METHOD FOR THE ACOUSTIC CHARACTERIZATION OF UNDERWATER SOURCES IN ANECHOIC TANKS BASED ON SIMULATED FREE-FIELD SCENARIO

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Abstract *– Underwater tanks for calibration are commonly used for transducer calibration and acoustic characterization. However, low frequency range is limited by tank dimensions and wall proximity to sound source. A possible solution may be to develop methods for underwater source characterization taking into account the reverberant field originated in the tank, but these methods are unable to solve source directivity. In this paper we show the development of a method for the acoustic characterization of underwater sources based on a simulated free-field scenario with absorbent material.*

Keywords *– Underwater anechoic tank, absorbent material, acoustic characterization, free-field simulation.*

INTRODUCTION

Characterizing underwater sources in open water is a hard task. There are numerous limitations varying from physical to economic matters. Physical limitations are related with uncontrolled relative displacement between acoustic source and hydrophone, undesired background noise, and flow noise generated by turbulences. Economic limitations are given mainly by the need of vessels and deployment platforms.

Underwater tanks for calibration are common for transducer calibration and acoustic characterization. It has several advantages when it is compared with open-water source characterization (controlled environment, cost efficient, etc), however, low frequency range is limited by tank dimensions and wall proximity to sound source [1]. Previous studies have developed methods for underwater source characterization taking into account the reverberant field originated in the tank, however, these methods are unable to solve source directivity [2].

We aimed, therefore to develop a low-cost method for the acoustic characterization of underwater sources based on simulated free-field scenario with absorbent material providing a controlled environment in which sound level and source directivity could be determined.

METHODOLOGY

The Project was developed in two different phases.

A. Design an Absorbent Material and Characterization.

During the first phase, we designed an absorbent material for underwater sound in the frequency range of 50 – 60 KHz (Fig. 1). UPV in collaboration with CTN measured the absorption coefficient (α) by means of an experimental method based on norm UNE-EN-ISO 354-2004 (Acoustics - Measurement of sound absorption in a reverberation room). It is important to note that this norm applies to aerial acoustics however, one of our objectives in this paper is to test and validate it for an underwater environment.

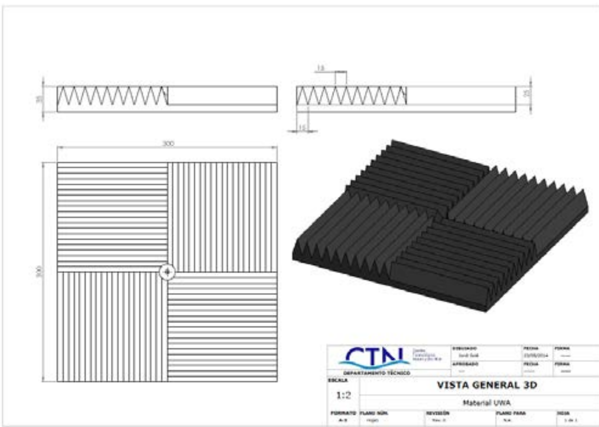

Fig. 1. Design of absorbent material

This method is based in the comparison of reverberation time in a chamber, with and without a sample of material (Fig. 2) Therefore, first, reverberation times in both situations (T1 and T2 respectively) are measured, taking into account that physical conditions of the chamber (temperature, pH, salinity, etc.) must not be changed during the measurements.

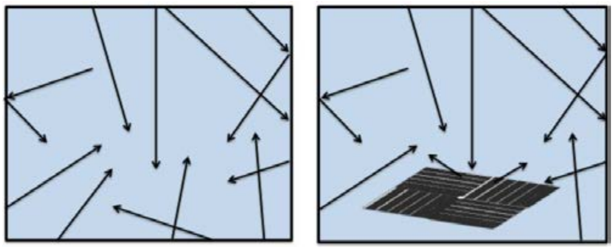

Fig. 2. Methodology for calculating the reverberation time in a chamber; Left: Chamber without material; Right: Chamber with material.

As from reverberation times, the equivalent sound absorption area (A_T) is calculated by means of Sabine equation: $A_T = \frac{55.3\,V}{c\,T2} - \frac{55.3\,V}{c\,T1}$ where V is volume of the chamber (in cubic meters) and c is the speed of sound propagation in water (in meters per second).

Using the equivalent sound absorption area, the sound absorption coefficient α can be calculated using $\alpha = \frac{A_T}{S}$, where S is the material area (in square meters)

Following requirements indicated in UNE-EN-ISO 354-2004, physical dimensions of the chamber were established so that useful measurement frequency range was 5 – 180 kHz. However, due to limitations of frequency range of transducers used in measurements, sound absorption coefficient was measured in the frequency range of 40 kHz to 160 kHz.

B. Design and Manufacture an Anechoic Tank for Underwater Sound Sources Characterization

During the second phase, CTN designed and manufactured an anechoic tank for underwater sound sources characterization Fig. 3. Tank's geometry was established taking into account that the distance between sound source and projector should be 1 meter. Sound source and hydrophone are placed at the bottom and top of the tank respectively. Sound source (P1) and hydrophone (H1) are disc-type hydrophone and present the same sound transmission and reception characteristics, having a resonance frequency located at 50KHz. Sound source directivity presents a main lobe of 45 degrees width as it is depicted on Fig. 4. This beam pattern is the same for sagittal and frontal planes.

Fig. 3. Anechoic tank for underwater sound sources characterization.

In order to avoid first-order reflections as much as possible, the height of the tank was set taking into account the width of P1 directivity pattern and that the minimum distance between P1 and H1 should be at least 1 meter. The only first-order reflections present in the measurements were those who came from the top of the tank, which was also covered with the anechoic material developed in this paper.

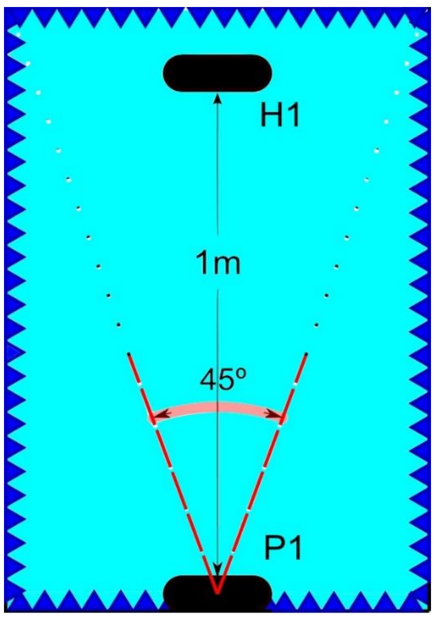

Fig. 4. Measurements schematic and sound source main lobe pattern directivity.

RESULTS

The absorption coefficient is frequency dependent. Values in the frequency range of 50 – 160 KHz are shown in Fig. 5:

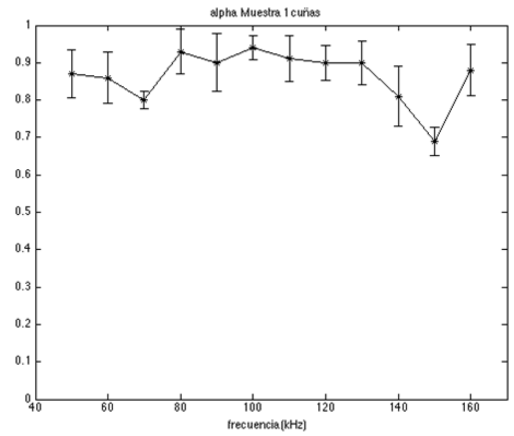

Fig. 5. Absorption coefficient (α) with standard deviation. Measurements were made according to UNE-EN-ISO 354-2004.

The anechoic tank performance was tested generating a 2 seconds pulse of 20 Vpp amplitude and frequency 50 KHz (wavelength of 0.03 meters). The signal received at the hydrophone is depicted in Fig. 6.

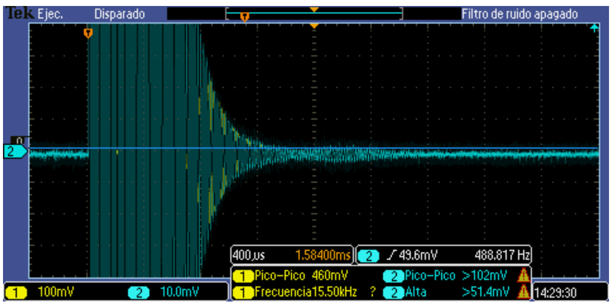

Fig. 6. Measurements of test signal in the anechoic tank.

DISCUSSION

According to Fig. 5 and [3], we found that the absorption coefficient (α) of the absorbent material was about 0.8 in the frequency range of 50 – 160 KHz. Best absorption performance is seen for the frequency range of 80 – 130 KHz. Therefore, we can ensure nearly free field conditions within this frequency range.

According to Fig. 6, we found that there were no strong early reflections. The signal amplitude decreases very fast reaching the 50 % of its maximum amplitude in about 0.20 seconds ensuring the good performance of the absorbent material. However, it can be seen that it remains a weak reverberant signal.

Results of the present paper are limited to the use of a directive transducer. Due to limitations of time, projectors with different pattern directivity were used and therefore results should be taken carefully in case of the use of other projectors and hydrophones.

CONCLUSIONS

The method based on simulated free field conditions has been proved to be useful to avoid early reflections. This is very useful when directivity pattern want to be measured due to the decrease of the order of destructive interferences. It is worth to be mentioned that, for this purpose, position P1 transducer has to be changed whereas H1 position remains.

Besides, when this method is compared to open water characterization methods, it shows several advantages in terms of controlled environment, uncertainty control and cost reduction.

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