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Managing Contraction and Stress in an Ambient Pressure Insulated 9%Ni Subsea Cryogenic Pipeline

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Abstract

The interest and rapid development in the transportation of LNG world-wide has prompted a fresh-look at how LNG is transferred to/from an LNG carrier that may be moored offshore in various locations. LNG subsea pipelines are emerging technologies that are critical to a new generation of offshore LNG loading and unloading terminals. This paper addresses a cost-effective pipe-in-pipe design configuration which uses ambient pressure, high efficiency aerogel insulation and high strength 9% Nickel alloys to manage the contraction forces and stresses in an end restrained cryogenic pipeline system. The paper discusses the derivation of stresses in the pipeline and how they compare to common industry codes and recommended practices. The paper also discusses the welding development and qualifications of welding a 9% Nickel alloy steel pipe to achieve the industry's first use of matched strength welds to the parent material, a significant technology breakthrough, with suitable welding consumables and techniques successfully applied in other pipeline projects.

The design discussed is based on proven industry materials and components, which have been combined together to form a new cost effective subsea LNG pipe-in-pipe configuration. The presentation discusses the review programs employed by ABS and DNV to certify the technology for project applications, which led to the award of "Fit for Service" certifications.

Introduction

At terminals for loading or offloading LNG, the connection piping between the LNG tank and the loading arms can sometimes be of significant length (several miles) so that the loading/offloading jetty structure can be at sufficient water depth for tanker access. As discussed in Ref. 1, the connection piping is traditionally supported by a trestle (Figure 1), however new technologies with subsea LNG pipeline have been developed in recent years (Figure 2) as an alternative.

Trestles have the disadvantage of high cost, potential interruption to coastal marine traffic, and security/safety concerns. A number of trestle structures have been built around the world for LNG and LPG handling and the lengths of these facilities range from a few hundred meters up to 10-km. The adjusted current costs of these facilities range from US$15 million / km to US$54 million / km (US$23 million / mile to US$87 million / mile). The installed costs shown are for the structure only and do not include the cost of the piping, which would be in addition. This represents a significant capital cost for a project, especially in the event there is a need to extend the jetty offshore for some distance.

In a number of proposed LNG loading terminals at present, the trestles can block access to fishing boats along the coast. In some of the world's LNG exporting regions, a long trestle may also be susceptible to attacks by insurgents or terrorists. In other areas, the location may have strong wind by cyclones or hurricanes which the trestle must be designed against.

A subsea pipeline can be used to transport the LNG from / to an offshore terminal thereby eliminating the need and cost for a connecting trestle. With current subsea cryogenic pipeline designs, LNG can be efficiently transferred over distances of up to 20 miles. Buried subsea pipelines are inherently safer from leaks and damage. The interruption to coastal marine traffic is minimal, the exposure to environmental forces is much smaller than trestles, and the pipelines can be much better protected against sabotage. In addition, having buried cryogenic piping may improve the thermal performance of the pipeline in hot climates. By adding features such as real time monitoring of the performance of the pipeline for structural integrity, thermal performance and leaks using fiber optic technology, the safety of the subsea pipeline can be further enhanced.