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Strain-Based Pipeline Repair via Type B Sleeve

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Integrity management of strain-based pipelines includes measures such as corrosion prevention, external damage prevention, ground movement monitoring, and geohazards mitigation. Despite preventive efforts, a pipeline may still become corroded or damaged. The damage may reduce the pipeline's strain capacity and a repair method to restore the pipeline's capacity will be required. This paper presents the qualification of the Type B split sleeve, a sealing repair methodology, for strain-based pipelines. The subjects addressed include selecting the Type B split sleeve as a repair candidate, finite element modeling of the repair, sleeve welding with in-service flow conditions, and full-scale proof testing of three repaired pipes.

INTRODUCTION

Production and delivery of hydrocarbons in remote locations often require transportation of the hydrocarbons across challenging terrain. This may expose a pipeline to geohazards including faults, landslides, permafrost, earthquakes, and ice gouging. Pipelines are traditionally designed for pressure containment (a circumferential load), whereas most geohazards affect a pipeline by imposing loading in the longitudinal or axial direction. In extreme cases, the longitudinal loading can cause significant degrees of plastic deformation. Traditional pipeline design does not consider extreme longitudinal loading and the design methodology must be modified to ensure that the pipe is able to withstand all loading conditions.

ExxonMobil has developed a strain-based design (SBD) technology (Panico et al., 2017; Fairchild et al., 2014, 2016; Tang et al., 2014; Macia et al., 2010) for building pipelines with the ability to sustain loads imposed by ground movement. Figure 1 illustrates the principal difference between SBD and stress-based pipeline design. A stress-based pipeline is designed for pressure containment considering hoop stresses such that, at the maximum pressure, the stresses will remain below the specified minimum yield stress (SMYS) by a prescribed amount. The difference between the allowable stress limit and the specified minimum yield strength is the design safety margin. For SBD, the pipeline is designed to contain pressure and sustain loading imposed by potential ground movement. It should be noted that, while pressure containment is constant, the loads caused by ground movements are typically upset events and often of long return periods; i.e., they are infrequent. When the ground movement does occur, it is allowed to cause yielding and plastic flow (straining) in the pipe up to the allowable strain limit.

The strain capacity of the pipeline system is defined as the strain at which the load capacity of the pipe begins to decrease as a result of tearing at a girth weld defect or plastic localization in either the weld or base pipe. Here, it is important to note that, for strain-based design, it is principally important to ensure ductile behavior in both the carrier pipe and girth welds. The capacity is noted in Fig. 1 by the peak of the curve. The peak is related to the

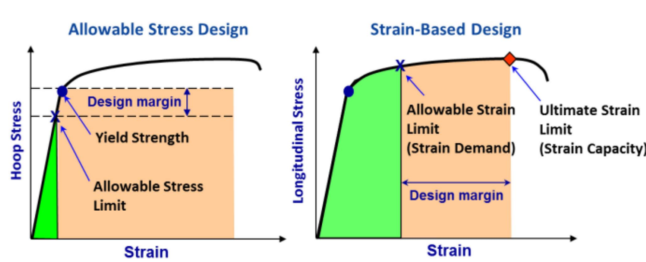

Fig. 1 Principles of SBD versus stress-based design

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KEY WORDS: Pipelines, strain-based design, repair, tensile strain capacity.