Challenges in Designing Residual Curvature Method on Large Size Flowline

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ABSTRACT

This paper discusses the design and installation challenges involved in employing Residual Curvature Method (RCM) as engineered buckle triggers in a large diameter reel-laid pipeline. The description provided in this paper is for a generic case study performed on a large diameter pipeline. One of the main uncertainties involved in RCM design is the as-landed orientation of the RCs and its impact on the efficacy of the method. The paper describes the various methods used in design to address this issue. The activity was of special importance due to concerns regarding the relatively high bending stiffness of large diameter pipelines. The various calculations and modelling, both deterministic and probabilistic, indicate that all aspects of integrity over the full design life of the pipeline are satisfied, irrespective of the as-landed orientations of the RCs.

KEY WORDS: Thermo-mechanical design; pipeline lateral buckling; reel-lay; residual curvature.

INTRODUCTION

Pipeline lateral buckling has been one of the main challenges faced by pipeline designers of high temperature and high pressure (HPHT) pipelines. Pipelines under high pressure and temperature are exposed to high compressive forces which may lead to lateral buckling at indeterminate locations along the pipeline. Such uncontrolled buckling may compromise the integrity of the pipeline with the pipe experiencing high bending at the buckle crown. To avoid uncontrolled buckling, the high compressive force will need to be reduced in a controlled manner by introducing engineered buckle sites at regular intervals along the pipeline. Different proven mitigation methods have been used in various projects in the past such as sleepers, buoyancy modules, snake lay, zero radius bend and rock dumping. Every mitigation has its own strengths and advantages compared to others, and the selection of the appropriate mitigation method usually considers various factors (cost, transportation/logistics requirement, seabed soil type, etc.)

One other mitigation method is the Residual Curvature Method (RCM) which has gained popularity in recent years as it offers a reliable and cost-effective solution for reel-laid pipelines. Curvatures can be introduced readily during the normal installation process prior to laying down onto the seabed without requiring pre-installation of additional structures or attachment of buoyancy modules.

Residual Curvature Method

Flowlines installed with reel-lay method are unreeled and straightened using reverse curvature process through the straightening equipment of the reel-lay vessel. This reverts the flowlines back to the initial straight condition with zero bending strain prior to it being laid. RCM is a method for reel-laid flowlines where a short section of the pipeline is made to have a residual curvature. To create a residual curvature (RC), the understraightening process of adjusting the setting of the top straightener module is utilized to economically create residual out-of-straightness, of 0.15% to 0.25% residual bending strain, at pre-determined intervals along the flowline that act as buckle initiators, as shown in Fig. 1 (Roy et al. 2014). The locations of the imperfections are determined during detailed in-place design and installation engineering. Typical pipe geometry of the residual curvature section subject to some axial tension is as illustrated schematically in Fig. 2.