PRIMARY METROLOGY IN FRANCE IN ACOUSTIC AND ACCELEROMETRY FIELDS

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Situation of French metrology

The coordination of metrology in France was previously under the responsibility of BNM (Bureau National de Métrologie) which was a group of primary laboratories and associated laboratories.
By decree of 25th January 2005, the French government transfers the full responsibility of metrology to LNE whose full name becomes Laboratoire national de métrologie et d'essais, the acronym remaining LNE, and create a Comité national de la métrologie to give advice and counsel to general manager of LNE who have the responsibility of decisions. Consequently, BNM is disbanded.

Situation of the acoustic laboratory

Since 2002, LNE has started a study in the field of acoustical metrology, in order to improve accuracy in microphones calibration and also in order to develop a method to measure the acoustical impedance of little elements such as the capillarity ducts build in the artificial ear.

Because the model for the sound pressure in the cavity given by the IEC standard was only based on the plane wave approximation, the study required first a more accurate analytical model. Two models have been developed :

The first one [1, 2, 3] use a plane wave description and includes the effect of the thermal conductivity of the gas, a new expression for the acoustic transfer admittance is proposed to replace the expression quoted in the IEC standard 61094-2(1992).

The second model [1, 4, 5] takes into account the radial wave-motion using a modal description. Moreover, the velocity profile of the diaphragms must be known to complete the model, this fine modelling may be the subject for further researches.

The obtained results could lead to a deep measurement method for the input characteristics of small acoustic components. Many applications (artificial ears, loudspeakers, microphones, among electroacoustic devices, especially those that will be miniaturised in the future using MEMS techniques) would require characterising the behaviour of small acoustic components such as small tubes, small rectangular or circular slits and small cavities. These small devices are usually described analytically using modelling wherein viscosity, heat conduction, inertia and compressibility of the fluid are considered, beyond realistic boundary conditions.

Characterising experimentally the input of these kinds of components, that is to say measuring their input impedances, was quite impossible until now because their input impedance is usually much greater than those involved in the measuring set-up. A measurement procedure

has been developed [1, 6, 7] which is assumed to be optimized because it uses the very well optimized reciprocity calibration method and the corresponding set-up available on the market. The first results obtained on classical elements are encouraging.

Transfer of the French accelerometry reference laboratory from CEA-Cesta to LNE

The national accelerometry references are being restructured after the decision taken by CEA CESTA in 2005 to stop being the reference laboratory in this domain, a task it had fulfilled since 1974. LNE has taken over this function and installed a new laboratory dedicated to this activity on its Trappes site.

The primary national references of CEA-CESTA were made up of three equipments :

- an absolute for medium and high frequency vibrations,
- two other for shock (medium and high level).

In the course of the year 2005, the medium and high-frequency vibration equipment as well as the laser velocimeter pick up of the shock equipment were transferred to LNE. CEA-CESTA is keeping the actual shock equipments (without velocimeter) for its own comparative calibration needs.

The transferred equipment makes use of the absolute calibration method for medium and high frequency vibrations (laser interferometer). In France, this station serves as reference for calibrating the accelerometers used by calibration laboratories for comparison measurements.

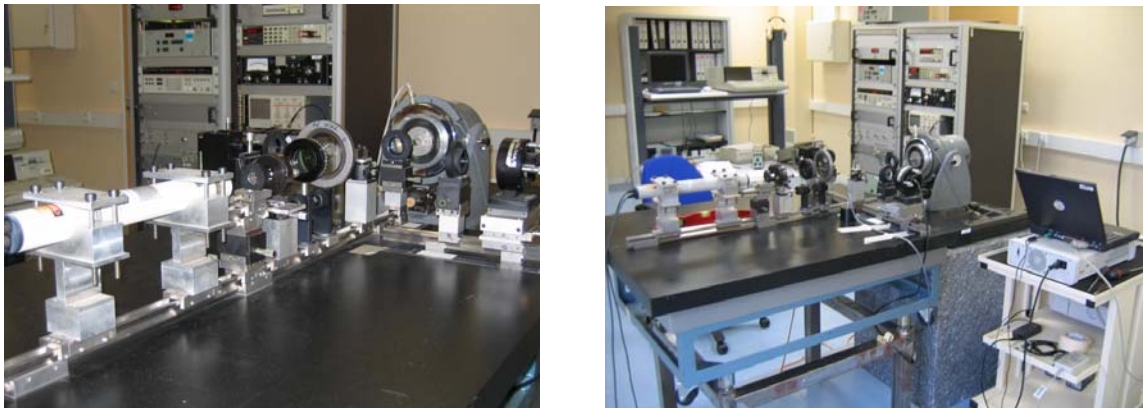

Fig. 1. Accelerometry equipment for medium and high frequency vibrations

In order to accept the new equipment, a 45 square metre laboratory was rearranged from three contiguous offices. This new laboratory is located on the ground floor of the Louis Lumière Building at the LNE's Trappes site. The seismic block of CEA-CESTA, installed in a mini-trench, was not transferred. A granite block weighing over a ton (1200 kg) was provided. It was placed on a concrete mat (base) of the type used under the LNE mass comparator blocks.

At CEA-CESTA the bench was controlled by an obsolete generation computer. To correct the situation, a spreadsheet (Excel) was developed. It allows to assist and to make possible a manual use of the transferred equipment. For purposes of setting parameters and their easy

management, a specific tab was created consisting of all the measurement parameters of the methods and procedures implemented. It involves a mini database of measurement parameters.

The main stages of the qualification carried out after the transfer were:

- Measurements of the vibration levels of the support table of the laser interferometer for different operating levels of the exciter. The movement of the interferometer itself is indeed of a nature to cause the moving measurement of the accelerometer to fail.
- Measurements of the crosswise movement rate of the moving part of the exciter. This crosswise movement disturbs the axial moving rate by the parallelism default created. On the other hand, based on the transverse sensitivity of the standardized instrument, an uncertainty component, as a function of the crosswise movement rate, is taken into account.
- Calibration of the measuring equipment. Each time, the calibration program applied by the previous laboratory was optimised relative to the usage domain and with the necessary and sufficient uncertainties.

The analysis of the results allowed for a new determination of uncertainties connected to the use of the bench. The uncertainty of determining the sensitivity of an accelerometer or an accelerometric chain becomes in relative value (k = 2) equal to:

± 1.0 % from 10 Hz up to 30 Hz

± 0.60% from 30 Hz (included) up to 10,000 Hz.

In order to verify the metrological continuity of the bench after its transfer, witness accelerometers were calibrated at CEA-CESTA before the move. These same accelerometers were again calibrated at LNE. The results allow supporting the continuity of accelerometry references after the transfer and are intended to confirm reliance on retained estimating of uncertainties. Accreditation by COFRAC has been obtained.

An Euromet comparison project was proposed by LNE (n° 897) and agreed. This comparison will be used to confirm CMCs witch will be re-proposed by France for vibration measurements. PTB as pilot laboratory will be the linking laboratory to the previous Euromet comparison (project 579) performed from 2003 to 2004 and to the BIPM Key Comparison CCAUV.V-K1 (Vibration) performed from 2000 to 2002. Three others countries joined this project. The circulation period started in June 2006 and will be finished before the end of this year.

Publications :

[1] C. Guianvarc’h. La cavité de couplage acoustique dans la méthode de réciprocité : modèles analytiques pour l’étalonnage des microphones et la mesure d’impédances de petits composants. PhD thesis Université du Maine, 9 septembre 2005.

[2] C. Guianvarc'h, J.-N. Durocher, M. Bruneau, A.-M. Bruneau. Acoustic transfer admittance of cylindrical cavities. Journal of Sound and Vibration, 292 (2006) 595-603.

[3] C. Guianvarc'h, J.-N. Durocher, M. Bruneau, A.-M. Bruneau. Attempt to improve the pressure reciprocity calibration of microphones. CFA-DAGA Strasbourg 2004.

[4] C. Guianvarc'h, J.-N. Durocher, M. Bruneau, A.-M. Bruneau. Improved formulation of the acoustic transfer admittance of cylindrical cavities. Acta Acustica united with Acustica, 92 (2006) 345-354.

[5] C. Guianvarc'h, J.-N. Durocher, M. Bruneau, A.-M. Bruneau. Microphone reciprocity calibration: acoustic field in the coupler. Forum Acusticum Budapest, 2005.

[6] D. Rodrigues, C. Guianvarc'h, J.-N. Durocher, M. Bruneau, A.-M. Bruneau. A method to measure input impedance of small acoustic components. Submitted to JSV (2006).

[7] D. Rodrigues, C. Guianvarc'h, J.-N. Durocher, M. Bruneau, A.-M. Bruneau. Méthode de mesure d’impédance de petits éléments acoustiques. CFA Tours, 2006.

[8] P. Averlant. Transfer of the French accelerometry reference laboratory from CEA-Cesta to LNE. XVIII Imeko World Congress, Brazil, September 2006