Advanced Monitoring Systems on Existing Deepwater Infrastructure for Intelli-Field Advances

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This paper details major successes in deploying advanced sensing systems on existing subsea structures. Advanced fiber optic sensors are able to measure strain, temperature, pressure, fatigue, and vibration of risers, flow lines, trees, and other subsea equipment. In the past, these monitoring systems were installed top-side during the construction of new flow lines or other subsea structures and prior to the installation. Installing on existing subsea structures without shutting down production has a number of challenges. Some of these challenges include marine growth, sensor designs that are non-penetrating, ruggedized sensor design for handling and installation, materials selection, ROV installable devices, and adhesives or clamps that bond long-term in the deepwater environment. In this environment, it is critical to have good coupling between the sensor and the measurement. These challenges and others associated with proactive monitoring systems that predict mechanical failure, hydrate formation, flow properties, leak detection, and deformation are included as tasks in the Clear Gulf Joint Industry Project (JIP), an industrial consortium started in 2010. This collaboration is a partnership between Astro Technology, NASA, and leading offshore companies to fundamentally address issues associated with deepwater development and production.

As an example of a recent success, a post install system on a deepwater flow line in the Gulf of Mexico has provided 6 years of data on a 56 mile tieback line in water depths of 6,750 feet. Shortly after the installation of the flow line, the electrically transmitted pressure signals failed at the well-head. An ROV installable clamp was designed to retrofit the pipeline with fiber optic monitoring sensors that measure the temperature and pressure inside the pipeline. This clamp-on device was successfully secured near the well-head. It is expected to provide continuous measurements over the design life of the flow line.

Tests performed by NASA show improved capabilities of the sensors to measure tensile stress and fatigue of components. Recent advances in bonding methods led to more advanced installations currently in use on two Tension Leg Platforms off the coast of West Africa. While the bonding strength decreased slightly when compared with dry environment bonding, laboratory testing shows adequate adhesion and long term service potential. Additional fatigue evaluation in an accelerated stress test environment confirms that this new bonding technology will be able to meet design life requirements for deepwater systems.

The objective of these advanced sensor systems is to provide data to both validate flow assurance and structural models and provide real-time sensor data for a new generation of control systems that have distributed sensors from the well-head to the platform. These Intelli-field systems are leading to a new approach to proactively monitor and control operations that are analogous to a central-nervous system. The objective of this system is to auto-adapt to changing environmental or internal conditions that may lead to plugging or mechanical damage such as sloshing and slugging, hydrate build-up, paraffin wax, asphaltenes, vortex induced vibration, and any other anomalous event. These deepwater sensing systems are designed to be used on both new and existing infrastructure.