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NOISE MEASUREMENTS PERFORMANCE GUARANTEE ON A FLOATING LIQUIFIED NATURAL GAS PLANT

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ABSTRACT

In the energy industry, noise impact is commonly evaluated during the engineering phase as part of the work process for new plant development. However, even if noise regulations shall be applied, a noise performance guarantee is generally not required, demonstrated or is limited to individual equipment. This situation is currently changing, and plant noise performance guarantee tends to become widespread in contracts. Its goal is to ensure compliance with local regulations, environmental and social impact assessment and/or clients' standards.
As a major energy industry engineering contractor, Technip Energies faces this challenge with the projects it executes. To deal with this emerging contractual requirement and due to the lack of acoustic measurements standards for offshore, Technip Energies has developed its own validation methodology for noise performance guarantee on a Floating Liquified Natural Gas (FLNG) facility.
This paper presents the methodology developed by Technip Energies to validate the noise performance guarantee on a FLNG, the feedback on the noise measurements and a summary of the measurements results recorded on an operational facility.

Keywords: *measurements, performance guarantee, offshore, industry.*

1. INTRODUCTION

Airborne noise control in the energy industry is of major importance to ensure safe work conditions. Information on the design methodology, including main noise sources and mitigation measures are provided in different papers such as "Controlling Vibration and Noise Hazards to Insure Safe Work Conditions in Oil and Gas Plants"[1] and "Acoustic Design of Alarming System in the Energy Industry"[2]. However, these scientific articles do not provide any information regarding noise performance guarantee that can be dealt with by the contracts.
In this paper, the methodology developed by Technip Energies to validate the noise performance guarantee on a FLNG is presented.
This methodology starts from the conformity criterion definition to the noise measurements results. Consequently, it completes the work performed for several years during the design phase.
The following sections will be developed in the context of a FLNG:

- Definition of conformity criterion,
- Definition of acoustic measurement procedure and measurement material,
- Encountered difficulties during measurements,
- Summary of measurement results and compliance.

2. MEASUREMENTS PREPARATION

2.1 Definition of acceptance criterion

As a FLNG is located offshore and most of the time there is no specific noise limit for airborne noise in the environment, it is necessary to define a specific acceptance criterion.
During the engineering phase, the noise generated by the FLNG has been modelled and noise maps have been issued for each module and each deck.
The acceptance criterion is based on these noise maps. Considering the loudest predicted noise level on the noise map (not less than 1m from a noise source) a different acceptance criterion is set for each deck. Due to the

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measurement material, a positive tolerance of 1.5 dB is added to the maximum predictive noise level.
An extract of a noise map is presented below (see Fig. 1) with a major noise source hatched in the center and the highest noise level achieved identified by an arrow and surrounded with a rectangular shape.

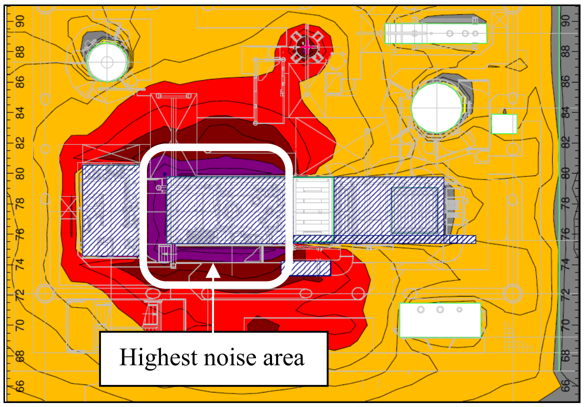

Figure 1. Extract of a noise map with a noise source and some equipment modelled as obstacles.

This criterion has been discussed and approved by all the parties involved in the project.

2.2 Measurement procedure and material

There is no recognized international standard specifically dedicated to noise measurements for offshore applications. The procedure presented in the following sections is influenced by ISO 11201 [3] and ISO 1996-2 [4] respectively related to noise measurements at a work station and related to description, measurement and assessment of environmental noise.

2.2.1 Measurements' locations and heights

For each deck or area, a minimum of 4 to 10 measurement points is defined depending on the deck or area size. Each measurement location is identified with a number on a plan, for example: see Fig. 2.
Noise measurements shall be performed 1.5 m above the floor.

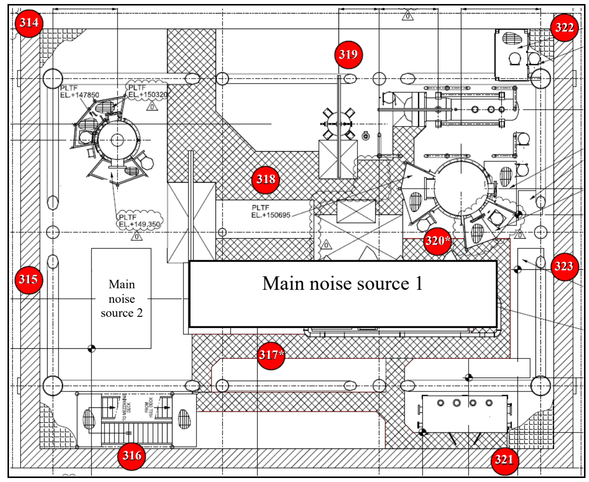

Figure 2. Example of measurement point identifications and locations.

2.2.2 Operating conditions

Noise measurements shall be performed during normal operation of the FLNG provided that:

- The rotating equipment and packages have proven stable reliable operation,
- All instruments related to the rotating equipment and packages are commissioned and have been operational for a sufficient period to prove their reliability.

During noise measurements, only necessary workers for the operation and the measurements shall be present in the area.

2.2.3 Measurement material

The following equipment used for the measurements shall be class 1 as per IEC 60942 [5], IEC 61260 [6] and IEC 61672-1 [7]:

- Calibrator,
- Sound level meter.

These devices shall be periodically verified by a national standard laboratory or a competent accredited laboratory.

2.2.4 Measurement time intervals and data to be recorded

For steady noise emissions the measurement time interval shall be at least 30 s.
If a noise level variation of more than 5 dB is identified during the 30 s measurement, the point shall be considered as non-steady, and the measurement shall cover one or more complete cycles to determine a representative average level. The source of the intermittence shall be investigated.

The operation time and time interval shall be noted and reported in the test results.
The equivalent sound pressure level shall be recorded in decibels using A-weighting filter (LAeq,1s). Additionally, during each measurement, octave band analysis between 31.5 Hz and 8000 Hz shall be recorded as well as the peak sound pressure level using C-weighting filter (LCpeak).

2.2.5 Calibration check

A calibration shall be performed before and after each series of measurements. If a gap higher than 0.5 dB is identified between the results of a calibration before and after the measurements, the results of this series shall be discarded, and the measurements shall be repeated.

3. MEASUREMENTS FEEDBACK AND RESULTS

3.1 Difficulties encountered during measurements

Conducting noise measurements on an FLNG is a challenging task due to the complexity of its environment. The combination of industrial activity, marine, weather conditions and spatial constraints creates a unique set of difficulties that must be carefully managed to ensure reliable results. This section outlines the challenges that could be encountered during the noise measurements.
To perform noise measurements on a FLNG, training and administrative work are necessary. This includes the Basic Offshore Safety Induction and Emergency Training (BOSIET) to access the FLNG. The specific regulations of the country and temporary admission for the measurement equipment shall also be considered, which means the need to gather all necessary documentation for foreign customs.
Additionally, one of the main challenges is that the noise measurement material may not be ATEX-certified. In these conditions, to conduct in-plant noise measurements, a hot work permit shall be requested daily. The purpose of the hot work permit is to ensure that the work is performed in safe conditions. Thus, it evaluates the different risks linked to the activity and details all necessary safety measures including the need for personal protection. As an example, a personal gas monitor to detect and prevent the presence of hazardous gas leaks could be permanently worn for field operations.
To validate the permit, the purpose of the noise measurements shall be explained to the different working areas safety representatives and their approval signatures shall be collected. This adds complexity and requires meticulous planning to ensure compliance and safety during noise measurements.

As the noise performance test occurs after the first start-up of the plant, unforeseen events could happen. This includes:

- Malfunctioning or under-maintenance equipment,
- FLNG shutdowns due to defective operation.

This would result in modification or cessation of ongoing measurements and therefore delays in the on-site measurements schedule.
Finally, unplanned measurements stoppages due to the noise generated by chopper traffic, bad or extreme weather conditions could further complicate the work progress.

3.2 Summary of measurements results and compliance

Despite the difficulties presented above, Technip Energies has implemented its procedure on an operational FLNG and the measurements have been performed. Main results are provided in Tab. 1.

Table 1. Measurements noise results.

Area	Number of measurements	Number of uncompliant measurements
Portside	265	13
Starboard	246	16
Hull Deck	173	25
Turret	15	0

The overall results of the noise measurements campaign show that 54 noise measurements exceed the acceptance criterion, over the 699 measurement points.
These exceedances are primarily located on the hull deck, resulting from:

- The main deck's configuration, which includes expansion holes not accounted for in the modeling phase,
- Reciprocating pumps generating high noise levels due to vibrations transmitted to the deck.

Exceeding measurement points on the topsides (portside and starboard) are mainly attributed to insufficient acoustic insulation on powerful compressors and pumps.

4. CONCLUSION

As previously mentioned, there are no specific international standards dedicated to noise performance tests for offshore applications. Consequently, it is incumbent upon acousticians to develop an appropriate methodology. The first step is the definition of the acceptance criterion.

This should be discussed with the different parties involved throughout the project.
Then, the noise measurement procedure shall be established to define the location of measurements points but also the measurement material, the interval duration of noise measurement points and the data to be recorded.
During the offshore noise measurements on a FLNG, safety shall not be compromised, and thus administrative work (permit to work) is of major importance.
In addition, measurement schedule can be impacted by unplanned events related to operation troubles, chopper traffic and/or extreme weather conditions.
Based on experience, it is advised to work with ATEX-certified sound level meters to reduce the risk associated with an explosion. Another point is to allocate extra time in case of unforeseen events that could disrupt the schedule.
Experience has demonstrated that the presented noise measurements procedure is appropriate for this type of work and environment.
Noise measurement results, with only 7% of the points exceeding the acceptance criterion, have been considered acceptable by all the parties. Thus, noise guarantee has been satisfied and FLNG is currently operating.

5. REFERENCES

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[6] IEC 61260-1 (2014): *Electroacoustics - Octave-band and fractional-octave-band filters - Part 1: Specifications.*

[7] IEC 61672-1 (2013): *Electroacoustics - Sound level meters - Part 1: Specifications.*