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Pressurized Natural Gas—Next-Generation Marine Gas Transport Solution

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Abstract

Natural gas can be brought to the consumer by a fleet of ships with compressed natural gas (CNG) technology. For this purpose, Knutsen OAS Shipping started to develop a new type of ships using the basic principles developed through the offshore pipeline industry to obtain an efficient and reliable cargo containment system design. The development has been done together with Europipe GMBH and Det Norske Veritas. The new solution for Compressed Natural Gas transport offered by Knutsen OAS has its proprietary name Pressurised Natural Gas - PNG[®].

The Knutsen OAS Shipping approach was to develop a CNG solution that could load and discharge gas onshore and offshore using elements from existing technology in use within the shipping and the oil/gas industry. To meet this objective, the Knutsen PNG[®] solution has been developed based on an interdisciplinary iteration process to ensure that PNG[®] provides safe, environmental friendly, efficient and economical gas transport.

The paper will focus on design, qualification, system integration, safety, reliability, environment, classification issues and operation. Further, the paper discuss how PNG[®] can be beneficial in new gas transportation chains with focus on requirements of the upstream and downstream part of the chain.

Introduction

The idea of being able to transport gas at ambient temperature and high pressure is equally old as the LNG development. The Compressed Natural Gas (CNG) option seemed especially tempting as this would allow for cost-savings in liquefaction, storage and regasification installations. The last years have shown a steady growth in LNG projects requiring many new LNG ships to be built. This trend will most likely continue into the future as the demand for clean fuel is increasing.

Environmental considerations will become more and more important. Energy losses within the value chain will be given more attention and the cost to bring clean energy to the market will face increased focus.

A few decades ago the design codes available implied that the thickness and weight of the CNG containment tanks was rather large, leaving little capacity left for carrying gas. This prevented economic solutions for CNG transport. However, important technological developments within high strength materials, welding, non destructive testing and production have taken place during the last decades mainly due to the oil companies requirements to move oil and gas into deeper water areas and over longer distances. The development of reliability based codes and standards based on first principles have been accepted and explicit risk acceptance criteria has been implicitly set.

The new pipeline standards of today are more or less based on the above technological development. This has improved project economics without compromising safety. One of the most used pipeline standard worldwide is the DNV standard for submarine pipelines, (DNV-OS-F101), [1]. For design against burst, the steel weight of the cargo tanks may be reduced by 50% compared with the pressure vessel codes. By defining the correct failure modes for CNG containment system based on submarine pipeline technology with proven track record, CNG can emerge as an economically viable option.

Marine Transportation of Natural Gas

The demand for natural gas has increased and will continue to increase on a worldwide basis as a result of the increase in world energy consumption and increasing environmental awareness. Among the fossil fuels available today, natural gas is by far the most clean and environmentally friendly energy source and will be increasingly important energy carrier in the next 20-30 years. Natural gas consumption in 2025 is projected to a total of 151 trillion cubic feet, nearly 70% higher than the 2001 total of 90 trillion cubic feet. The natural gas share of the total energy consumption is projected to increase from 23% in 2001 to 25% in 2025 [2].

The natural gas resources are to a large extent located far from their markets. Some 30% of the discovered gas is considered *stranded*. Stranded is defined as reservoir gas fractions that prevent the development or optimal production from an oil or gas field due to their distance from the market or existing infrastructure.