Short report on INRiM activities in Acoustics, Ultrasound and Vibration.

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1. Presentation of INRiM

INRiM is one of the National Metrology Institutes of Italy, together with ENEA-INMRI that is in charge of the ionising radiation standards. INRiM is the results of the 2006 merging of IMGC, that was the NMI for mechanical and temperature quantities, and IEN that dealt with electrical quantities, time, photometry and acoustics. INRiM is under the supervision of "Ministero dell'Istruzione, dell'Università e della Ricerca".

INRiM is organised in four Divisions, Acoustic and Ultrasound being part of "Termodinamica" Division and Vibration of "Meccanica" Division.

Among the activities of INRiM in the AUV field are the development and maintenance of national standards, a service of traceability to calibration laboratories, research in the field of materials for acoustical and vibration mitigation, type approval of instrumentation and devices for noise measurement, testing of properties of materials, in the fields of building acoustics for sound in air, and for tissue mimicking gels, nanobubbles and dummies for ultrasound in medicine.

In the "Termodinamica" Division, an acoustical programme is active in the determination of the speed of sound in gases and in liquids, for the characterisation of their thermodynamic properties, and in sonochemistry.

In the framework of SIT Italian calibration accreditation service, 16 laboratories in the field of Acoustics, 7 in Vibration and one in Ultrasound obtain the traceability of their transfer standards from INRiM. INRiM is no longer responsible for the calibration accreditation in Italy. ACCREDIA is now the Italian organisation for accreditation in all fields. INRiM is still active in accreditation with its technical experts and has a representative in ACCREDIA executive board.

2. Standards in AUV

INRiM is in charge to operate the Italian national standards of acoustical pressure, sound power, ultrasonic power and acceleration. The measurement capabilities in these field are listed in the CMCs database on BIPM website.

The standard for acoustical pressure is realised by primary calibration of laboratory standard microphones in the range 20 Hz to 25 kHz, according to the pressure reciprocity method described in IEC 61094 part 2 norm. The calculation program has been updated to follow the 2009 Ed. 2 of the standard.

The sound power standard consists of the calibration of reference sound sources in a hemi anechoic room following ISO 6926 norm.

The ultrasonic power from 0.01 W to 15 W in the frequency range 1.8 MHz to 11 MHz is measured by means of a radiation force balance with both absorbing and reflective targets.

Vibrations standards follow ISO 16063 part 11 and part 21 standards and cover the frequency range from .5 Hz to 10 kHz.

Ultrasonic power up to 300 W can be measured by an apparatus based on a submersible load cell, that is fast and can measure forces with short duration signals that do not damage the absorbing target. The apparatus was developed in order to cope with the requirements of HITU power measurements. The lower S/N ratio of the load cell signal requires correlation analysis between driving signal and force output at low power levels.

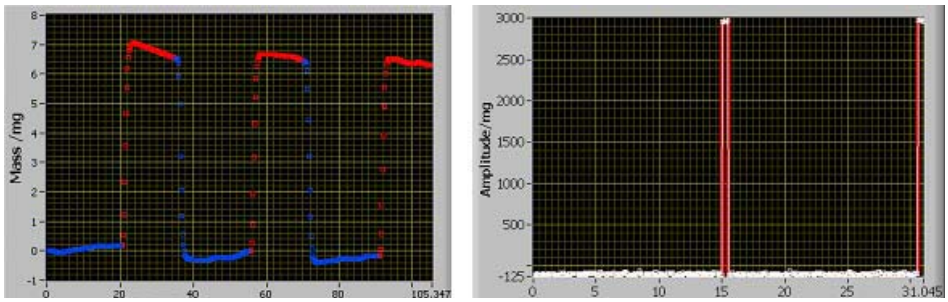

Fig 1. Comparison of signal duration for ultrasonic power measurements, on the left traditional force balance, on the right target directly connected to submersible load cell. Time scale in s.

A request for extension of the CMC range for ultrasonic power is planned for 2011.

The range of pressure reciprocity calibration of LS1 type microphones will be extended to 2 Hz in 2011; the measuring apparatus has been updated and tested, the uncertainty budget is under evaluation.

3. Other activities related to AUV

A considerable work is done on the characterisation of the acoustical and vibration properties of materials. Testing is routinely performed according to ISO standards on sound transmission loss, absorption coefficient, flow resistance and dynamic stiffness.

Methods for the determination of the physical properties of materials based on the measurement of the speed of sound of longitudinal and transversal waves in solids produce data for mathematical models of the same materials.

The effect of structural noise propagation and the characterisation of noise sources and their power is investigated by measurements on a reception plate facility. This activity is in co-operation with Liverpool University.

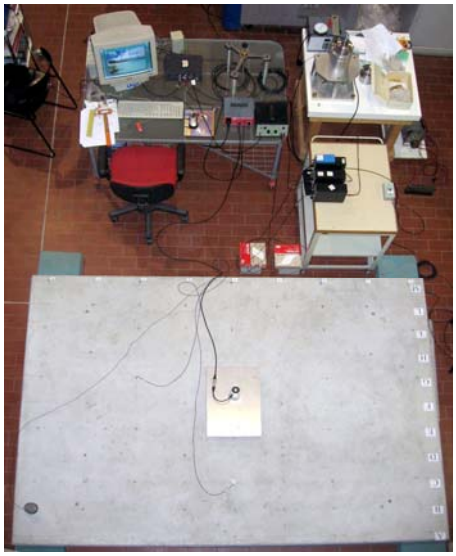

Fig. 2. Reception plate facility for the measurement of power of source of structural noise.

Production and size distribution measurements methods of nano bubbles for diagnostic ultrasound image enhancement and for carrying drugs in a controlled way are carried out.

Ultrasonic field and power of medium to high power ultrasound devices used for therapy are measured and checked against safety indexes contained in relevant IEC standards.

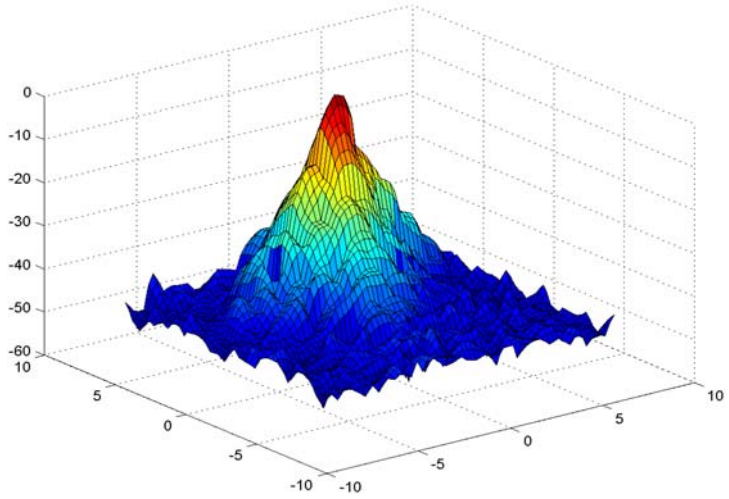

Figure 3. Ultrasonic field emitted from a physiotherapy device.

In the ultrasound field, materials for making phantoms mimicking the characteristics of organic tissues have been realised and their properties characterised. The temperature increase produced by HITU focalised ultrasonic fields is measured with infrared thermometry (thermographic camera).

In cooperation with Università di Torino Dipartimento di Neuroscienze and Politecnico di Torino, a Reference Centre for Ultrasound in Medicine has been created, co-financed by Regione Piemonte. Among its scopes there are provisions of facilities for verification of ultrasound diagnostic instruments, developments of measurements protocols and training of hospital technicians.

4. Cooperation in metrology and standardisation organisations

INRiM participates in EURAMET TCAUV, and is the convenor of the "Sound in air" Sub Committee. INRiM participates in Working Groups of IEC TC 29 that deal with standards for microphones, calibrators and instrumentation for the measurement of noise, and in TC 87 for standards on ultrasonic power and ultrasonic transducers and equipment. INRiM is also active in ISO and IEC national TC for acoustics and ultrasound.

INRiM participates in BIPM/CIPM key comparison CCAUV.U-K3 on ultrasonic power.

In the framework of iMERA project TP2 JRP7 "External Beam Cancer Therapy", Working Package 2, INRiM participated to inter-laboratory comparison of HITU power measurement. In the same project is working on comparison of temperature measurement methods in HITU fields.

The EURAMET project 1056, "Comparison of methods to determine corrections to obtain the free-field response of a sound level meter", is an example of co-operation between metrology and standardisation, and INRiM is the pilot laboratory.

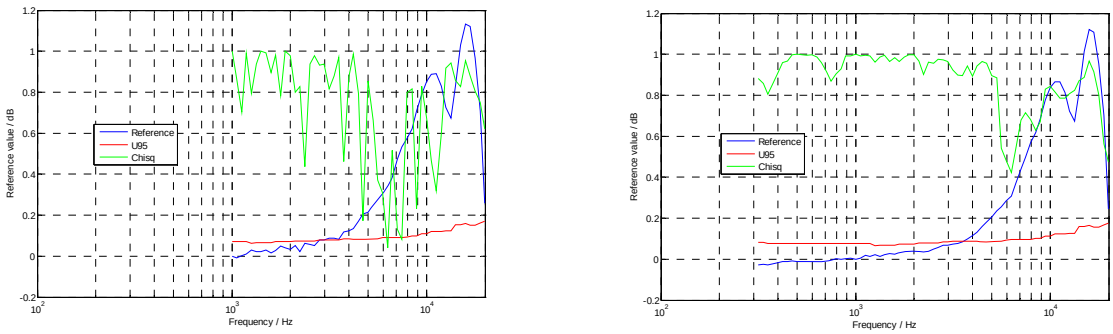

Fig.4. Measurements of free field response of a SLM microphone. All methods (left). Methods that use time selective techniques for cancellation of the effects of reflections (right).

Not in direct relation with AUV field, but using acoustic techniques, the precision measurement of the speed of sound in spherical resonators is part of the INRiM contribution to iMERA+ research project TP1 - JRP “Determination of the Boltzmann Constant”. The results of this activity are now available in a Metrologia paper.