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Status Report of CENAM

Mexico to the CCAUV 2008

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Status report of CENAM, Mexico to the 5th Meeting of the CCAUV 2008

The strategy followed by CENAM in response to the demands and needs of the industry, accredited laboratories, and inputs from customers, was to organize several workshops focused to specific sectors of economy. In relation to the AUV fields, three workshops were prepared for industrial hygiene, health care, and automotive industry, respectively. The findings of these workshops as well as feedback from stakeholders and government were taken into account in the medium- and long-term plans to improve: i) measurement and calibration services; ii) measurement standards; iii) measurement technology; and iv) knowledge transfer.
In 2008 the body of Directors of CENAM decided to strengthen the internal quality management system, which has been defined according to ISO 9001 and ISO/IEC 17025 international documentary standards. One of the improvements is that the internal audits will be conducted by experts of CENAM, while external audits will be of the peer evaluation type. CENAM is interested that the international leaders in the AUV fields would conduct such evaluations.
In the following paragraphs is described some of the most representative developments which define the current measurement and calibration capabilities in AUV at CENAM. The information is classified by each of the three fields of AUV.

1. Vibrations Group recent developments.

Primary calibration system at low frequencies (0,1 Hz to 160 Hz)
Several accelerometers for low frequencies have been measured in the last years with different functional principles, i.e. piezoelectric, capacitive, and MEMS. Up to now some of the MEMS accelerometers have shown the highest accuracy and competitive price in market. For the measurement of voltage at frequencies lower than 10 Hz, dc voltage is preferred over the ac voltage , digitalizing the voltage while avoiding errors like Nyquist. The complex sensitivity of accelerometers (i.e. sensitivity magnitude and phase shift) at low frequencies is obtained.
Several laser vibrometers have been calibrated at low frequencies using as measurement reference a laser interferometer.

Secondary calibration of vibration transducers by comparison to a reference standard
Due to the number of calibration services demanded from accredited laboratories, research centers, and the industry, it was necessary to establish three secondary calibration systems, specifically for low frequencies, for medium frequencies, and for high frequencies.
The secondary calibration system for low frequencies covers a frequency range from 1 Hz to 160 Hz. The system uses an APS vibration exciter and uses as reference accelerometers both capacitive and MEMS accelerometers.
The secondary calibration system for medium frequencies works from 50 Hz to 10 kHz using a vibration exciter and a reference accelerometer both from B&K.
The secondary calibration system for high frequencies covers a frequency range from 100 Hz to 20 kHz using a laser vibrometer as a reference transducer and a vibration exciter equipped with air bearing. The laser vibrometer used in this secondary calibration system is calibrated by laser interferometry.

Primary calibration system of laser vibrometers at high frequencies, i.e. 5 kHz to 100 kHz
Technical specifications of laser vibrometers commercially available nowadays state a frequency range from 0,1 Hz to 100 MHz. Traceability to primary measurement standard is demanded over the specified measurement ranges of the measurement instrumentation. At the level of National Metrology Institutes, primary calibrations of laser vibrometers have been carried out in the frequency range from 0,4 Hz to 20 kHz. A new documentary standard for the calibration of laser vibrometers is under preparation, i.e. ISO 16063-41.

The current stage of this documentary standard (i.e. the 2nd CD) was recently approved and the next stage of a Draft International Standard (DIS) is planned to be achieved still in 2008. The current version specifies calibration methods from 0,4 Hz to 50 kHz, but has been demonstrated that it is possible to use the three standard methods up to 100 kHz or even higher frequencies [see publication 1.2]. A fourth highly accurate method was developed, called the coincidence method, which is applicable up to 100 kHz where a displacement of λ/4 can be attained [see publication 1.2], where λ is the wavelength of the laser. A scientific paper was presented in the 8th International Conference on Vibration Measurements by Laser Techniques in June 2008, the research and experimental work were developed in cooperation with Dr. H.-J. von Martens, we take this opportunity to thank Dr. von Martens for his cooperation.

Primary calibration system by shock excitation at medium intensities (50 m/s2 to 35 km/s2)

The measurement reference of this system is a laser interferometer. Two calibration methods are used, time interval and phase unwrapping of the two signals from the interferometer. Initially the working range of the system was from 50 m/s2 to 5 km/s2, but the upper limit has been improved and now is 35 km/s2. The excitation type is a half sine squared shape.

By using a Hopkinson bar, it has been possible to excite levels of about 100 km/s2. The calibration procedure for this high intensity primary calibration system is currently under development.

There is a demand of calibrations for impact hammers expressing kinetic energy from 0,2 J to 1 J. This calibration system measures the velocity of a moving element with known mass. The velocity measured in this calibration system is about 2,5 m/s.

Establishment of primary calibration system of angular acceleration (1 Hz to 100 Hz)

Nowadays there is a demand for the calibration of angular acceleration transducers and instruments, i.e. inclinometers, angular accelerometers, angular laser vibrometers, among others. CENAM is establishing a primary calibration system of angular acceleration which includes a rotational laser vibrometer from Polytec, an angular acceleration exciter from Acutronic and a dc motor. A conditioner amplifier has been developed for angular position sensors.

Two different excitation objects are used, specifically a dc motor and a position and rate table. The dc motor: has a working frequency range from 10 Hz to 100 Hz, continuous rotation, angular displacement of 40° peak and angular velocity of 4000 rpm simultaneously excited. The position and rate table was manufactured by Acutronic, has a working frequency range from dc to >35 Hz, angular velocity 500 rpm, and angular acceleration 700 rad/s^2.

Design of metallic cases for MEMS accelerometer and calibration at low frequencies

Several MEMS accelerometers commercially available have been measured, i.e. Analog Devices, Motorola, Colibrys, Kistler, etc. Metallic cases have been designed and manufactured to cover some of the MEMS accelerometers prior to calibration. The calibration results have been showing that MEMS accelerometers can be as accurate as the best accelerometers available in the market, at least for frequencies lower than 200 Hz. Up to now, the MEMS accelerometers have been showing a temporal stability within the same range of standard accelerometers for low frequencies.

2. Ultrasound Group recent developments.

Medical ultrasound activities and some local issues about traceability

Recent participations in workshops and talks with several local health professionals have allowed the ultrasound group at CENAM to corroborate that calibration of medical devices and instruments is hardly performed on an average health institution, despite having quality management systems certified under ISO 9001:2000.

The main priorities that, in general, prevail in most public health institutions until now contacted are:

1) There shall be enough health professionals (physicians and nurses) in a given hospital,

2) The health personnel shall receive their respective paychecks on time,
3) The prescribed medications shall be available for all patients,
4) The waiting time a patient has to spend before he/she is diagnosed by a physician shall be reduced, and
5) Maintenance and cleaning services of the hospital facilities shall be provided so that normal operations are not interrupted.

So it appears that, calibration of medical instruments available in unfortunately many hospitals is an estrange activity scarcely considered as part of a systematic health service process; situation that is not exclusive in Mexico but also present in many countries, perhaps more than we are aware of now. As eventual users of such health services, the perspective is not precisely a good one. Manufacturers take care of the so-called calibration; either the equipment belongs to a private or a public hospital.

Diagnosis and therapy using ultrasound are mistakenly considered extremely safe tasks and far from being dangerous. Most physicians that use some kind of ultrasound equipment in their daily duties (e. g., gynecologists or therapists) relay on the safety of ultrasound power levels and do not foresee any serious problem with having an ultrasound device not calibrated over several years. Calibration of ultrasound devices and transducers has not been enforced. As far as we know, regulations towards making calibration of ultrasound medical devices mandatory are also an open issue in several other countries. NMI members of the CCAUV perhaps could share their corresponding experiences and provide further evidence on the lack of traceability in their respective home countries regarding ultrasound medical instruments. The manufacturing and refurbishing of medical devices (e. g. ultrasound instruments) is part of a large business. In our opinion, not enough emphasis has been put on the importance of traceability in a large number of calibrations currently performed worldwide. Medical ultrasound metrology infrastructure from which safer and better ultrasound therapies and diagnostics might be available would hardly be possible if no calibrations are demanded as in the industrial sector. Ultrasound equipment for diverse industrial applications is being calibrated; however, ultrasound equipment for medical applications is not.

In the case of ultrasound equipment, the main transnational distributors do not have accredited calibration laboratories in Mexico and usually representatives of these companies perform all maintenance services to the equipment. It is not clear if any calibration service provided by them comply or not with ISO/IEC 17025:2005 requisites. Traceability of calibrations on medical devices used in diagnosis is not well defined. In the case of ultrasound instruments for diagnosis and therapy, the calibration may become even more necessary as the ultrasound equipment gets old, requires refurbishment or needs mayor repairs. Health authorities in Mexico are being advice to check what, how often and how medical equipments are being calibrated, not just the ones related to ultrasound. These aspects together with other perspectives and challenges for Metrology and its application to Medicine related services were addressed in a 2006 workshop organized by CENAM in collaboration with the IMSS (Instituto Mexicano del Seguro Social, one of the most important and nationwide health institutions in Mexico). Conferences and further details are available in http://www.simet.gob.mx/fss/publico/default.htm, see Figure2.1. The event was attended by more than 270 professionals of the health sector with interest in metrology, standards and conformity assessment. And certainly there is much to be done to foster good metrological practices in medical and diagnostic laboratories.

Figure 2.1 Metrological Perspectives and Challenges in the Health Sector, 2006-November-14.

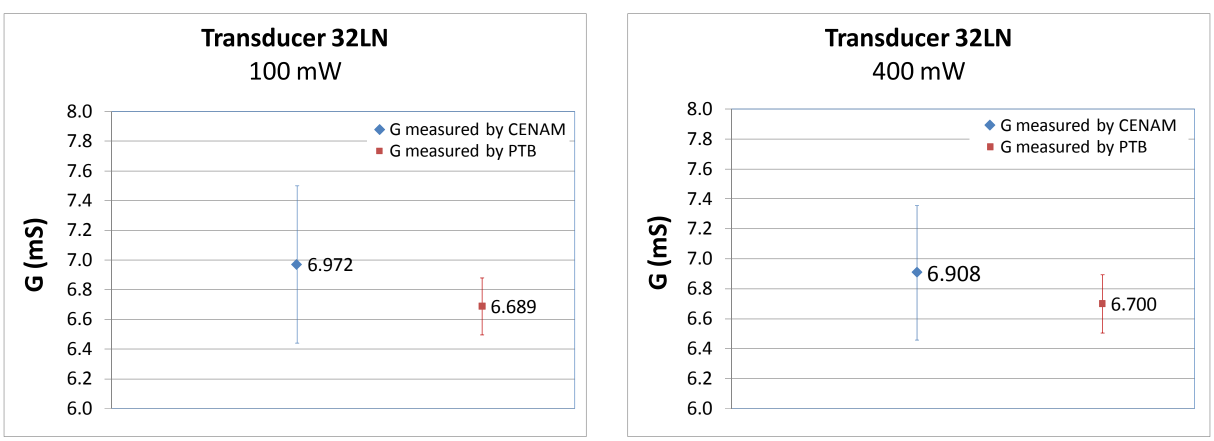
(Conferences and further info: http://www.simet.gob.mx/fss/publico/default.htm)

Ultrasound power measurements

The ultrasound group received technical assistance from Dr. Christian Koch, PTB, from 12 to 22 November, 2007. The discussions and technical advice topics addressed were mainly,

a) Calibration of underwater hydrophones and measurements in kHz-frequency range, b) ultrasound power measurement by radiation force balance, c) use of phantoms and their characterization, and d) hydrophone measurements in the MHz range.

A good number of hints were given by Dr. Koch to improve measurement techniques and associated procedures used at CENAM. Remarks on avoiding reverberations, needs of a higher resolution for power measurements, characterization of phantoms, and elimination of noise from step motors when performing planar scanning of ultrasound fields were indeed very useful. In addition, three ultrasound power transducers built by the PTB were incorporated as part of our ultrasound facilities currently available. Support from PTB´s Technical Cooperation Office is kindly acknowledged. See Figure2.2.



a) G(mS) from power measurements at 100 mW   b) G(mS) from power measurements at 400 mW

Figure 2.2 Radiation conductance results.

Ultrasound perspectives for industrial applications

There is a large number of testing laboratories that perform non-destructive testing on pipes, oil-ducts, tanks, pressure vessels and automotive assemblies. The application of ultrasound on industrial processes is steadily increasing. Applications such as evaluation of welds and acoustics microscopy are two areas associated to fault detection in which CENAM is expecting to develop joint innovation and technology related projects with local industries. Assistance on uncertainty estimation as a relevant aspect associated to the reliability of an evaluation is also being requested.

3. Acoustics Group recent developments.

Measurement of sound power

CENAM had developed the measurement of sound power according to ISO 3745:2003 and for reference sound sources as in ISO 6926:1999. CENAM's hemi-anechoic chamber has to change its absorbing characteristics for allowing measurements at low frequencies (100 Hz). In order to fabricate the acoustical wedges in México, CENAM is trying to work together with a local industry to develop a provider of acoustic materials.

Measurement of sound insulation in buildings and of building elements

CENAM and CCADET-UNAM (National Autonomous University of Mexico, Mexico City) have been working together in order to develop in México the evaluation of Sound Reduction Index according to ISO-140-3:1995, ISO 15186-1:2000 & ISO15186-2:2003. This work also researched measurement methods based on Digital Signal Processing. The project was financed by the mixed funding from the Science and Technology National Council (CONACYT) – State Government of Queretaro.

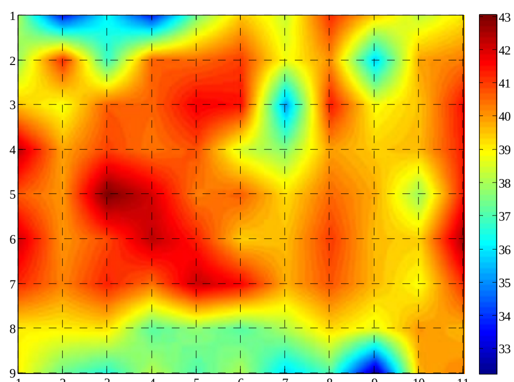


Figure 3.3. Example of an intensity map at 1 kHz of a prefabricated material mounted in the transmission suite at CCADET-UNAM.

Proficiency tests for accredited laboratories and verification units for legal noise measurements

CENAM has been working with other national organizations, local and state governments in order to improve the legal noise measurements in Mexico. This has been done through the development and application of Technical Proficiency Test (PAT, Prueba de Aptitud Técnica) for both environmental noise measurements and occupational noise measurements according to national standards. Proficiency tests for environmental noise measurements have being carried out for the last 11 years at CENAM. In 2007, CENAM developed a proficiency test for occupational noise measurements and in 2008 started to apply this proficiency test to the accredited laboratories and verification units.

4. Publications

Vibrations

[1.1].- *A bilateral acceleration comparison between CENAM and INMETRO*; G. P. Ripper (INMETRO), and G. Silva-Pineda (CENAM); IMEKO 20th TC2, 3rd TC 16 and 1st TC 22 International Conference; 27th to 30th November, 2007. Merida, Mexico.

[1.2].- *Calibration of laser vibrometers at frequencies up to 100 kHz and higher*; G. Silva-Pineda, H.-J. von Martens, S. Rojas, A. Ruiz, and L. Muñiz; 8th International Conference on Vibration Measurements by Laser Techniques; June 17-20, 2008. Ancona, Italy.

[1.3].- *Primary calibration of vibration transducers by laser interferometry and trends*, G. Silva-Pineda; 2008 NCSL International Workshop and Symposium; August 3-7, 2008. Florida, USA.

Ultrasound

[2.1].- "*Aseguramiento metrológico en los ensayos no-destructivos por ultrasonido*", A. L. López-Sánchez, R. Amezola-Luna, A. Elías-Juárez, 7ª. Conferencia Mexicana de Pruebas No Destructivas, 28 al 30 de agosto, 2007, Cd. México.

Acoustics:

[3.1].- "*A Method for determining sound insulation without the use of a transmission chamber*". O. Moreno-Amezcua, S.J. Pérez-Ruiz & A. E. Pérez-Matzumoto. IEEE 4to Congreso Internacional en Innovación y Desarrollo Tecnológico, October 11-13, 2006, Cuernavaca (México).

[3.2].- "Estudio *de la influencia de diferentes parámetros sobre la medición de emisión de ruido de vehículos evaluada conforme a la norma NOM-079-SEMARNAT-1994*". A. Esquivel-Delgado, O. Llamas-Llamas, G. Loera-Medrano & A. E. Pérez-Matzumoto. Simposio de Metrología 2006. October 25-27, 2006. Querétaro (México),

[3.3].- "*Sistema Primario para la Calibración de Micrófonos Patrón en Campo Libre*". J. N.-Razo-Razo & A. E. Pérez-Matzumoto. Simposio de Metrología 2006. October 25-27, 2006. Querétaro (México),

[3.4].- "*Comparación de la medición en laboratorio del aislamiento acústico de materiales de construcción por el método de cámara de transmisión y la técnica de intensidad acústica*". A. Esquivel-Delgado; A. E. Pérez Matzumoto y S. J. Pérez-Ruíz. IEEE 5º Congreso Internacional en Innovación y Desarrollo Tecnológico, October 10-12, 2007, Cuernavaca (México).

[3.5].- "*Importancia de parámetros experimentales sobre la estimación del índice de reducción sonoro por la técnica de intensidad acústica*". A. Esquivel-Delgado; A. E. Pérez Matzumoto y S. J. Pérez-Ruíz. Simposio de Metrología 2008. October 25-27, 2008. Querétaro (México), (accepted to be published).