Full Scale Bend Testing of Strain Based Designed High Grade Buried Gas Pipeline

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ABSTRACT
Design of high pressure long distance gas pipelines laid in harsh environments requires deep understanding of mechanisms associated with deformation development and control. This paper presents the structure of the Eni Gas & Power TPI (Transportation at Intermediate Pressure based on X80 grade steel linepipe) Project, describing a key tool of such a Project that is the new full scale four point bend testing device specifically designed to test large diameter high grade steel gas pipeline in plastic regime. First testing results are presented and commented.

KEY WORDS: Strain Based Design; High Grade Steel Pipeline; Full Scale Testing.

INTRODUCTION
The need to transport gas from remote regions pushes the pipeline industry to put in place new transportation solutions gathering the gas to the final market. In many circumstances High Pressure Transportation approach linked with the use of High Strength Steel pipeline appears the most convenient way to combine technical feasibility and cost effectiveness. Crossing harsh and very different terrains means that different hazards must be faced; very often the overall pipeline integrity must be achieved only by exploiting new design criteria (Strain Based Design, SBD as an example). This novel approach needs to be deeper understood for the land pipeline application and mainly needs validation tests, as it was developed for offshore utilization where load and constraint are quite different.

CSM and Eni G&P have started a program to improve understanding for onshore pipeline use of it. A lot of efforts/studies have been recently provided on the matter (see for instance Lillig, 2009 and Wang, 2009) but from a joint gap analysis (CSM-Eni G&P) the need to improve the existing way to perform pipeline full scale test bend testing has appeared to be one of the most important issue to face in order to get a realistic validation program.

The paper addresses some details on this topic in the Eni Gas & Power TPI (Transportation at Intermediate Pressure based on X80 Steel Linepipe) Project, presenting a key tool of such a Project that is the new full scale four point bend testing equipment specifically designed jointly by CSM and University of Cagliari to test large diameter (up to 56") high grade steel (up to API 5L X100) gas linepipe in plastic regime. Finite Element Analysis has been extensively used to design the testing device, paying specific attention on relevant details such as load application points, possibility to test both straight pipe and bend as well as to follow test evolution after plastic instability onset and to carefully measure displacement and deformation pattern. The test can be performed with or without internal pressure, which is known to have an important influence on pipe structural resistance under bending. This paper presents testing results and main characteristics of the new equipment showing how it has been designed for reaching the target, that is testing of high grade large diameter gas pipeline to be operated in SBD conditions.

TPI PROJECT
Demand of natural gas has increased to reduce CO₂ emission. In these circumstances it is often that gas pipelines are installed in harsh environments as the distance between production areas and final consumption market is increased.

Eni since mid 90’s is exploiting different transportation solutions for long distance gas transmission with a devoted R&D project started in 1995 on this matter (Barsanti, 2002). In 2003 a large project on X100 steel linepipe called TAP was launched and successfully executed (Spinelli, 2004) but up to now the “in field” application of X100 steel pipeline appears to be not yet ready and worldwide accepted. So in this contest Eni G&P launched in 2008 a research project called TPI (Transport at Pressure Intermediate) aimed to fulfill the main technology gaps existing on X80 grade steel linepipe for enhanced applications (operating pressure higher than 10,0 MPa) and to produce guidelines to allow safe and reliable “in the trench” application based on “full scale approach” to get data for validating models.

Although X80 grade pipeline steel can bear higher pressure having the same steel weight, higher operating pressure has a beneficial effect in term of cost saving either in CAPEX and OPEX as less compression