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New Tests Advance Sloshing Knowledge

About the Author

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Sloshing is the violent motion of a liquid in a partially filled tank. Liquid natural gas (LNG) transported at -162ºC is under consideration here. The LNG industry is concerned about the effect of sloshing loads on containment systems and their supporting structures. The fact that the motion in a tank is a function of many parameters and that the resulting impact – spatially localized and including several physical phenomena - interacts with a complex containment system has made sloshing assessment extremely challenging.

LNG carriers have an excellent track record therefore sloshing seemed to have been mastered. However, advancement is required because the conventional assessment of new membrane LNG carriers traditionally follows the comparative approach along with a filling level limitation on the current fleet. Experience is therefore lacking to assess new designs for FLNG units operating with partially filled cargo tanks.

During the last decade a profound knowledge basis has been created. Together with the industry, MARIN has carried out several investigations. The focus was twofold. On the one hand, commercial and Joint Industry Projects such as SALT, COMFLOW, HAWAI and Off-Loading operability addressed the reduction of sloshing occurrence by focusing on the factors that define sloshing. These included environmental conditions, shape and dimensions of the vessels, number, size and geometry of LNG tanks, the filling level of the LNG tanks and the coupling between the motions of the floating structure and the LNG.

EXTENSIVE RESEARCH

On the other hand, the investigation focused on the sloshing loads and the containment system integrity. This is the subject of extensive international research. MARIN's Hydro-Structural Services (HSS) led part of this research by setting up a confidential and exclusive JIP, "Sloshel", together with Gaztransport & Technigaz (GTT), Bureau Veritas and Shell. Ecole Centrale Marseille, the American Bureau of Shipping, Chevron, Lloyd's Register, Det Norske Veritas and ClassNK joined the project later on. The Sloshel project includes full- and large-scale testing of membrane containment systems, numerical developments carried out by Bureau Veritas and validation studies undertaken by the consortium members.

Results of the first full-scale tests carried out by MARIN at the turn of 2007 were already unveiled in 2009. Unidirectional breaking waves were generated in a flume in order to impact an instrumented transverse wall with embedded test structures, i.e. a rigid structure and the N096 membrane containment system. In 2009, these tests were reproduced at the scale 1 to 6.

MARIN and GTT worked together on the database and developed a physical understanding on the scaling of pressure measurements, the structural behaviour of the containment system during impact and the interaction between the wave and raised elements. Sloshing assessment remains a challenging task but the project has helped to sort out the relevant phenomena to formulate common starting points of the assessment methodologies and it has supported design choices.

USER GROUP

The latest test campaign in the Sloshel project ran in April 2010. New full-scale impact tests on the MarkIII membrane containment system and its rigid equivalent were carried out. A series of 142 tests were successively performed. Pressure, strain, acceleration, global forces and corrugation forces were measured and unique, high-speed video recordings were made. The maximum measured pressure was 56 bar and the measured data, visual inspection and destructive testing showed no damage to the MarkIII containment system.

A Sloshel User Group has been set-up to analyze the database of the latest full-scale tests. All of the existing partners joined the group and expressed their willingness to open up the group to new participants. If you would like to take part in the continuing Sloshel project, you are welcome to contact MARIN.