Technical Challenges of Unbonded Flexible Risers in HPHT and Deepwater Operations

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ABSTRACT

This paper presents the technical challenges of unbonded flexible risers in the high pressure and high temperature (HPHT) conditions with deepwater applications. Based on the structural characteristics of unbonded flexible risers, the key factors that have an impact on the stress and fatigue damage of unbonded flexible risers are discussed, and the potential failure modes at such HPHT and deepwater conditions are highlighted. It is proposed that developing the failure driver approach of the risk-based strategy to the systematically assessment of the failure modes, incorporated with the riser system condition monitoring and integrity management, will be an effective way to meet the technical challenges of the unbonded flexible risers in HPHT and deepwater operations.

KEY WORDS: Flexible Risers; High Pressure and High Temperature (HPHT); Deepwater.

INTRODUCTION

As many offshore oil and gas productions are now operated in the high pressure and high temperature (HPHT) conditions with deepwater applications, the unbonded flexible risers have to face more and more technical challenges due to such HPHT and deepwater effects. Here, the deepwater means the water depths of between 500m and 1499m, while the ultra-deepwater is defined as the water depth in 1500 m and more. The deeper the reservoir, the more likely HPHT conditions will be present. The relevant HPHT conditions are classified as below:

- HPHT: Between 10,000 and 15,000 psi and below 350°F
- Extreme HPHT: 15,000 to 20,000 psi and 350°F to 400°F
- Ultra-HPHT: Above 20,000 psi and 400°F

In this paper, the key cross-sectional layers of unbonded flexible risers are analyzed based on the structural characteristics. The functions and influence on the stress and fatigue damage of the flexible risers are discussed. The potential failure modes at such HPHT and deepwater conditions are investigated in detail.

At HPHT and Deepwater Operations, the key technical challenges will come from the fatigue damage under combinations of internal pressure, axial and bending loadings, and possible twist of the unbonded flexible risers. When the tension and bending moments, the curvature and the range of motion are applied to the critical locations of the flexible risers, these combined loading and operating conditions may result in the polymer pressure sheath’s gap span creep and aging failure at high bore pressure, high fluid temperature. If the outermost polymer sheath is damaged to expose the annular space in an aggressive environment, then a corrosion fatigue for the tensile armour wires has to be taken into consideration. In addition, other technical challenges may include the burst and collapses of the pressure sheath, both the upheaval buckling and lateral buckling / bird-cage buckling, the tensile amour wire residual stress and wire broken inside the end fitting, etc.

Based on the review of the possible failure modes on the unbonded flexible risers, this paper presents how the flexible riser designers and manufacturers are developing new design solutions to address such technical challenges in terms of the extreme loading & fatigue response, new materials development including the lightweight, noncorrosive, and loads reduction, optimum design of the bend restrictors. It is proposed that developing the failure driver approach of the risk-based strategy to the systematically assess failure modes, incorporated with the riser system condition monitoring and integrity management, will be an effective way to meet the technical challenges of the unbonded flexible risers in HPHT and deepwater operations.

OVERVIEW OF UNBONDED FLEXIBLE RISERS

As shown in Fig. 1 as below, unbonded flexible risers as a technical alternative to the steel catenary risers and other traditional steel rigid risers have been widely used in offshore oil and gas production. As the oil and gas production systems are moving from shallow water to deepwater, the unbonded flexible risers get more and more widely applications due to their advantages.