Q2 2016 CT cell failures

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Summary

During Q2 2016, a batch of six combined conductivity-temperature ("CT") OSP cells was manufactured at RBR. These had a design flaw which, coupled with the effects of hydrocarbons used in the manufacturing and assembly process, resulted in water ingress through the seal at the base of the CT cell stem. The oversight was corrected in subsequent batches, prior to understanding that a failure would occur. During Q2-Q4 2017, a number of these cells were deployed on Teledyne Webb APEX floats and leaked, resulting in the loss of the float. Investigations in Q4 isolated the root cause, and verified that other batches of cells were not susceptible to the same problem.

There are no cells currently deployed which are vulnerable to this issue, and no further action is required at this time.

Design flaw

The base of the stem of the combined CT cell, until early 2016, was sealed with a combination of face and bore o-rings. A threaded rod was used to apply the necessary torque to seal the face o-ring, and the bore o-ring never saw pressure differentials during normal use. However, a design change led to the removal of the face seal, and the bore seal became the primary pressure seal for a batch of cells manufactured in Q2 2016. This exposed the lower part of the stem to sea pressure, including the area where the threaded rod was inserted and thread-locking adhesive was used.

The manufacturing sequence for Argo float CTDs is slightly different from that of self-contained CTDs ("loggers"). In the latter case, the CT cell (and pressure gauge) is mounted on the logger and the entire instrument is calibrated as a single unit. For Argo CTDs, the CT cell and pressure gauge are mounted on a test logger, temperature and pressure calibration performed (including the temperature compensation thermistor that is located internal to the CT cell) and then the sensors are relocated from the test logger to the float endcap. In this final assembly, conductivity calibration is performed (under no higher pressures than 1dbar).

This removal of the CT cell from the endcap of the test logger necessitates the breaking of the thread locking seal (used in two places), applying a high torque loading to the polymer used in the CT cell. In addition, the thread locker that was used is hydrocarbon based. Stress corrosion cracking ("SCC") has the possibility of occurring under the combination of these conditions, coupled with a minimum wall thickness in the area supporting the bore o-ring. Cracking is potentially visible to the naked eye, but might occur behind the installed o-ring, and would escape detection.

Impact

For CT cells where SCC did occur, water ingress would occur usually in the first or second profile to 2000 dbar. At the time of these cells being utilised at Teledyne Webb, the assembled float was not subject to complete-float pressure cycling, and thus the leak would occur after deployment. The floats would either die without notice, or provide leak detection warnings, then die.

Design correction

A face seal o-ring has been added to all CT cells manufactured at RBR since end of Q1 2017. This o-ring prevents the area where the threaded rod is inserted to be exposed to a pressure differential. Since discovery of this issue, RBR ensured that the manufacturing and assembly process avoids at any stage the use of hydrocarbons.

Conclusion

Our design review process has been tightened to ensure that no feature modification such as this one can be repeated. RBR is very aware of the immense expense, far beyond that of the CTD, that is incurred by such failures, impacting both the float manufacturer and the entire chain of individuals and organisations involved in deployments. We will continue to endeavour to be open about shortcomings and faults, analyse fully, and share the results of those investigations.