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A hydrophone calibration centre for the Mediterranean area

Silvano Buogo, Paola Calicchia, Andrea Belleggia and Giovanni Bosco Cannelli

CNR-Istituto di Acustica 'O.M.Corbino', Via del Fosso del Cavaliere, 100, 00133 Rome, Italy
giovannibosco.cannelli@idac.rm.cnr.it

The Underwater Acoustics Laboratory of the Institute of Acoustics "O. M. Corbino" in Rome, Italy, has recently achieved accreditation for hydrophone calibration. It can offer hydrophone calibration services operating under a management system compliant with UNI EN ISO/IEC standard and traceability of measurements to NPL primary standards. Precise, traceable measurements are needed today in all applications of underwater acoustics, where a faithful response of measuring devices is essential for a correct evaluation of the system performance and for a rigorous assessment of the environmental impact of man-made activities at sea. To attain these requirements the Laboratory has a water tank 6 m long, 4 m wide and 5,5 m deep, equipped with a motorized two-trolley positioning system capable of handling loads of up to 100 kg. A variety of test and measurement equipment is available, controlled by a computer acoustic calibration system, and standalone instruments for signal generation, acquisition and analysis. Besides, two windows are provided on one of the tank walls for combined acoustical and optical measurements, which can be performed using the available Laser Doppler Vibrometer (up to 100 kHz) and the 16-mm film rotating prism high-speed camera (up to 10 000 frames per second).

Introduction

The Underwater Acoustics Laboratory (UAL) of the Institute of Acoustics "O. M. Corbino" in Rome is the first laboratory of the Italian National Research Council (CNR) that has been accredited to ISO 17025 by SIT, the Italian Accreditation Body, as a Calibration Centre. The Laboratory is also the only accredited Calibration Centre for hydrophones in the entire Mediterranean Area. The Institute has a long tradition of research in all major fields of Acoustics. Actually, it was established in 1936 with a decree signed by Guglielmo Marconi, who at that time was President of CNR, and has been active in the past 20 years in underwater acoustics with EU Projects and international patents.

With a dedicated laboratory expressely built for this purpose in the CNR Research Area of Rome - Tor Vergata, the Institute of Acoustics can now offer hydrophone calibration services to clients. The laboratory operates under a Management System compliant with UNI EN ISO/IEC 17025:2005 Standard. Measurements are traceable to NPL primary standards which had several collaborations with UAL in the last years [1].

Precise, traceable measurements are needed today in all applications of Underwater Acoustics, where a faithful response of measuring devices is essential for a correct evaluation of the system performance and for a rigorous assessment of the environmental impact of man-made activities at sea. To meet these requirements, manufacturers and end-users such as offshore industries, defence and oceanographic institutions may take advantage of the Institute's competence, independence and of a convenient location at the heart of the Mediterranean Sea. Also, clients may choose from a variety of offered services, going from accredited hydrophone calibrations, for which SIT certificates are issued, to testing of underwater acoustics equipment, and to scientific consulting and personnel training as well.

2 Lab facilities and services

The laboratory features a water tank 6 m long, 4 m wide and 5,5 m deep, equipped with a motorized two-trolley positioning system capable of handling loads of up to 100 kg (Fig. 1). Two windows are provided on one of the tank walls for combined optical and acoustical measurements, which can be performed using the available Laser Doppler Vibrometer (up to 100 kHz) or the 16-mm film rotating prism high-speed camera (up to 10 000 frames per second) (Fig.2). Both trolleys provide X-Y motion and rotation around the vertical axis, with additional Z travel in one trolley for precise acoustic beam alignment. A variety of test and measurement equipment is available, controlled by a computer acoustic calibration system, and standalone instruments for signal generation, acquisition and analysis.

Fig. 1 Top: Equipped water tank of the Calibration Centre at the the Institute of Acoustics "O. M. Corbino in Rome. Bottom: The Control Laboratory of the Calibration.

The Centre is accredited to perform calibration of measuring hydrophones with two methods: the *Free-field comparison* and the *Free-field reciprocity*, both having frequency range from 5kHz to 300 kHz and sensitivity range from – 170 dB to – 260 dB, but with different

uncertainties, 1,0 dB and 0,6 dB respectively. Sensitivity are expressed in dB re 1V/μPa and the uncertainties are the declared *Best Measurement Capabilities* expressed as the expanded measurement uncertainty for a confidence level of approximately 95%. For these measurements a SIT Calibration Certificate is issued.

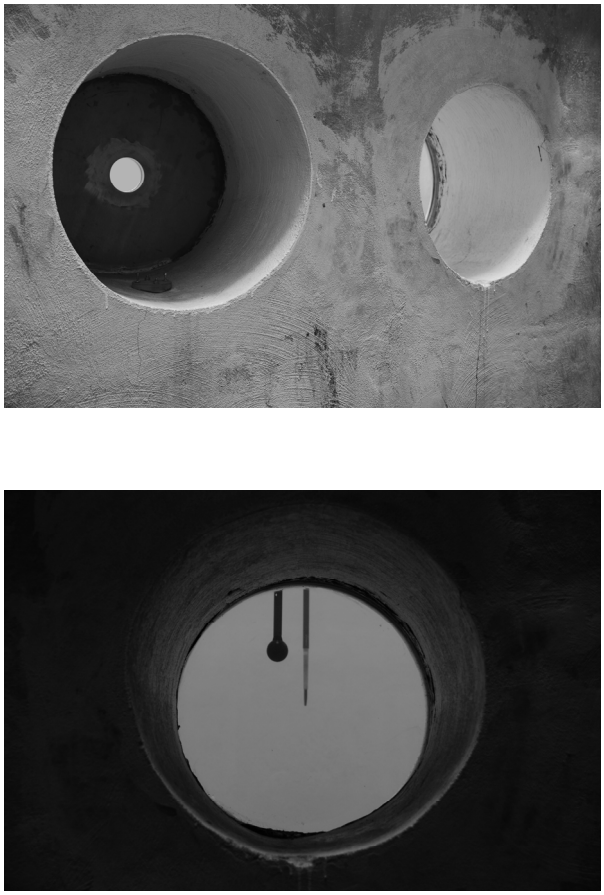

Fig. 2. Two windows are provided on one of the tank walls for combined optical and acoustical measurements (in addition to the accreditated ones), which can be performed using the available 16-mm film rotating prism high-speed camera (up to 10 000 frames per second) and the Laser Doppler Vibrometer (up to 100 kHz), respectively.

Test and research activities

Beyond the scope of accreditation, the laboratory can perform the tests listed below on various types of transducers and arrays.

• Receiving/ Transmitting response from 5 kHz to 500 kHz

• Directional response from 5 kHz to 500 kHz

• Electrical impedance from 100 Hz to 5 MHz

For these measurements a technical report is issued.

The scientific staff of the UAL has gained experience during the past 20 years on the development of high-power pulsed sound sources based on electrical discharge (sparkers) [2,3], and on their application to geophysical and archaeological prospecting [4]. These sources employ specially designed paraboloidal reflectors to focus the acoustic energy emitted by the spark. A number of international patents were filed for several different configurations of transmitting-receiving transducers based on paraboloidal geometry [5].

The following research activities are currently active:

- Study of bubble dynamics induced by underwater sparks (in collaboration with the Technical University of Liberec, Czech Republic);
- Methods for high-resolution prospecting under the seafloor, and signal processing techniques for acoustical imaging in marine environment, particularly in shallow water (in collaboration with CNR - Institute of Marine Science, Venice);
- Development of a pulsed sound source for characterization of acoustic sensors used in large area detectors of cosmic ray particles (in collaboration with INFN, Italian Nuclear Physics Institute, Rome and Catania).

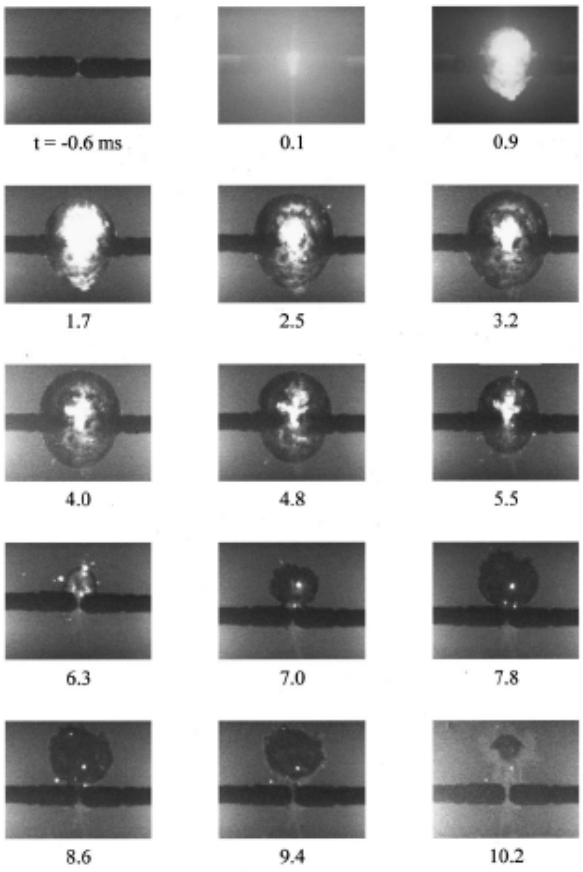

Fig. 3 Tank experiments at UAL: Selected frames showing bubble growth and collapse for a 720-J spark. Each frame is labelled with the time elapsed since (or before, if negative) spark breakdown. The frame is 154 μs.

An important aspect of present research at the UAL is the understanding of bubble phenomena. Bubbles are extremely efficient in producing underwater sound, and the acoustic signature of paraboloidal sparkers was seen to be characterized by powerful pulses due to the growth and collapse of a large vapour bubble, capable of reaching a radius of 3-4 cm in about 3 ms (Fig. 3). When the bubble implodes, a pressure wave is released with typical duration 20 μs and typical peak pressure of 0.15 MPa at 1m (Fig. 4).

The paraboloid enhances this peak value up to 0.5 MPa. This sound source is well suited for applications where a powerful, broadband signal is needed, such as high-resolution acoustic imaging or archaeological prospectings.

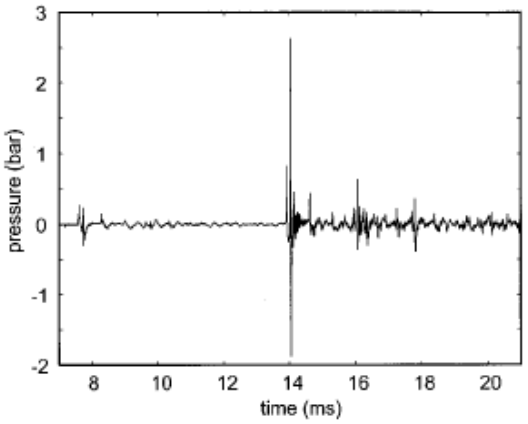

Fig. 4 Acoustic signature of the paraboloidal sparker recorded during the bubble evolution shown in the above frames of Fig.3. The voltage is applied at zero time, the primary pulse appears at 7.7 ms, and the first bubble pulse at 14 ms.

Acknowledgments

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