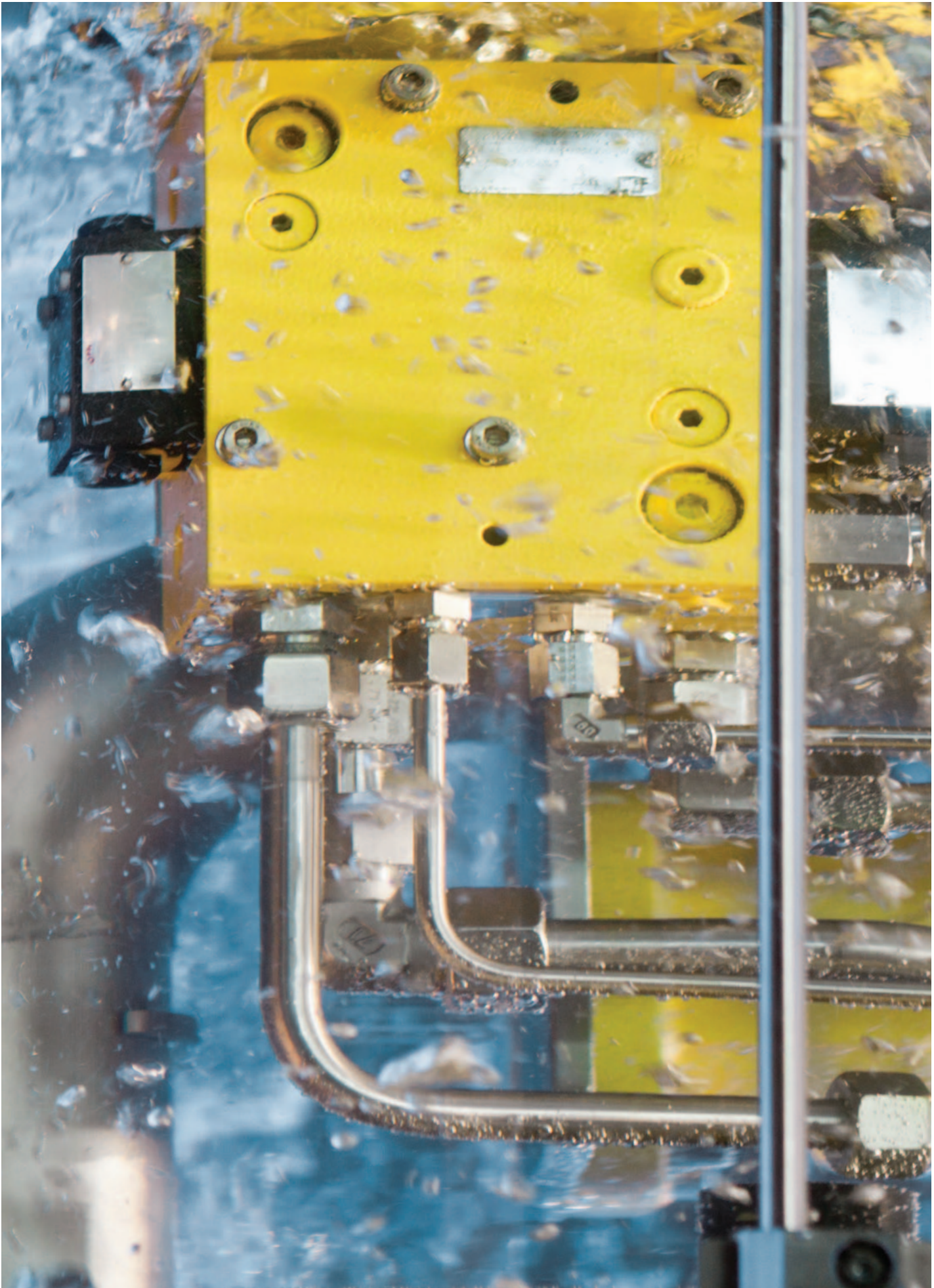


Discovering the deep sea with Rexroth hydraulics





Deep sea hydraulics – proven solutions for up to 6,000 m water depth

The globally increasing demand for raw materials, such as oil, natural gas and minerals, with simultaneously decreasing reservoirs makes the development of new production areas necessary and economically interesting.

Most of the recently discovered sources are located in the deep sea, some of them as deep as 5,000 meters below water surface. New powerful production machinery will be needed to harvest these sources in the future. Hydraulic drives can prove their full strength in these machines: they are powerful, compact, precise, and intelligent. In the past years special systems and components for deep sea applications were developed and their functionality has been proven during pressure chamber tests. Discover the results.

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History and future perspectives

Hydraulic components for deep sea applications are not really new in principle. Already in the Seventies the first hydraulic components for large machines were developed.



◀ Sub sea crawler equipped with a hydraulic drive system

These machines were for instance used for carrying out drilling, digging and trenching at water depths of up to approximately 200 meters. Their track drives, manipulator arms and drilling tools were driven with hydraulic cylinders and motors and were controlled by hydraulic valves. As the production and numbers of these components were few and thus relatively costly, the development would move to the background in the following years.

This new century however seems to bring new opportunities for deep sea hydraulics. This is partly due to the fact that fossil fuels and minerals have to be extracted from

continuously greater depths. The most recent sources are located at a depth of 3,000 meters and more below sea level. Some of the harvesting and processing equipment will no longer be located on the ship or platform, but has to be lowered down to the seabed, as to carry out the necessary activities right there and then. It is a logical decision to drive this equipment hydraulically, considering the fact that hydraulics are compact and intelligent, as well as combining a great force density with the required precision.

Deep sea applications

To handle heavy loads and carry out installation works on the seabed, heavy machinery is used. Hydraulic hammers drive piles in the seabed to ensure a tight fixation of the equipment to the seabed. Also for civil engineering structures such as bridges and harbors these hammers are used.



Deep sea installations

New, highly sophisticated crawlers can install heavy equipment and carry out test drillings right on the seabed. In order to protect oil and gas pipelines from mechanical damage due to shipwreck, natural currents and earthquakes, trenching crawlers are used to bury the pipelines into the ocean floor. Thanks to most modern and sensitive Rexroth hydraulic systems, these crawlers offer excellent handling and manoeuvrability.

◀ **Hydraulic pile driving hammer used for deep sea installations. Rexroth components ensure reliable and continuous performance of the hammer.**

▶ **Deep sea crawler with sophisticated Rexroth hydraulic system**
▼ **Underwater trencher for cable and pipeline installation on the seabed**



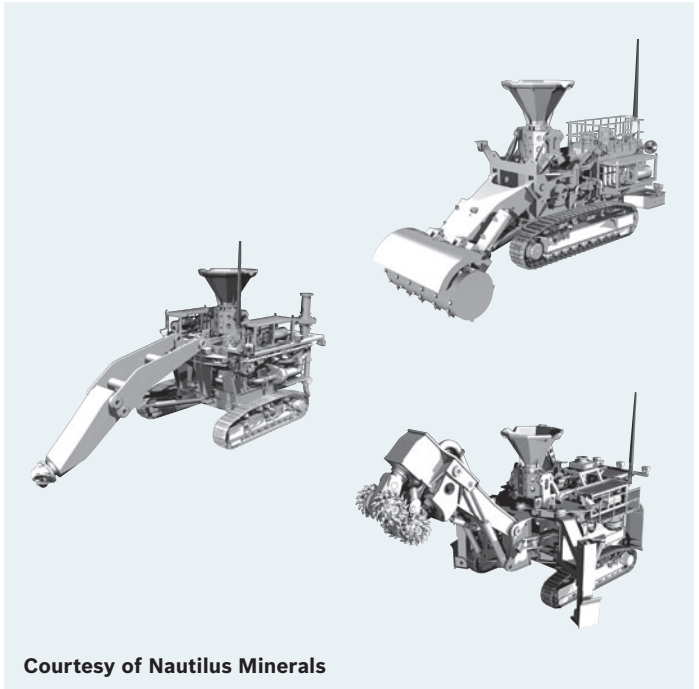
Courtesy of Seatools B.V.

Deep sea mining

Deep sea mining activities are really increasing in the past years. The first commercial exploration and mining of Seafloor Massive Sulfides is about to be realised. High grade copper, gold, silver and rare earth minerals will soon be harvested in the South East Pacific.

With it's Deep sea hydraulics Rexroth makes this reality. Heavy duty seafloor production crawlers are operated hydraulically. Rexroth's Active Heave Compensation systems ensure safe and secure launch and recovery of this expensive equipment.

New and unique Rexroth hydraulic valves operate in trailblazing subsea pumps that are used for deep sea mining and for the revolutionary dual gradient drilling in oil and gas explorations.

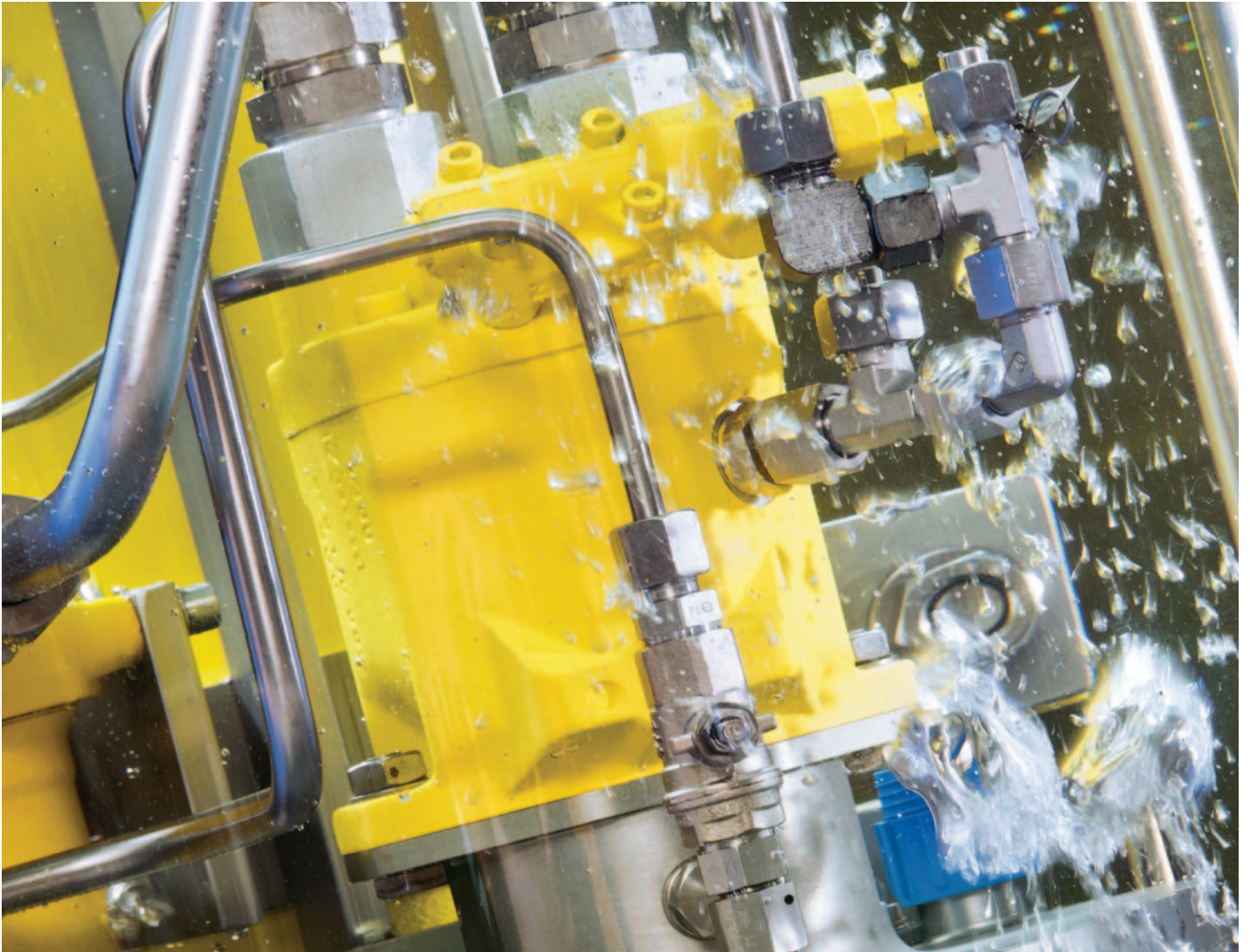


▲ Seafloor production tools that will be used for deep sea mining



◀ Launch and recovery system (LARS) with Active Heave Compensation

▲ Hydraulic valve specially designed for new and trailblazing subsea pumps



Requirements for deep sea hydraulics

In order to make hydraulic components work in the deep sea, various challenges need to be overcome.



► Example of sea water protected components



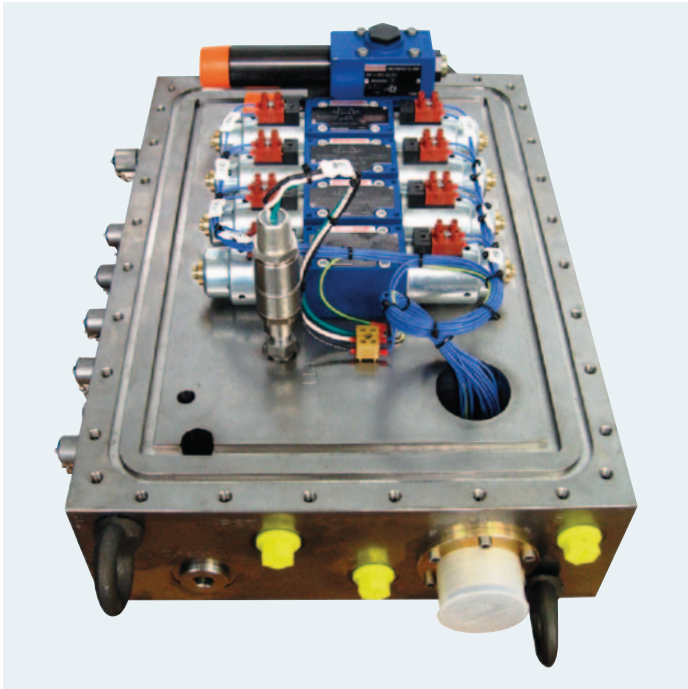
First of all, the components and equipment must be resistant to high ambient pressures. Every 10 meter water column increases the pressure by 1 bar, which means for instance that a depth of 5,000 meters comes with an ambient pressure of 500 bar. A so-called pressure compensator is the key to success and in greater water depths absolutely necessary.

Secondly the equipment has to function in a salt water environment. An optimal corrosion protection is therefore necessary. Rexroth offers a wide range of seawater protected components that can be used in submerged applica-

tions. They are either made out of corrosion resistant materials and/or special coatings have been applied. To avoid short circuit, all solenoid operated hydraulic valves have to be enclosed and secured against water ingress.

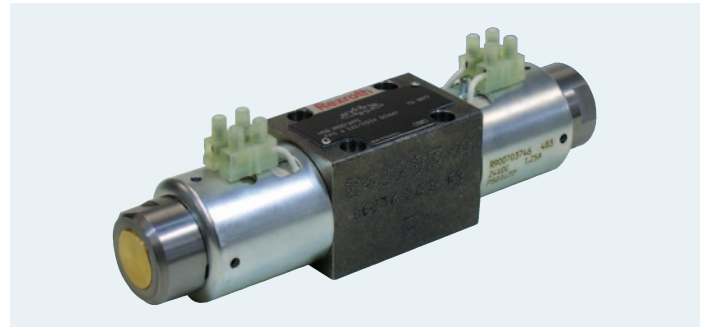
Finally, the designer has to take into consideration the fact that the machines that work at such a depth cannot easily be hoisted up in the case of a malfunctioning. A reliable and sensitive performance as well as a long, maintenance-free life span are therefore desired. Rexroth's excellent quality and application know how ensures that these requirements are taken care of.

Solenoid switching and proportional valves



◀ Hydraulic valve manifold for deep sea applications

▼ Special hydraulic valve for deep sea applications



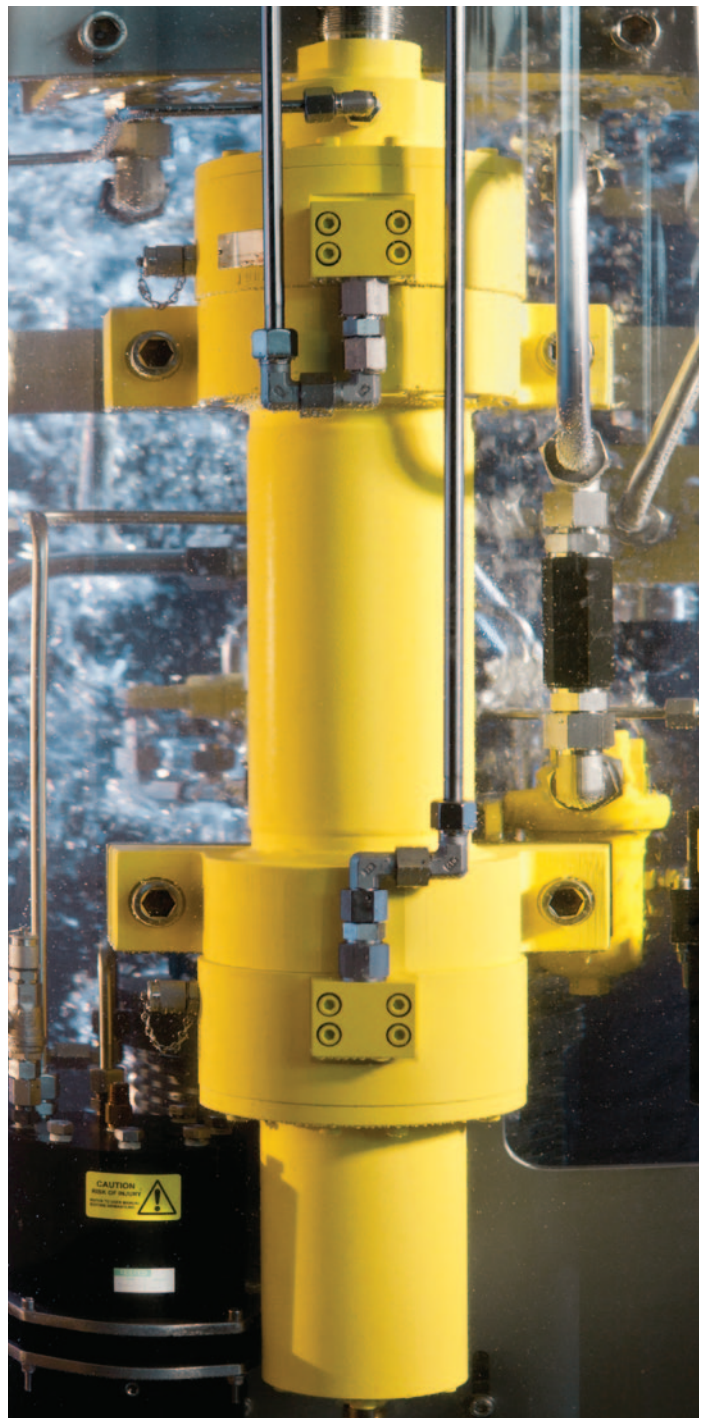
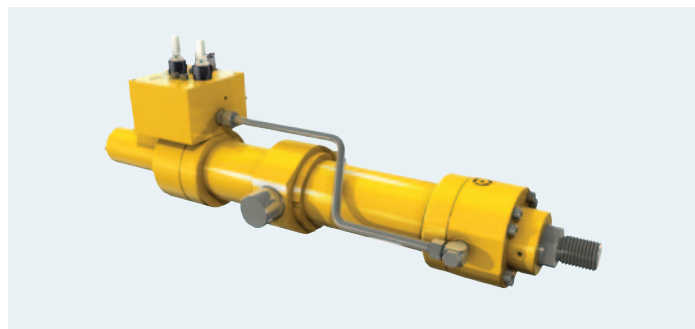
Standard solenoid operated hydraulic valves can not operate submerged under water. The valves, or the complete manifolds, need to be placed in a fluid filled enclosure that is pressure compensated with the surrounding pressure. Due to the fact that the volume of the pressure compensator is limited, it is critically important that any captured air within cavities and chambers in the valve and/or the manifold is vented completely. Rexroth has developed a special line of conventional and proportional valves which incorporate unique modifications to eliminate or bleed any captured air.



Deep sea cylinders

As a full liner Rexroth also offers a wide range of hydraulic cylinders, that can be modified to suit deep sea applications. Depending on the customer's requirements, customized cylinders are also possible, control manifolds can be mounted to cylinder directly. Rexroth has extensive experience with offshore cylinders used in riser tensioning, heave compensation, skidding, deck mating and jacking applications. The surface technology for piston rods of hydraulic cylinders is one of the most essential parts of the hydraulic installation. The new Enduroq 3200, a dual layer, Ultimet based heavy-duty coating has been specially developed for offshore splash and submerged applications and is the only coating in the market meeting the stringent DNV rules. One special feature of Rexroth deep sea cylinder design is the pressure compensated cylinder head: In order to protect the wiper ring from the high ambient pressure, the chamber between wiper ring and main seal is pressure compensated. Secondly, the main seal is not in contact with salt water and well lubricated by the hydraulic fluid.

▼ Customized Rexroth deep sea cylinder with built-on control manifold, integrated position encoder and pressure compensated cylinder head



Diagnosis and monitoring



◀ **New Cylinder Integrated Measuring System (CIMS) MK4 designed to work with the new Enduroq surface technology**

▶ **Bosch inertial sensors for measuring accelerations and angular rates. These sensors can be used for dynamic control systems of sub sea vehicles**



All remote controlled sub sea vehicles and crawlers use many kinds of different sensors to check condition and function of all systems. The signals are communicated to the control system and the operator. This applies also to the hydraulics. Rexroth deep sea cylinders for instance are either equipped with position transducers or proximity switches, pumps with a swivel angle transducer and track drive motors with speed sensors.

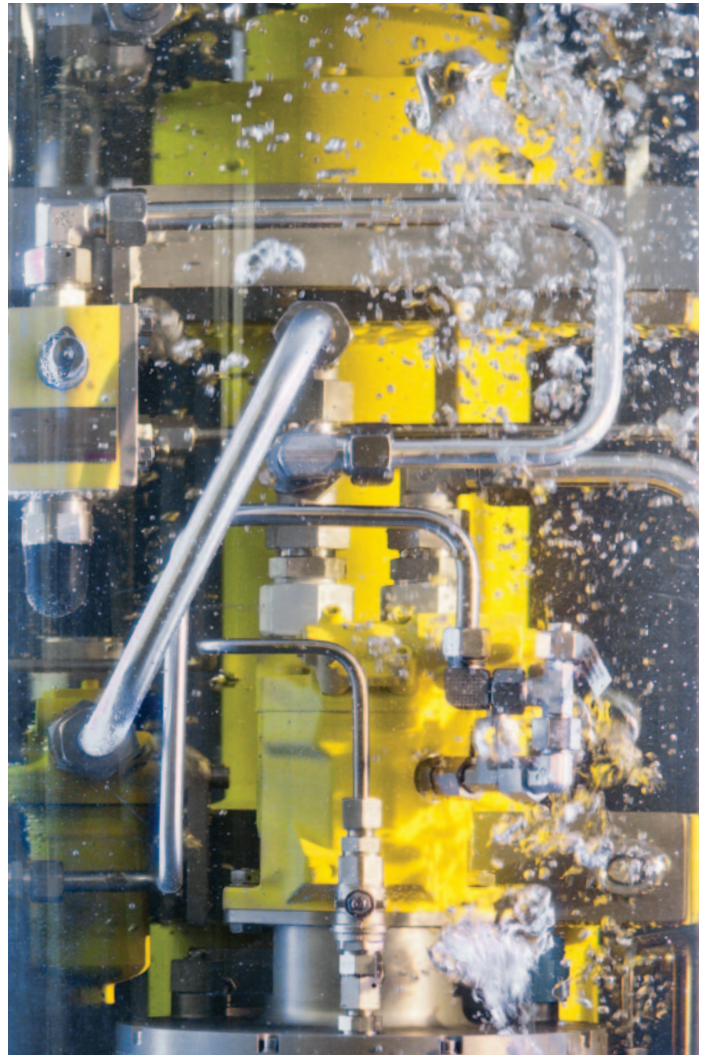
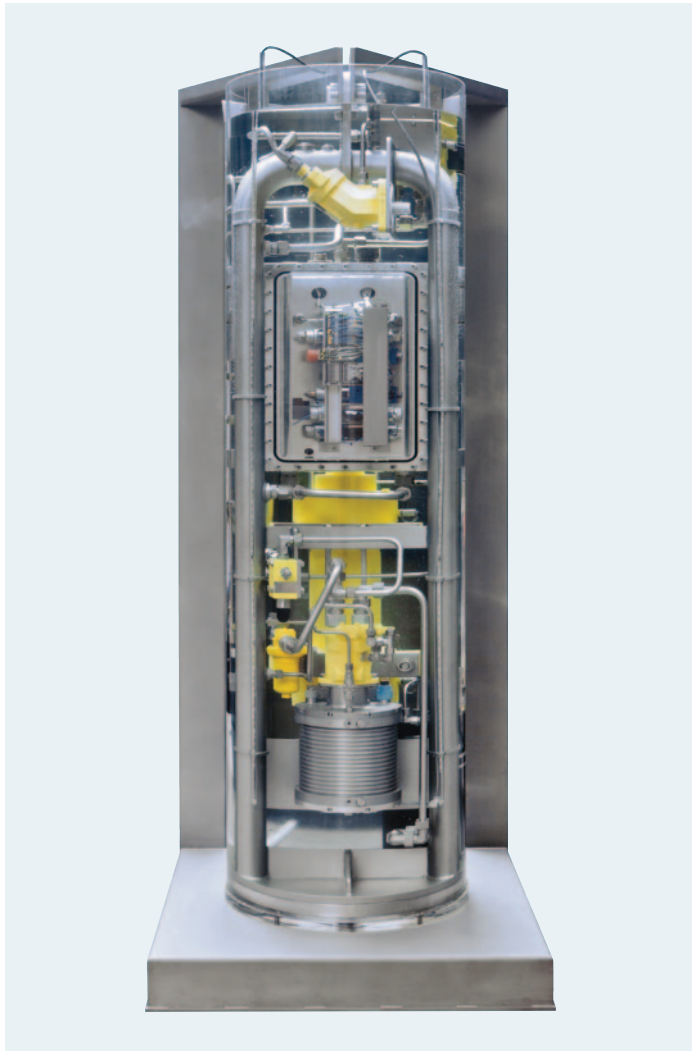
Rexroth's mother company, Robert Bosch GmbH, has extensive experience in designing and manufacturing sensor technology for the automotive industry. The requirements of this industry regarding environmental conditions and 100% liability are similar in deep sea applications. Together with the Bosch Engineering GmbH, that has the task to apply automotive sensor technology also to other industries, Rexroth has the knowledge and the ambition for future sensor solutions. One excellent example is the new position sensor CIMS MK4 for hydraulic cylinders. Combining Rexroth's knowledge about surface technology for piston rods and Bosch's sensor know how, a new, trailblazing sensor has been developed.

Diagnosis of hydraulic system

- ⊕ Deep sea cylinders either with proximity switches or position encoders
- ⊕ Pumps fitted with swivel angle transducer
- ⊕ Speed sensors for track drive motors
- ⊕ Clogging indicator for pressure and return filters
- ⊕ Particle counter in return line
- ⊕ Special sub sea pressure sensors
- ⊕ Water ingress and temperature sensors

Test power unit in pressure chamber

To ensure reliable functionality and performance of the new components and sub systems extensive tests up to 600 bar ambient pressure in a hyperbaric chamber have been carried out. A specially designed power unit comprised a wide spectrum of different hydraulic components and sub systems. The final conclusion: everything functioned correctly in the pressure chamber during the entire test cycle.



Your benefits

- ✓ extensive application know how
- ✓ understanding your challenges
- ✓ superior, state of the art technology
- ✓ modular and customized solutions
- ✓ wide variety of components
- ✓ world wide service

Tough application
ingenious solution } exactly



Bosch Rexroth AG

Zum Eisengießer 1

97816 Lohr, Germany

Phone +49 9352 18-0

Fax +49 9352 18-40

www.boschrexroth.com/hydraulics

Find your local contact person here:

www.boschrexroth.com/addresses