Zhang, F., Liu, M., Wang, Y.-Y., Surface, R, and Phillips, A., Pipeline Integrity Analyses for Construction in Mountainous Areas, Proceedings of the 10th International Pipeline Conference, 2014, Calgary, Alberta, Canada, Paper no. IPC2014-33235

Abstract

The construction of a pipeline in mountainous terrain often exposes great challenges compared to that on flat land. To accommodate the terrain and resultantly complex route, the pipeline design must incorporate a large quantity of cold bends and elbow fittings. A recently constructed project provides a prime example of a pipeline crossing such terrain. The challenging construction conditions and the bends and elbows make the assessment of stress impacting long-term pipeline integrity critical, yet difficult. This paper focuses on three specific aspects of long-term integrity for construction in mountain areas using advanced finite element analysis (FEA).

The first scenario is tie-in welding. Tie-in welding connects separate pipeline segments constructed independently. In general practice, considerable lengths of pipe are left unburied to reduce the potential resultant stress due to the misalignment between the pipes at the tie-in weld location. However, in mountainous terrain the length of unburied pipe may be constrained by field conditions of the tie-in location. The implications are amplified at a tie-in adjacent to bends or elbows.

The second scenario is hydrostatic testing. The gravitational weight of water generates additional internal pressure in the pipeline segments at low elevations. In areas of significant elevation change, hydrostatic test section design defines the segments based on the maximum allowable hoop stress level calculated for straight pipe. However the bends and elbows often encounter increased combined stresses at such locations that may not be adequately considered.

The last scenario is ratcheting. Exacerbated by complex routing and profile, pipelines constructed in mountainous areas are at risk to develop significant uplift in the soil at bend locations during hydrostatic testing and initial operating cycles. If such uplift displacement accumulates during subsequent operating cycles, a phenomenon known as ratcheting, the pipe may eventually fail by upheaval buckling.

This paper evaluates the above scenarios of a NPS 30 section of pipeline consisting of several segments with wall thicknesses varying from 12.0 mm through 19.6 mm, and contains frequent bends and elbows. The pipeline route is mountainous with slopes exceeding 70 degrees, and includes a tunnel immediately adjacent to water crossings and steep slopes. Tie-in welds are made in tight confines at either end. Analysis based on this project profile provides detailed information and insight into the design and construction of pipelines in mountainous terrain.

Keywords

Pipeline Construction, Stress Demand, Tie-in Welding, Hydrostatic Testing, Ratcheting, upheaval buckling