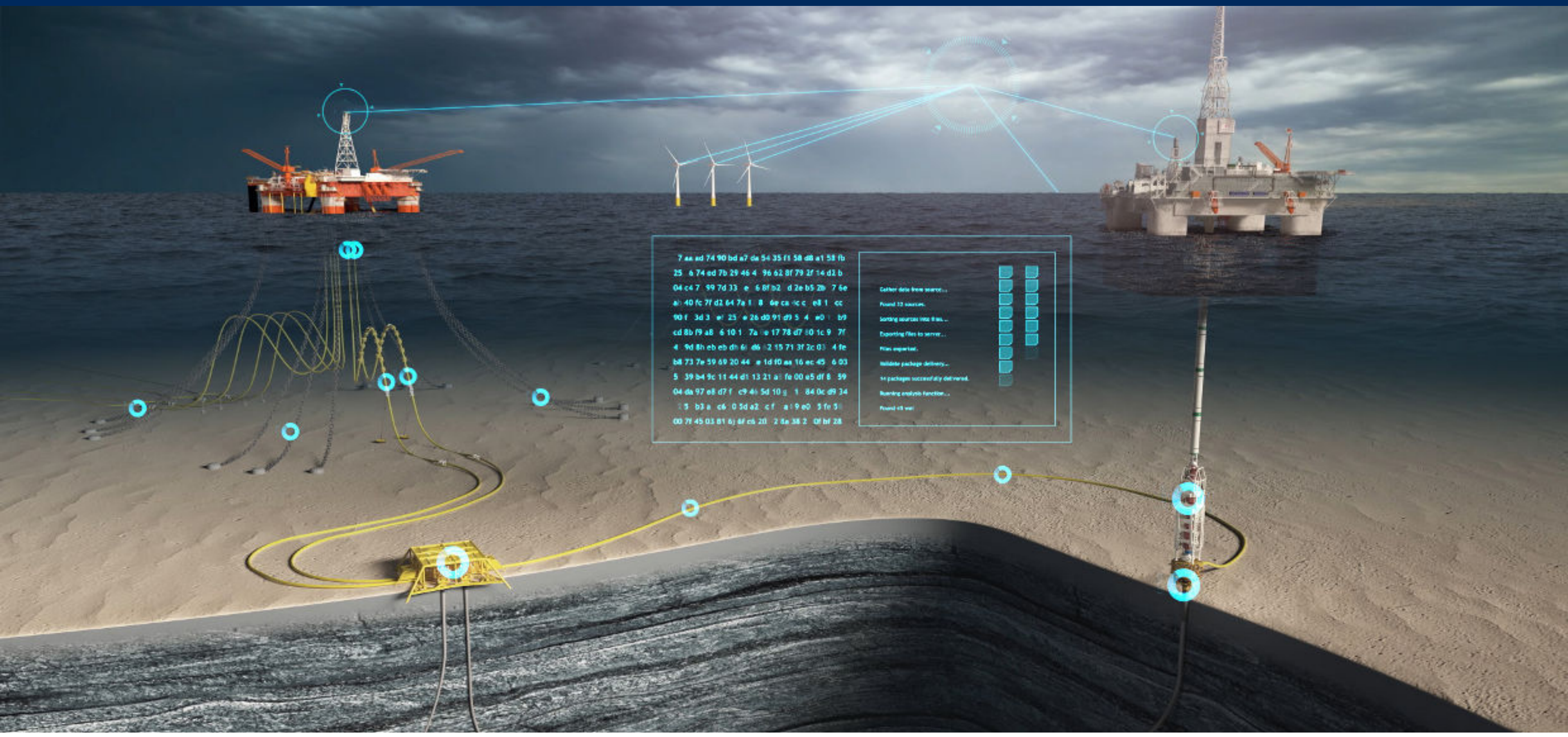


Mitigating Hydrate Blockages in Flexible Risers Using Insights from Local FE Analysis

This case study highlights the successful collaboration between Shell, a leading oil and gas company, and 4Subsea, a provider of specialized engineering expertise in offshore operations. The project was carried out by 4Subsea's SURF Expert Services department, a team of experts offering critical decision support to energy providers.

The key outcome of this partnership was the establishment of a framework for determining the maximum differential pressure to be applied during the hydrate removal phase. The goal is to use the highest possible differential pressure without risking riser failure. While too low a pressure would unnecessarily slow down the process, too high a pressure could cause riser damage, leading to costly riser replacement and, in the worst case, a complete field shutdown.

THE QUICK OVERVIEW

WHAT: Transfer the differential pressure applied across the hydrate from the carcass, through the pressure liner, and onto the tensile wire layer by leveraging friction and the geometrical interaction between the riser's various layers.

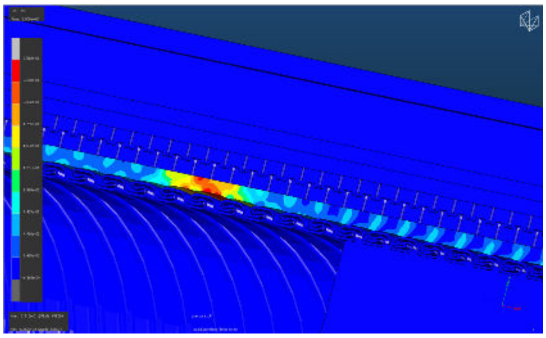
WHERE: North Sea

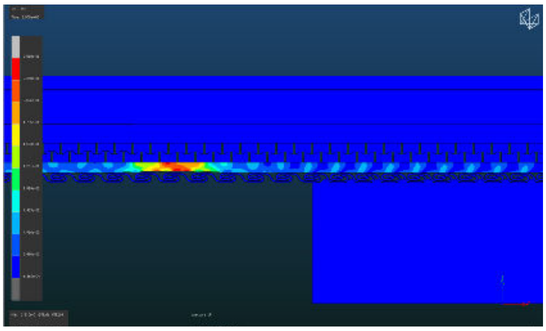
HOW: Through detailed local FE analyses of a flexible riser affected by hydrate bore blockage, the maximum allowable differential pressure for safe hydrate removal was accurately estimated.

WHY: Determing the maximum differential pressure to be applied during the hydrate removal phase

CLIENT OVERVIEW

Shell is a global leader in the energy sector, operating in over 70 countries and focusing on the exploration, production, and refining of oil and natural gas. The company is also a major player in renewable energy, investing in wind, solar, and hydrogen. Shell is committed to safety, efficiency, and sustainability, driving the transition to a lower-carbon future while continuing to meet global energy demands and support economic growth.

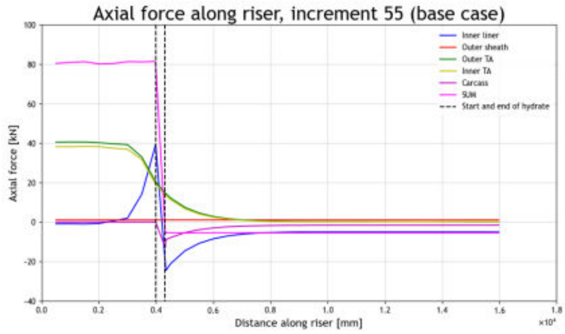




CHALLENGES

During the startup phase, Shell detected unusually high pressure spikes, prompting further investigation, which revealed that the riser bore was obstructed by hydrates. To effectively remove hydrates, it is common practice to apply differential pressure across the hydrate to dislodge it, often in conjunction with liquids that enhance its solubility. The objective is to apply the maximum possible differential pressure without compromising the integrity of the riser's inner layers.

The hydrate interacts with the flexible riser through the inner carcass layer. The spiral-shaped structure of the carcass effectively prevents axial movement of the hydrate within the riser. The pressure liner, extruded around the outside of the carcass, typically engages with the carcass through small nubs on the liner's inner surface. These nubs are formed both during the extrusion process and as a result of material creep over time. Surrounding the pressure liner are tensile wire layers, which are designed to handle significant axial loads.



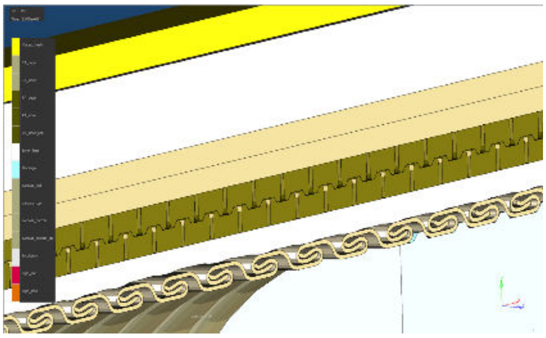
The primary objective is to transfer the differential pressure applied across the hydrate from the carcass, through the pressure liner, and onto the tensile wire layer by leveraging friction and the geometrical interaction between the riser's various layers. The challenge, however, lies in the fact that the detailed internal geometry of the flexible riser is often unknown.

OBJECTIVE

The results of the 4Subsea study produced a comprehensive matrix that detailed the allowable differential pressures for each of the various load scenarios. This matrix was the culmination of extensive analysis and testing, providing a clear framework for Shell to evaluate the operational limits of the flexible riser during the hydrate removal process. By offering precise data on the maximum safe differential pressures, the matrix played a crucial role in Shell's decision-making, helping to ensure that the removal process was both efficient and safe. With this information, Shell could optimize the procedure, applying the highest feasible pressure to expedite the removal of hydrates while mitigating the risk of riser damage or operational failure. The matrix became an indispensable tool, guiding Shell's operations and contributing to the overall success of the project.

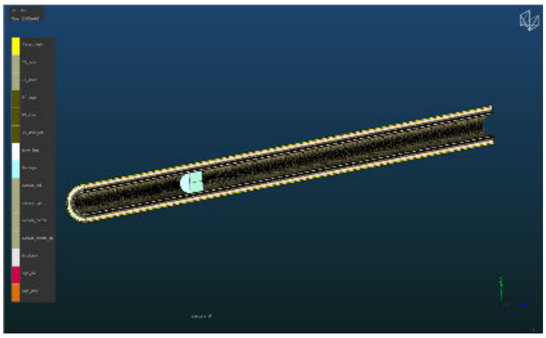
SOLUTION

4Subsea, with many years of experience, has developed its own analysis methodology to estimate the maximum allowable differential pressure for the hydrate removal process. This methodology has been validated through full-scale testing.



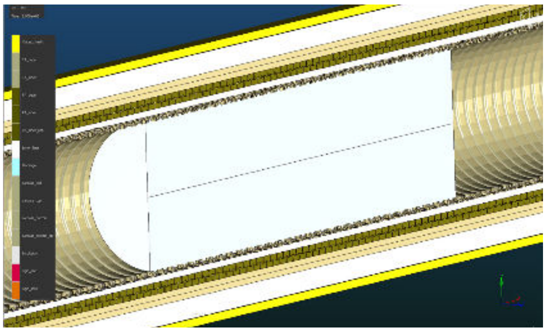
Local FE models of the flexible riser, incorporating various load scenarios, are constructed and analyzed. The load scenarios are determined in collaboration with Shell, leveraging their extensive experience with the riser's loading history and the specific location of the hydrate.

In the FE analysis, the differential pressure is incrementally increased, and the utilization of the relevant layers within the flexible riser is calculated. The most common failure modes that must be evaluated include axial load on the carcass, strain in the pressure liner, and nub jumping at the interface between the outer carcass and the inner surface of the pressure liner.



CONCLUSION

Through detailed local FE analyses of a flexible riser affected by hydrate bore blockage, the maximum allowable differential pressure for safe hydrate removal was accurately estimated. This work, carried out in close collaboration between Shell and the SURF Expert Services department at 4Subsea, enabled the safe and efficient removal of the blockage. The partnership successfully mitigated operational risks and ensured a reliable solution to a complex engineering challenge.



Contact +47 66 98 27 00 | contact@4subsea.com | www.4subsea.com