TOTAL

TECHNO NEWS #8 August 2018 DTG/CTG

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UNDERWATER REPAIRS TO FLEX JOINT CONNECTORS

Joint and fl ange failures can occur. Such offshore failures, and particularly when underwater, are additionally challenging and induce potential safety and environmental risks, not to mention lost production. Total Nigeria was faced with this scenario when, during a routine inspection, two fl ex joints at the top of the water injection riser systems connected to AKPO FPSO were found to be leaking. Without intervention either of these leaks could have led to a catastrophic failure. The solution chosen was both innovative and a breakthrough, as it identifi ed the root cause of the problem and enabled a repair to be put in place safely without production losses and avoided harm to the marine environment.

A flange leak at FPSO AKPO

AKPO FPSO stands in 1300 m water depth offshore Nigeria. The subsea pipelines are linked to the FPSO using Steel Catenary Risers (SCR)'s connected to the topsides using fl exi joints (FJ's). The joint supports the SCR weight of about 200 tons, as well as transferring liquid at a pressure of about 25 MPa. During a routine underwater inspection in 2016, leaks were discovered at two of these flex joints (see Fig.1).

Fig. 1.Increased leak

Investigation found the cause to be incorrectly sized ring seals (gaskets), further investigation including specially developed ultrasonic inspection with IS-Industrie revealed not only the source and cause of the leaks, but critically that ongoing leakage was leading to cavitation erosion that would ultimately lead to a catastrophic failure if the situation was not corrected. The investigation established that the same "non-conforming" gaskets were also installed on all of the water injection FJ's but fortunately not on the production, gas injection, or gas export riser FJ's.

An innovative repair carried out in-situ and without lost production

The investigation concluded that an intervention would be needed to correct and/or repair all 4 water injection FJs, and the aggressive nature of the leak meant this was time critical, therefore a six month target was put in place, even though a technical solution was still to be developed. Under normal circumstances, replacing a gasket would be a conventional task. However the additional cavitation damage to the metal flange surfaces would require replacement or repair. This was not straightforward, the upper portion of the joint, being part of a replacement spool, could be changed out, however the lower portion was fixed to the FJ and would require an in-situ repair.
A technical solution was studied involving underwater machining using divers, but after several months planning and testing it was concluded that this would not be feasible as the machining tool was not suitable for use by divers.

Fig. 2 Epoxy primer application

The technical solution fi nally chosen involved the use of a composite epoxy repair together with a hybrid steel elastomer gasket. A steel hybrid gasket was selected as the steel interleaf would limit stress relaxation (creep) at very high pressures. The gasket would have to be robust enough to accommodate some surface anomaly. The gasket would be installed underwater, and would therefore need to dispel any water from its ring groove during tightening in order to prevent trapped water from resulting in over pressure and gasket failure (incompressibility of the water).

Fig. 3 Application of the composite repair material inside the groove

Total was able to contract its affiliate Hutchinson to design this very specialised custom gasket.
The hybrid gasket was demonstrated to be sufficient for surface anomalies up to 1mm x 1mm, beyond this the epoxy material would fill additional anomalies and distortion caused by the cavitation erosion. A simple and cheap technology recently developed on Moho Nord project, named underwater plasticine, has been used for performing the cavitation erosion measurement. Total contracted 3 X Engineering to develop the composite epoxy mastic, a material usually used for pipeline repair, however the approach would first require subsea shot blasting in order to facilitate proper adhesion of the mastic.

Fig. 4 Mould in place during the curing time

The mastic would then need to be applied by divers with a suffi cient curing time of 1 hour to remain soft enough for application, yet be cured in under 8 hours to limit the time of the operation, after which it would have to withstand a compressive strength of 70 MPa imposed by the gasket.

It can be seen that with the application of the composite repair material, the geometry of the groove was successfully rebuilt

Fig. 5. Plasticine mould of the groove before repair (left) and after repair (right)

Within only a few months Total was able to develop an innovative repair procedure to resolve a major integrity threat, without LTI (Lost Time Incident) or any impact on production from the FPSO. The integrity of the repair has been inspected regularly without signs of degradation. It is worth noting that other companies have since been in contact with Total, having experienced the same problem, with the objective of selecting this solution.

With 718 votes out of 2800 this project recieved the « Prix des Collaborateurs » on the 28th June at the Best Innovators 2018.