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## Combined Effect of Flowline Walking and Riser Dynamic Loads on HP/HT Flowline Design

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### Abstract

Some high pressure, high temperature (HP/HT) flowlines have experienced a gradual, overall axial displacement over a number of heating/cooling cycles. This phenomenon is called “flowline walking” or “flowline ratcheting”. Thermal transients along the flowline (during heating/cooling cycles), seabed terrain, and steel catenary riser (SCR) bottom tension can all contribute to flowline walking. Flowline design is further complicated when flowline walking is combined with dynamic SCR loads.

Route curve pullout and anchor loads are typically based on riser static loads only. However, a different tension profile can be set up along a short flowline by a full cool-down of the riser/flowline system after flowline walking. The high tension can affect the system behavior when subjected to large dynamic riser loads. Larger anchors may be required to control walking, and smaller route curvatures may be required to control route curve pullout. This paper investigates the dynamic riser load propagation along the flowline beyond the touchdown point (TDP), and to better understand the combined effects of riser dynamics and flowline walking on PLETs, flowlines, and anchors associated with the riser/flowline system.

This paper discusses the combined flowline walking and riser dynamic loading response determined through finite element (FE) modeling. An in-house, ABAQUS-based program is used with a user subroutine to model soil-flowline interactions along the flowline under cyclic loading conditions. A dynamic analysis is also performed to simulate the global load response of an assumed 100-year hurricane. Detailed discussions include route curve pullout due to the SCR tension and/or flowline walking, and optimization of the anchor design.

### Introduction

It is common for SCR dynamics (Refs. 1 through 3) and flowline thermal cycling and walking (Refs. 4 through 8) to be analyzed separately. However, in some cases, it is important to couple them together as discussed in this paper.

Figure 1 provides a frame of reference for the following discussion. The figure shows a typical floating production system with a steel catenary riser (SCR) and flowline, with the flowline terminating at a subsea well or manifold. The tieback length from the SCR touchdown point (TDP) to the flowline end termination (PLET) in this example is 5,400 ft (1,646 m).

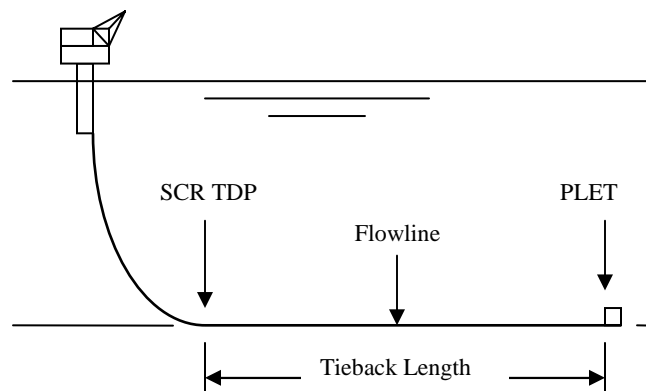


Figure 1 – Example Subsea Tieback with SCR Flowline and PLET

The flowline is short enough to become fully mobilized during the heating and cooling cycles associated with normal operation. Fully mobilized flowlines having a net effect force imbalance are subject to axial ratcheting or walking over a number of operating cycles. In this case, walking moves the flowline incrementally toward the SCR TDP due to the high tension at that location. To control walking, and to prevent overstressing of the jumper connecting the PLET to the well or manifold, an anchor is located at the PLET end. The PLET allows the flowline end to expand, but limits its contraction. After some walking, the flowline will react against the anchor during full cooldowns.

The flowline parameters associated with the example case of Figure 1 are presented in Table 1.