

TECHNOLOGY IN THE ARCTIC



The decline of easy-to-access oil will increase the need to develop new resources in ever more remote and hostile environments in order to help meet rising long-term energy demand. The Arctic is one of those environments. Shell believes the region's rich oil and gas resources should only be unlocked with technology that helps reduce environmental and social impacts – and achieves high levels of safety. Costs will be high, so the long-life, complex projects needed must be economically viable over many years.

Shell has a record of leading the development and use of technology as a means of overcoming physical challenges to enable oil and gas development in increasingly deeper water and harsher environmental conditions. At the same time we are continuously working to improve safety and reliability, and to meet social and environmental challenges.

Building safe, reliable and cost-effective operations, however, depends on developing and using the right technology adapted for Arctic conditions. →





Mobile drilling rigs enable operations to move easily to new locations.

CHALLENGES AND SOLUTIONS

The Arctic poses special physical challenges: remoteness, ice, extreme temperatures, and long periods of darkness. Technology is the key to meeting these challenges.

For example, ice conditions can vary considerably between regions, within regions and depending on water depths and distance to shore. The ice also changes through the seasons: freezing up in autumn, getting thickest in winter, melting in spring and creating open water in summer. During the months when ice grows, wind and water currents cause it to move and form ice ridges that can be many times thicker than ice held fast to the land.

Protecting the region's fragile biodiversity poses an additional technical challenge. Advances in technology are central to reducing physical footprints, discharges, air emissions, and marine sound.

Energy industry technology has come a long way in the past three decades, with advances in safety equipment and more cost-effective design of ships and structures. Other technical advances include better satellite capability to see through clouds and darkness, and more efficient oil and gas exploration and production technology.

Our approach means:

- We combine existing with new technologies, and Shell-developed technologies with those developed by others to create specific technical solutions to the challenges of the Arctic;
- We build on our Arctic and sub-Arctic operational experience gained from projects in Alaska, Sakhalin and the North Caspian Sea;
- We apply our extensive and pioneering deep-water and well technology and experience gained from projects such as Ormen Lange off Norway; and
- We work with industry partners to achieve shared standards and solutions, especially in the areas of safety and environmental protection.

Shell recognises the need and importance of incorporating traditional knowledge into our technology programmes. Indigenous peoples' knowledge can add to scientific data and our own expertise from projects around the world to create technology solutions. Exchanging traditional and technical know-how has proven to be a valuable way of building engagement between industry and native Arctic communities.

Examples follow of how Shell is developing and applying technology to overcome the physical demands of working in ice-covered waters; to help conserve the environment and protect the lifestyles of indigenous people.

SEISMIC SURVEYS

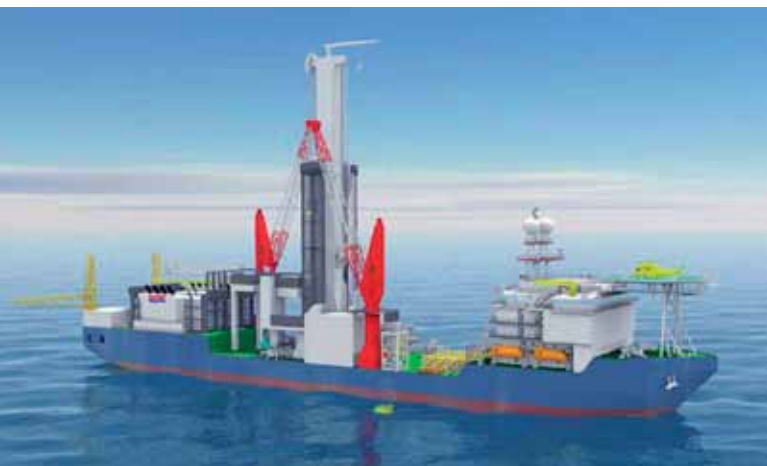
Carrying out seismic surveys is a key part of the exploration process. Most recently, Shell conducted three years of open water surveys in the Alaskan Chukchi Sea and Beaufort Sea, starting in 2006. Shell has also conducted seismic tests on ice during winter to avoid disturbing marine mammals, such as whales, which are away in warmer waters at that time. The decision to test seismic on ice followed a request to Shell by local communities to carry out seismic surveys outside the main whaling season when subsistence whaling and hunting traditionally take place. However, seismic in ice does not work in all Arctic conditions, as it needs land-fast ice that does not move.

We use 3D seismic surveys to locate and analyse oil and gas reservoirs. These use sound waves to generate a 3D computer model of the undersea geology. Ice can distort the sound waves and therefore create an inaccurate picture. It had been thought that seismic surveying in Arctic conditions was too difficult and that ice-free conditions were needed to obtain high quality data. But Shell found that a combination of vibrating sources on the ice and microphones placed in the water below the ice and on the seabed recorded accurate information. We conducted our first successful tests with 3D seismic on ice in 2007.



Conventional open water seismic surveying (below) and seismic tests on ice (above right).





The “bully rig” drillship is lighter, smaller and more energy-efficient than normal drillships.

EXPLORATORY DRILLING

Offshore drilling in the Arctic region poses extra challenges because of very low temperatures, ice conditions and darkness. Exploratory drilling usually takes place during the short open water season from ice strengthened mobile drilling rigs. Where conditions allow, winter and year-round drilling can take place from artificial gravel islands and specialised rigs that rest on the seabed.

Mobile drilling rigs are used so that operations can move easily to a new location once drilling is complete. However, these rigs are limited to open water conditions because at other times the movement of ice makes drilling impossible. Regardless, normal drilling procedures and the use of equipment must be adjusted to Arctic conditions to withstand and work safely in ice. These include the use of barriers and procedures to prevent spills (see box on barriers, next page). Additionally, we continuously seek ways to reduce any impacts of our operations such as the effect that the sound of drilling can have on marine life.

DRILLING RIGS

Shell engineers have helped develop a new drillship that is easier to manoeuvre and more energy-efficient than traditional drillships. This “bully rig” is 25% smaller and 60% lighter than normal drillships, and has a reinforced ice-class hull that increases protection between its cargo and the sea. The bully rig can drill to a depth of four kilometres and can also navigate in shallow water. Shell owns and operates the Kulluk, one of the few Arctic rigs capable of year-round operation in severe ice environments. We also redesigned and refurbished the Frontier Discoverer drilling rig for Arctic service.

MONITORING THE ICE

We use a combination of expert experience, traditional knowledge, weather forecasts, ice statistics, satellite imagery and icebreakers to manage ice conditions and ensure a safe working environment. Drifting sea ice for example can damage well piping and other equipment if it moves the drillship. To avoid this we use icebreakers and ice strengthened vessels to protect our drilling equipment. If needed icebreakers break the ice around the drillships into smaller pieces to reduce the forces it exerts, and thereby keeping our operations safe. Shell has ice-monitoring centres in its Arctic locations. In Anchorage, Alaska, our centre combines radar images from ships and satellites to provide a continuous real-time picture of sea ice cover and movement. Shell’s experts work with external scientists and meteorologists to support the advanced ice and weather forecasting systems we use.

The drilling rigs can move to another site when necessary, enabling us to suspend operations before ice can cause any damage. We also use ice observers who are on board all drilling-related vessels and report on the size and behaviour of any threatening ice forces that could affect drilling operations.

Our Real Time Operations Centres continuously monitor, analyse and optimise our exploration and production activities.





Crew training with oil response vessel Nanuq, Alaska.

PREVENTING AND RESPONDING TO SPILLS

Although oil spills in the Arctic offshore are extremely rare, Shell has plans in place to respond to a spill in the Arctic or in ice-covered waters in the unlikely event it happens. We use several approaches to be able to react to a range of weather and ice conditions. Our whole ethos is prevention during all phases of development – from exploration to production. The first step is the design of barriers. And during drilling there will always be standby response vessels. During production, underwater pipelines are buried metres under the seabed to prevent damage by submerged ridges of floating ice. We also use detection technology that can give us an early warning of a possible leak. Valves will stop the flow of oil if a very small drop in pressure is detected in the pipelines.

One recent joint industry project involving Shell aims to improve the way oil spills in the Arctic can be tackled. The project was led by the independent Norwegian SINTEF research institute. It tested several innovative response techniques, such as in situ burning of oil in broken ice, dispersion of oil in broken ice and oil detection under solid ice. In May 2009, researchers carried out a large field experiment off Svalbard in Norway to demonstrate advanced techniques to deal

BARRIERS

As in any good oil-field practice, a top priority is always to prevent leaks or spills. A multi-layered well control system ensures that if any one system or device fails, it should not lead to an uncontrolled oil spill from a well, known in the industry as a “blowout”. We use a number of early detection measures such as sophisticated sensors that immediately alert specialists at our global real time operations centres. And we use mechanical barriers such as “blowout preventers” to seal off the wells. Mechanical barriers work rapidly and effectively. But in the unlikely event these measures fail, it is possible to drill a relief well alongside that can pump cement or heavy mud into the original well to cut off the flow. We also have a stringent process in place to ensure the safe and controlled temporary suspension of operations if needed.

with oil spills in ice. The results of the field experiments are promising, and have led to increased knowledge that advances the development of reliable and efficient techniques for handling oil spills in Arctic conditions. In situ burning and the use of dispersants show great promise for efficient use in the Arctic.

REDUCING SOUND FROM OPERATIONS

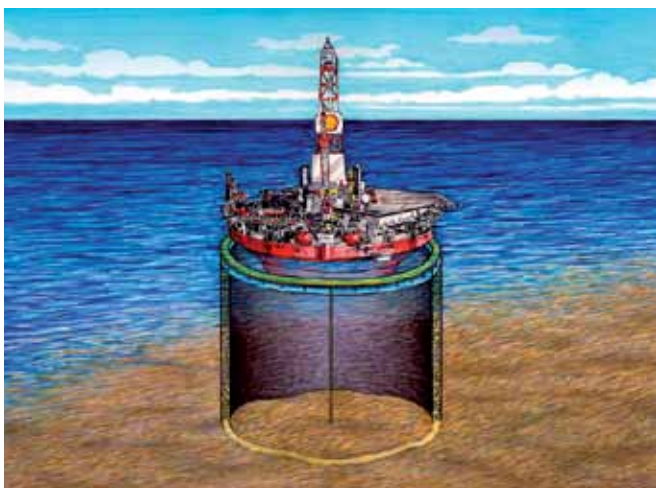
Sound from oil and gas activities can affect marine mammals. Such man-made sound comes from sources such as seismic surveying, propellers, vibrations from engines, flow turbulence from moving vessels, and other mechanical impacts. Shell develops and tests advanced technologies that help to quieten offshore facilities and lower the noise from marine supply vessels. We have conducted measurements around our exploratory drilling rigs in Alaska and our production platforms in Sakhalin II to better understand drilling sound sources and we are developing several technologies to insulate noise. We also carry out real-time monitoring of our underwater sound from our installations.

We use different mechanisms to reduce sound at its source. These include isolating machinery vibrations from the hulls of vessels and rigs and the use of insulating acoustic barriers to muffle vibration.

And we continue to look for new ways to reduce sound from our Arctic offshore operations. We have worked with two approaches to date. One is a physical bubble curtain made of plastic spheres to wrap around the undersea sections of offshore installations. Another is to use generators on the seabed to create a constant flow of air bubbles the size of a tennis ball that surround the installation. The different techniques and sizes of bubbles are still being piloted, but the approach looks promising. Both technologies have already been used successfully to reduce noise from pile driving during bridge construction.

Shell is also working to reduce noise from marine vessels. For example, we are building a new ice-class vessel for the waters off Alaska to set the anchors that hold our mobile drilling rigs in place. The 110-metre vessel is designed to be quieter than similar vessels and will play a major role in Shell's Alaska exploration plan.

Bubble curtains could help reduce sound from offshore operations.



Testing of an unmanned surveillance aircraft, a ScanEagle made by Insitu.

WITHSTANDING THE ICE

Moving sea ice can exert enormous loads on offshore oil and gas structures. The design of platforms and other production equipment we use in Alaska, for instance, is based on knowledge of ice conditions gathered over more than 50 years of experience, coupled with the results of leading scientific studies and traditional knowledge. These designs also take into account predicted changes in ice conditions such as type, movement, thickness and strength.

One example is the Sakhalin II oil and liquefied natural gas project in Russia's far east, in which Shell is a partner. Temperatures can drop to -45°C in winter. The production platforms off the coast of Sakhalin Island stand on giant concrete legs more than 20 metres wide and some 56 metres tall. They are extra thick to withstand earthquakes and rounded so that ice floes slide around them. Where the sea is less than 30 metres deep the pipelines are buried under the seabed to provide protection against ploughing from ice ridges. The pipeline was reinforced with extra steel. Our experience of Sakhalin II has taught us a lot about measuring ice loads. We use this experience to investigate a number of new design models and approaches to reduce the safe depth pipelines must be laid at, saving costs and reducing the impact of excavation. To ensure safe pipeline construction, it is also important to obtain detailed knowledge about the conditions of the seabed, such as the depth of the gouges caused by ice ridges.

Shell is testing the use of remote-controlled robots that can help us do these initial under water site surveys while reducing environmental impact and disturbance to marine mammals.

FUTURE OPPORTUNITIES

Most offshore oil and gas are still produced the traditional way with a platform connected to a well drilled into the seabed. Typically, the oil and gas are processed on the platform before being either shipped out or piped to shore.

In some cases we produce the oil or gas using installations on the sea floor connected to pipelines that take it onshore for processing, sometimes many kilometres away. This approach could work in some but not all Arctic areas and conditions because it avoids the hazards of manning and re-supplying a platform in harsh and icy conditions. The Ormen Lange gas field in the Norwegian Sea is a good example of how we use seabed installations. Shell was instrumental in the design of the system that connects the wells in the field with the onshore processing facility. One challenge is to maintain a constant flow of gas in sub-zero temperatures as gas hydrates – frozen gas – can form to cause blockages. To help prevent this we use anti-freeze chemicals in the pipelines.

IN SHORT

The use of technology that helps reduce environmental and social impacts is essential if the Arctic's rich oil and gas resources are to be developed. Operating safely and reliably is also critical. The approaches and technologies described here are some that we are testing or are already using in Arctic and sub-Arctic operations today. There are more. We continue to use our creativity and to work with local communities as well as other organisations, industry partners and academia to find the most effective technological solutions for developing Arctic resources safely and responsibly.

SAKHALIN II TECHNICAL HIGHLIGHTS

- Platforms use the largest friction pendulum bearings ever manufactured
- Minimal crossing of fault lines along the 800-kilometre oil and gas pipeline corridor
- Ability to withstand the type of earthquakes that occur around once every 200 years
- Environmental impact reduced considerably
- Novel solution for allowing pipeline movement in frozen ground

SAKHALIN ENERGY

Engineers from Sakhalin Energy Investment Company Ltd. use technology and traditional knowledge to address environmental concerns related to that project. Tribal leaders helped secure the construction of the two 800 km pipelines in a sustainable way. These pipelines cross around 200 rivers and streams classified as sensitive areas for salmon spawning. In addition, the river valleys are home to sable, reindeer and bears. The pipelines were laid in mountain areas where melting snow and rainfall causes landslides and in swampy areas in the lowlands that are difficult to access in winter. Each river and stream was crossed in winter when the ground was frozen. In some places, engineers tunnelled under seven rivers and one bay using directional drills deep below the waterbed and pulling pre-welded pipeline segments through. Some tunnels were up to 1,800 metres long. Furthermore, Sakhalin Energy rerouted offshore pipelines to avoid the feeding grounds of the rare Western Grey Whales.

Sakhalin II platform in ice, Russia.



This publication is one of a series of briefing notes on challenges related to oil and gas development in the Arctic. The series includes Shell in the Arctic, Arctic Biodiversity, Working with Indigenous People, Technology in the Arctic, Preventing and Responding to Oil Spills, Climate Change and Developing Arctic Oil and Gas.

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