ABSTRACT

The paper describes the first full scale tests on a real membrane containment system subjected to action of breaking waves representative of sloshing impacts in LNG tanks. The waves were generated in a water flume using a wave focusing method. The tests were carried out within the Sloshel project which is described in several accompanying papers.

This paper focuses on describing the test method, the experimental setup and the post processing of the data collected in 110 tests. The paper explains how the project goals were translated into the design of the test setup and the instrumentation. After that, it describes an extensive qualification of data acquisition system and sensors. Emphasis is on the sensors developed within the project such as pressure gauges and a novel optical sensor capturing the last stage of sloshing impact. The test programme and some preliminary results are summarised. Conclusions regarding system performance, data quality and the use of data for achieving the project goals are given.

KEY WORDS: sloshing, full scale testing, large scale testing, LNG, membrane containment systems, NO96, pressure sensors

INTRODUCTION

The Sloshel project is introduced in the paper by Brosset, Mravak, Kaminski, Collins & Finnigan (2009). The Sloshel experiment was designed to collect full scale data describing sloshing impacts and associated structural response. This data set will be used to verify different assessment methods of membrane type containment systems subjected to sloshing.

Conventional sloshing assessments of new membrane LNG carriers traditionally follow the comparative approach that is based on small-scale model testing, numerical simulations and over 40 years of successful operating experience of LNG carriers. Model testing provides the maximum loads, based on statistical analysis of measured pressures. The response of the containment system to these loads is numerically simulated and checked against different limit states.

However, with the filling level limitation on the current fleet, experience is lacking to support comparative methods for partially filling cargo tanks. To move forward, the industry is developing a methodology to assess membrane systems by a direct comparison of the loads and the structural capacity. To develop such methodology, MARIN recognised the need for full-scale validation already back in 2003 (see Figure 1).

A confidential joint industry project Sloshel was organised by MARIN, Gaztransport & Technigaz (GTT), Bureau Veritas (BV) and Shell. Successively Ecole Centrale Marseille (ECM), American Bureau of Shipping (ABS), Chevron, Lloyd’s Register (LR), Det Norske Veritas (DNV) and ClassNK joined the project. Recently the consortium has decided to disseminate part of the obtained results.

The scope of work included the full and large scale tests being carried out by MARIN, developments of simplified numerical methods being carried out by BV and validation studies being carried out by individual consortium members.

Figure 1. Sloshing assessment and role of Sloshel project

This paper describes 110 full scale sloshing tests successfully carried out by MARIN in the Delta flume operated by Deltares. Malenica, Korobkin, Ten, Gazzola, Mravak, De-Lauzon & Scolan (2009) described simplified numerical methods developed by them. Maguire, Whitworth, Oguibe, Radosavljevic & Carden, (2009), and Wang & Shin (2009) described validation studies undertaken by LR and ABS, respectively.

TEST METHOD

As stated in the introduction, sloshing assessment of a membrane LNG vessel has traditionally been carried out using small-scale model tests and additional numerical simulations. The questions are: “How close to