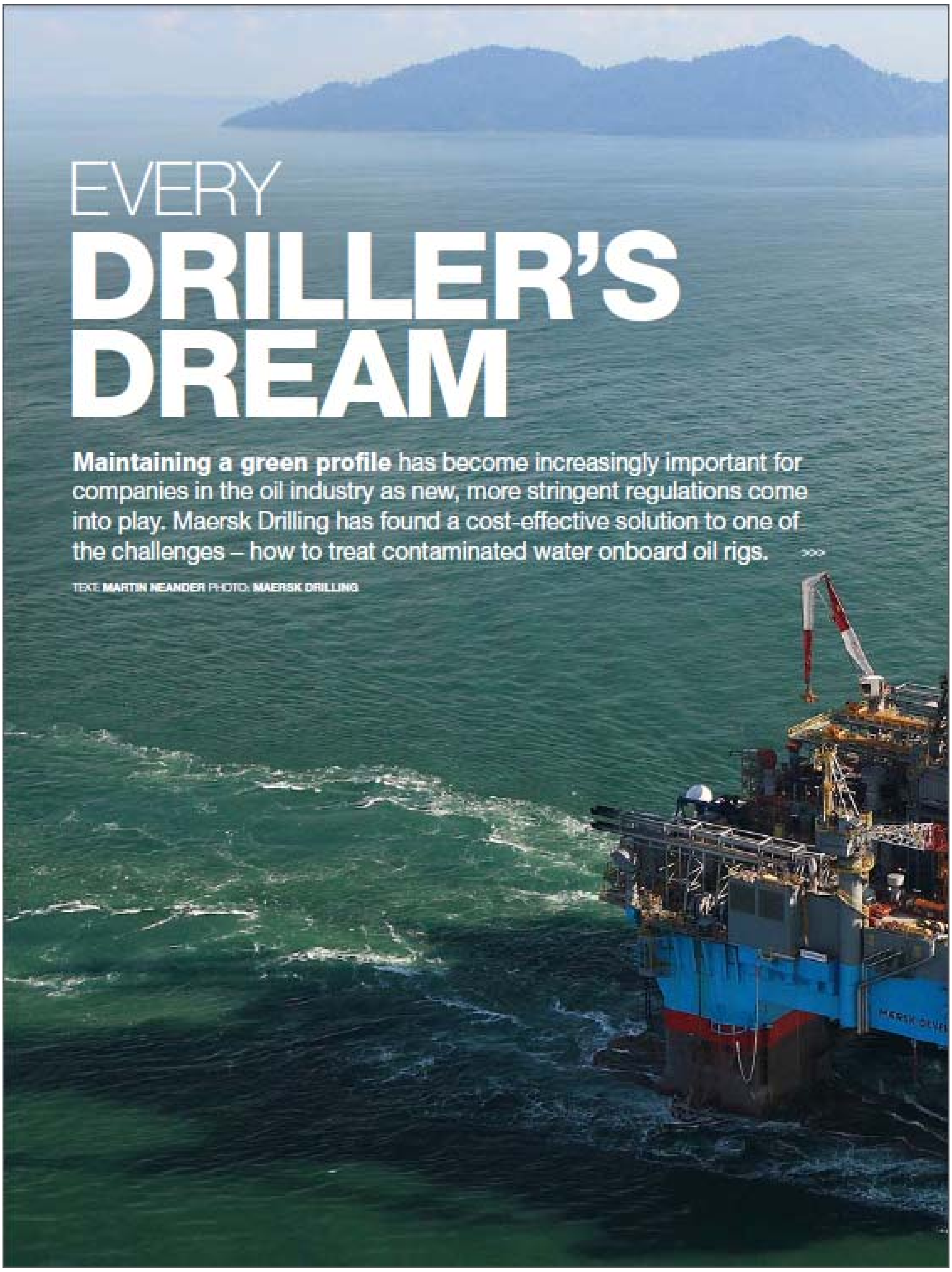
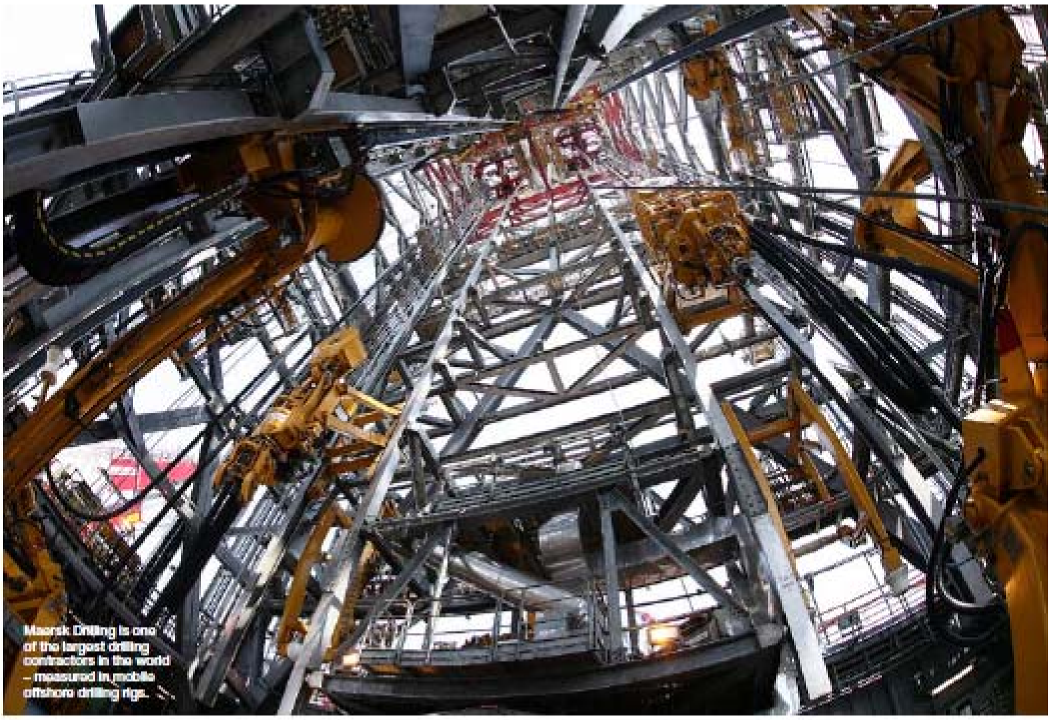


EVERY DRILLER'S DREAM

Maintaining a green profile has become increasingly important for companies in the oil industry as new, more stringent regulations come into play. Maersk Drilling has found a cost-effective solution to one of the challenges – how to treat contaminated water onboard oil rigs. >>>

TEXT: **MARTIN NEANDER** PHOTO: **MAERSK DRILLING**



Maersk Drilling is one of the largest drilling contractors in the world – measured in mobile offshore drilling rigs.

>>> **RUNNING ENVIRONMENTALLY** safe operations is crucial for companies within the oil industry. Oil spills from both tankers and offshore oil rigs can wreak havoc with the marine environment and cause irreversible harm to a company brand. Not only will the company name be connected to the incident in countless headlines affecting public opinion, but investors may decide to turn their backs as well.

"Produced" waters – formation water, brine, injection water and other technological waters – also pose an environmental hazard, one that increasingly stringent legislation is seeking to eradicate.

When drilling for oil, injection water is pumped into the injection wells in quantities of hundreds of thousands of tonnes to maintain the pressure in the system and push the hydrocarbons toward the producing wells. Formation water and brine are extracted along with oil. All of these waters are typically polluted by oil, natural low-molecular-weight hydrocarbons, inorganic salts and technological chemicals, and must be cleaned before they are discharged into the sea.

The International Maritime Organization regulations say that water discharged from drilling rigs can contain a maximum of 15 parts per million of oil. But countries and regions also apply their own legislation, which companies in the oil industry must abide by, and the stringency of this legislation varies.

MAERSK DRILLING IS one of the largest drilling contractors in the world – measured in mobile offshore drilling rigs – and operates a worldwide fleet of drilling rigs and mobile production units for oil companies to rent. The company has made environmental improvements a part of its overall strategy.

"To live up to our strategy," says Gregers Kudsk, vice president and CTO, Maersk Drilling, "we run a comprehensive environmental performance programme, which forms the baseline for our plans to reduce emissions and the total impact on the environment as a result of our activities."

Part of that commitment is to clean the dirty water onboard the company's oil rigs.

Offshore rigs operate with large volumes of mixtures of oil, water and solids, and the mixtures are often in the form of complex emulsions that are difficult for traditional separation systems to tackle. Cleaning under marine conditions is a complicated technical task.

A common solution is to store the water onboard the rig until it can be shipped to shore for cleaning. This is usually paid for by the oil companies and can cost as much as 600,000 euros in a year to clean roughly 3,000 cubic metres of contaminated water.

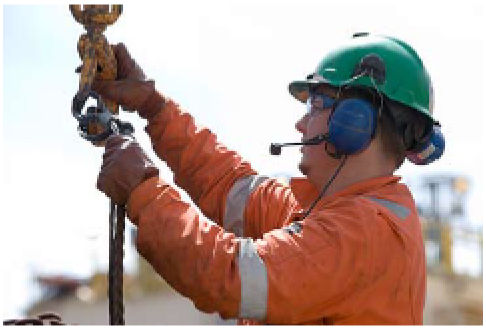
"For Maersk Drilling it has been important for our rig operations to find a solution that can deal with all sources of water contamination directly onboard our rigs," says Ulrik

▸ Facts

WORLDWIDE OPERATIONS

Maersk Drilling is part of the AP Moller–Maersk Group and is one of the largest drilling contractors in the world – measured in mobile offshore drilling rigs. Other company facts:

- Founded in 1972
- Headquarters in Lyngby, north of Copenhagen, in Denmark
- Offices in 11 countries
- 9,500 employees worldwide
- 26 oil rigs in use in the North Sea, Brunei, Dubai, Caspian Sea, Gulf of Mexico and other regions.



> “It has been important for our rig operations to find a solution that can deal with all sources of water contamination directly onboard our rigs.”
>
> **ULRIK FRIIS,** ***head of Technical Support, Maersk Drilling***

Friis, head of Technical Support at Danish Maersk Drilling. “These sources include bilge water, tank cleaning, deck drains and drill-floor drains.”

Solutions for cleaning contaminated water onboard the oil rigs include static filtering units, mechanical separation and chemical treatment, all inadequate for cost-effective processing of oily, contaminated water. Gravity settling is a slow, ineffective approach that requires plenty of space and large quantities of chemicals. Filtration systems can only separate solids from liquids, and have limited capacity. Centrifugal separation alone cannot remove all the types of contamination in widely varying concentrations and at different flow rates.

“The static filtering is cheaper to use than mechanical separation,” says Friis. “But it's also my experience that filtering alone is not as efficient as a separation technique. The drill mud creates different kinds of emulsions, which filtering solutions can't handle in a good way.”

MAERSK DRILLING HAD tested a chemical treatment system that Friis says was very efficient, but the high operational cost and the use of chemicals were major drawbacks. Maersk Drilling wanted to determine whether a screening solution using chemicals could be combined with a mechanical Alfa Laval system for cleaning contaminated water onboard oil rigs, which was already onboard its deepwater semi-submersible drilling rig in the Caspian Sea, the Maersk Explorer. Maersk Drilling invited Finnish chemicals company Kemira and Alfa Laval to carry out tests.

The final outcome was a new system called Alfa Laval Phoenix, which involves a decanter centrifuge module, a screening module and a disc stack centrifuge module.

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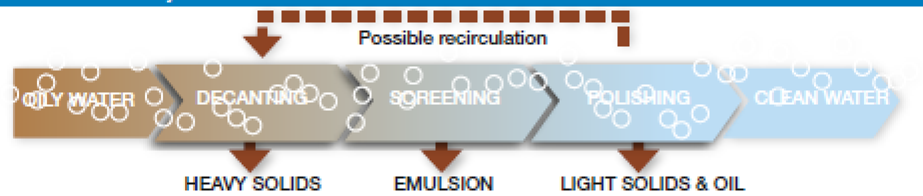
▸ The Alfa Laval Phoenix system



Clean water in three steps

The Alfa Laval Phoenix contaminated water treatment system combines different separation cleaning techniques in one system.

The system features three separate modules, each designed to remove specific contaminants from the water stream in order to tackle the different separation requirements: a decanter centrifuge module, a screening module and a disc stack centrifuge module.

The decanter centrifuge deals with the initial stage in the treatment process, focusing on solids removal. The following screening stage is a combination of mechanical separation and chemical dosing, although the system is built to minimize chemical consumption. In this step emulsion composed of small colloidal particles and droplets bound together are removed. Finally the disc stack centrifuge is used to separate low concentrations of oil and fine particles.

“The screener can remove some of the viscous oil without clogging up,” says Ulrik Friis, head of technical support at Danish Maersk Drilling. “This makes the job easier for the disc stack centrifuge. While all three components remove different kinds of contaminations, they can help and complement each other for the best result.”

The Alfa Laval Phoenix system ensures that all water leaving the system is cleaned to the appropriate level. A three-way valve with an oil-in-water monitor at the outlet of the system recirculates water that contains more than 15 parts per million of oil back into the system to be processed again.

The system is also built to minimize energy consumption.

“The payback time for the Phoenix system is 13 to 14 months,” says Franck Gregoire, business manager for oily water treatment at Alfa Laval. “This is based on a cost–payback analysis we have done, looking at issues such as investment costs, partnering services, consumables and chemicals. We compared the Phoenix to the next best alternative, which was to collect all the water in large tanks and ship for treatment onshore.” ■

Maersk Drilling has 26 oil rigs in use around the world. The company has made environmental improvements a part of its overall strategy.

"We have had good experiences from Alfa Laval's system on Maersk Explorer, and we are looking forward to seeing the new system in action in the Gulf of Mexico."

ULRIK FRIIS, *head of technical support, Maersk Drilling*

>>> Says Franck Gregoire, business manager for oily water treatment at Alfa Laval, "Maersk Drilling specified how it wanted the system to work, and we provided our expertise on how to separate different liquids. So we really developed the new system in conjunction with the customer."

The Phoenix system works in three steps: First a decanter removes the bulk of the solids, then a screener unit removes the emulsions, and finally the disc stack centrifuge takes away the oil and the rest of the solids.

The three-step solution was first installed in a retrofit version onboard the Maersk Explorer. It proved to be both robust and flexible. Later the first factory-built Phoenix system was installed on Maersk Developer, a new-built highly advanced deepwater development semi-submersible rig that will go into operation in mid-2009 in the Gulf of Mexico with StatoilHydro as its first customer.

"The reason for installing Phoenix on our Maersk Developer oil rig is that we have had good experiences from Alfa Laval's system on Maersk Explorer," Friis says. "And we are looking forward to seeing the new system in action in the Gulf of Mexico."

He says the difference between the retrofit unit on Maersk Explorer and the new Phoenix on Maersk Developer is that the new system provides better system control. "On the new Phoenix unit the different parts are more aligned to work together," he says. "It will be highly intuitive to use, and operations are much more automated."

APART FROM THE FACT that Phoenix can save a lot of volume, space and weight on drilling rigs – the use of Phoenix requires a 30-cubic-metre feed tank for the oily water, in contrast to an ordinary storing tank, which normally must be big enough to hold 300–500 cubic metres of dirty water – Friis points out that the contaminated water treatment onboard will be attractive to oil companies, because they will no longer have the cost of shipping the dirty water onshore. "This is an advantage for Maersk when we negotiate contracts with oil companies," Friis says.

New Phoenix systems will also be installed on two similar semi-submersible rigs that are being built at the Keppel Fels shipyard in Singapore. The first one of the two will be used in Australia by oil company Woodside and will go into operation in spring 2010.

Expectations of the new system are high. "If Phoenix turns out to be a success, there is the possibility that it will become standard on our drilling rigs in the future," says Friis. ■

▸▸ www.alfalaval.com/here/watertreatment/maersk

▸ Facts

RIGOROUS LEGISLATION

- The International Convention for the Prevention of Pollution from Ships, known as MARPOL, is valid for marine activity. The convention is adopted by the International Maritime Organization (IMO). MARPOL 73/78 deals with the prevention of contamination from vessels.
- The requirements for oil separation and filtration equipment are safeguarded by the Marine Environment Protection Committee (MEPC), which is a subsidiary of the IMO. As of 2003, resolution MEPC.107 (49) states that oil separation and filtration equipment must be able to purify oil-contaminated and emulsified wastewater to an oil concentration below 15 parts per million – 0.0015 percent by volume.
- There is also various national and regional legislation that must be taken into account. Norway, for example, is putting pressure on oil companies and drilling contractors to comply with its legislation, implementing severe sanctions for non-compliance.

High-tech healing

Drugs produced by biotechnology are spreading quickly across the globe, raising hope for safer, more effective cancer treatments. Crucial for large-scale production of these complex drugs is gentle but effective separation technology.

TEXT: **MARTIN NEANDER** PHOTO: **ROCHE**

WHEN ALEXANDER FLEMING discovered penicillin in 1928 it was a major medical breakthrough. His observation that colonies of the bacterium *Staphylococcus aureus* could be destroyed by the mould *Penicillium notatum* led to the development of medicines that could kill certain types of disease-causing bacteria inside the body, effectively treating many previously serious diseases such as syphilis and Staphylococcus infections.

Although many types of bacteria have since become resistant, penicillin is still widely used today, and pharmaceutical drugs continue to play a major role in health care worldwide.

However, life expectancy is rising around the globe, and people are running greater risks today than they did even 20 years ago of being affected by various other serious ailments. The need for treatment for different types of cancer, for example, calls for highly advanced drugs and new production methods.

The latest production technique for complex protein-based drugs is cell culture-based drug production. From the initial research carried out in the United States in the 1980s it has spread across the globe to Europe and lately to Asia. In fact, growing and harvesting mammalian cells to produce new medicines has turned into one of the most thrilling sections of the life science industry.

Proof that microbial and pharmaceutical drug production is in a negative trend and that cell culture-based drug production is on the rise comes from the US Food and Drug Administration statistics. Of 100 new drugs per year that are filed as new drug applications (NDAs), about 60 rely on cell culture-based production, while only 15 are produced by microbial fermentation (the remaining 25 are produced by traditional chemical processes). Out of the 100 NDAs, about half address cancer diseases.

FROM A DRUG PRODUCTION perspective, there are huge benefits to be found in the cell culture process. Compared with production using microorganisms, the mammalian cell can produce complex proteins that target diseases better and in a more direct and structured way, which is of great importance for cancer drugs based on monoclonal antibodies. These bind only to cancer cell-specific antigens and induce an immunological response against the target cancer cell.

The cell culture-based production process basically involves three steps: fermentation, harvesting and purification. Fermentation involves the growth of the mammalian cell broth. In the cell-harvesting phase, cells are separated from the fermentation broth. The liquid or "centrate" from the harvesting stage is then purified, and the desired protein is separated and collected.

Research in the mammalian cells field to create advanced medicines began in the 1980s. From the start, Alfa Laval worked with industry leaders in the development of large-scale cell culture fermentation. During this journey, it became obvious that cell culture characteristics called for an extremely gentle separator design.

Centrifuges have a powerful ability to separate in a continuous mode and can reach very high G-forces in rotation, which benefits the cell-harvesting process. However, because mammalian cells are fragile and easily break apart, the design of the harvesting centrifuge is crucial. If shearing forces are generated at the inlet, cells are torn apart. Separation becomes highly difficult, and the flow rate has to be kept lower.

"Thanks to the gentle design of our Culturefuge separators, the fragile cells are not torn apart, and full separation is achieved even at high flow rates," says Tom Manelius, manager, Process Analysis & Design at Alfa Laval.

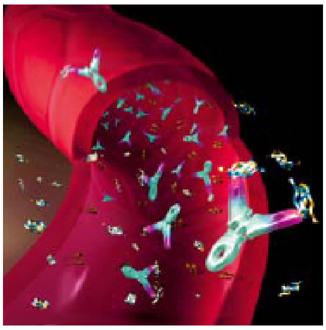
AVASTIN AGAINST CANCER

Avastin, developed by US biotech company Genentech, is one of the newest cancer-treatment drugs produced using cell culture technology. It is a protein that slows down the development of cancer by restraining the formation of blood vessels in tumours. Avastin is made from mammalian cells.

To provide additional production capacity for the production of Avastin, Roche Pharma Biotech Production Basel has built the MAB Building 95 in Basel, Switzerland. It has 6 x 12.5 cubic metres of fermentation capacity and two downstream processing lines for the recovery and processing steps that yield the final product. Alfa Laval has delivered equipment to the building for the production of this innovative cancer drug.

Cell-culture processes have opened up large-scale production of new cancer-treatment drugs.

Below: Antibodies in a cancer-treatment drug enter the bloodstream, where they bind to VEGF (vascular endothelial growth factor) secreted by the tumour.



"Growing and harvesting mammalian cells to produce new medicines has turned into one of the most thrilling sections of the life science industry."

The single most important location inside the centrifuge is the acceleration zone, where the fermentation broth is accelerated within fractions of a second. "Our way of designing the acceleration zone has been crucial to the superior performance in the harvesting of mammalian cells," Manelius says.

THE LEVEL OF lactate dehydrogenase (LDH) is one way to measure the shear in cell culture processes. LDH is an enzyme released from damaged cells; the greater the concentration, the larger the percentage of broken cells. Manelius says that the inlet design used in traditional microbial fermentation may generate an LDH increase in the range of 10–20 percent. "When using the extremely gentle liquid-filled inlet in our Culturefuges, the LDH elevation typically stays under 5 percent," he says.

The hollow spindle design of Alfa Laval's Culturefuge product range allows the gentlest acceleration possible in a centrifugal disc stack separator, according to Manelius. This reduces the destructive shearing forces that the cells are exposed to.

"The use of a hollow spindle also eliminates an air-liquid interface, because the feed zone is completely filled with rotating liquid," he says. "This is unique compared with other solutions on the market. The hermetic outlet ensures that there is no contact with the air or any external environment. In this way, foaming is avoided."

Another source of undesirable shear forces is the feed pump. With the Alfa Laval Culturefuge design this is not an issue because it does not use a feed pump. Instead, the fermentation broth is fed to the harvesting centrifuge by applying overpressure to the fermentor.

Manelius says an interesting result was found in a research study when comparing two disc stack centrifuges – one with a classic nonfilled acceleration zone and the other with a hollow spindle hermetic inlet for gently accelerating the feed. The research group found a 2.5-fold increase in throughput for the same clarification performance when processing through a hollow spindle-type centrifuge. ■

To learn more about Alfa Laval's solutions for the biotech and pharmaceutical industries please visit www.alfalaval.com/biopharm