

# Istituto Nazionale di Ricerca Metrologica, INRIM

## Unità di Acustica e Ultrasuoni

### Short Report on Activities, September 2006

#### Introduction

INRIM is the result of the merging of two Italian National Metrology Institutes, IMGC-CNR and IEN. Its activity started in January 2006. INRIM maintains the national Italian standards of all quantities except ionising radiation, which is still the responsibility of ENEA IMRI.

INRIM is active in research on materials, nano technologies, metrology in chemistry and other fields.

The Acoustic and Ultrasound Division is active mainly in calibration of instrumentation for noise measurement, characterisation of materials for noise insulation and absorption, measurement of the speed of sound in gases and liquids, and measurements of ultrasonic power.

The activity in vibration, formerly in IMGC-CNR, is still operating at INRIM and traceability to national standard is assured for calibration laboratories in the Italian accreditation scheme, SIT, but at present the vibration unit is being reorganised.

#### Research activities

A considerable effort has been devoted to the precision measurement of the speed of sound in gases and in liquids.

The aim of the measurement of speed of sound in gases is the determination of the molar gas constant  $R$  and of the Boltzmann constant  $k$  with an accuracy adequate for a possible new definition of the Kelvin. Two different strategies, involving different perturbations of ideal spherical geometry, have been pursued. Namely, misalignment of the two hemispheres comprising the resonator, and the realisation of an ellipsoidal cavity. In both cases the geometrical perturbations are intended to increase the precision achievable in measuring multiple degenerate microwave modes, while maintaining the corresponding perturbation of the acoustic field within a few ppm.

The measurement of speed of sound in liquids is a part of an ongoing research program to measure physical properties of n-alkanes. Measurements have been made in n-Nonane 293.15 K and 393.15 K and at pressures from 0.1 MPa up to 100 MPa, with an estimated uncertainty  $< 0,2\%$ .

The effect of cavitation and sonoluminescence has been studied for its effects on chemical reactions, and amorphous products with high surface to weight ratios (in excess of 220 m<sup>2</sup>/g) have been synthesised.

In sound in air, comparison calibration in hemi free field have been developed both for WS microphones and for SLMs. Effects of source type and dimensions and of the echo removal algorithms have been studied. An activity in aero acoustics in cooperation with Politecnico di Torino started in 2006.

## **Calibration and measurements activities**

The measurement of ultrasonic power by the radiation force balance method has been improved, both in the electrical measurement of the driving AC voltage and in the reduction of the total measurement time by automatic variation of the distance between transducer and target, with its associated reduction of the effects of drifts. CMCs dealing with ultrasonic power measurement between 10 mW and 20 W at frequencies up to 20 MHz have been submitted to EUROMET for regional evaluation. The CMCs are supported by a bilateral comparison with PTB.

Other activities in Ultrasound focus on the determination of the field emitted by transducers and their behaviour in the time domain, in a large tank, in order to be able to measure all the parameters needed for the assessment of safety in medical ultrasound diagnostic.

Some preliminary calibrations of user ultrasonic wattmeters have been performed in 2006.

The activity in sound in air deals with the improvement of the uncertainty of the calibration of laboratory standard microphone by the primary method of pressure reciprocity. Recent improvements have been a better control of environmental parameters, in particular static pressure, and the reduction of the uncertainty of the electrical transfer function by the use of selective voltage measurement.

In Italy, 15 calibration laboratories are accredited in the field of acoustics. Each laboratory needs to calibrate one or more LS2p laboratory microphone at least one a year. INRIM microphones (about 15) are calibrated approximately twice a year.

In 2005, a service of pattern approval of Sound Level Meters according to ISO standard 61672 part 2 has been established.

Reference sound sources are calibrated in the anechoic chamber according to ISO standards.

Characterisation of the acoustical properties of materials according to ISO standards in reverberation and sound transmission rooms is flanked by new techniques based on a more direct measurement of the physical properties on small samples. New measuring apparatuses for the measurement of the long term decay of the properties of materials for the insulation of vibrations have been realised and tested.

## **Cooperation in metrology and standardisation**

INRIM acted as pilot laboratory, in cooperation with DPLA, for the EUROMET.AUV.A-K3 comparison in 2004-2006. Draft B has been submitted in September 2006.

A bilateral comparison on the measurement of ultrasonic power with PTB has been successfully completed, under EUROMET project 879.

The acoustic and ultrasound division participates in iMERA projects proposed for acoustical thermometry and comparison calibrations in sound in air.

INRIM holds the chair of Italian national committee for standardisation on electro acoustics and ultrasound, CEI CT 29/87; participates in several WGs of TC 29 and in one WG of TC 87 of IEC.