Fact sheet from

OLF The Norwegian Oil Industry Association

Zero discharges

The Norwegian Shelf is subject to stringent environmental requirements, and the petroleum industry works continuously to reduce its discharges. Development of new technology is essential in making production of oil and gas as environmentally friendly as possible.

The industry is working on comprehensive environmental measures aimed at removing environmentally harmful discharges to sea from existing installations by the end of 2005. For new field developments in northern waters, there are to be no discharges of produced water to sea during normal operations. With the exception of the top-hole section, discharges associated with the drilling of wells will also be prohibited.

This fact sheet addresses discharges to sea from the oil and gas activities on the Norwegian Shelf, and how the industry works to achieve its zero discharge goals.

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Discharges to sea

The Norwegian Shelf is subject to stringent environmental requirements and the industry has worked systematically for many years to minimise discharges. Few industries have such a good overview of their discharges as the oil industry. The Norwegian Pollution Control Authority (SFT) approves all planned discharges, and the companies must demonstrate that the discharge permits are met. Every day, the produced water discharged over board is measured. In this way, the companies have a good overview of what and how much is being discharged. This information is reported to the authorities, as are any accidental discharges. On the right you will see an overview of traditional planned operational discharges to sea.

Type of discharge	**Source**	**Most important components**
Produced water	Water that comes up from the reservoir together with the oil and gas that are produced. The produced water is separated from the oil and gas on the platform. The water is then cleaned before it is discharged to the sea.	• Water • Minerals from the formation • Oil residues • Salts • Heavy metals • Natural low level radioactive compounds • Chemical residues
Ballast water	Seawater in the storage cells that is discharged from the platform as the storage cells are filled with oil	• Seawater • May contain small residues of oil
Drainage water	Rainwater	• May contain dirt from the deck
Cooling water	Seawater	• Seawater at a higher temperature
Hydraulic fluid	Fluid used to operate valves on the seabed	• Hydraulic fluid

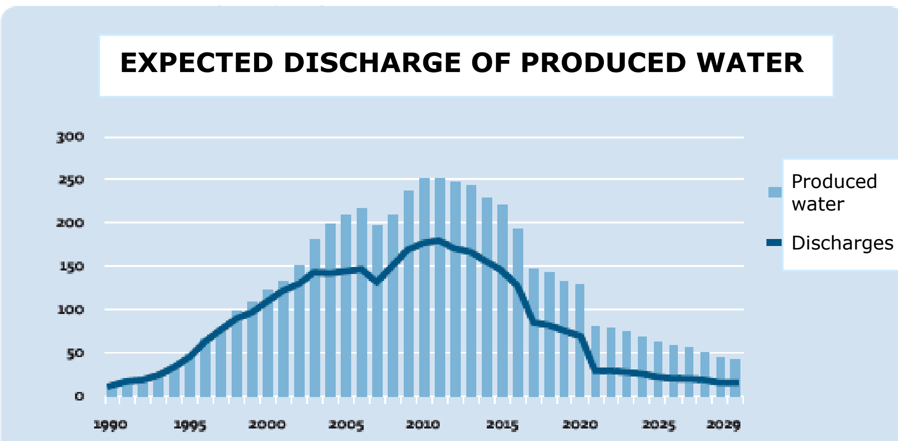
• FACT •
In 2003, produced water accounted for 70 percent of the total discharges of oil to sea from the petroleum activities.

Of the continuous discharges from a platform, produced water represents the greatest challenge. Because the produced water has been in contact with the geological formations for millions of years, it will contain various non-organic salts and organic substances. Even though the produced water is cleaned before it is discharged over board, it will still contain small residues of hydrocarbons (oil/condensate).

To some extent, the use of chemicals to produce oil and gas is necessary. Therefore, produced water will often contain residues of these chemicals. The composition of the produced water will vary from platform to platform and over the field's lifetime. Fields that produce gas and condensate produce little water in the first years. Wells are usually shut in when they start to produce larger volumes of water. Oil fields, on the other hand, often start to produce water relatively early, and the older they are, the more water they produce. In time, the water can account for as much as 90 percent of the wellstream.

Effects of produced water

Laboratory tests have shown that certain substances in produced water may have a negative impact on the marine environment. Among other things, attention has been given to potential negative effects of dissolved organic compounds such as PAH and alkyl phenols. The extent to which this affects the environment depends on many factors. The composition and volume of the discharges must be considered in connection with the environment's ability to dilute, break down, convert, absorb, accumulate or utilise the substances.



The graph shows how the volumes and discharges of produced water have developed on the Norwegian Shelf, and how the trend is expected to continue. The discharges are considerably lower than the total volume, thanks to use of reinjection.
(Source: The Norwegian Petroleum Directorate)

There is broad-based agreement that we do not know enough about the long-term effects of discharges. In the research program "Long-term effects of discharges to sea from the petroleum activities", the industry and the authorities are working together to enhance knowledge concerning prioritised problem areas. This program is administered by the Research Council of Norway. It started in 2002 and the plan is to continue the program until 2008 with an annual budget of approx. NOK 20 million. The oil industry finances 60 percent of the research program through OLF.

The goal of zero environmentally harmful discharges

Both the authorities and the industry have worked for a number of years to reduce the discharges of environmentally harmful substances to the sea, as well as to reduce the environmental risk associated with these discharges. In 1997, Storting White Paper No. 58 "On sustainable development" introduced the zero discharge term. Based on this White Paper, the objective of zero environmentally harmful discharges to sea by 2005 was established. In the spring of 2003, SFT issued the "Zero Discharge Report" in co-operation with the Norwegian Petroleum Directorate (NPD) and OLF. This report put the "zero environmentally harmful discharges" concept into more concrete goals. The objective entails the following:

Restrictions in the use of chemicals:

- No discharges of environmental hazardous chemicals
- No discharges of other chemicals, if the discharges can harm the environment
- No discharge, or minimal discharge, of environmentally harzardous substances that are contaminant in the chemicals

Restrictions in the discharge of oil and other natural substances brought up with the oil and gas:

- No discharge, or minimal discharge, of environmentally hazardous components
- No discharge of other substances if the discharges can harm the environment

"Zero environmentally harmful discharges" means that the discharges shall not inflict harm on the environment. Such an approach requires methodology and tools to evaluate whether or not a discharge entails harm. In 1999, the Environmental Impact Factor (EIF) tool was put into use as a tool for regular discharges to sea. The EIF tool says that environmental harm occurs when the concentration of a component in the sea exceeds the "no effect" limit. Today, EIF is used by all of the operating companies on the Norwegian Shelf, and it is a good tool for evaluating the effect of various improvement measures.

Zero discharges in the north

It is important for the industry to gain access to new acreage. Many of the most promising prospects are located in environmentally sensitive areas. In order to avoid a discussion of just how far one can stretch the precautionary principle in these areas, the industry has committed itself to the following objective:
Zero discharges of produced water during normal operations for all new, non-approved field developments in Nordland VI, all areas north of 68 degrees and for areas that are particularly sensitive as regards the environment. If unforeseen circumstances lead to discharges of produced water, the water must be cleaned to remove environmentally hazardous substances using the best available technology.

With the exception of the top-hole section, discharges to sea when drilling wells will not be allowed. Drilling waste must be reinjected or sent to shore unless other solutions are better from an environmental or safety point of view.

Environmental technology

The environmental risk associated with discharges of produced water can be reduced by minimising the use of chemicals, as well as ensuring that the chemicals used have the best possible environmental qualities. This means using new and better cleaning technology, avoiding discharges by injecting the produced water back into the reservoir or into another formation or, preferably, using technology that ensures that produced water does not reach the platform. Seabed separation or water cut-off are examples of such technology.

The oil industry has invested considerable work and resources towards improving existing technology and developing and testing new technology to ensure that we reach this 2005 goal.

• FACT •

The top-hole section is the uppermost portion of the borehole. It is drilled without using drilling mud, and the waste is a mixture of gravel and seawater.

Reduction

The Norwegian oil fields currently produce about 0.7 cubic metres of water for each cubic metre of oil produced. It is expected that the volume of produced water will increase by an additional 30 percent up to 2006. A main challenge is therefore to reduce water production by getting rid of the water as close to the source (the well) as possible. This also helps decrease consumption of chemicals and energy, thus reducing overall discharges and emissions. This can be achieved by means such as seabed separation, in which oil and water are separated on the seabed. The water is injected back into the well, while the oil and gas are brought up to the platform.

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Re-use

When produced water is re-injected back into the reservoir, this helps maintain pressure and thus contributes to improved oil production. As of today, this takes place to a greater or lesser extent on more than 20 fields on the Norwegian Shelf. In 2002, 12 percent of the produced water was re-injected. The percentage of re-injected produced water is rising.

REDUCTION OF DISCHARGES TO SEA CAN BE ACHIEVED USING THE FOLLOWING PRINCIPLES:

Reduction →	**Re-use** →	**Disposal** →	**Cleaning/separation**
Example: • Zone cut-off • Downhole separation • Seabed separation • Avoid use of chemicals	Example: • Reinjection of produced water as pressure support • Re-use of chemicals	Example: • Injection of produced water in another reservoir without use as pressure support • Injection of chemicals, drilling fluids, drainage water, sand etc.	Example: • Improved separation • Extraction technology • Droplet growth technology • Flotation technology • Gravitation technology • Combined techniques

From SFT's press release, 5 December 2003:

SFT has evaluated the zero discharge reporting submitted for 2003

"In SFT's assessment, the planned minimisation of environmentally hazardous discharges will largely be in line with the zero discharge goal for most substances," says SFT Director Håvard Holm.

Discharges of environmentally hazardous substances offshore are relatively low, about one percent of the national levels. If the companies follow their plans, the discharges of prioritised environmentally hazardous substances will, in most cases, be reduced by 80 percent or more.

From SFT's press release, 1 September 2004:

On the way to zero environmentally hazardous discharges

"The petroleum industry is on its way to achieving the goal of zero environmentally hazardous discharges to sea by the end of 2005. The goal of zero environmentally hazardous discharges is the result of good co-operation between the oil companies and the authorities. SFT wants to continue this co-operation, also after 2005, and will continue to be a driving force for further reduction of the discharges."

Disposal

Produced water, cuttings, drilling fluids, drainage water and produced sand can all be injected into other formations. However, this assumes that there is another formation reasonably close by that is suitable for accepting this waste. Another alternative to injection is disposal on land.

Cleaning

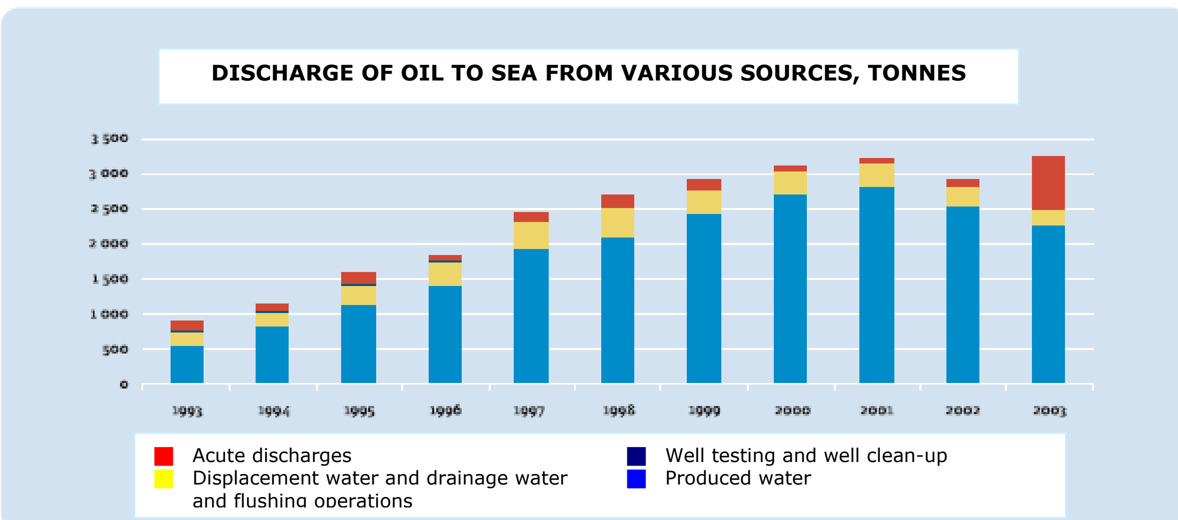
The last type of measure is separation and cleaning. Current requirements stipulate that produced water discharged to the sea may contain no more than 40 mg/l of dispersed oil. This requirement will be changed to 30 mg/l starting from 2006. The average oil concentration in discharges of produced water from Norwegian fields was 16,9 mg/l in 2003. Common cleaning technology in use up to the present primarily removes dispersed oil, but does not generally address the dissolved substances. So far, hydrocyclones have been the most-used cleaning technology, and they normally remove 75-80 percent of the dispersed oil. The larger the oil droplets in the produced water, the more effective are the hydrocyclones. The oil droplets are usually small in gas/condensate, and that is why hydrocyclones are more effective on oil fields than on gas/condensate fields.

The traditional cleaning technologies do not function satisfactorily as regards the substances that are dissolved in the water (carboxylic acid, aromatic compounds, phenols and alkyl phenols). However, when the environmental risks of produced water are assessed, it is often these dissolved compounds that contribute most to the overall risk. In order to solve these environmental challenges and achieve the goal of zero environmentally harmful discharges, we are therefore working to develop and put to use new and improved technology that also removes these components. As part of the zero discharge work, the various oil companies in Norway have invested considerable resources in developing new and improved cleaning technology. Information on some of the technologies being developed may be found below.

C-tour is a new cleaning method developed in Norway. It has the potential of removing about 90 percent of both dispersed oil and dissolved hydrocarbons (PAH and phenols). Tests show that, in some cases, it can also reduce the content of production chemicals. The principle of the C-tour process is to inject condensate in the produced water stream before the stream is routed through existing hydrocyclone systems. Condensate functions as a solvent, drawing dissolved hydrocarbons out of the water phase and over into the condensate phase. The small oil droplets are then drawn together to form larger oil droplets which are then removed in the hydrocyclones. A precondition for use of this technology is access to condensate. C-tour has been tested and will be installed on the Statfjord and Gullfaks fields.

Epcon was developed in Norway. The produced water flow into a large tank, which is rotated. Oil and gas are gathered in the middle. Natural gas or nitrogen gas is added, helping to lift the oil droplets to the surface while the water is drained from the bottom of the tank. Epcon removes dispersed oil and some of the dissolved components. The developers are also working on a filter unit that can remove both chemicals and dissolved compounds, while further reducing the amount of oil droplets in the water.

PECT-F and Mares Tail were developed in the United Kingdom. Both are based on the use of fibre material to get the oil droplets in the produced water to join. PECT-F and Mares Tail are used in combination with hydrocyclones. These technologies have the greatest potential when a moderate growth in droplet size will yield a significant improvement in the effectiveness of the hydrocyclones. This may often be the case for gas/condensate fields. The cleaning effect of the hydrocyclones can be improved by up to 50 percent through the use of PECT-F or Mares Tail.



The figure shows historical development for all discharges of oil on the Norwegian Shelf. One discharge from the Draugen field accounted for 84 percent of the total acute discharges of oil in 2003.

Environmental solutions in practice

Kvitebjørn

Kvitebjørn consists of a fully integrated, fixed steel platform with drilling and process facilities and living quarters. The water depth is 190 metres and the reservoir is located at a depth of about 4000 metres. The field contains about 55 billion cubic metres of gas and 22 million cubic metres of condensate.

The Kvitebjørn field is ready for start-up with good solutions for the environment.
(Photo: Øyvind Hagen, Statoil)

The Statoil-operated Kvitebjørn field, which started production in 2004, is operated without harmful discharges to sea and record-low CO_2 emissions.

With the aid of the reservoir pressure in the field, produced water is routed back to the subsurface. Drilling fluids, oily sand and cuttings are also pumped back into the subsurface.

The gas is routed to land through a pipeline, assisted by energy from the reservoir. The heat from the wellstream is used to process the condensate, which means that there has been no need to build a separate heating agent in the platform's process facility.

Exploiting the high pressure in the reservoir saves energy and leads to fewer emissions of CO_2. The Kvitebjørn field's emissions of greenhouse gases associated with production are estimated at about 15 kg per tonne, while the average for the industry worldwide is more than 100 kg per produced tonne.

The field has also aimed at a high level of material quality on the platform. This ensures better safety, reduces the need for maintenance and benefits the environment because there is less need for corrosion inhibition chemicals.

Troll Pilot

The world's first subsea facility for separation of produced water has been installed on the Troll C field in the North Sea. The pilot facility handles about ten percent of the field's water production, and is situated 3.5 kilometres from the platform at a water depth of 340 metres. The produced water is injected back into the reservoir, while the oil and gas are routed up to the platform. Norsk Hydro is the operator.

Illustration: Norsk Hydro

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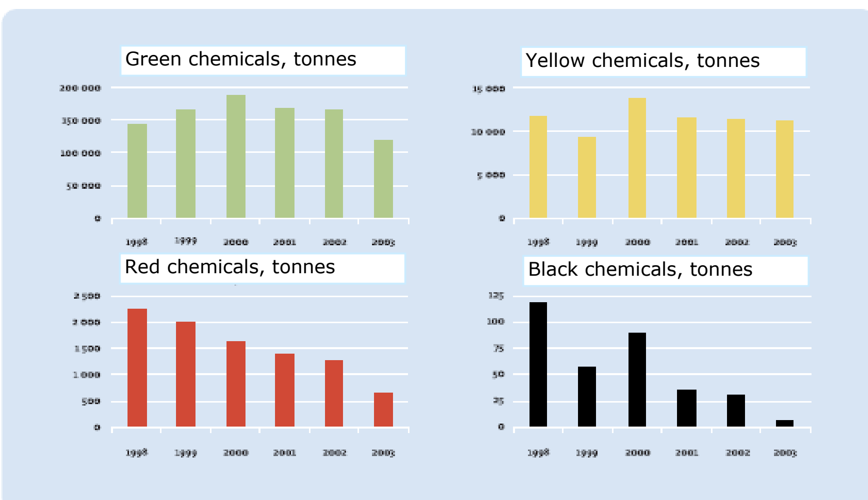
The zero discharge target - status

The oil companies have planned how they will achieve the objective of zero environmentally harmful discharges to sea by 2005. In the summer of 2004, all of the companies reported on the status of this work. When different measures are evaluated in relation to each other, cost-benefit evaluations over a life-cycle perspective form the basis for selecting measures. The industry wants to invest in measures that give the most environment for the money. SFT has reviewed the industry's zero discharge work and has concluded that the plans are largely in line with the zero discharge target.

Use of harmful chemicals has declined sharply

The figures below show historical development in the discharge of chemicals. In 2003, consumption of chemicals was 407,643 tonnes, a reduction of 32 percent compared with the previous year. The total discharge of chemical residues was 130,000 tonnes in 2003, which represents a reduction of 26 percent from 2002.



Even more important is the fact that the industry has made substantial progress in the transition to environmentally friendly chemicals. This is a key part of the work towards achieving the zero discharge target. The environmentally hazardous chemicals, the red and black groups, accounted for less than one-half percent of the discharges in 2003.

Discharges of red and black chemicals have been reduced by 84 and 48 percent respectively since 2002. For example, 122 tonnes of black chemicals were discharged in 1998, compared with 5 tonnes in 2003.

Timeline

1991 Discharge of cuttings is banned.

1994 A requirement stating that environmentally hazardous chemicals must be replaced is included in the discharge permits.

1995 On the Ula field, BP implements the first re-injection of produced water back into the well.

1997 Storting White Paper 58 (1996-1997) introduces the zero discharge concept.

2001 Hydro starts operations on Troll Pilot, the world's first and only, so far, seabed installation for separation and re-injection of produced water.

2003 SFT, NPD and OLF present a common definition of the objective of zero environmentally harmful discharges to sea.

2005 The objective of zero environmentally harmful discharges to sea must be achieved.

Read more about the petroleum industry and zero discharges at **www.olf.no/miljo**