Integrity Assessment of a Passing Export Riser Valve

Client Confidential
North Sea

The Problem

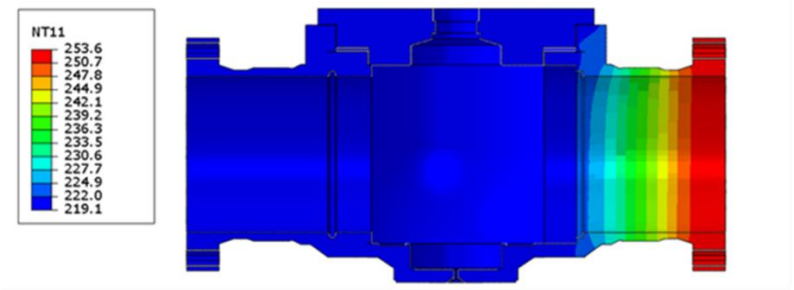
The gas export pipeline riser ESD valve on our client's offshore platform had been leaking at a significant rate for some time. The leak rate was below the maximum leak rate permitted by the Performance Standard. However, the leaking gas caused cooling of the valve and pipeline due to the Joule-Thomson effect, and considerable ice build-up was observed around the valve. As the valve body was manufactured from Low Temperature Carbon Steel (LTCS), with a normal minimum test temperature of -46°C, the client asked MMI Engineering to perform an integrity assessment of the passing valve under various postulated leakage conditions.

Our Approach

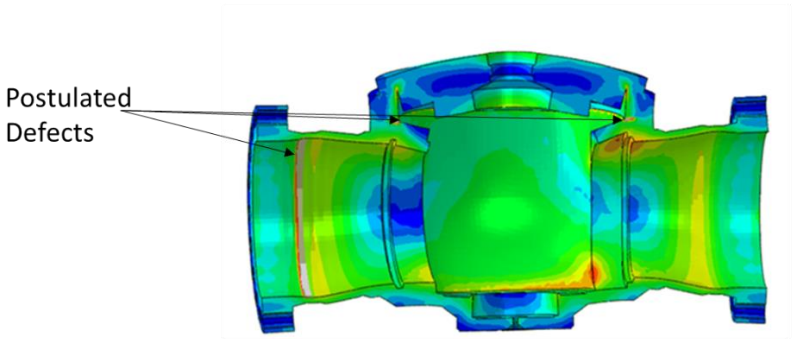
The integrity of the valve was assessed using computational fluid dynamics (CFD) and finite element (FE) methods. For the purpose, 1D computational fluid dynamics (CFD) and hand calculations were carried out to assess the heat transfer coefficients and associated bulk flow conditions within the valve body and local pipework. Thermal boundary conditions obtained from the 1D CFD and hand calculations were used in the FE heat transfer analyses of the valve assembly. Linear elastic FE analyses were subsequently performed to assess if the valve assembly was fit-for-service under internal pressure, external loads and thermal loads. An XFEM based fatigue crack growth analysis of postulated defects based on the inspection methods was also undertaken. The results of the analyses were used to determine the highest permissible leakage flow rate.

Outcome

The steady state heat transfer analysis predicted the lowest metal temperature of 219.1ºK (-54ºC), which was lower than the minimum test temperature of -46°C for ASTM A352 LCC and ASTM A350 LF2 materials. The linear elastic FE results showed that the stresses in the valve remained below the material yield stress. XFEM fatigue crack growth analysis demonstrated that the postulated defects did not grow to critical depth after 300 full pressure cycles (equivalent to one shut-down per month for 25 years). Moreover, it was confirmed that the postulated missed defects remained stable under all plausible release flowrates with no crack growth. The results of the integrity assessment were used by the client in their safety case presented to HSE and provided justification for continued operation of the export riser.



FE predicted temperature (°K) distribution



FE predicted deformed shape and von Mises stress contours of the valve with postulated cracks