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The Use of Composite Materials in Repairing and Reinforcing Pipelines, Piping, and Structures

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Abstract

The purpose of this paper is to provide the oil and gas industry with an evaluation of composite repair and reinforcement systems to properly evaluate how composite materials should be used to repair and reinforce high pressure pipelines and offshore risers. The contents of the paper will include discussions on what critical elements should be evaluated for each composite system, items of caution and concern, and the importance of evaluation to ensure safe long-term performance. Based on a review of available research, composite materials can be used to reinforce damaged pipe materials. Specific examples include reinforcing mechanical damage subjected to cyclic pressure service and reinforcing corroded offshore risers.

Insights gained through the past decade can be used to apply composite repair technology to new systems and structures. The pipeline industry has led the use of these materials as a repair method in the same way the aerospace industry adopted this technology in the 1960s and 1970s. Using a “lessons learned” approach better positions us to understand the capabilities and limitations of this technology.

Introduction

Composite materials have been used to repair damaged gas and liquid transmission pipelines for more than a decade. Mechanical damage involving dents with gouges is one of the leading causes of transmission pipeline failures in terms of both static and cyclic pressure loading. Because of the severity of this defect type, pipeline companies are required to respond to these anomalies by either removing damaged sections or repair using welded sleeves. Composite materials have been used to repair corroded pipelines and their use has gained wide acceptance across the pipeline industry. Numerous systems have been tested with results being presented in the open literature.

Because the primary method of loading for onshore pipelines is in the circumferential direction due to internal pressure, most composite systems have been designed and developed to provide hoop strength reinforcement. On the other hand, offshore pipes (especially risers), unlike onshore pipelines, can experience significant tension and bending loads. As a result, there is a need to evaluate the current state of the art in terms of assessing the use of composite materials in repairing offshore pipelines and risers. Through combined efforts, greater understanding exists in evaluating composite repairs subject to pressure, tension, and bending loads.

Risers are critical components in offshore operations as they extend the wellhead at the mudline to the surface as shown in Figure 1. During operation, risers are subject to degradation mechanisms including external corrosion and mechanical damage due to contact with outside forces. To permit risers to operate safely it is sometimes necessary to perform repairs. Conventional repair techniques incorporate external steel clamps that are either welded or bolted to the outside surface of the riser. Challenges exist with installing steel clamps that include issues such as mobilizing the heavy clamp, welding to an operating riser pipe (including safety issues), and installation expenses. For these reasons, alternative solutions such as composite repair sleeves provide an attractive option as they are relatively inexpensive, lightweight, do not require welding, and are relatively simple to install.