Influence of Sampling Rates on Sloshing Pressures Prediction

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ABSTRACT
The aim of this study is to evaluate the influence of different sampling rates on sloshing peak pressures prediction. This study is performed for a long-duration sloshing test: 480 hours at full scale, generated by 96 five hours individual tests, at a low partial filling for one critical sea state regarding sloshing.

For this study, two different measuring systems are considered:
- The first system, considered as the reference in this study, which processes the replicated signal, coming from pressure sensors, with peak memory cards. The equivalent sampling rate of such analog measuring system is 100 kHz.
- The second system which records the raw signal, coming from pressure sensors at a 20 kHz sampling rate. This sampling rate corresponds to industrial practice.

Moreover, this raw signal at a 20 kHz sampling rate is degraded at two other sampling rates of 10 kHz and 5 kHz. Then, the influence of these 3 sampling rates (5, 10 and 20 kHz) on sloshing peak pressure prediction is investigated through comparison with the reference sloshing pressure peak prediction coming from the peak memory cards which is considered to be 100 kHz. This comparison relies on statistical tools such as different fitting distributions, goodness of fittings, estimated pressures and confidence intervals.

KEY WORDS: Sloshing Test; Sampling rate, Partial Fillings; Extreme Value Statistics; Offshore LNG Terminals.

INTRODUCTION
Sloshing model tests, submitted by the designer, are standard part of Bureau Veritas comprehensive sloshing assessment. These sloshing tests determine the sloshing loads, here pressures to be applied on the Cargo Containment System (CCS) (Bureau Veritas, NI564, 2011).

Both observations of the few sloshing events which occurred at sea and sloshing model tests clearly indicate variability of sloshing pressures (Gervaise, De Seze & Maillard, 2009). This stochastic behavior of sloshing pressures result in a flat tail exceeding probability curve. As a consequence, a small change in the probability level can have strong influence on the expected pressure. Moreover, for time and cost reasons, sloshing model tests can not cover all the ship’s life duration or more that is required by the long term approach for the sloshing assessment (Bureau Veritas, NI554, 2011).

During last ISOPE Conference (Fillon & al., 2011), it was shown, for a long duration sloshing test of 480 hours at full scale, at low partial filling which is the most critical in terms of sloshing loads, that the Generalized Pareto (Gpa) distribution is more suitable than the 3-parameter Weibull and the Generalized Extreme Value (Gev) distributions for fittings of pressure peaks.

As pressure acquisition cards used by Bureau Veritas involved a peak memory device, rarely used by other company, it was decided to investigate the sensitivity of the maximum pressure statistics by the means of peak pressure measurement.

The same long duration sloshing test (480 hours at full scale) is here used in order to investigate the influence of sampling rates on sloshing pressures prediction. Two different measurement systems are considered:
- The first system, considered as the reference in this study, processes the replicated signal with peak memory cards. The equivalent sampling rate of such analog measuring system is considered to be 100 kHz.
- The second system records the raw signal at a 20 kHz sampling rate corresponding to industrial practice. This raw signal at a 20 kHz sampling rate is degraded at two other sampling rates of 10 kHz and 5 kHz.

These last 3 peak pressures samples (5, 10 & 20k Hz) and their statistical post-processing are then compared to the peak pressure sample of reference measured by the peak memory cards and its statistical post-processing. Based on these comparisons, the influence of the sampling rates on sloshing peak pressure prediction is evaluated.

Especially, from pressure sample extracted from signal processed by peak memory card of 480 hours duration, we obtain an estimate of pressure associated to a 50-hour return period which is our reference. Then we compare pressure estimates, associated to a 50-hour return period, of the 3 samples extracted from signal processed by raw card, to our reference.

EXPERIMENTAL SETUP
Model Test Setup
The test rig used for the model tests is a six-degree-of-freedom platform called hexapod. This model is a mistral type from SYMETRIE®. The specifications of this rig allow us to generate motion within the 1dof limits are given in the following table: