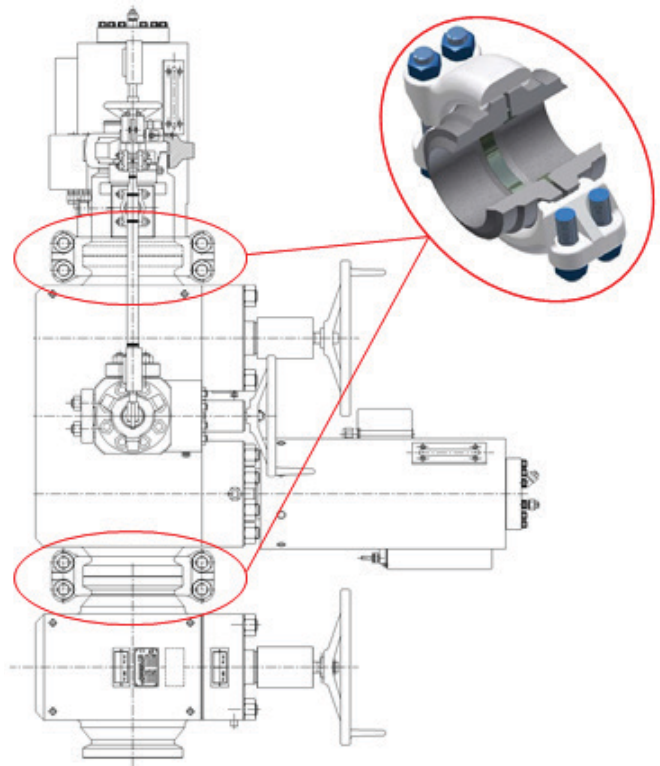


Oceaneering Develops Bespoke Integrity Management Strategy for Internally Corroded Pipe Clamps

The strategy allows clients to effectively screen, measure, quantify, and evaluate acceptability of metal loss inside the pipe clamps to facilitate replacement planning

Project Overview

Oceaneering was tasked with developing a suitable integrity management strategy for an aging offshore asset in the North Sea. The scope of work focused on high-pressure pipe connectors on the Xmas tree configuration on the asset's well heads. This work included developing a strategy for identification of pipe clamp connectors with suspected metal loss, in-situ quantification of the metal loss, and development of acceptance criteria. Although all affected systems were designed for operation at the same maximum pressure, individual systems could be subjected to different levels of pipe stress and structural loads, with developed acceptance criteria to be generic in nature to avoid detail assessment of each individual affected clamp.



Issues

While there are many advantages to using clamp connections instead of conventional flanged connections, their integrity is not given much consideration. Susceptible degradation is typically limited to atmospheric corrosion, with integrity management normally consisting of visual inspection, periodic fabric maintenance, and replacement based on subjective assessment without any discernible guidance or well-defined acceptance criteria.

Removal of a clamp connection during routine maintenance on an aging asset revealed significant metal loss on the inner cylindrical surface of the clamp, even though the external clamp surface was in apparent good condition. Visual inspection

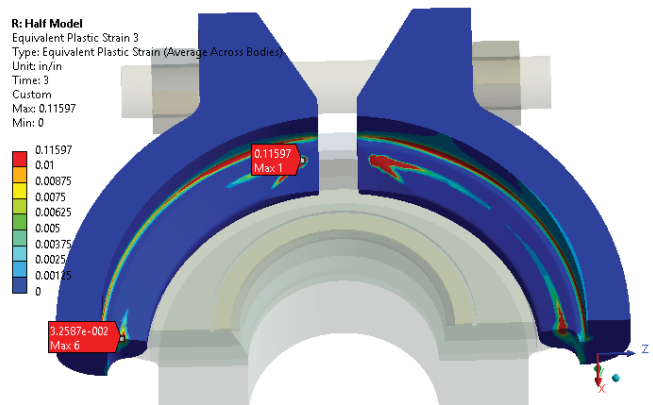


of the corroded clamp discovered plugged relief grooves, preventing the free drainage of moisture from the uncoated inner cylindrical clamp surface. Inspection of a sample of similar clamps revealed plugging of relief holes and angled installation inhibiting draining on a large number of clamps in critical high-pressure applications.

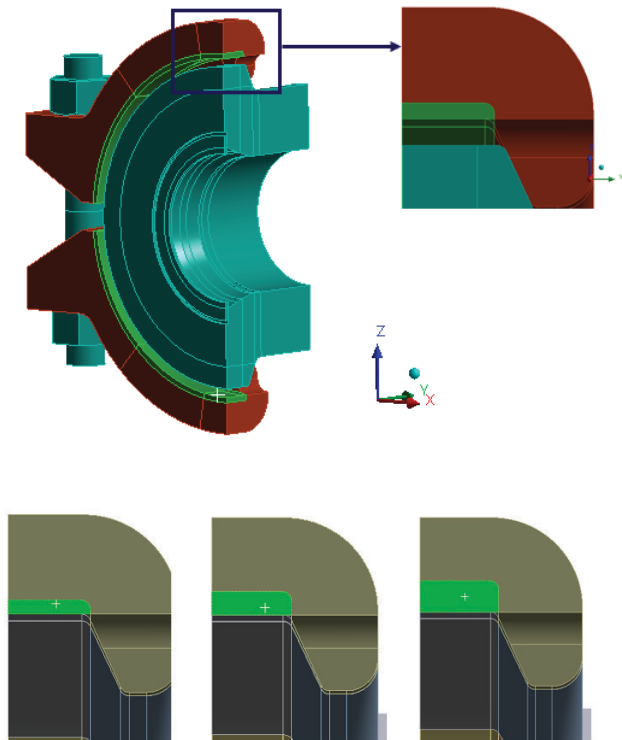


The Oceaneering Solution

Following code design procedures and two-dimensional, linear-elastic finite element stress analysis, the maximum allowable axial force and bending moments for the clamp configuration at the maximum design pressure, was calculated. The maximum allowable axial force, bending moments and pressure were subsequently applied to a three-dimensional elasto-plastic stress analysis model, while incrementally increasing metal loss, to determine the limits of permissible metal loss, while maintaining associated localized plastic deformation to code acceptable levels.



After determining the maximum allowable metal loss for worst-case design condition, sensitivity analysis was performed to determine the tolerance for further metal loss in the event of reduced levels of pipe stress and structural loads. A table of maximum allowable metal loss and corresponding level of maximum allowable structural load, expressed as weight force or “suspended load,” were developed for easy reference and expedient integrity evaluation of clamp condition without the need for additional calculative assessment.



Various ultrasonic thickness measurement techniques were tested on the corroded ex-service clamp to verify the effectiveness of detection and accuracy in quantification of metal loss.



An appropriate inspection technique for bulk screening and detection of clamps with metal loss was identified, together with a more specialized technique for accurate quantification of metal loss in individual clamps. Appropriate, application-specific inspection procedures were developed for the selected inspection techniques.



Challenges

At the start of the project, potential challenges were identified. For example, the team knew that various clamps could be exposed to different pipe stress levels such as one well head having additional pipework connected to it, which adds further stress from a clamp that does not have a similar set up.

One difficulty for the team was to develop generic criteria that were independent of pipe stress. We accomplished this by looking at the data for 'worst case' pipe stress levels and developed a table for acceptance criteria that corresponds to specific pipe stress levels.

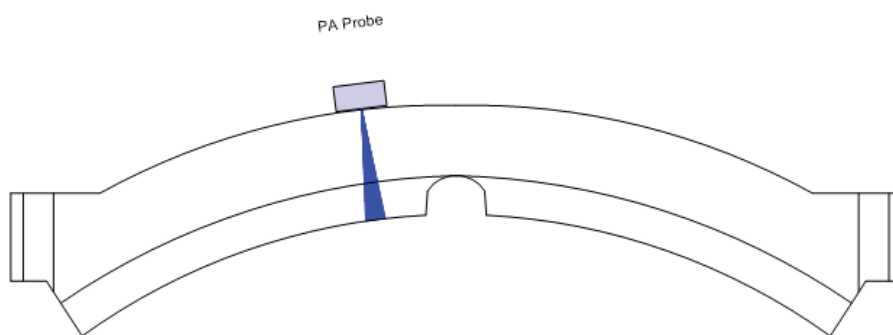
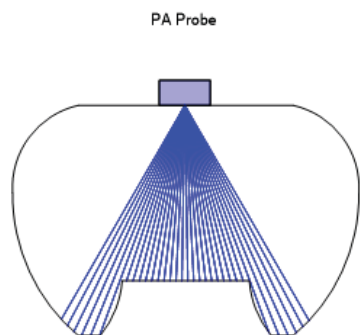
Another challenge would be how to measure metal loss on the inside of the clamp due to difficult clamp configurations. Some clamps had a surface finish with embossed lettering and rounded corners. The team conducted trial ultrasonic measurements through the clamp body using various non-destructive testing (NDT) techniques and verification. This allowed the team to identify NDT techniques for rapid screening and accurately measure the amount of metal loss to determine clamp acceptability.

Results

The results of the engineering study enable the client to implement a strategy of rapid screening of all suspect clamps using the core inspection team onboard. Affected clamps that are isolatable can either be identified for urgent replacement or further quantification of metal loss.

A specialist inspection team can subsequently be mobilized to quantify the metal loss in identified clamps remaining in service. Minimum measured thickness values can be compared with acceptance criteria for 'worst case' loading conditions. Clamps with an unacceptable thickness level can be further scrutinized with consideration of external loading and pipe stress, using the developed acceptance criteria based on reduced axial force levels.

Our Integrity Management and Digital Solutions group leveraged Oceaneering's extensive expertise in integrity assessment and non-destructive testing to provide our client with a solution to rapidly assess the integrity and quantify the risk associated with a previously unknown integrity threat affecting a large number of critical components.



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