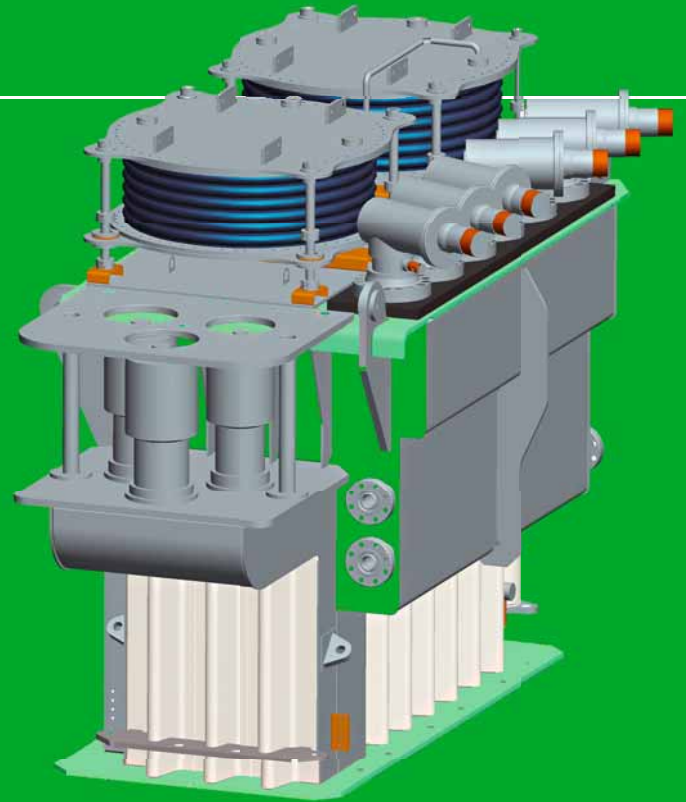


Under pressure

ABB's subsea transformers

Esa Virtanen, Mark Curtis

Underwater oil fields are among the most extreme environments in which transformers are required to operate. ABB has been developing subsea transformer technology for almost 25 years and remains the world's only manufacturer with installations powering pumps and compressors to extract oil and gas from reservoirs below the seabed, keeping wells productive for longer.



The continued exploitation of offshore oil in shallow waters is declining as these relatively local reserves diminish. Often to maximize oil extraction seawater or gas is pumped into the well to increase pressure and drive the remaining fuel trapped beneath the seabed to the surface. Similar techniques are used in deep water oil fields, at much greater distances from the shore, which now present additional challenges to the industry. Such operations require specialized knowledge and expertise particularly when powering compressors, pumps and motors at depths of several kilometers, possibly 50 km or 100 km away from the shore. To bring power to such remote offshore locations, with low losses, requires transmission at high voltage through subsea cables. Such transmission relies on step-up transformers to increase the voltage

levels for transmission and step-down transformers to reduce the voltage to a suitable level to operate the specialist electrical equipment at the offshore site. Since this specialized equipment operates deep beneath the sea surface, the step-down transformer must be capable also of operating at similar depths.

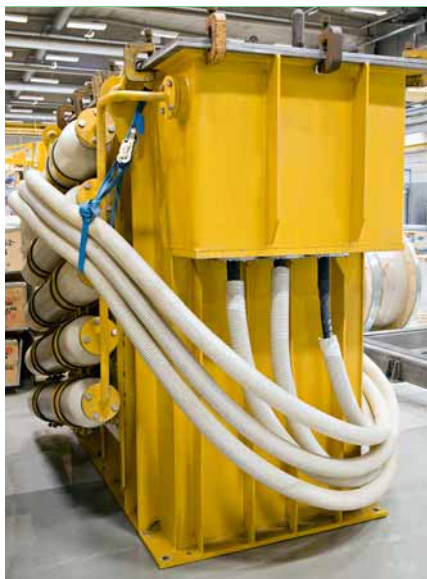
ABB has been developing subsea transformers since 1985. The first two subsea transformers, rated at 1.6MVA (megavolt amperes) 11 kV /1 kV, were submerged in 1999 to a depth of 500 m and have remained reliable to-date, powering oil booster pumps for the last 10 years. Since then ABB has been incrementally developing larger units. These transformers require specialized design features that enable them to operate at depth, under pressure. This has meant that all air and

gas-filled vaults within the outer casing must be eliminated by immersing components in liquid and developing a pressure compensating system to keep the internal pressure close to the outside water pressure. Since transformers get hot when operated, the type of liquid used inside the transformer is critical to its successful operation. High-class insulating oil with a low expansion coefficient that is compatible with the other material and components of the transformer was used. Such oil is degassed prior to installation since the transformer is housed in a solid tank, which cannot expand, even when hot. The heat generated by the transformer during operation has the potential to accelerate chemical reactions, possibly enhancing the corrosive effects of seawater and since the transformer is cooled by natural convection, has the

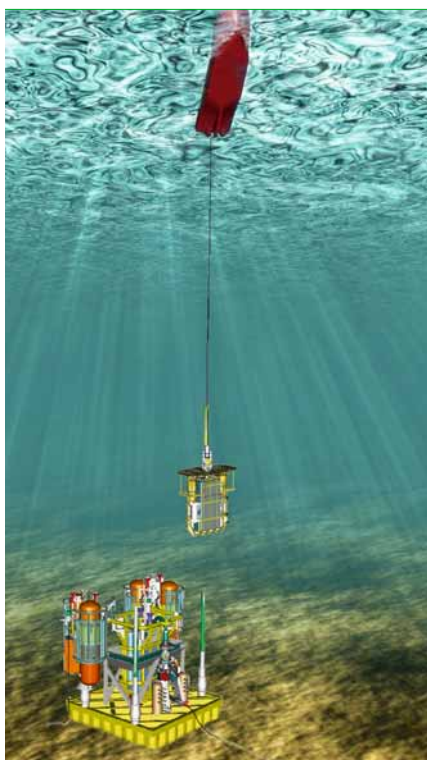
Powered by innovation

potential also to attract living organisms to the outer surface of the casing. These factors have dictated the use of special high-grade steel for the casing, which is also especially able to cope with the high pressures associated with deep-sea locations. Such subsea transformers are about 2.5 m tall, 3.5 m long and 1.2 m wide and contain a volume of insulating oil of about 4 m³ **1**. When combined with

1 Subsea transformer



2 Installing a subsea transformer



the pump, valves and piping the entire unit can weigh about 20 to 50 metric tons, which would likely sink into the mud or sand if it were simply lowered to the seabed. This entire structure is mounted, therefore, on strong piles, which are first hammered into the seabed. Tubes on the underside of the structure slot over the piles so that the structure stands a few meters above the seabed when properly installed. Once installed no further maintenance or repairs are required. In fact, since the scope for doing repairs is limited, due to the expense of raising equipment to the surface, ABB has invested a great deal of time and effort to ensure all components are of the highest quality and have undergone rigorous testing. These stringent tests have ensured that all 15 subsea transformers currently installed are operating reliably and safely, providing great performance and cost benefits to offshore developments.

ABB's newest subsea transformer is rugged, powerful and capable of operating at depths of up to three kilometers.

Pipeline heaters

In the Gulf of Mexico, for example, at a depth of about 2,000 m the oil pipeline must be warmed to de-solidify oil, which due to pressure and cold, has frozen.

A mobile plant is transported by boat to the place where the pipeline is frozen. The mobile plant consists of an electrical system, a subsea cable and a subsea skid. The subsea skid, which includes a subsea transformer and the electrical connectors required to contact the pipeline, is lowered to the seabed **2**. With the help of a ROV (remotely operated vehicle) the electrical connectors are attached to the pipeline and the power is switched on.

The ship's diesel generator produces 480 volts and a step-up transformer is used to raise and regulate the voltage between 1 kV and 11 kV. At the seabed, the subsea transformer lowers

the voltage to a suitable level for the pipeline. The pipeline is then heated up and usually after a few days the blockage dissolves.

Highly rated

The most recent subsea transformer technology will ensure continuous production in a gas field located 400 meters under water off the coast of Norway. At the Norway site, building a new offshore platform near the gas field was considered too costly. Moreover, the field is 150 km from land, and 50 km from the nearest offshore platform. At these distances using conventional transmission voltages (6.6 kV) most of the power required to keep the compressor motors running on the seafloor would be lost. Instead ABB's newest subsea transformer is rugged, powerful and capable of operating at depths of up to three kilometers. With the highest power and voltage ratings (rated at 15 MVA / 50 kV / 6.6 kV) and the highest operating frequency (200 Hz), ABB's subsea transformer is the most efficient on the market and capable of reliable operation at this site.

The oil and gas industry constantly present new challenges as fresh fields are discovered for extraction. As a result ABB is already building even higher rated subsea transformers for 20 MVA 132 kV / 22.5 kV and 16.5 MVA 22 kV / 3.5 kV / 2.8 kV (title picture) that will be delivered in time to test equipment for the world's largest gas field, Ormen Lange, in Norway.

ABB remains the world's only manufacturer of subsea transformers capable of delivering reliable power underwater with minimal losses.

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