water (especially in the case of water-in-oil emulsions), be highly viscous and, most importantly, be present in very variable proportions in the mixture recovered. Their use should therefore be considered on a case by case basis, according to the specific response conditions.

Furthermore, the possibility of releasing the settled water may be subject to regulatory restrictions (e.g. MARPOL annexes on the discharge at sea of oily effluent). To avoid problems relating to this issue, the settled water should be discharged upstream of the clean-up site or recovery system.

Gravity settler with its power pack

Compact separator test

Pollutant separation and recovery system

Recovery vessels

Specialised vessels

Vessels specially designed to recover oil from the water are mainly small vessels (such as barges or small workboats) designed for use in harbours and exceptionally in coastal waters. These boats become very rapidly limited by their poor seakeeping ability, as well as by their small fuel tanks and lack of supplies... Furthermore, they have the drawback of having a low to very low storage capacity.

"Pre-fitted" vessels

Floating pollutants are recovered by some such vessels by direct flow into the vessel's tanks through an opening in its hull. This orifice may be located at the surface or a few dozen centimetres below it and, in this case, be connected by a hose to a floating weir skimmer. The advantage of these systems lies in the fact that they do not require a pump, meaning that they can be used on light to very viscous, or even solid, oils. They must however operate in conjunction with large capacity vessels (oil tankers, dredgers, large trawlers), pre-fitted to store the pollutant.

Spill response barge

Coastal tanker pre-fitted to deploy skimmers alongside it

Convertible multipurpose vessels

Platform supply vessels are most frequently used for offshore recovery operations. These ships have a number of advantages. Firstly, they are readily available, given the other purposes they generally serve, meaning they are very often, if not permanently, within the immediate vicinity of high risk areas. They have a vast work area on the rear deck, where response equipment can be stored and operated. Finally, these vessels show good manoeuvrability, even at low speeds, and some have integral (and sometimes even heated) storage capacities of up to 1,000 m^3 or more. They can be pre-fitted for spill response while also performing other roles. However, the generally deep draught of these vessels means that they are unable to work in shallow coastal waters.

Despite their high storage capacity, coastal tankers or bunker vessels are more rarely considered to be an interesting solution as convertible multipurpose vessels. This can be explained by the fact that their main economic activity is poorly compatible with their rapid mobilisation for spill response, in particular if they require to be unloaded and degassed, and that they are not very easy vessels to manoeuvre at the low speeds required for recovery operations.

Dredgers have long been identified as particularly suitable for recovering large quantities of floating pollutant and as a convenient solution for response to spills around major ports located in estuaries, where they generally operate. Furthermore, they can be rapidly demobilised from their normal work to respond to a spill. The use of their own suction systems and buckets can even be envisaged in specific circumstances (thick slicks of near-solid substances).

Oil spill response vessel (OSRV)

Supply vessel

Dredger

Vessels of opportunity

As long as the spill is far from the coastline and relatively concentrated at the surface, specialised vessels are the best suited and most cost-efficient choice. However when the spill reaches shallower coastal areas where it drifts in the form of fragmented slicks (to a varying extent according to sea and weather conditions and the length of time spent at sea), the use of a large fleet of vessels of opportunity can be an interesting solution. These non-specialised vessels are equipped with suitable small equipment (nets or floating trawls and big bags in crates for solid or semi-solid pollutants, booms, small skimmers and tanks for liquid pollutants). Sea and weather conditions permitting, they will supplement the fleet of specialised vessels thanks to their large number, extend it by their ability to access narrower and shallower areas, and even replace all or part of these vessels which can then be used to store the recovered substances and/or as an On Scene Commander vessel, command post, logistics base (equipment, personnel, etc.) and to provide aerial guidance.

The use of vessels of opportunity, which by definition are not pre-fitted (but can however be pre-identified), provides major logistical support, even although they are not necessarily as efficient as specialised vessels. Their use and performance can therefore be improved by ensuring that the recovery equipment and other additional resources are as suitable as possible: for instance, the US Coast Guard with its Vessel of Opportunity Skimming Systems (VOSS) or the French Navy with its surface trawls to be deployed by trawlers.

> The use of vessels of opportunity proved particularly efficient in the case of the *Prestige* spill, whereby the quantity of oil recovered by fishing boats was slightly higher than that recovered by the specialised recovery vessels. This result was largely thanks to the fleets of Spanish fishing boats and, in particular, the involvement of Basque trawlers, which were particularly well suited to recovering patches, patties and tarballs of near-solid fuel oil after having spent several weeks, if not months, weathering and emulsifying at sea.

Fishing boats involved in the response to the Deepwater Horizon *blowout in the Gulf of Mexico (US) in June 2010*

Fishing boats involved in the response to the Prestige *spill in Spain in 2003*

A7

Operational limits for the use of skimmers and their ancillary equipment

The limitations on the use of skimmers and their ancillary equipment, in particular containment booms, are related to the possibility of deploying and maintaining an effective containment and recovery system, without compromising human safety.

The operations manager is in charge of analysing the situation to ensure compliance with safety recommendations for the implementation of recovery operations.

In addition to safety precautions relating to personnel, the implementation of the recovery chain is also restricted by operational aspects relating to:

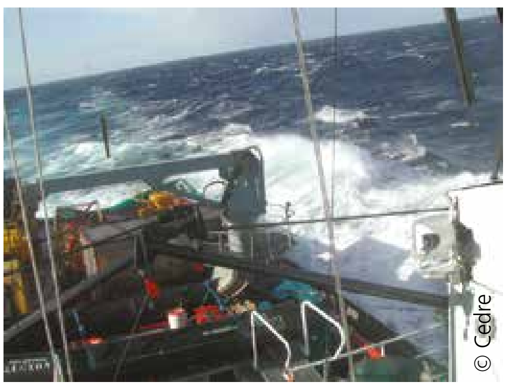
- Deploying and maintaining the configuration of skimmers and their ancillary equipment
- The physical, mechanical and hydrodynamic phenomena affecting their efficiency (directly, e.g. waves, or indirectly by influencing the physical and chemical evolution of the pollutant to be recovered), sometimes making them less attractive than other response options.

Viability limits relating to metocean conditions (waves, sea state, current)

Although no set rule can be given, it is generally accepted that sea state 4 to 5 E6 is the upper limit for implementing containment and recovery operations.

The *Erika* spill in December 1999 off the French coast followed by the *Prestige* spill in 2002 off the Spanish coast were cruel reminders of the efficiency limits of equipment recommended as some of the most seaworthy models, but also of limits in terms of responder safety. However these spills also highlighted the advantage of having vessels ready to respond to the spill as soon as the weather conditions improved as no clean-up operations could be carried out at sea during the first hours and even days following the spill.

The wind generally only had an indirect effect on the feasibility and efficiency of recovery operations, by creating surface agitation. Generally speaking, the waves, and in particular chop, had a detrimental effect on recovery, and more specifically on selectivity. The skimmers with a high inertial mass were the most affected.



Response to the Prestige *spill, 2002*

Limitations related to containment efficiency

As a general rule, except when the pollutant is concentrated around a skimmer by sustainable natural containment (against a dock wall, at the foot of a cove, etc.), recovery on the water will only be efficient if containment booms can be set up to deflect, concentrate and, as far as possible, contain the pollutant.

This is especially true for fluid pollutants with a strong tendency to spread and become fragmented. However, even in the case of extremely viscous pollutants, which in the open sea can form thick slicks (several, or even several dozen, centimetres in the case of the *Erika* spill in 1999), booms are useful, or even essential, to force the pollutant towards the skimmer inlet and thus ensure a constant flow.

In addition to the above-mentioned limits relating to the sea state, the main limitation of the efficiency of containment is related to the risk of leakage under the boom skirt, which occurs when the relative speed between the boom and the water surface reaches approximately 0.7 knots (0.35 $m.s^{-1}$). See Cedre operational guide released in 2013 on "Manufactured Spill Response Booms".

In addition to having consequences on the possibility of protecting a coastal site with strong currents, or else deflecting and containing a spill in a river (or estuary), this leakage phenomenon has consequences for dynamic containment and recovery operations in that it constitutes a constraint in terms of the capacity of vessels towing containment systems to operate at very low speeds (0.7 knots, or slightly higher if the pollutant accumulates at the apex of the boom and is continuously recovered). All vessels are not able to operate, and moreover are not easily manoeuvred, at such low speeds.

A few containment systems have been designed to conduct dynamic containment at higher speeds.

Leak under a U-formation boom with a skimmer working at the apex

Collection system able to work at higher speeds

Limitations related to the physical and chemical characteristics of the spilt products

The type of pollutant will influence the decision whether or not to carry out recovery operations. For instance, if the product spilt is petrol (gasoline) or a very volatile light oil, recovery operations are rarely feasible for safety reasons. Furthermore, wherever possible (if there is no immediate risk of sensitive sites or resources being reached), it is always best to leave natural degradation processes (evaporation, dissolution, dispersion, photo-oxidation, etc.) to remove the oil from the sea surface. These considerations relating to flammability risks mainly apply to incidents in ports (refineries, terminals, oil storage facilities, etc.) or oil exploration/production sites at sea (drilling, platforms, production line, etc.).

In the case of a single release from a stricken vessel, the time required to mobilise and deploy the necessary resources is such that that the risks will have almost disappeared by the time response operations are implemented due to the rapid evaporation of the light fractions of the oil. In all cases, it is nevertheless crucial to ensure that there is no fire or explosion risk by finding out the flash point of the product at the time of the spill and controlling it over time (using explosimeters).

Generally speaking, in the event of a spill, the product may change state at a varying rate, which can reduce the need for and possibility of implementing recovery operations on the water. When an incident occurs, the Standard European Behaviour Classification (SEBC) can be used.

SEBC CATEGORY		EXAMPLES OF CHEMICALS AND OIL "EQUIVALENTS"	RECOVERY ON THE WATER
E	Evaporators	• Hexane, benzene • Petrol (gasoline), kerosene	Inappropriate
F	Floaters	• Phtalates, vegetable oils • Heavy fuel oils, weathered crude oils	Recommended (according to viscosity)
F & E	Floaters and evaporators	• Styrene, xylene, aniline, ethylbenzene • Diesel, light crude oils	Rarely appropriate
F & D	Floaters and dissolvers	• Valeric acid	Rarely appropriate
D	Dissolvers	• Acetones, acids, alcohols, ammonia • E90	Rarely appropriate
S	Sinkers	• Dimethyl disulphide • Very heavy crude oils and refined products	Inappropriate

This classification is based on the main physical and chemical properties of the substance, i.e. its state (solid, liquid or gas), its relative density with respect to water, its partial vapour pressure and its solubility in water.

Whatever the case, it is also important to ensure that the substance to be recovered is compatible with the different components of the skimmer and its ancillary equipment, in particular for containment on the water and the storage of the recovered product (fabric, glue, connectors, etc).

However, even for products for which recovery is an option, the type of pollutant must be taken into consideration for the selection of recovery equipment. The efficiency of this equipment will generally depend not only on the density and viscosity of the pollutant, but also its pour point. If the pour point is close to the ambient temperature, the product will behave almost like a solid and will therefore be very difficult to pump. This was the case, for instance, of the heavy fuel oils spilt by the *Erika* and the *Prestige*, which barely floated, were very sticky and highly viscous, especially after mixing due to agitation at sea. A highly viscous oil is difficult to pump and will not readily flow at the water surface. In this case, few devices are able to recover viscous oil and particular attention should be paid to the choice of transfer pump. Nevertheless, certain skimmers, such as belt and brush skimmers, work better on more viscous substances, as the increased thickness and cohesion of the film of oil improves its collection at the water surface due to a mechanical effect. The only problem which remains, as was the case for the *Erika* spill, is how then to remove the product from the belt or brushes.

Conversely, skimmers suitable for recovering viscous products can show very poor performances for the recovery of fluid pollutants. It is therefore often necessary to have different types of skimmers within a stockpile intended for responding to different types and origins of spills. Thus, during the response to a given spill, the most suitable skimmers at the beginning of the spill are not necessarily the best option during a later phase, when the pollutant has weathered and emulsified.

Recovering diesel

Recovering crude oil

Recovering vegetable oil

Recovering viscous heavy fuel oil

Limitations related to the quantity and location of the spill

The quantity spilt will of course determine the quantity to be recovered, and hence the storage capacities required. It will also influence the surface area and thickness of the slicks to be contained and recovered and hence the number and choice of equipment to be deployed. Given the large amount of equipment required to carry out offshore oil containment and recovery operations, it can be considered that such operations are only justified if at least several dozen, if not hundred, tonnes of pollutant have been spilt. In the case of a small spill (a few dozen tonnes), the decision to attempt to recover oil at sea is only justified if it can be reasonably assumed that almost all of the oil spilt can be encountered and contained. This calls for equipment to be mobilised and positioned on site as rapidly as possible (which will be partly dependent on the location of the spill).

On the other hand, in the event of a major spill, the recovery equipment which may be rapidly mobilised is likely not to be sufficient, which may lead to another option being chosen, for instance aerial application of dispersants, or at least several options being implemented simultaneously, as was the case for instance for the spill in the Gulf of Mexico in 2010 with the simultaneous implementation of recovery, dispersion and in situ burning operations.

Recovery at sea. Prestige *spill (2002)*

Recovery at sea. Spill in the Gulf of Mexico (2010)

Recovery at sea. Spill in the Gulf of Mexico (2010)

Recovering washing effluents in a river

Recovering washing effluents on the shoreline

The location of the spill will influence the decision whether or not to carry out offshore recovery operations and, if such operations are to be carried out, the logistics to be implemented to minimise the impact of the distance to the nearest port on response times and the transport of the substances recovered to an on-land storage facility. The closer the spill is to the coast, the shorter the time frame will be before the oil reaches the shore. However, in this case the time required to transfer the oil to the shore will also be shorter. On the other hand, while in the case of a spill far from the coast the time window for response operations is greater, the storage and transfer of recovered products are major issues which may only be satisfactorily resolved through the availability of large storage capacities at sea (e.g. an oil tanker).

The location of the spill will also have an impact on the aerial guidance of spill response operations (see B3 and C1).

In coastal areas, on certain sites, response operations may only be implemented from the sea. It is therefore necessary to have self-propelled skimmers or skimmers which may be towed to the site by a small vessel. Furthermore, if the products cannot be directly evacuated to land, the skimmers should ideally have their own storage capacity, or be used in conjunction with a floating storage capacity (barge or bladder).

Recovering pollutant from the water at a difficult access site

As these storage tanks are generally limited in capacity to the equivalent of less than one hour of skimming, the response scenario should include a nearby unloading point either on land, at a dock where the skimmer can be moored, or on the water in areas where the water is deep enough to allow a larger storage capacity to be anchored. This unloading point should be as close as possible to the recovery area to minimise transport times.

If however the area is easily accessed from land and vacuum trucks can be positioned next to the slick, it is generally better to implement direct suction, by fitting a flat skimming head, floating or otherwise, to the suction hose to decrease the proportion of water in the collected mixture.

Recovery from a dock

Recovery from a beach

Limitations related to slick thickness

The slick thickness greatly affects the efficiency of skimmers and is determined by a number of factors, notably the quantity spilt, the initial characteristics of the pollutant (viscosity, spreading coefficient, pour point) and to a greater extent its characteristics after the time spent on the water (evaporation, emulsification), but also the natural or artificial containment of the spill. The operation of skimmers is generally hampered by the rapid spreading and fragmentation of most floating pollutants, hence the need for the combined use of containment equipment to prevent spreading and concentrate the spill around or in front of the skimmer.

A counterexample was however encountered in the case of the *Erika* spill (heavy fuel oil spill in December 1999). The recovery vessels were confronted with very thick, compact slicks (up to 30 or even 50 cm thick), which blocked the entrance to the skimmers and which sometimes had to be broken up with hoses in order to enter the weir skimmers.

Skimming thick slicks of heavy fuel oil without a containment boom, Erika *spill (1999) and* Prestige *spill (2002)*

Using a boom to concentrate the oil and promote its recovery, Gulf of Mexico spill (2010)

Skimming oil while using a boom to concentrate the oil, Gulf of Mexico spill (2010)

Limitations related to the presence of debris

The presence of solid waste obstructs the pollutant's access to the skimmer. If the skimmer features a filter system, it is liable to become rapidly clogged with seaweed, pieces of wood or other floating debris which prevents the pollutant from flowing freely into the skimmer. If however there is no filter, the debris is liable to obstruct the intake orifices or other vital parts of the pumps with which certain skimmers are fitted. Finally, debris can also prevent the discs, brushes or ropes from rotating in the case of oleophilic models. To avoid being hampered by solid waste, it is advisable to set up a filtering system made of net in front of the skimmer, providing the waste that gathers there is regularly removed by responders.

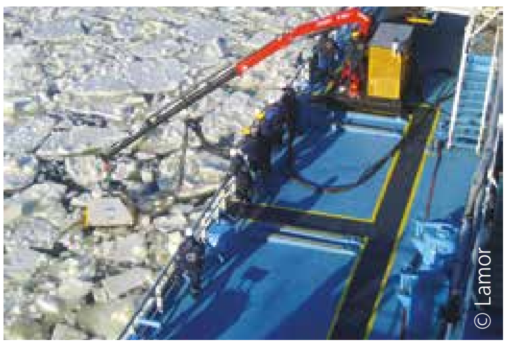
Oiled debris in a harbour, Lebanon (2006)

Debris screen around a skimmer, Ambès (2007)

Presence of plant debris, Gabon (2012)

Limitations related to the presence of ice

The presence of ice also obstructs the pollutant's access to the skimmer. In Arctic conditions, the oil, whose viscosity is far higher in low temperatures, becomes trapped under the ice, or even in cracks in the case of fractured blocks of ice. Icebreaker vessels can be used to clear the ice from certain areas so that skimmers can be deployed. Otherwise the mechanical recovery of mixtures of ice and pollutant is liable to result in large quantities of ice containing only a small percentage of pollutant.



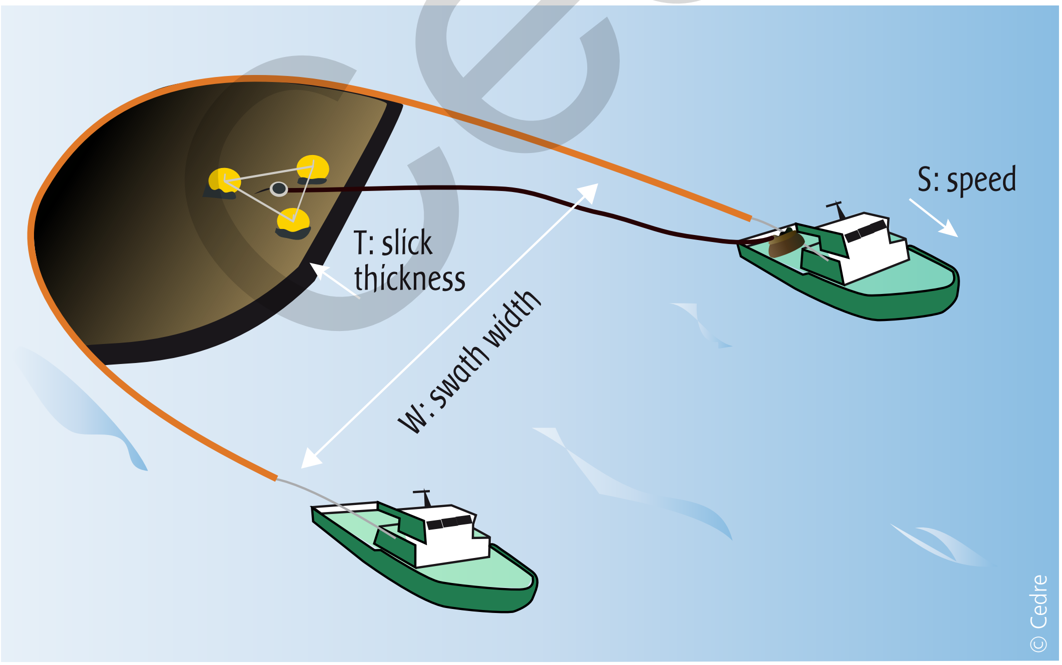
Skimming in ice-infested waters

A8

Skimmer performances

The advantages and disadvantages highlighted for the different devices on the market or in spill response stockpiles are often rather subjective and require to be reassessed in relation to one or more specific need during a spill or in relation to a risk assessment and the identification of spill scenarios as part of preparedness efforts (establishing or updating contingency plans, purchasing equipment, selecting contractors, etc.).

The performance values indicated by equipment suppliers and reported in certain specialised catalogues are always very optimistic and are an indication of the performance in ideal conditions which are almost never encountered in the case of real-life spills. There can commonly be a factor of 1 to 5, or even 1 to 10, between the results obtained in the field and the performances indicated, especially if the recovery rate indicated is in fact the nameplate value in water for the integrated or separate transfer pump (certain catalogues, such as the World Catalog of Oil Spill Response Products, however clearly state the difference between the recovery rate and pump rate). The gap between the performances indicated and the results obtained is particularly obvious for operations in the open sea where all containment and recovery systems are first and foremost limited by their encounter rate.



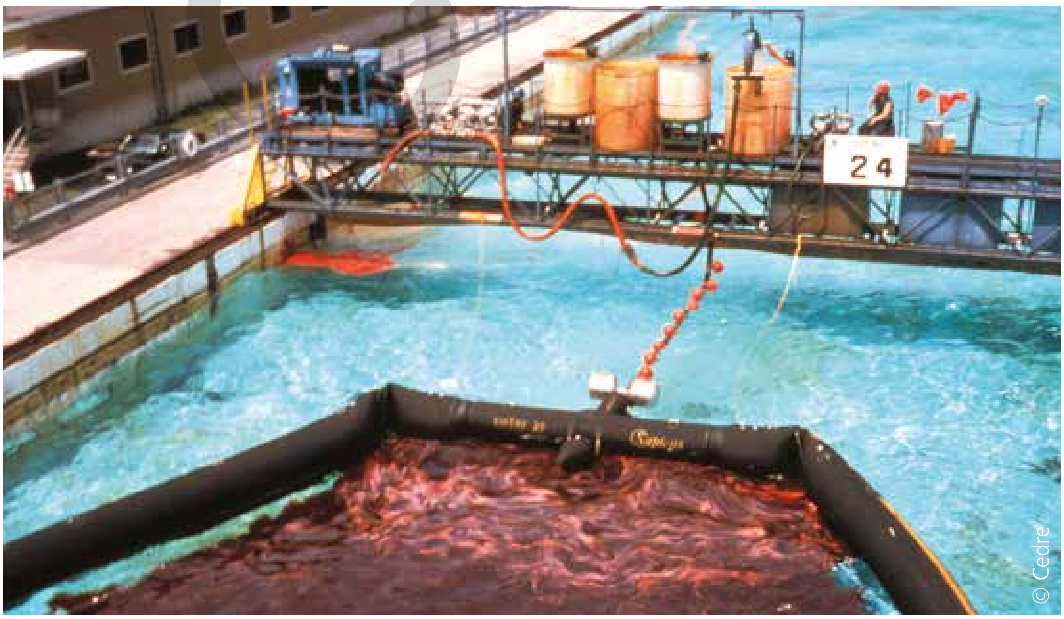
Encounter rate: C = S x W x T

The agitation of the water body heavily influences skimmers' performances, in particular in terms of water uptake, but again little quantitative data is available to more accurately characterise this influence. Generally speaking, due to a lack of trial programmes, data on real performances in different conditions is generally not sufficient to guarantee the best choice of equipment for a given situation, except possibly for simple cases of response in calm waters to a pollutant with low to moderate viscosity.

The storage capacity, either integrated within the skimming device (recovery barge, harbour cleaning boat) or provided by its support boat, may also be limiting factor, causing collection operations to have to stop while the pollutant already recovered is transferred to a storage tank on land or a storage vessel positioned near the response site to reduce idle time.

Comparing the efficiency of mechanical and oleophilic skimmers

Trial using a self-adjusting weir skimmer



Assessing skimmer performance in a trial basin

A9

Storage, pre-positioning and right-sizing

Skimmers and their ancillary equipment (booms, pumps, storage tanks, etc.) are often deployed in an emergency to respond to a spill. Boom storage locations and methods should therefore be chosen and prepared to enable rapid response and easy deployment, preferably close to high risk sites.

Contingency plans should define the locations that will ensure maximum efficiency in case of deployment.

Storage methods

The storage method and pre-positioning of skimmers and their ancillary equipment are predominant factors in their deployment time. For rapid intervention in the open sea, the necessary containment and recovery equipment should therefore ideally be permanently stored aboard recovery vessels or, where this is not an option, may be positioned on the dockside, or on a floating pontoon, in their home port. The skimmer and all the additional equipment (pumps, power packs, hoses, etc.) required for the operation should ideally be stored in a single container.

Pre-positioning

Recovery equipment should be pre-positioned as close to the potential spill area as possible, and even on the water body in some cases. The equipment can be positioned on the deck of a ship, a pontoon, barge, dock or jetty, as close as possible to the risk area so as to reduce deployment time. Equipment in containers or trailers should preferably be positioned on the dock, on a pontoon or in a shelter.

The equipment can also be stored in a trailer or container. This storage method means that the equipment can easily be transferred to different sites.

The skimmer and its ancillary equipment should be protected from the sun's rays, frost, weather conditions (spray, wind...). In areas where the climate is humid (tropical or equatorial), it is important to make sure that sufficient ventilation is provided to prevent mould from forming and premature deterioration of the equipment. The equipment should also be protected from rodents.

Stockpiles of skimmers and other spill response equipment

Examples of stockpile sizes (as an indication)

Dynamic recovery at sea

Scenario

Incident: major spill in the open sea in relatively calm conditions.

Consequence: pollutant spreads and drifts in slicks, pushed by the current and wind.

Dynamic recovery, Gulf of Mexico spill (2010)

ITEM	QUANTITY
Skimmer with integrated transfer pump	1
Hoses (hydraulic and pump discharge)	50 m
Reel-mounted inflatable boom	300 m
Power pack	1
Engine-driven blower (to inflate boom)	2
Supply vessel	1
Tug (preferably offshore else harbour)	1
Onboard storage (ship's tanks including 1 for settling, preferably equipped with a heating system)	1,000 m^3
Additional equipment required to deploy the boom and skimmer	

It is crucial to have support from an aircraft (helicopter or light plane), to guide operations to the most concentrated areas of pollution, and therefore if possible to have a command vessel with a helipad.

Furthermore, the necessary safety equipment and instructions must be provided, for instance the use of petrol engines (notably for blowers) in the presence of flammable vapours.

Equipment stockpiles, assistance agreements, insurance, hire/loan

Equipment stockpiles

Oil Spill Response is currently the largest international oil spill response cooperative. Based in Europe, it also has regional offices in Asia, America and the Middle East. In 2013, it had 43 participant members and 88 associate members, representing over 60% of the world's oil production. Its mission is to provide resources (personnel and equipment) to respond to oil spills worldwide. Each member (largely oil companies) contributes to the funding of this cooperative which owns a vast quantity of equipment. For more information see: www.oilspillresponse.com

Other cooperatives work in a similar way: Alaska Clean Seas, Marine Spill Response Corporation (MSRC), Eastern Canada Response Corporation, Australian Marine Oil Spill Centre (AMOSC), Norwegian Clean Seas Association for Operating Companies (NOFO). Certain cooperatives own recovery vessels, either directly or via their members (MSRC, NOFO).

FOST (Fast Oil Spill Team) is an Economic Interest Group for the Total Group entities through an agreement with the city of Marseille and Marseille's Navy Firefighters Battalion (BMPM) since 1993. FOST is composed of personnel specialised in oil spill response and has an equipment stockpile. Its vocation is to respond to oil spills in water, as well as to providing training and improve preparedness in this field. FOST is a Tier 2 centre for the oil industry and is certified as an IMO 1 training centre. The FOST equipment stockpile is designed for response to spills of a few dozen cubic metres of oil, according to conditions, in coastal waters and rivers. It is based in Rognac (Bouches-du-Rhône), near the Marseille Provence airport and a motorway intersection to allow quick mobilisation of the equipment. For more information see: www.fost.fr

As is the case of coast guards in various countries, in France the Navy charters supply vessels in order to carry out recovery operations at sea by deploying suitable containment and recovery equipment, stored at POLMAR-Sea stockpiles and positioned in the country's major military ports, ready to be quickly loaded on board vessels. The POLMAR-Sea stockpiles also contain recovery equipment, in particular trawl systems, to be deployed from vessels of opportunity. For more information see: www.ceppol.fr/en/materiel.html

Storage centres in mainland France

France has 13 marine pollution response stockpiles along the French coastline, 8 in mainland France (Dunkirk, Le Havre, Brest, Saint-Nazaire, Le Verdon-sur-Mer, Sète, Marseille, Ajaccio) and 5 in overseas French territories (Guadeloupe, Guiana, Martinique, Réunion - Mayotte, Saint-Pierre-et-Miquelon). These centres are managed by the French Ministry of the Environment, Energy and the Sea. The defence zone prefects mobilise the resources available in these centres upon request by departmental prefects in the event of major spills.

Recovery vessels contracted by EMSA

One of the main responsibilities of the European Maritime Safety Agency (EMSA) is to ensure that offshore recovery resources are available to help member states to respond to major spills like the *Erika* (France, 1999). The agency has therefore established a network of Stand-by Oil Spill Response Vessels to supplement the EU member states' own resources. These are merchant vessels which can rapidly be converted to be used for oil spill response. They have large storage capacities and a range of recovery equipment (sweeping arms and containment and recovery systems).

To ensure an efficient response at sea, each vessel is equipped with:

- Specialised spill response equipment selected according to regional factors, in particular the weather conditions in the given area. All the specialised and associated equipment is stored in containers in order to facilitate rapid installation onboard the vessels.
- A local radar-based oil slick detection system.
- A system in order to decant the excess water in the mixture recovered so as to maximise the utilisation of the onboard storage capacity.
- A heating system for the recovered cargo and high capacity screw pumps in order to facilitate the discharging of heavy viscous oil.

Cover of the 2014 EMSA brochure on the network of oil spill response vessels

Assistance agreements between port organisations

It is recommended that agreements be drawn up to pool response equipment in case of a spill in a port or harbour. It is important to check that these agreements are renewed and to regularly run response equipment deployment exercises between organisations within the same port area.

Hire/loan of spill response equipment

During "peacetime", such agreements can be made between port or industrial organisations, in particular with contractors specialised in spill response that are able to rapidly provide equipment.

It is essential to check that the response equipment is interconnectable and compatible. In the case of hire or loan, prior to use it is important to find out about the repayment terms in the event of damage to equipment.

Registering and contracting vessels of opportunity

It is recommended that requirements in terms of non-specialised vessels, in particular fishing boats, be anticipated in advance of any spill and the technical and financial terms of their involvement be defined. This can include the establishment of stockpiles of spill response equipment suitable for use onboard these vessels. Furthermore, the deployment methods for this equipment should wherever possible minimise difficulties in returning the vessels to their usual functions. If possible, taking oiled spill response equipment (booms, surface trawls, etc.) aboard these vessels should be avoided.

A spill response trawl system being deployed by fishing boats

Retrieving a trawl system onto a specialised vessel following deployment by fishing boats

Insurance

Equipment deployed during exercises or in response to real spills can, in some cases, be insured against damage when used on site, or even against acts of vandalism.

Situation assessment

B

B1

When and where can skimmers be used?

Conditions of use

The type of product spilt will affect the decision whether or not to implement recovery operations on the water. Below is a list of the main categories of substances divided into those for which recovery on the water is possible and those for which it is not recommended.

RECOVERY POSSIBLE	RECOVERY NOT RECOMMENDED
• Oil in different forms (slicks, tarballs, emulsion) • Litter and debris • Vegetable oil (castor, soybean, oleic acid) • Floating chemicals that evaporate slowly (phthalates) • Styrene, xylene, aniline, ethylbenzene (near coast or in port areas)	• Very volatile light oil (explosion risk, rapid evaporation) e.g. petrol • Chemicals that dissolve or sink (acid, soda, acetone, alcohol) • Chemicals that evaporate quickly (benzene, hexane)

Recovery equipment will be deployed in the following circumstances:
(C2 practical datasheets)

- Containment and recovery of a spill in the open sea by specialised vessels
- Containment and recovery in coastal waters by vessels of opportunity
- Containment and recovery of a spill in a port
- Recovery on the water in front of and from the shoreline
- Recovery on the water during shoreline and bank clean-up operations
- Dynamic containment and recovery in a watercourse
- Deflection and static recovery in a watercourse, estuary or along the shoreline.

The volume spilt will affect the storage capacities required and the number and choice of equipment to be deployed. Oil containment and recovery operations at sea are only justified for a spill of at least a few dozen tonnes.

Containment and recovery in the open sea

Type of environment

Skimmers and their ancillary equipment can be used on different types of water bodies. According to the environment (offshore, inshore, port, inland waters) and the related constraints (hydrology, weather conditions, currents), this equipment will be used differently.

Ice

Recovery in ice environments raises specific difficulties, both in terms of accessing and setting up clean-up sites, and in terms of the efficiency of recovery operations, without forgetting the management aspects for recovered products. Access to the pollutant is difficult, and most spill response equipment is not designed to work in low to very low temperatures. The development of oil exploration and production activities in Arctic areas has encouraged research and development work into skimmers designed to work in ice conditions.

Skimmer designed to operate in ice conditions

Offshore

In the open sea, pollution response equipment must be deployed rapidly once an incident has occurred so as to limit drift and reduce the quantity of pollutant liable to wash up onshore. Such pollution may result from a shipwrecking or a platform incident, or from an accidental or deliberate release.

In such cases, skimmers and their ancillary equipment can be used:

- in dynamic mode, deployed by one or more vessel(s)
- in deflection and concentration mode, anchored or moored downwind of slicks and in line with the current so as to collect "streams" of pollutant drifting towards them
- statically, to recover a spill contained at its source (around a wreck for instance).

Recovery at sea in static mode around a wreck (Peter Sif, *Ushant Island, France, 1999)*

Inshore

Near to the shoreline, skimmers can be used in addition to booms deployed to protect sensitive sites. On the other hand, according to the type of site, its morphology and the currents present, booms can also be used to deflect the pollutant to facilitate its recovery or to contain the slick at the coast to prevent it from polluting other sites.

Natural accumulation areas are generally conducive to recovery operations. Unfortunately, all types of debris accumulate along with the liquid floating pollutants to be recovered, hindering the use of most skimmers. It must therefore be removed from the environment, especially if it is contaminated.

Where possible, it is easier to deploy skimmers from the shoreline, especially if there is an access point, or even a car park, close to the recovery site.

- **Cliffs**: generally characterised, in exposed areas, by difficult access and are rarely conducive to recovery on the water. Recovery operations can potentially be carried out near cliffs at sheltered sites (e.g. coves) and should preferably be conducted from the sea.
- **Rocks**: rocky shores are generally not conducive to recovery operations on the water, except in the case of support for clean-up operations.
- **Sandy beaches**: recovery operations on the water may be conducted on sandy beaches at the end of bays which are liable to trap pollutant, especially if they can be easily accessed by heavy-duty equipment (e.g. tanker trucks).
- **Marshes**: recovery operations cannot easily be implemented on such sites and are not recommended given their vulnerable character. If however recovery operations are necessary, because the site was not efficiently protected and on the basis that operations will not have a greater impact than the spill itself, they must be carried out very cautiously, keeping trampling to a minimum.
- **Lagoons**: as it is difficult to protect lagoons at their mouth, they may be liable to trap pollutant, thus calling for recovery operations on the water.
- **Estuaries**: deflection booms can be laid to channel the slick to a recovery area that can be accessed by terrestrial vehicles. If the current is too strong, only dynamic recovery operations can be implemented and only in waters deep enough for vessels to operate.

Recovery in coastal waters

Recovery in front of and from the beach

Area surrounding shoreline or bank clean-up site

Skimmers can be used, along with containment booms, to collect floating pollutant in washing effluent from clean-up operations on the banks or shore.

Recovering washing effluent, Exxon Valdez *spill, Alaska (1989)*

Inland waters

Lakes

In lakes, which tend to form large stretches of deep water, currents may be created by watercourses or other mechanisms, such as wind action at the water surface. In such cases, recovery techniques on the water will be subject to the same constraints as when implemented offshore.

Containment and recovery in a lake

Rivers

The flow rate in rivers cannot always be controlled and the current speed is often high. Deflection booms can be laid to channel the slick to a recovery area that can be accessed from the banks. If the current is too strong, only dynamic recovery operations can be implemented and only in waters deep enough for boats to operate. Particular attention has to be paid to the many branches driven by the current, which are liable to disturb recovery operations, and even deteriorate equipment.

Dynamic recovery using a system composed of a skimmer and sweeping booms

Small watercourses

In streams, floating pollutants can be recovered in association with barriers built across them, from one bank to the other, which either channel the pollutant towards one of the banks or form an apex in the centre of the stream (see Cedre operational guide published in 2012 entitled "Custom-Made Spill Response Barriers"). Floating sorbents, in particular in the form of booms or pads, can often be used to recover minor spills in small watercourses (see Cedre operational guide published in 2009 on the "Use of Sorbents for Spill Response").

Oleophilic skimmer on a small watercourse

Containment and recovery in a watercourse and storage of the recovered oil

DECISION-MAKING FACTORS FOR CONTAINMENT AND RECOVERY OF OIL OFFSHORE AND INSHORE			
TYPE AND QUANTITY OF POLLUTANT	**CHARACTERISTICS OF THE SPILL SITE**	**CHARACTERISTICS OF THE THREATENED SHORELINE**	**AVAILABLE RESOURCES**
◗ Type of oil • density • viscosity • pour point • degree of emulsification • flash point (flammability) ◗ Volume spilt (instantaneous or continuous spill)	◗ Distance • from the coast • from a major port • from an on-land storage site for the recovered products ◗ Sea and weather conditions • swell or waves • wind • surface currents • air and water temperature • salinity and/or turbidity of the water	◗ Sensitivity • ecologically or economically sensitive sites • sites conducive to containment and recovery on the water • easily cleaned foreshores • accessibilty by land or sea ◗ Sea and weather conditions • exposure to swell and breaking waves • tides and currents	◗ Specialised spill response equipment • floating booms • skimmers • floating storage tanks • pumps and accessories ◗ Vessels, handling equipment and oil storage capacities ◗ Personnel (qualified or not) ◗ Guidance aircraft (helicopters, planes)

Selection criteria

Performance criteria

To achieve their defined goal, i.e. optimal collection of the pollutant at the surface and transfer to storage facilities, recovery equipment is designed to meet the main performance factors namely:

- The **encounter capacity**, or the surface swept per unit of time. The encounter capacity is the product of the swath width multiplied by the operating speed and can be converted to the encounter rate by taking the average slick thickness (e.g. 1 mm in the World Catalog of Oil Spill Response Products).
- The **throughput efficiency**. This is the quantity of oil recovered in relation to that encountered. However, given the difficulty in evaluating this parameter, this rate is being used less and less.
- The **recovery rate**, generally of a mixture of pollutant and water (free or as an emulsion in the oil).
- The **recovery efficiency (or selectivity)**, i.e. the percentage of oil in the oil and water mixture recovered.

The first factor applies mainly to skimmers intended for dynamic use and if they comprise a containment capacity (e.g. recovery systems comprising booms). The recovery rate multiplied by the recovery efficiency gives the recovery rate of pure pollutant, which can be used as a basis to scale operations.

Experience has shown that it is neither feasible, nor necessarily always desirable, to meet all these different criteria simultaneously. An increase in the encounter capacity will generally lead to a drop in the throughput efficiency or recovery efficiency. Most skimmers seek a compromise between these factors by favouring one of these four, generally selected according to the intended usage. This is true for their design as well as for their operational method in relation not only to the type of spill but also of the additional equipment. Therefore, in the case of a small spill and available vessels with a low storage capacity, it is important to be as selective as possible. On the other hand, in the case of a large spill and available vessels with a large storage capacity, the aim should be to ensure a high encounter capacity and a high recovery rate by accepting a lower recovery efficiency and possibly a lower throughput efficiency. An increased encounter capacity can be achieved by adding containment booms, bearing in mind that towing speeds must be kept very low to prevent leakage under the boom.

Furthermore, the performance may be affected to a varying degree by different parameters specific to the spill and the environmental conditions during the response, hence the need to select a skimmer (and its ancillary equipment) based on pre-defined criteria B1.

Other criteria

The expected performance is not the only selection criterion, nor necessarily the priority criterion. The use of equipment that is reliable and easy to deploy for instance can help to greatly improve the efficiency of a recovery operation, compared to the use of more sophisticated equipment, which generally requires more complex adjustments and is more prone to failures. This is particularly true in rough sea conditions and when responder safety is compromised.

SELECTION CRITERIA			
PERFORMANCE	RELIABILITY	DEPLOYMENT	MAINTENANCE AND COSTS
◗ Encounter capacity and throughput efficiency (for a skimmer used in dynamic mode) ◗ Recovery rate ◗ Recovery efficiency (percentage of oil in the mixture recovered) ◗ Sensitivity to the nature of the pollutant: • density • viscosity ◗ Sensitivity: • to debris • to slick thickness • to current speed • to waves (swell, chop) • to wind	◗ Seakeeping ability ◗ Complexity of mechanisms ◗ Solidity ◗ Strength of materials ◗ Resistance of materials to chemical pollutants ◗ Possibility and ease of on-site repairs	◗ Transport and handling equipment required ◗ Deployment requirements (personnel and equipment): • number of operators • containment equipment (booms, hoses, etc.) • pumps • power packs • handling equipment • support boats • storage tanks for recovered products • rapidity of deployment • safety of deployment • dimensions, draught, freeboard	◗ Ease of cleaning, maintenance and repair, by unqualified operators ◗ Delivery costs and times ◗ Warranty

Ancillary equipment and logistics required for the recovery chain

Aerial guidance

For operations in the open sea, or in certain estuarine or port areas, except where the spill is recovered directly at the source, aerial guidance is a permanent necessity in order to direct the recovery equipment towards the thickest slicks C1. Guidance by helicopter is only possible if the operations are taking place close enough to the coast or if a helicopter pad is available at sea for take off and refueling. Guidance by plane is less limited by distance but guidance is less accurate except if the plane has remote sensing equipment. All aircraft must have an air-to-sea communication system to convey their observations directly to the spill response vessels.

Aerial guidance for spill response vessels, Prestige *(2002)*

Support vessels

To conduct response operations in the open sea, it is essential to rapidly mobilise appropriate vessels to transport and deploy booms and skimmers before the pollutant spreads and fragments, preventing efficient recovery.

> The various methods of using containment booms are described in many publications, including the Cedre guide published in 2013 on "Manufactured Spill Response Booms".

Support vessels and containment booms

B3

As skimmers themselves have a practically non-existent storage capacity, separate capacities are required and will either be positioned onboard support vessels or towed. The use of integral storage tanks is rarely possible, except in the case of large trawlers, certain dredgers or coastal oil tankers which cannot always operate at low speeds and can therefore not easily use recovery systems.

The use of towable bladders or barges may be a solution which is generally easier to implement. However, flexible tanks generally have low capacities and therefore require more frequent shuttle runs to secondary storage facilities. Furthermore, closed tanks are often difficult to empty when the pollutant is viscous. The use of tanks with a removable cover can resolve the problem A5 .

Coastal oil tanker converted into a recovery vessel

Storage tanks onboard a recovery vessel

An onboard tank fitted with heating coils

Flexible tank with a removable cover

Storage bladder being towed

B4

Organising the management of recovered products

Pollutant recovery operations on the water have the advantage of usually generating only liquid waste, mixtures of water and pollutant, often in the form of a water-in-oil emulsion. In certain cases, in particular when recovery operations are carried out in areas where floating pollutants have naturally accumulated, for instance in harbours or on the shoreline, floating debris may be mixed in with the products recovered. When recovering very weathered oil or certain products with a high pour point, this may mean recovering solid products and, if trawl systems are used, having to manage contaminated nets or trawls.

Mixture of oil and water collected by a mechanical skimmer

Oiled trawlnet stored in a tank on the deck of a vessel

In all cases, unnecessary storage and transport of free water should be kept to a minimum by separating it off at primary storage facilities, whether it be in the tanks of a vessel or recovery barge or in flexible or rigid tanks positioned near the skimmers (on a beach, dock, etc.), and discharging the water on site, possibly after implementing a more advanced separation or filtration method than simply gravity settling.

Flexible storage tank fitted with a valve to drain off water after settling

Liquid mixtures, with varying viscosities, recovered at sea can be taken to a port either directly by the recovery vessels or else by a storage vessel, which plays a buffering role between recovery and treatment phases. In both cases, the products brought to the port can be transferred using hoses or pipes to intermediate storage capacities or directly to treatment facilities. The treatment phase may

Mixture containing a large proportion of oil recovered by an oleophilic skimmer consist simply in more advanced separation (possibly by heating the products) in order to remove almost all the water (free and in an emulsion) as well as to recover a recyclable pollutant, for instance which can be incorporated in refinery streams or at least burnt in a cement works.

Products containing debris and contaminated nets should be managed differently and are often incinerated.

On the shoreline and in harbours, the products recovered on the water may be transferred from primary storage facilities to specialised tanker trucks and transported to specialised facilities to undergo similar treatments to those applied to products recovered in the open sea, according to their nature. The question of disposal should be anticipated as far as possible in contingency plans, potentially with the necessary developments to allow for the berthing and unloading of vessels carrying these products.

Transferring a fluid oil and water mixture to a storage tank

Emulsified oil and debris

In all cases, it is important to monitor the flows of recovered products, including as accurate as possible an estimation of the quantities and an indication of the products' characteristics (free water content, proportion of water in emulsion, solid waste, etc.).

More detailed information on managing recovered products can be found in the Cedre guide published in 2004 on "Oil Spill Waste Management".

Recovering low viscosity oil

Collecting a water-in-oil emulsion

Response – Practical datasheets

Precautions prior to response

The success of recovery operations requires a well prepared organisation, an accurate assessment of the situation, the selection and rapid mobilisation of the most suitable resources for the situation (according to their availability) with all the necessary logistics and well trained and equipped teams. Wherever possible (in particular in terms of space onboard response vessels), it is worth taking a range of different types of equipment to test on site.

It is vital to:

- Consult the product's Material Safety Data Sheet (MSDS). These documents provide information on the pollutant's characteristics, the risks for operators, the possible impacts on the environment in the event of a spill and the behaviour of the substances in the environment.
- Ensure operators are wearing suitable Personal Protective Equipment (PPE) according to the tasks in hand (handling, lifting, aquatic environment...) but also to the substances to be recovered.

Responder wearing self-contained breathing apparatus

C1

When deploying recovery equipment, operators must be equipped with:

- a **life jacket**, in the case of personnel working on board boats and at the water's edge; a lanyard with a carabiner when working at the stern of the supply boat

- **safety footwear**

- **protective helmet**

- hearing protection **earplugs** (if there is a power pack or other source of noise)

- **gloves and coveralls**: resistant to the pollutant(s) and compliant with the standards in force (mechanical, chemical, biological risks...)

- **protective goggles**

- **protective mask** with filter cartridges suitable for the vapours emitted by the pollutant, in the case of a large quantity of volatile fractions in the pollutant

- **H_2S detector**

- **self-contained breathing apparatus** if the pollutant produces toxic or particularly nauseating vapours. This is however unlikely for a product which can be recovered on the water.

Worksite organisation

A recovery worksite should be organised according to the safety constraints dictated by the conditions of use of the equipment.

From a technical point of view, the worksite will depend on the throughput of the skimmers and on the evacuation rate and capacity of each element in the recovery chain. Intermediate storage capacities should be chosen in order to act as a buffer and separation facility (to remove water and possibly debris) between the recovery site and the evacuation chain.

Supervision is required to ensure optimal deployment and set-up of the equipment (notably the positioning of skimmers on the thickest part of the slick, optimised set-up of the skimmers and pumps in terms of rate and water uptake) and to ensure that no debris accumulates (or to continuously evacuate any debris to prevent it from stopping the skimmer from operating correctly or from damaging the equipment).

A recovery worksite should include a team of technicians capable of attending to any malfunction of the equipment as well as of advising operators on its use.

Recovery operations should be started by personnel used to deploying the equipment and who can then provide on-the-job training to other operators. Furthermore, the worksite organisation must take into account all the additional equipment required to conduct the operation correctly, from skimmer deployment through to waste storage.

A daily log should ideally be kept, detailing the recovery equipment used, the results obtained (quantities recovered after settling, etc.), as well as any problems and failures encountered. This keeps the command centre informed and is useful for the subsequent preparation of claims submitted either directly to the polluter or insurer or else to a compensation fund.

Shoreline clean-up site

Recovery and storage site in a port area

Containment and recovery site in a coastal area

Guiding operations at sea

Given that most pollutants will natural spread and fragment at sea and in order to optimise the use of resources and in particular to implement recovery operations where the pollutant is at its thickest, it is essential to map the pollution as regularly and accurately as possible and to continually guide the spill response vessels, and in particular recovery vessels. Mapping is generally based on information gathered by planes, ideally with remote sensing equipment to allow thick patches to be distinguished from areas of sheen. It provides an overview of the spill and helps the response resources to be appropriately distributed. Guidance, carried out at close range, helps the crews onboard to visualise the pollution surrounding them and to direct their vessel to the thickest patches. It can be provided by helicopter, or by video cameras or other detectors deployed using surveillance balloons or drones, or else by using onboard radars requiring a suitable signal processing system.

More detailed information can be found in the Cedre operational guide published in 2006 on "Aerial observation of oil pollution at sea".

In order to be efficient in the open sea, the use of helicopters for aerial guidance requires the support or command vessel on site to have a helipad and be able to refuel the helicopter. This method has the advantage of being able to guide several recovery vessels operating in the same area, with the provision of sequential information in exchange.

Surveillance balloon and radar

Aerial guidance of operations at sea

During the *Prestige* spill, one of the keys to the success of operations conducted by the Spanish Basque fleet was their aerial coordination, directing them towards the thickest patches, in contrast to the difficulties encountered on several occasions by specialised vessels lacking direct information on the location of the slicks from surveillance planes. This major issue had already been encountered in the case of the *Erika* spill. As the information was often not conveyed until after the plane had landed and was transmitted via the command centre, there was inevitably a delay between the aerial observation and the information being received by the response vessels. The situation was ultimately improved thanks to the presence of an On Scene Commander (OSC) surface vessel with a helicopter onboard, although the service provided was less efficient than if images or maps had been provided in near real time by a spotter plane.

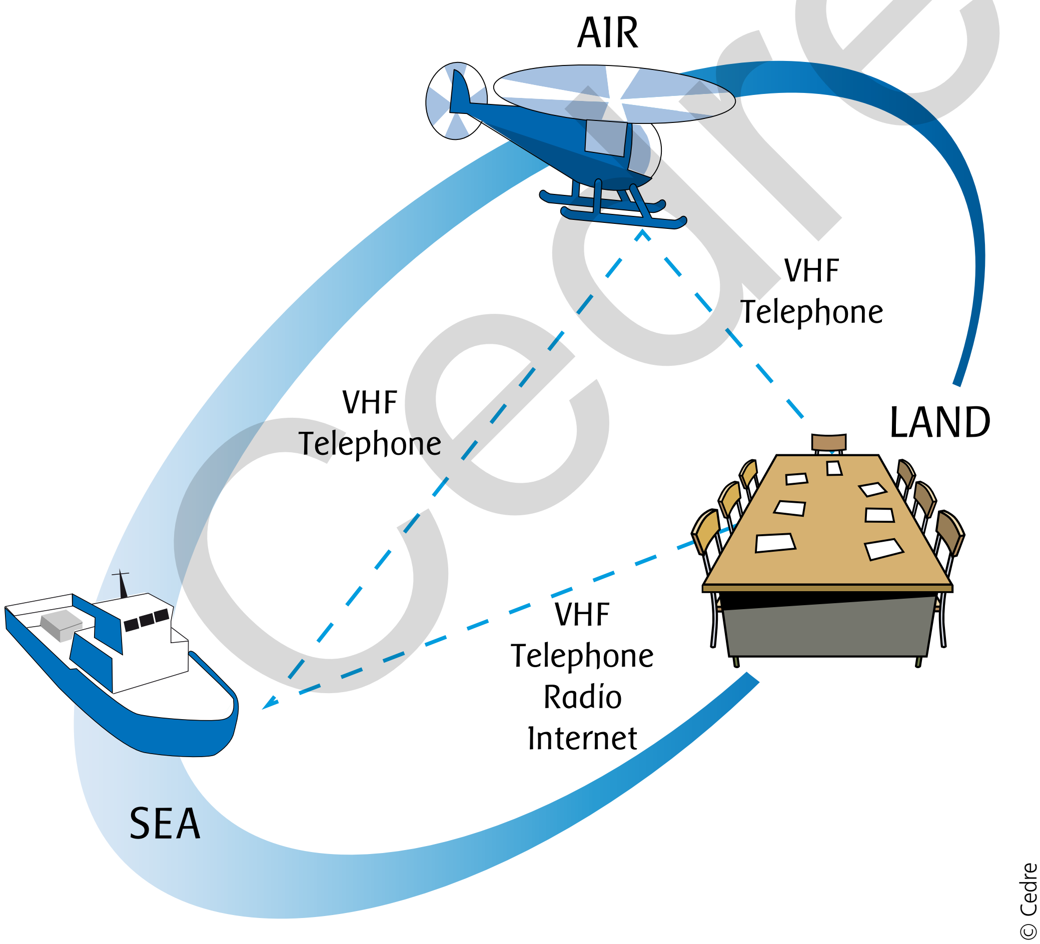


Diagram illustrating the organisation of aerial guidance in place for the Basque fleet during the Prestige *spill (2002)*

Practical datasheets for skimmer deployment

Containment and recovery of slicks in the open sea by specialised vessels

- **Substances**: floating, fluid to highly viscous
- **Environment**: offshore. Slight to moderate conditions
- **Equipment required:**


© Cedre


© Cedre

Skimmer	• Offshore skimmer, suited to the viscosity of the product to be recovered
Vessels	• A recovery or supply vessel for deploying the boom on the water and deploying the skimmer, with internal (integral tank in the vessel's structure, if possible with a heating system to facilitate settling and pumping) or external (storage tanks placed on deck) storage capacities. • An offshore or port tug (or fishing vessel) with sufficient motor power to tow the length of boom and to open and maintain the containment area.
Aerial support	• Helicopter, guidance plane or other aerial means
Ancillary equipment	• Heavy-duty (inflatable) boom (height > 1 m) • Engine-driven blower (for inflatable boom) • VHF, walkie talkie, compact radio communication equipment • Safety equipment (life jackets, life rings) • In the case of light or crude oils, explosive atmosphere measurements must be taken and suitable PPE worn (respirator masks, gloves...)

- **Set-up time**: 2 hours to inflate and deploy boom, deploy skimmer and position it at the apex of the boom
- **Number of operators required**: around 10 (variable according to circumstances)

Advantages	Difficulties
• Reduces the impact of the pollution on the shoreline by attempting to remove as much pollutant as possible at sea	• Requires large storage capacities onboard to reduce shuttle runs to land, except if a storage vessel is available at the scene • Efficiency of the recovery/containment system highly dependent on sea and weather conditions in the area

- **After use**: the skimmer, hoses and boom should be placed in skips or on watertight tarpaulins then cleaned and repacked. If the equipment is reaching its end-of-life or is heavily contaminated (and considered beyond repair), it should be sorted and recycled. Final cleaning and repacking operations are carried out at the port. It is essential to provide the logistical support (lifting equipment, dump truck, etc.) required to transport the contaminated equipment to a predefined cleaning site.

SHEET 2

Containment and recovery in coastal waters by vessels of opportunity

- **Substances**: floating, fluid to highly viscous
- **Environment**: port areas, estuary areas, shallow coastal waters (in which offshore recovery vessels cannot work due to the depth)
- **Equipment required:**

Skimmer	• Offshore or coastal skimmer, whose weight and size must be compatible with the support vessel's lifting equipment, suited to the viscosity of the substance to be recovered and the sea conditions
Vessels	• 1 or 2 manoeuvrable, low draught boats with sufficient motor power (> 55 hp): trawler, oyster barge...
Aerial support	• Helicopter, guidance plane or other aerial means
Ancillary equipment	• Medium-sized curtain booms • Outrigger or paravane if system towed by a single vessel • Ropes or hawsers for towing • Towable bladder or tank placed on the deck of one of the boats • VHF, walkie talkie, compact radio communication equipment • Safety equipment (life jackets, life rings) • In the case of light or crude oils, explosive atmosphere measurements must be taken and suitable PPE worn (respirator masks, gloves...)

- **Set-up time**: 30 to 45 minutes (or more according to where the boats and booms are pre-positioned)
- **Number of operators required**: 1 pilot and 2 operators on each boat (variable according to size of boat)

Advantages	Difficulties
• Can be used to work dynamically to collect slicks in shallow waters • Can be used on sites which are difficult to access by land • Involvement of local professionals and use of their know-how, local knowledge, etc.	• Delicate operations requiring thorough training for crews and suitable boats. • Requires good knowledge of the response area (shoals) • Inefficient operations in rough waters

- **After use**: contaminated equipment should be placed in skips or on watertight tarpaulins, then cleaned and repacked, and/or could ideally be collected by a specialised vessel or a vessel better suited to this task than, for instance, fishing boats.

Containment and recovery of a spill in a port

- **Substances**: floating, fluid to highly viscous
- **Environment**: ports and harbours
- **Equipment required:**

Skimmer	• Skimmer + pump suited to the type and volume of pollutant to be recovered and to the storage capacities for the product recovered • Or recovery barge (for liquid pollutants and possibly floating debris)
Vessels	• Light workboat(s) to deploy the associated boom and to take the skimmer to the thickest patches • And/or a work pontoon to deploy the skimmer and its pump as close as possible to the spill • Possibly a harbour cleaning boat to recover contaminated floating waste which could prevent the skimmer from operating correctly
Aerial support	• Helicopter, drone or surveillance balloon, fitted with a video camera in the case of large port sites
Ancillary equipment	• Quick deployment booms of suitable dimensions according to local conditions • Fire hoses using a flat jet to push the slick towards the skimmer • Possibly, a collection or deflection system for floating waste • Storage capacities for recovered products (metal tanks, flexible tanks, etc.) preferably designed to allow settling • VHF, walkie talkie, compact radio communication equipment • Safety equipment (life jackets, life rings) • For light and partially volatile products, an explosimeter and suitable PPE (respiratory masks, gloves, etc.) must always be used

- **Set-up time:** at least 2 hours to set up the boom, skimmer and ancillary equipment
- **Number of operators required**: at least 3 or 4 (more in the case of a large spill)

Advantages	Difficulties
• Enables response close to the spill source, limits the spread of the spill • Draws upon natural containment features (dock corner, harbour basin, etc.) • Can be implemented from a dock, using port lifting equipment, and storage capacities (or even tanker trucks) can be placed on the dockside	• Floating waste often present • Disturbs the port's economic activities (ship movements, etc.) • When pumping from a dock in a tidal port, potential difficulties related to the suction height

- **After use**: contaminated equipment should be placed in skips or on watertight tarpaulins, then cleaned and repacked.

Recovery on the water in front of and from the shoreline

- **Substances**: floating, fluid to highly viscous
- **Environment**: ports and harbours
- **Equipment required:**

Skimmer	• Skimmer + pump suited to the type and volume of pollutant to be recovered and to the storage capacities of the product recovered; alternatively a slurry tanker or vacuum truck can be used to pump the recovered products • Or a recovery barge
Vessels	• Light workboat(s) to deploy the associated boom and to take the skimmer to the thickest patches
Aerial support	• Helicopter, drone or surveillance balloon, fitted with a video camera to locate the thickest patches and monitor the situation
Ancillary equipment	• Boom suited to the site specificities • Storage capacities for recovered products (metal tanks, flexible tanks, etc.) preferably designed to allow settling • Possibly, a collection or deflection system for floating waste • VHF, walkie talkie, compact radio communication equipment • Safety equipment (life jackets, life rings) • For light and partially volatile products, use an explosimeter and suitable PPE (respiratory masks, gloves, etc.)

- **Set-up time**: at least 2 hours to set up the boom, skimmer and ancillary equipment
- **Number of operators required**: at least 3 or 4 (more in the case of a large spill)

Advantages	Difficulties
• Prevents the spill from spreading • Draws upon natural containment features (cove, etc.) • Can be implemented from a platform area or carpark; uses mobile lifting equipment; storage capacities (or even tanker trucks) can be placed on the platform area	• Floating waste often present • When working at a tidal site, must adapt system to tidal movements and possible difficulties related to the suction height and distance

- **After use**: the skimmer, hoses and boom should be placed in skips or on watertight tarpaulins then cleaned and repacked. If the equipment is reaching its end-of-life or is heavily contaminated (and considered beyond repair), it should be sorted and recycled. Final cleaning and repacking operations should be carried out as close as possible to the port. It is essential to provide the logistical support (lifting equipment, dump truck, etc.) required to transport the contaminated equipment to a predefined cleaning site.

Recovery on the water during shoreline and bank clean-up operations

- **Substances:** floating, fluid to highly viscous
- **Environment:** coastal and harbour areas, estuaries, marshes, etc. (any polluted coastal area requiring clean-up operations)

- **Equipment required:**

Skimmer	• Selective worksite skimmer (preferably oleophilic, thus capable of operating continuously with limited surveillance) • Or a recovery barge, if the water is deep enough and the manoeuvring area next to the clean-up site is large enough
Ancillary equipment	• Shore-sealing boom, light-weight containment boom • Sorbents (conditioned) for final clean-up • VHF, walkie talkie, compact radio communication equipment • Safety equipment (life jackets, life rings)

- **Set-up time**: 1 to 2 hours for a pair of trained operators
- **Number of operators required**: 2 to 3

Advantages	Difficulties
• Allows the pollutant to be recovered and reduces dispersion	• Is dependent on tides • Highly complex in difficult access areas (e.g. cliffs with no access by land).

- **After use**: contaminated equipment (skimmer, hose, boom) should be placed in skips or on watertight tarpaulins, then cleaned and repacked.

SHEET 5

Dynamic containment and recovery in a watercourse

- **Substances:** floating, fluid to moderately, or even highly, viscous
- **Environment:** estuary, wide river
- **Equipment required:**

Skimmer	• Boom + skimmer or recovery system suited to the site dimensions (e.g. river width) and the capacities of the support vessels, as well as to the type and quantity of pollutant to be recovered and the storage capacities • Or skimmer incorporated in a recovery vessel
Vessels	• Support vessel to deploy the containment recovery system alongside it • Or pair of vessels, one of which will deploy the skimmer and store the product recovered • Recovery vessel suited to the site (especially for port or estuary site)
Aerial support	• Helicopter, drone or surveillance balloon, fitted with a video camera to guide operations
Ancillary equipment	• Storage capacity onboard the recovery vessel or one of the support vessels, preferably designed to enable settling of the recovered product and discharge of the water (upstream of the skimmer) • Possibly, a collection or deflection system for floating waste • VHF, walkie talkie, compact radio communication equipment • Safety equipment (life jackets, life rings) • For light and partially volatile products, use an explosimeter and suitable PPE (respiratory masks, gloves, etc.)

- **Set-up time:** at least 2 hours if based near the site (especially for a port in an estuary)
- **Number of operators required**: at least 3 or 4 (according to the size of the system), in addition to the minimum crew requirements laid down by the regulations

Advantages	Difficulties
• Prevents the spill from spreading • Can be adapted according to current speed, if need be by moving away from the banks if the current is strong, the site wide enough and the vessels sufficiently manoeuvrable • Can be implemented from a platform area or carpark; uses mobile lifting equipment; storage capacities (or even tanker trucks) can be placed on the platform area	• Potential presence of floating waste (cut vegetation, branches, plastic litter, etc.) • Need to remain in the shipping passage and impossibility of approaching the banks, except with very low draught workboats

- **After use:** the skimmer, hoses and boom should be placed in skips or on watertight tarpaulins then cleaned and repacked. If the equipment is reaching its end-of-life or is heavily contaminated (and considered beyond repair), it should be sorted and recycled. Final cleaning and repacking operations should be carried out as close as possible to the spill. It is essential to provide the logistical support (lifting equipment, dump truck, etc.) required to transport the contaminated equipment to a predefined cleaning site.

Deflection and static recovery in a watercourse, estuary or along the shoreline

- **Substances:** floating, fluid to highly viscous
- **Environment:** river, lake, estuary or coastal area
- **Equipment required:**

Skimmer	• Skimmer + pump suited to the type and volume of pollutant to be recovered and to the storage capacities of the product recovered • Or litter collection boat (in the case of a solid pollutant or floating contaminated waste), if the manoeuvring area is large enough
Vessels	• If necessary, workboat to deploy the associated boom and to take the skimmer to the thickest patches
Ancillary equipment	• Boom suited to the site specificity and in particular to the presence of currents or wavelets (preferably inflatable or self-inflating at sites with currents) • Storage capacities for recovered products (metal tanks, flexible tanks, etc.) preferably designed to allow settling • Possibly, a collection or deflection system for floating waste • VHF, walkie talkie, compact radio communication equipment • Safety equipment (life jackets, life rings) • For light and partially volatile products, use an explosimeter and suitable PPE (respiratory masks, gloves, etc.)

- **Set-up time:** 2 hours to set up the boom and position the skimmer and ancillary equipment (pump, storage tank, etc.)
- **Number of operators required**: at least 3 or 4 (more in the case of a large spill)

Advantages	Difficulties
• Limits the spread and reduces the impact of the pollution • Draws upon natural containment features (cove, etc.) • Can be implemented from a platform area or carpark; uses mobile lifting equipment; storage capacities (or even tanker trucks) can be placed on the platform area	• Potential presence of floating waste (cut vegetation, branches, litter, etc.) • Possible difficulties related to the suction height and distance

- **After use:** the skimmer, hoses and boom should be placed in skips or on watertight tarpaulins then cleaned and repacked. If the equipment is reaching its end-of-life or is heavily contaminated (and considered beyond repair), it should be sorted and recycled. Final cleaning and repacking operations should be carried out as close as possible to the port. It is essential to provide the logistical support (lifting equipment, dump truck, etc.) required to transport the contaminated equipment to a predefined cleaning site.

How to clean skimmers and their ancillary equipment

After use, skimmers and their ancillary equipment must be cleaned and checked for any signs of wear or damage, which should, wherever possible, be repaired before repacking. These cleaning operations should be carried out in a suitable, protected area where the washing effluent can be collected.

It is recommended to keep running the skimmer as it is retrieved from the water so as to continue pumping the pollutant residues contained in the hoses. When removing the skimmer from the water, the skimmer can be fed with water using a fire hose. Weathered oil makes clean-up more difficult and restrictive. It is therefore advised to wash oiled equipment within hours of completion of the recovery operations. Hot water jets and solvents can be used to facilitate cleaning. Surface active agents are however advised against for washing skimmers and must never be used on oleophilic skimmers. As a general rule, reference should be made to the supplier's instructions to carry out cleaning operations after use.

Cleaning a skimmer at a suitable site

Cleaning a skimmer at the clean-up site

Resources required to wash small equipment (rough indication):

- Watertight washing area (minimum surface area of 5 m x 20 m) with a gutter and oil separator, close to a water body (careening area, dry dock, etc.)
- Sorbents (2 rolls of sorbents: 1 x 30 m, 20 m of sorbent boom)
- Geotextile (non-woven geotextile to protect the ground): approx. 50 m²
- Washing agent containing no surface active agents (dearomatised petroleum fraction), sprayer
- High pressure washer with suitable nozzle (80 bar pressure) and motor pump (with connectors, hose, jerrycan, funnel), fuel.
- Freshwater
- Storage skip for waste recovery and storage
- Vehicle/lifting equipment for waste removal (tractor, loader or crane equipped with hooks and straps).
- Suitable PPE for operators.

How to maintain skimmers and their accessories

Skimmers and their ancillary equipment are generally ruggedly built to withstand the usual conditions of use. Failure and damage can however occur due to poor use or general wear. These risks can be significantly reduced by regular maintenance.

A maintenance programme will normally include a pre-established schedule for replacing worn parts after a predefined period of use, changing lubricants and regularly (at least once a year) running the equipment (dry runs).

As a general rule, reference should be made to the supplier's instructions and maintenance schedule.

Before returning them to their storage facility, skimmers and their ancillary equipment should be repacked so as to protect them against corrosion (humidity, salt, etc.) and against all other factors liable to accelerate equipment ageing (notably UV rays for plastic parts), as well as against rodents.

Manufacturers often propose specially designed containers or cradles for a given skimmer and its ancillary equipment.

Managing recovered products

When operations are carried out from land (coastal sites, river banks, docksides, etc.), the purpose of primary storage is to gather the pollutant and contaminated materials collected at a recovery site in the immediate vicinity, before evacuating them to an intermediate storage site or treatment facility.

During their storage, the pollutants and contaminated materials collected are sorted according to their nature (liquid with a varying pollutant content, with or without solid elements; solid pollutant or thick pastes; vegetation or other contaminated debris or waste; contaminated recovery nets, etc.) and may undergo rough pretreatments (separation of water, debris, etc.).

On-site storage areas are a node in the waste management chain at which:

- The vehicles involved in pollutant recovery operations hand over to vehicles more suitable for use on roads.
- The differences in flow between the input and output are controlled (transport/treatment logistics).

Equipment should be chosen and set up according to the site and the characteristics of the materials to be collected (nature, daily flow, etc.). The table below presents the different possible storage methods.

STORAGE METHOD	WASTE TYPE	RECOMMENDED SITES	IMPLEMENTATION OBSERVATIONS
Trenches (100 to 200 m^3; 3 m deep)	Liquids, pastes	Loose ground	• Dig trenches or build raised trenches • Provide artificial protection using geotextiles and geomembranes
Watertight skips	All types	All types	• May be crane-lifted
Big bags	Pastes, solids	All types	• May be air-lifted by helicopter
Flexible self-supporting tanks	Liquids	Flat surface	• May be used for initial settling
Flexible tanks with metal structure	Liquids	Flat surface	• Certain types of tanks can be used to drain off the water after settling
Flexible floating tanks/bladders	Liquids	Calm water body	• Tanks with a removable cover are easier to empty and clean
1 m^3 IBC tank	Liquids	Flat surface	• Very rapidly available

More details can be found in the Cedre guide published in 2004 on "Oil Spill Waste Management".

Monitoring and assessment

Dos and don'ts

- Always ensure responder safety; mitigate risks related to the sea state, slippery decks, etc.
- Wherever possible, always enhance the encounter rate by channelling oil towards the skimmer: do not skimp on the use of containment equipment (booms, etc.) whenever the sea and weather conditions allow their deployment.
- Adjust the speed or power of recovery equipment according to the state of the product. These characteristics can evolve with changes in temperature. Depending on the type of skimmer, excess speed can increase the emulsification rate of the pollutant.
- Prevent floating solid waste from clogging up the skimmers and preventing them from operating correctly, regularly evacuate collected waste.

- Do not attempt to recover highly volatile products and do not deploy unsuitable equipment if there is a risk of ignition or explosion.
- Do not run skimmer elements (discs, drums, ropes, brushes) or their integrated or separate pumps at full speed or power if the slick is not thick or concentrated enough.
- Do not use dispersants on oil prior to recovery. If the chosen strategy involves applying both techniques on the same spill, they should be implemented in distinctly separate areas.
- Do not use dispersants or other surface active agents to clean skimmers, in particular oleophilic skimmers; follow the procedures and use the products recommended by the manufacturer.

Low recovery efficiency due to excessive brush rotation speed

Optimising the use of a skimmer by deploying a containment boom

D1

Floating solid waste can clog up skimmers and prevent them from operating correctly

Deploying a skimmer without containment: operations inefficient and hence rapidly abandoned

Skimmers' weaknesses

Among the main weaknesses identified for skimmers, independently of their individual performance, we find:

- Difficulties in adjusting the weir height for weir skimmers
- The fragility of moving parts (discs, brushes, ropes, etc.) and their potential deterioration by floating debris
- The lack of protection from floating debris
- Corrosion of metal parts
- The lack or poor design of handling points
- The variety of connectors (for attaching hydraulic hoses, pumping/suction and discharge pipes)

Hydraulic transfer hoses and their connectors

Disc skimmer deployed in the presence of floating debris

Weir skimmer

Brush skimmer deployed in the presence of floating debris

Oleophilic rope skimmer

D2

Practice, training and exercises

While recovering oil at sea is the best solution for responding to a spill in terms of the objectives to be achieved, it is also often the most difficult operation to be conducted as it requires not only specialised equipment, but also vessels and aircraft. The most recent experiences confirm that it should nonetheless be planned as a priority option, on the condition that the location of the spill and the sea state are conducive to ensuring efficient operations, before the slicks wash up on the shoreline. The type and number of devices should naturally be determined according to the extent of the spill. The choice of these devices from the many specialised systems on the market, as well as the choice of vessels, is not the only key to success. The efficiency of the response operation at sea will depend as much, if not more, on the quality of the organisation and how well it meets the problem to be resolved as the theoretical performances of the skimmers used.

The results obtained following the *Prestige* spill by Spanish Basque fishing boats are a good illustration, with the adaptation of anchovy fishing practices for spill response, in the form of aerial guidance coordinated by the Basque institute for fisheries and food science, AZTI. Both for fishing boats and specialised spill response vessels, the equipment must be simple to deploy and users must be continually trained, preferably through regular exercises or, like in the above-mentioned case, by adapting techniques commonly used for other purposes.

Fishing boats involved in an exercise

On-the-water recovery of oil requires specialised resources whose performances depend on their suitability for the conditions of use and the deployment techniques used. These techniques draw upon simple notions involving the creation of accumulations and require additional equipment, in particular booms which can vary in their ease of handling and deployment. In order for the different devices required to establish a full chain of recovery to be rapidly efficient following their deployment, it is important that the personnel in charge of deploying it be trained and for regular exercises to be carried out involving the combined deployment of all the necessary equipment.

In a similar way to fire drills, which involve safety officers, drills and exercises involving site operators and external operators (berthing station, pilotage, port authority) should be carried out. These exercises should be conducted as frequently as possible and should take into account staff changes.

During exercises, the response strategies outlined in the contingency plan are implemented. These drills are the chance for operators to familiarise themselves with the handling and adjustment of spill response equipment, as well as with the manoeuvres to be implemented by the vessels when deploying and retrieving the equipment.

The exercises, combined with planned training sessions, also provide the opportunity to validate or improve pre-established deployment plans.

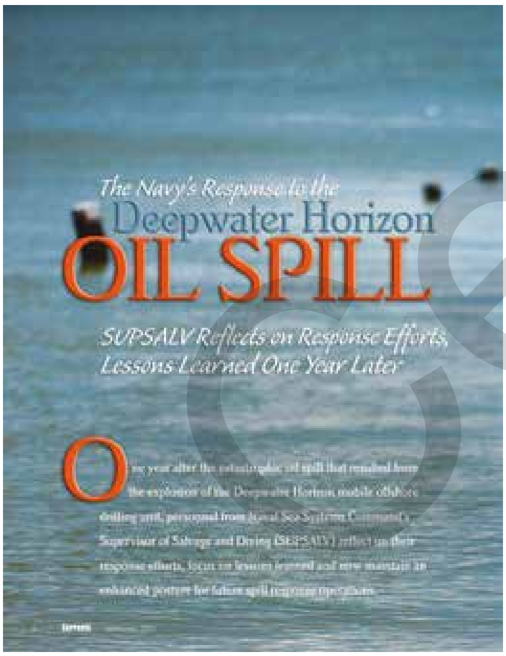
Training responders in the use of skimmers at a port site

Exercise involving the deployment of containment and recovery equipment and a floating storage capacity

Media impact of recovery

Oil spills have a very strong emotional impact on the general public. It is therefore important to inform them of the efforts made to mitigate the spill. When a spill occurs at sea or on the shoreline, regularly broadcast images of vessels (specialised vessels, fishing boats), skimmers and booms deployed conveys a clear message to the media and public opinion of the human and material resources deployed in response operations.

It is important however to be able to explain the limits of spill response equipment, whether it be booms, skimmers or even recovery vessels, and that the safety of operators must remain a priority, especially if the weather conditions are very poor.



Cover of a brochure published during the Deepwater Horizon *spill*

Further information

Glossary and acronyms

ABS: American Bureau of Shipping, classification society.

AFNOR: French standardisation association.

ASTM: the American Society for Testing and Materials, organisation which develops standards relating to materials, products, systems and services.

Big bag: large flexible container fitted with loops for lifting.

Cerema: French Centre for studies and expertise on risks, environment, mobility, and urban and country planning.

Coating: protective layer, generally made of plastic, applied to fabric.

Cofferdam: insulating space between two parts of the hull of a ship; it is located between two watertight bulkheads.

Debris: various forms of waste, either of human or natural origin, floating at sea or deposited onshore.

DNV: Det Noske Veritas, classification society.

Draught: distance between the waterline and the bottom of a floating object (skimmer, boom, vessel).

Drydock: basin from which the water can be drained to carry out maintenance work on vessels.

Effluent: waste waters or liquid waste released into the water during clean-up operations as part of spill response.

Encounter capacity: product of the swath width (of a skimmer or dynamic containment and recovery system) multiplied by the speed of advance (in relation to the water surface).

Fluid Recovery Rate (FRR): total volme of fluid recovered (water-pollutant mixture) per unit of time [m^3/h].

Foreshore: section of the shore between the high and low water levels.

Freeboard: height of the above-water section of a floating object (skimmer, boom, vessel).

H_2S: hydrogen sulphide, chemical compound composed of sulphur and hydrogen, responsible for the foul odour of rotten eggs, toxic for human health at concentration of over 14 mg/m^3, i.e. 10 ppm.

Hawser: thick rope used to moor vessels.

Hydrocarbon: compound containing only carbon and hydrogen, main constituent of oil.

IMO: International Maritime Organization.

ISO: International Organization for Standardization.

Knot: unit of speed equal to 1 nautical mile per hour, i.e. 0.514 m/s or 1852 m/h.

NEBA: Net Environmental Benefit Analysis.

NOFO: Norwegian Clean Seas Association for Operating Companies.

Oil Encounter Rate: product of the encounter capacity multiplied by the pollutant thickness (in m^3/h)

Oil Recovery Rate (ORR): total volume of pollutant recovered (oil, emulsion, etc.) per unit of time [m^3/h].

Oleophilic: which has an affinity for fats, absorbing them selectively.

OSC: On Scene Commander.

OSV: Offshore Service Vessel.

PAJ: Petroleum Association of Japan.

Patty: small patch of weathered oil (10 cm to 1 m wide).

PPE: Personal Protective Equipment.

Recovery efficiency: proportion of pollutant in the mixture recovered (in %).

SEBC: Standard European Behaviour Classification of chemicals spilled into the sea.

Sorbent: any product designed to absorb liquids released into the environment to facilitate their recovery.

Spray: droplets formed by breaking waves and carried by the wind.

Sump: a collection well within a skimmer into which the recovered mixture flows.

Supply boat: vessel with a large storage capacity on deck and in its tanks.

Tarball: small ball of weathered oil (1 to 10 cm), a microtarball is less than 1 cm in diameter.

Tidal range: vertical difference between low tide and high tide levels.

Vessel of opportunity: vessel not specialised in spill response.

Vortex: spiral motion, that can be observed when emptying a bath for instance.

AFNOR standards

French standards NF guarantee the compliance of equipment with regulations as well as with additional quality and safety criteria established according to the type of equipment.

Certification may be issued directly by AFNOR Certification or by its agents.

Standard	Title	Content
NF T71-200 May 1999	Equipment for protection against water pollution by hydrocarbons. Pumping systems. Data sheet. Standard lay-out.	List of technical characteristics to be included on the technical data sheet of pumping equipment used for oil spill response operations.
NF T71-300 May 1999	Equipment for protection against water pollution by hydrocarbons. Skimmers. Data sheet. Standard lay-out.	List of technical characteristics to be included on the technical data sheet of skimmers used for oil spill response operations.
NF T71-401 July 1999	Equipment for abatement of water pollution by oils. Pumping means. Test methods for performance assessment.	Test procedures to assess the performances of pumping equipment used for oil spill response operations.
NF T71-500 July 1999	Equipment for abatement of water pollution by oil. Skimmers. Test methods for performance assessment in a controlled environment.	Test procedures to assess the performances of recovery equipment used for oil spill response operations (evaluation of recovery rates, recovery efficiency, tendency to emulsify, attraction capacity, tolerance to floating debris, other characteristics).

ASTM standards

The American Society for Testing and Materials has published and regularly updates many standards in the field of oil spill response, several of which relate to skimmers and their ancillary equipment.

Standard	Title
ASTM F625-94 (2006)	Standard Practice for Classifying Water Bodies for Spill Control Systems
ASTM F631-99 (2008)	Standard Guide for Collecting Skimmer Performance Data in Controlled Environments
ASTM F1778-97 (2008)	Standard Guide for Selection of Skimmers for Oil Spill Response
ASTM F1780-97 (2010)	Standard Guide for Estimating Oil Spill Recovery System Effectiveness
ASTM F2008-00 (2012)	Standard Guide for Qualitative Observations of Skimmer Performance
ASTM F2709-08 (2013)	Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems
ASTM F1599-95 (2014)	Standard Guide for Collecting Performance Data on Temporary Storage Devices

DNV certification

In cooperation with the Norwegian Coastal Administration (NCA), in 2002 the Norwegian classification society Det Norske Veritas (DNV) finalised a framework for assessing oil skimmers. This comprises two main standards and one procedure:

1. Standard for Assessment of Safety, Functionality and Quality of Oil Spill Skimmers
2. Standard for Performance Testing of Oil Spill Skimmers
3. Procedure for Preparation of Emulsion for Testing of Oil Spill Response Equipment.

These standards and procedure form the basis for a skimmer certification system offered by DNV to skimmer manufacturers. They also provide equipment buyers with a set of criteria, or even specifications, for drafting tenders.

The skimmer certification process involves two separate phases. The first phase focuses on safety, functionality, quality and the technical documentation provided. It is carried out based on inspection of the unit, design drawings and documentation. The second phase assesses the oil spill recovery capability through physical performance testing in controlled conditions. These tests show many similarities with the standard ASTM F631-99 A4, with stronger emphasis on slick thickness control. In order to carry out these tests, the test facility must be capable of simulating current and waves.

NB: Standards NT CHEM 001 (1991), NT CHEM 002 (2002) and NT CHEM 003 (2002) published by Nordtest (Finland) refer explicitly to the two above-mentioned DNV standards and the DNV procedure.

Similarly, ISO standard 21072-2 (2009), "Ships and marine technology – Marine environment protection: performance testing of oil skimmers" draws upon the work carried out by DNV and ASTM, which all together contribute to an overall homogeneity of the terminology used in skimmer assessment.

Skimmer trials at the NCA test facility in Horten

E4

OILREC class notation, NOFO standard

OILREC class notation

DNV issues the class notation OILREC (DNV ship rules, Pt.5 Ch.7 Sec.10 - previously Oil Recover) to vessels liable to occasionally handle, store and transport oil products with a flash point below 60°C, recovered following a spill. This class notation is mainly issued to Offshore Service Vessels (OSVs), tugs and specialised vessels. Hazardous areas are identified aboard these vessels, when in OILREC mode, including the cargo tanks used to store the recovered oil, the deck area above these tanks and the cofferdams and ballast tanks adjacent to these cargo tanks.

The American Bureau of Shipping (ABS) has also established its own rules, notably through the Guide for Vessels with Oil Recovery Capabilities which distinguishes two classes of vessels. The first (OSR-C1) is restricted to vessels able to handle products with an unknown flash point, while the second (OSR-C2) relates to ships only capable of recovering products with a flash point exceeding 60°C.

NOFO standard

NOFO, the Norwegian Clean Seas Association for Operating Companies, has developed a set of rules laid out in the NOFO standard "Requirements for oil recovery vessels on the Norwegian Continental Shelf". These rules, first established in 1985 and regularly updated since, notably lay down a minimum storage tank capacity for recovered oil of 1,500 m^3. These ORO (Oil Recovery Operation) tanks must be equipped with a permanent system for heating recovered oil and a high flow rate pump for viscous products (500 m^3/h at 3 bars and 300 m^3/h at 7 bars at a fluid viscosity of 3,000 cSt). Vessels must also be pre-equipped to carry and deploy NOFO containment and recovery equipment. Furthermore, they must have remote detection equipment permanently installed, using the vessel's X-band radar or a specially installed radar.

Beaufort and Douglas scales

Beaufort Scale and sea state description

The Beaufort Scale is an empirical measure of average wind speed over a ten minute period that is used for maritime purposes. It comprises 13 classes. At sea, it is practical to be able to estimate wind speed by simply observing the effects of wind on the sea surface.

FORCE	DESCRIPTION	WIND SPEED KNOTS	WIND SPEED KM/H	SEA CONDITIONS
0	Calm	1	1	Smoke rises vertically. Sea surface smooth and mirror-like
1	Light Air	1 to 3	1 to 5	Scaly ripples, no foam crests
2	Light Breeze	4 to 6	6 to 11	Small wavelets, crests glassy, no breaking
3	Gentle Breeze	7 to 10	12 to 19	Large wavelets, crests begin to break, scattered whitecaps
4	Moderate Breeze	11 to 16	20 to 28	Small waves becoming longer, numerous whitecaps
5	Fresh Breeze	17 to 21	29 to 38	Moderate waves taking longer form, many whitecaps, some spray
6	Strong Breeze	22 to 27	39 to 49	Larger waves, whitecaps common, more spray
7	Near Gale	28 to 33	50 to 61	Sea heaps up, white foam streaks off breakers
8	Gale	34 to 40	62 to 74	Moderately high waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks
9	Strong Gale	41 to 47	75 to 88	High waves, sea begins to roll, dense streaks of foam, spray may reduce visibility
10	Storm	48 to 55	89 to 102	Very high waves with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility
11	Violent Storm	56 to 63	103 to 117	Exceptionally high waves, foam patches cover sea, visibility more reduced
12	Hurricane	64 and +	118 and +	Air filled with foam, sea completely white with driving spray, visibility greatly reduced

Douglas Sea Scale

The sea state is the description of the sea surface under the influence of the wind (which generates waves) and swell. The Douglas Sea Scale is used by crews and provides 9 classes for "wind sea height".

Force	Description	Height in metres*
0	Calm	0
1	Rippled	0 to 0.1
2	Smooth	0.1 to 0.5
3	Slight	0.5 to 1.25
4	Moderate	1.25 to 2.5
5	Rough	2.5 to 4
6	Very Rough	4 to 6
7	High	6 to 9
8	Very High	9 to 14
9	Phenomenal	14 +

* (measurement of the difference between the crest and trough of a wave)

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