ABSTRACT

The worldwide utilisation of natural gas has led producing countries to look for transportation solutions. Marine transportation becomes economically feasible for long distances or when pipe laying becomes unpractical. In order to ship natural gas in sufficient quantities to make a complete energy supply project viable, it is liquefied at -163° C thereby reducing its volume by a factor of 600.

Several containment technologies have been implemented, including SPB, Moss and Membrane. Contrary to its two main competitors, where the insulation is installed on the outer part of a self-supporting tank, the membrane systems (the only currently used designs on board LNG carriers are exclusively developed by Gaztransport & Technigaz) incorporate a liner fitted directly onto the double hull. One of the main characteristics of this type of system is that it transfers to the double hull the loads induced by liquid motions inside the tanks.

This hydrodynamic phenomenon, also known as sloshing, can lead to high magnitude impacts on the walls with potential consequences on the containment system response. This is why sloshing is extensively studied in the LNG shipping industry and more especially in GTT, where dedicated high-tech numerical tools and testing facilities have been developed for many years.

At the same time, we have recently observed a rapid growth in the number of membrane LNG carriers in service, their cargo capacity and the variety of operating procedures (spot market, offshore regasification, etc). In parallel, a few unexpected incidents related to sloshing impacts have recently been recorded. No such incident had been observed since those isolated ones observed on former designs in the late seventies.

Research and development effort into the sloshing phenomenon has never been so intense, particularly within GTT, and the overall knowledge on this subject has reached an unprecedented level. Particularly, the feedback and lessons learned from these incidents are of inestimable interest for the scientific community, and help increase the phenomenon’s knowledge. However, some particularities of these incidents and thus of the sloshing phenomenon itself, still have not been as yet explained to our entire satisfaction.

Given the strong expectations from the industry to improve understanding and thus better tackle the sloshing phenomenon and its consequences, this paper will introduce most of the research studies that have been performed recently or which are currently in progress as well as a major evolution of the methodology for sloshing assessment. Each of these items will be then described and discussed in detail during dedicated ISOPE presentations.

KEY WORDS: Sloshing; LNG; membrane containment system; model tests; numerical simulations; sloshing incidents.

INTRODUCTION

Over since man started to sail the oceans, he has shipped different kinds of liquids with him, whether it was for the crew’s own consumption or for commercial purposes. As the size of the vessels increased, amphorae became barrels and the shipping routes lengthened and diversified, but still the amount of liquid to be loaded was limited, due to the fact that it was stowed in casks or tunns (hence the term “tonnage”) in the ship’s hold. This shipping mode was the prevailing one until the second half of the 19th century. However, it had some important drawbacks:

- The barrel’s weight: a standard empty 40-US-gallon wooden barrel weights 29kg, which represented 17% of the total weight of a full barrel if filled with water, and nearly 20% of the total weight if filled with petroleum oil (Chisholm, 1911).
- Leakages of a wooden cask could be quite important and either lead to non-acceptable product waste or even worse place the vessel at risk, in case of oil transportation, for example.
- The barrel’s cost had a strong impact on the profitability of liquid transportation by sea. For example, in the early years of the Russian oil industry, barrels accounted for half the cost of petroleum production (Tolf, 1976).