GATE KEEPER
A Technical Newsletter for the Oil & Gas Industry
MAY 2015

Riser Integrity Monitoring for HP/HT Wells

The increased use of dynamic risers as an enabling technology for the movement of the oil and gas industry into the deepwater basins of the world has presented new technical challenges related to the prevention of corrosion failures and other forms of degradation. This has been particularly evident when considering production from the next generation of high pressure/ high temperature (HP/HT) subsea developments in locations such as the Lower Tertiary trend in the Gulf of Mexico. In order to avoid potential riser failures or replacement campaigns for anticipated service lives that may extend to 30 years or more, process facility components such as risers and flowline systems must now be subjected to more enhanced integrity monitoring through the whole of their service life.

The integrity management of both rigid and flexible risers is increasingly factored into the design of new installations to ensure that operating risks are maintained at as low as reasonably practicable levels, in part by ensuring that monitoring systems will be sufficiently robust and reliable to support ongoing condition assessment and risk analysis. In addition, the life extension of existing assets beyond their original anticipated design life, as a result of the current oil price environment and the need to optimize field development expenditure, is an ongoing challenge. Operators would like to extend riser service life, while many of the technologies required for the validation of their ongoing condition are not yet mature enough to provide confidence that this is a viable strategy.

Key Threats to HP/HT Riser Integrity

The most effective risk mitigation tool is to design out any threats to overall asset integrity. The earliest Gulf of Mexico deepwater riser systems are now in the 'golden years' of their design life. As predicted, most failures occurred early on, primarily due to incorrect design assumptions and/or material defects [1].

The following possible issues can be considered as key threats to HP/HT riser integrity beyond these initial failures:

- Corrosion including: Top-of-Line-Corrosion (TOLC), Internal Corrosion of SCR's, External Corrosion of Risers Above Water Level and Corrosion in Flexible Risers
- Vibration-Induced Fatigue and Stress and Fatigue of the SCR Touch-Down Point and Top Tension Riser (TTR) Upper Sections
- Riser Strake Fouling

Top-of-Line Corrosion (TOLC)

TOLC risks at the riser base can be greatly exacerbated by the presence of H_2S in the produced fluids. This can be particularly problematic where H_2S levels are uncertain, either for fields that may experience reservoir souring or where produced fluids contain H_2S, but were not expected to when at the design stage. Where H_2S concentrations are known, there are now published assessment methods for determining the risk of TOLC, including the Heuristic method, based on indirect determination of TOLC rates, and the holistic method based on a system wide risk assessment, implemented through a System Component Analysis (SCA) approach supported by proven dynamic thermal-hydraulic and corrosion models and coupled with field experience [2].

Internal Corrosion of SCR's

Any mismanagement of corrosion mitigation for produced fluids can cause wall loss by general corrosion or corrosion fatigue that under a combination of operational pressure, fatigue and stress can lead to riser failure. Inspection by intelligent pigging is not always possible, hence, other manual techniques such as caliper surveys must be considered. Typically, it is now standard practice to internally clad an SCR with a nickel-based alloy in fatigue critical regions such as the touch down region and the hot spot region at the top of the riser. For sour service, a minimum knock-down factor of 15 from the SN D-fatigue curve is typically applied for all non-clad sections of the production riser. This does not apply to metal clad sections.

Basically, all sections of the riser that meet the minimum fatigue life target without a knock down factor, but exceed the target once the factor is applied, are typically to be internally clad with nickel alloy 625 [3].

Current Monitoring Techniques For Each Riser Integrity Threat

Threat	Monitoring Technique
TOLC	Advanced Modeling Techniques
Vibration-Induced Fatigue	Combination of Motion & Strain Sensors, Inclinometer
Internal Corrosion of SCR's	Inspection by Intelligent Pigging
External Corrosion of Riser's Above Water Level	Visual Inspection Combined with Ultrasonic Testing of Any Corroded Sections
Stress and Fatigue of the SCR	Visual Inspection & Monitoring of Tension & Calculated Bending Loads
Corrosion in Flexible Risers	Optical Fiber Monitoring & Pressure/ Temperature/ Water Sensors, Gas Detection
Riser Strake Fouling	Coatings To Control Marine Growth Without Environmental Impact

GATE KEEPER

MAY 2015

GAT2004-2015.05

Riser Integrity Monitoring for HP/HT Wells

External Corrosion of Risers Above Water Level

Similarly to internal corrosion, external corrosion can cause wall loss and contribute to riser failure. Methods to identify and repair above water risers are mature. Visual inspection combined with ultrasonic testing of any corroded sections will allow a detailed assessment of the damaged area.

Corrosion in Flexible Risers

The armor wire in flexible risers can be subjected to corrosive fluids and rupture due to internal or external sheath failure. Flexible riser pipe design is such that there may be no visual indicators of a problem. The typical approach is annulus testing, which, like guided wave UT, can be too subjective depending on the non-destructive testing (NDT) operator. This is an important aspect of monitoring for measurements of free volume, level of water ingress, measurements of the rate of gas diffusion and the collection of samples of vented gas (through the inner polymer barrier) on the topside end-termination. Optical fiber monitoring and pressure/temperature/water sensors may be installed to carry this out. Other inspection technologies such as acoustic monitoring still need to be matured as a viable alternative [4].

Vibration-Induced Fatigue

While many aspects of asset integrity are addressed at the design stage, vibration-induced fatigue of subsea piping systems are typically left till a later phase. However, failures of this nature can be catastrophic and result in complicated and expensive repairs. Previous experience has indicated that these issues were not significant until recently. While the likelihood of a vibration-flow induced fatigue failure due to turbulence and pulsation is relatively small, the potential overall risk and impact could be substantial.

Pressure pulsation is a discrete frequency excitation caused by flow instability or vortex shedding (oscillating flow), generally confined to relatively dry gas systems. Vortex shedding is the result of vortices generated by gas flow across the internal corrugations of a flexible riser or jumper. A joint industry project has been completed to provide methods to predict the response to flow-induced pulsations in flexible risers and jumpers that includes the prediction of onset velocity, frequency content and pulsation amplitude [5].

Real time monitoring systems should be capable of capturing all the fatigue components of a Steel Catenary Riser (SCR) due to wave, vortex induced vibration (VIV), and vessel motions while providing valuable data on riser response. The combination of motion and strain sensors placed along critical locations of the riser provides the ability to track extreme loads and confirm integrity. Such systems require a significant design effort at an early stage of the project to ensure that the best decisions are made regarding choice of monitoring instrumentation, the location and number, as well as integration with the existing infrastructure [6].

SCR Touch-Down Point & Top Tension Riser (TTR) Upper Sections

Cyclic loading and large stress events will accumulate damage at the SCR touch-down point, which can lead to through wall cracks and /or catastrophic failure. Design standards recommend a safety factor of 10 since the validation of deepwater riser fatigue is currently not an accepted engineering practice. However, effective fatigue-tracking algorithms can be generated and validated to assess fatigue damage based on real-time environmental parameters. Centralizers in the upper riser sections can degrade and /or 'back off', because the fatigue and strength response is often optimized based on centralizer location/gap. The degradation can lead to unexpected operational loads. Visual inspection and monitoring of available tension and calculated bending loads should be carried out regularly.

Riser Strake Fouling

Riser strakes in the upper 500 ft tend to foul with marine growth, typically within 3 to 5 years. One study indicated that as the marine growth exceeds 1/3 of strake height, the VIV suppression frequency begins to drop. Anti-fouling treatments are largely ineffective and water-jetting is very time consuming with risk of damage. Hence, advancement in coatings to control marine growth without impact to the environment should be investigated.

Structural Monitoring

As offshore projects become more ambitious in terms of complexity and longevity, structural monitoring technology will continue to adapt, providing novel applications of simple tried and trusted technologies, based on a consistent set of solid principles. Of these, perhaps the most significant is strain measurement, which comes in two forms: the absolute strain measurement (i.e. the numerical distance from the value zero); and dynamic strain (the relative changes in the structures). Absolute strain is measured to determine whether a riser has suffered a specific instance of compression or over-tensioning, either of which can compromise riser integrity, even causing buckling or collapse. Dynamic strain measurement captures the shifts in values as a structure moves. It is used to calculate the fatigue history and expected lifespan [4].

Conclusion

As hydrocarbon developments continue to go into deeper and deeper water, significant challenges will need to be addressed to ensure that safe production can be obtained in more extreme conditions. Monitoring of riser integrity and testing methods will continue to evolve to ensure satisfactory integrity management of risers for deepwater HP/HT wells.

References

1. MacDonald, J., "Looking ahead: Riser Integrity Management in the GOM", Offshore Magazine, Aug 2011.

2. Osorio, N.F., Bukkaraju, S., Garduno, J.L. and Jordan, L.C., "Top of Line Corrosion: An evaluation of Critical Parameters that Drive Mitigation Methods and System Design in Deepwater Gas Systems, Paper OTC-26007-MS, Houston, Texas, May 2015

3. Price, J.C., "Options in Material, Coating and Chemical Selection to Mitigate Failure in Hydrocarbon Production", ISOPE 2012, Rhodes, Greece.

4. Kluth, R, "Riser Monitoring Evolving to Suit New Deepwater Configurations", Offshore Magazine, September 2011.

5. Swindell, R., "Hidden Integrity Threat Looms in Subsea Pipework Vibrations", Offshore Magazine, Sept 2011

6. Karayaka, M, Ruf, W and Natarajan, S, "Steel Catenary Riser Response Characterization with On-line Monitoring Devices'. 28th International OMAE proceedings 2009, Hawaii, Paper 79437.