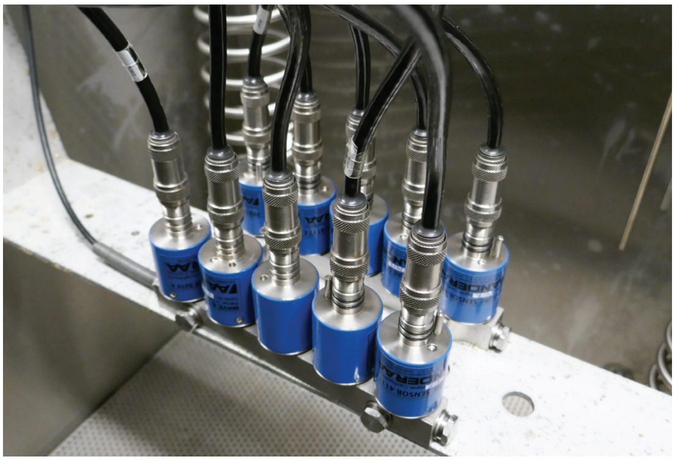
Sensor stability crucial to monitoring vertical seafloor movements in subduction zones

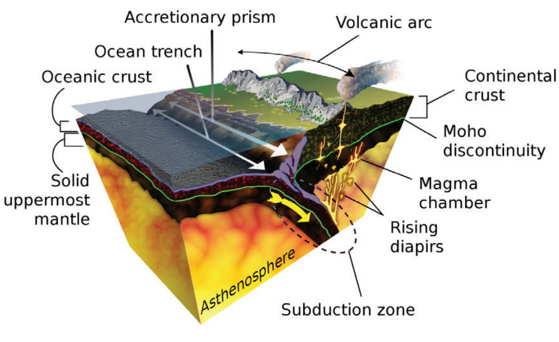
Aanderaa started to deliver stable and accurate pressure based water level and wave/tide systems (WLR/WTR 4/5 and 7/8) in 1975. These instruments used quartz pressure sensing elements.

In 2006 a new series of compact Pressure/Wave/Tide sensors based on silicon sensing elements using a piezoresistive measuring principle were introduced. These sensors have demonstrated excellent accuracy, resolution and stability. Also they consume little energy, can handle shock and are able to withstand 50% overpressure without damage and need for recalibration. This application note is the second in a series of several that describes projects where these sensors have been used.

Researchers from the Scripps Institution of Oceanography in California (USA) have long experience using quartz pressures sensors for detection of miniscule seafloor movements in earthquake zones. In such applications high resolution and long-term stability are essential.



Pressure/Wave/Tide senors at calibration. Calibrations are automatic in 20-25 points, 5 temperatures and 4-5 pressures. All calibrations are referenced to established traceable standards.



In a recent publication it is stated that "*instrumental gauge drift is often larger than the sought after geophysical and oceanographic signals*"[1]. Typically in an ocean subduction zone it is desirable to detect seafloor height changes of 1cm or less over one year from a deep-water installation, most subduction zones are found in the deep sea.

12 quartz and 3 piezoresistive Aanderaa (model 4117) pressure sensors were evaluated for drift in the Scripps pressure facility for 12 months at around 20MPa (approximately 2000m water depth).

"These sensors have demonstrated excellent accuracy, resolution and stability."

In the first 6 months the drift of the sensors was verified every 7-8 days by connecting to a Piston Gauge Calibrator (PGC), which is an established traceable standard for pressure sensor calibrations. The PGC was kept at 22MPa.

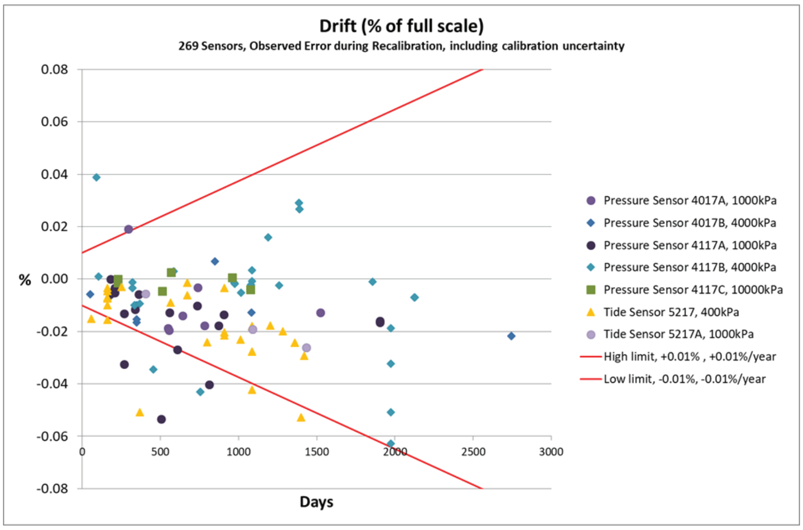
The following 6 months the sensors were occasionally connected to atmospheric pressure to evaluate if connecting to a pressure case kept at atmospheric pressure at the deployment site could be a viable method to carry out an in-situ drift control. The exposure to atmospheric pressure was followed by connection to the PGC to again evaluate the sensor drift against an absolute reference.

When compared to the PGC standard the Aanderaa sensors consistently drifted lower by an average of 1.07kPa/year while the quartz pressure sensors, after removal of values from two faulty sensors, drifted both higher and lower with an absolute average of 3.7kPa/year.

With respect to the atmospheric pressure reference the Aanderaa sensors still drifted lower by an average of 0.8kPa/year and the quartz pressure sensors continued to drift both lower and higher by an average rate of 0.6kPa/year.

We have learned that the drift of our piezoresistive sensors becomes lower over time. Consequently aging of the sensing elements will improve the stability further. This with a more easily predictable drift should make it possible to achieve a desired accuracy which is better than 1cm. The specific physical mechanism for drift in quartz pressure sensors is not well known.

Pressure sensors with different types of pressure tube inlet caps. Upper is standard, lower is with antifouling and a membrane to prevent particles to enter. For sites with high sediment load.



Applications

Barriers & dams / oil / gas / subduction zones / well monitoring / slope stability / cabled observatories / tsunami warnings / ports & harbours / Moorings (0 -12 000m)

Accuracy/Precision/Stability:
0.01% / 0.001% / 0.005% per year of full scale.

Full scale drift per year:
See graph to the left which summarizes the drift of 269 sensors (different models and ranges) that were returned to the factory for re-calibration during a time period of 7 years.

[1] IEEE Access PP(99):1-1 · October 2018, G. S. Sasagawa, Laboratory Simulation and Measurement of Instrument Drift in Quartz-Resonant Pressure Gauges

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