High Strain Capacity Pipeline Qualification for the PNG LNG Project

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ABSTRACT

The onshore pipeline portion of the Papua New Guinea Liquefied Natural Gas (PNG LNG) project traverses terrain with seismically active faults with potential soil displacements up to four meters. The resulting longitudinal strain demand exceeds 0.5% strain, thereby requiring use of the strain-based pipeline design method. This paper discusses the application of previously developed strain-based design methodologies to successfully qualify the PNG LNG pipeline system for a design tensile strain demand up to 3%, and flexibility to increase the design strain demand with additional restrictions on key variables impacting strain capacity at select locations. The qualification timeline, key engineering and project decisions, and lessons learned from this qualification effort are described.

KEY WORDS: High strain pipeline; linepipe; strain-based design; strain capacity; strain demand; full scale testing

INTRODUCTION

Bringing energy to world markets can require constructing pipeline systems from energy resources geographically isolated from consumer markets by challenging terrain. The initial phase of the PNG LNG project is expected to produce 9 trillion standard cubic feet of natural gas. This requires an investment exceeding US$15 billion in the development of gas fields located in the PNG Highlands. There are four major components of the project: Facilities (wellheads and gas conditioning plant), Onshore Pipeline, Offshore Pipeline and LNG Plant.

The onshore pipeline portion of the PNG LNG project includes a 293 km long gas pipeline that descends from approximately 2,100 m to sea level, while traversing terrain with geotechnical challenges including slopes greater than 50% and seismically active fault crossings with potential soil displacements up to four meters (Figure 1). Crossing these active faults with buried pipelines results in pipeline longitudinal strains exceeding 0.5%. To safely design a pipeline to accommodate longitudinal strains above 0.5% due to differential soil movement requires use of strain-based design (SBD) in addition to conventional working stress design that sets the pipeline minimum wall thickness to withstand internal pressure. Preliminary analysis of each crossing of the active faults yielded a maximum anticipated longitudinal strain demand of 3%. These crossings constituted approximately 1 km of the total pipeline length. The five active seismic faults were crossed by three pipelines with outer diameters of 813 mm (32” NPS), 273 mm (10” NPS) and 219 mm (8” NPS), all of which were API 5L grade X60. The large diameter pipeline was constructed from longitudinally seam welded (SAWL) pipe, while the two smaller diameter lines were constructed from seamless (SMLS) pipe.

Figure 1: An example of an escarpment resulting from seismic fault movement.

The pipeline was constructed according to the Australian onshore pipeline code (AS 2885) with additional requirements specified by ExxonMobil. Previously published papers have focused on the general methodology of SBD (Kan 08, Macia 10), qualification of high strain pipeline systems (Newbury 09, Macia 10), tensile strain capacity and strain-based engineering critical assessment methodologies (Minnaar 07, Kibey 08, Kibey 09, Kibey 10, Fairchild 11, Fairchild 12). This paper discusses the application of this SBD technology for establishing tensile strain capacity and its use for the successful qualification of the PNG LNG pipeline system to satisfy a design tensile strain demand up to 3%, and the flexibility to increase the design strain demand with more stringent girth weld offset (misalignment) and flaw size requirements at select locations.