SUBSEA INTERVENTION & SURVEY

SEAWATER SENSOR CALIBRATION IN A HYDROSTATIC PRESSURE CHAMBER

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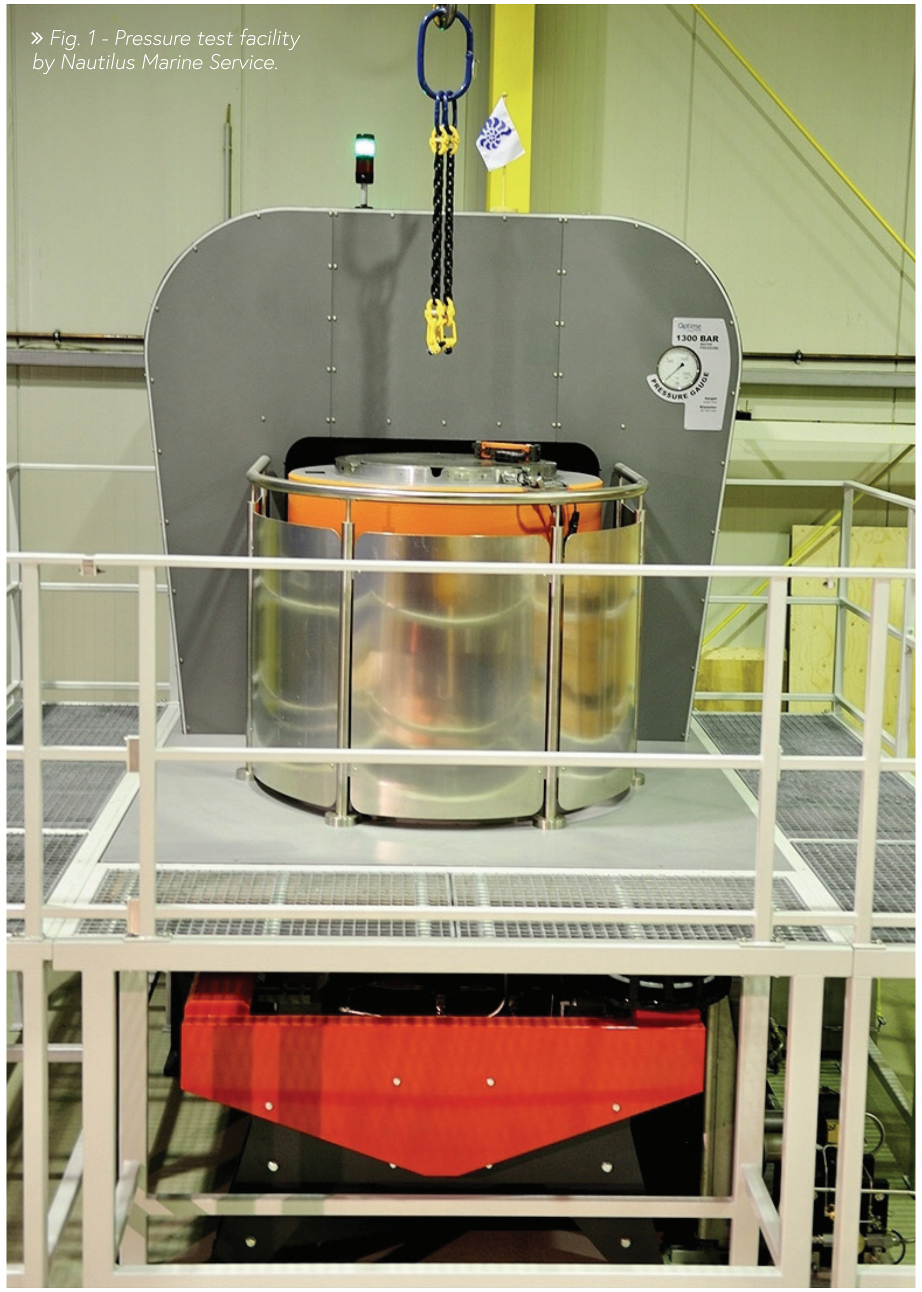


» Fig. 1 - Pressure test facility by Nautilus Marine Service.

Working in the deep sea is challenging for many reasons, not least the enormous pressure that quickly accumulates with every meter below the surface. Instrumentation has to withstand the high pressure and not implode or have water leak inside. If measurements are to be taken at depth, sensors also have to work accurately over a wide range of pressures. This task has engineering as well as calibration aspects, and for both, pressure testing is necessary to provide reliable instrumentation. Pressure testing can be conducted in-situ, but testing facilities provide more efficient environments with lower cost and carefully controlled conditions for such tests, as well as support for many different customers and applications.

The pressure test facility operated by Nautilus Marine Service GmbH in Germany (Fig. 1) can create pressures from 1 bar to 1300 bar—equivalent to the pressure at the sea surface down to the deepest parts of the Mariana Trench. The pressure change rate can be set from 10 bar/min to 60 bar/min, and the pressure profile to follow over time can be specified exactly. Depending on the purpose of the test, stepwise increases with wait times at every step, or rapid cycling of pressure increase and decrease, or even sinusoidal pressure curves might be desirable.

The test sequence can either be operated and monitored by a Nautilus engineer on site or by remote access, which means that a client who wishes to run a pressure test, does not necessarily need to be present in person (Fig. 2).

Recently, the Canadian company RBR Ltd. sent two oceanographic instruments for seawater pressure testing at the Nautilus facilities in Buxtehude, Germany. These instruments, RBR*concerto*³ CTDs (Fig. 3 and Fig. 4), measure the electrical conductivity of water, temperature, and pressure (and, with additional sensors, many other variables). From the conductivity, temperature and pressure measurements, a variety of other variables can be derived, such as salinity, depth, density, and sound velocity. The data are used to characterize oceanic conditions for a multitude of purposes, from optimizing fish farming to providing baseline data for climate predictions. Since conductivity sensors are sensitive to hydrostatic pressure, this sensitivity must be quantified to achieve RBR's high accuracy specifications. It is difficult and expensive to do this work with vessel-based deep-sea measurements. Using a constant salinity pressurized tank is the ideal experimental configuration to quantify the effect of hydrostatic pressure on the conductivity sensor.

» Fig. 2 - Pressure profile example.

» Fig. 3 - RBRconcerto³ CTD.

The pressure chamber operated by Nautilus Marine Service GmbH is primarily designed to meet the challenging demands for conducting tests on VITROVEX® glass enclosures and related products and has been optimised in terms of speed, accuracy and robustness over traditional pressure test facilities.

Although computer-based calculations and sophisticated simulation algorithms are available today and certainly help to shorten the development process for such parts, only a test can really prove that the design is according to specification, the right material has been chosen, and that no signs of fatigue over the planned operation period will occur. Additionally, pressure tests are often mandatory as part of the certification process to be accomplished by a notified body.

» Fig. 4 - RBR conductivity sensors: 750 dbar, 2000 dbar, 6000 dbar models.

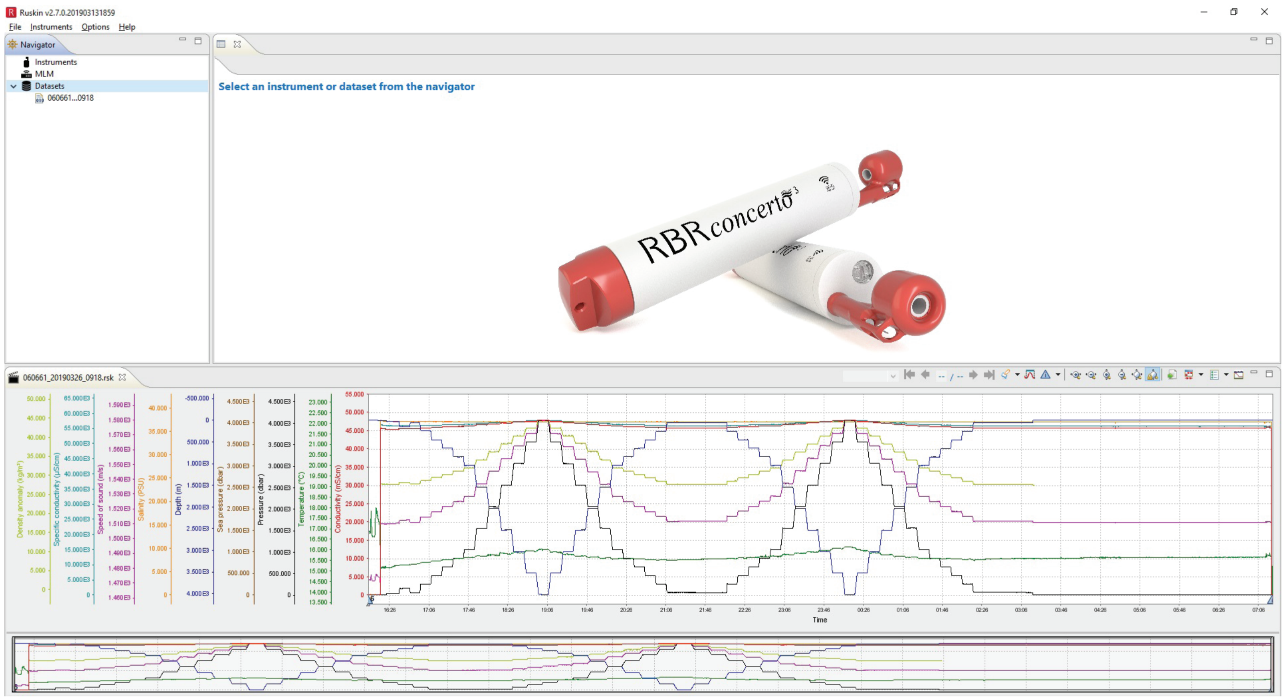
This complex field of activity opens up seemingly endless areas of applications for the Nautilus pressure testing facilities and related services.

For RBR's tests, for example, pressure was cycled between atmospheric pressure and 400 bar at varying rates of change. During a test, the volume of the pressure chamber stays constant and the pressure change is created by pumping water in or out. Even though we tend to think of water as incompressible, to increase pressure from 0 bar to 400 bar in the 700 Ltr. pressure chamber, an additional 12.6 Ltr. have to be added. And of course, a change in pressure also results in temperature changes – increasing pressure by 400 bar causes temperature to increase by 1.5°C.

Salinity inside the pressure chamber can also be set to customers' specifications. For the RBR tests, artificial seawater was prepared by Nautilus engineers from distilled water and aquarium sea salt. The sea salt is commercially available, and its chemical composition is designed to mimic seawater and therefore the conditions in which the instruments will operate.

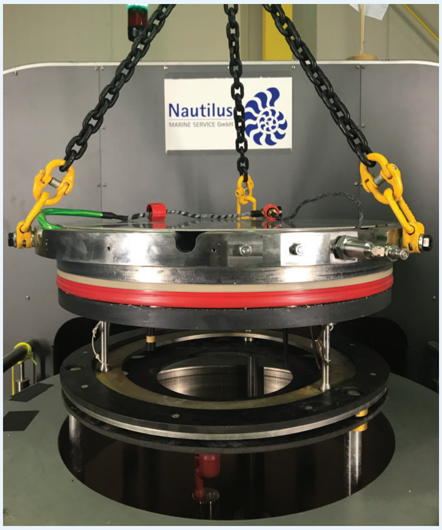
During the CTD tests, data were recorded internally by the test instruments and downloaded afterward.

Figure 5 shows a screenshot of the RBR Ruskin software interface to the instrumentation with data of several parameters collected during pressure testing in different settings—slow, stepwise increase and decrease of pressure and later rapid cycling between low and high pressures.



» *Fig. 5 - Recorder test data in RBR Ruskin software.*

RBR scientists analysed the data to meet two test objectives. The first objective was to determine how well the conductivity cell can withstand repeated exposure to high pressures. The second was to compute a pressure-dependent conductivity correction factor. The correction factor is necessary to offset the impact that hydrostatic pressure has on the conductivity measurement; correctly doing so ensures the sensor meets RBR's high accuracy specifications.



» *Fig. 6 - Lid of pressure chamber with interfaces.*

In other applications real-time access to data measured inside the pressure chamber might be desirable. This is also possible with the Nautilus pressure chamber as several leads through the lid can connect instrumentation inside the pressure chamber to computers on the outside. For example, if metal housings are to be tested, it could make sense to monitor in real-time if and how they are deforming. This can also be directly observed via cameras and lights available inside the pressure chamber.

Figure 6 shows the lid of the pressure chamber connected to a frame loaded with the instrumentation that is lowered inside the pressure chamber for testing.

Note: The cable feedthroughs in the lid enable the instruments inside the pressure chamber to be connected to computers in the lab for real-time observations.

SUMMARY

High pressure saltwater testing proved to be highly valuable for characterizing the metrological and mechanical performance of RBR CTDs. The two most desirable aspects of this testing were the scientific benefits of a controlled salinity environment, and the lower cost relative to field studies. RBR will continue to rely on these tests as an effective way to characterize instrument and sensor performance.

Nautilus Marine Service GmbH operates a pressure test chamber with capability that extends to full ocean depth and beyond, and it has the pressure test chamber available to outside clients also to carry out contracted pressure testing.

For further information on RBR products and pressure test services from Nautilus Marine Services, please visit
www.nautilus-gmbh.de

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