Brief Report of the Acoustics and Vibrations Division at CENAM, México To the 5th Meeting of the Consultative Committee of Acoustics, Ultrasound and Vibration of the CIPM, 24 to 25 of September 2006

The Acoustics and Vibrations Division at CENAM continues to hold the responsibility of establishing and maintaining the national standards for Acoustics, Ultrasound and Vibrations in México.

The Division is composed by three Groups, one for each of the disciplines involved. The three working groups, each with their own resources and activities, are:

1. Vibrations Leader: *Guillermo Silva-Pineda*	+ 6 technical staff
	2 National standards* and 1 reference system*
	1 Secondary laboratory in full activity.
	20< Calibration and measuring services*, training courses, etc.
2. Ultrasound Leader: *Alfredo Elías-Juárez*	+ 2 technical staff
	1 National standard* and 1 reference system*
	2 Secondary laboratories with limited capabilities for industrial ultrasound measurements
	5 Calibration and measuring services*, training courses, etc.
3. Acoustics Leader: *Andrés E. Pérez-Matzumoto*	+ 4 technical staff
	1 National standards* and 1 reference system*
	1 Secondary laboratories in full activity
	10< Calibration and measuring services*, training courses, etc.
Total AUV Division	15 technical staff
	4 National standards and 3 reference systems
	4 Secondary laboratories in different stages of development
	35< Calibration and measuring services, training courses, etc.
Area of Physics Metrology	Salvador Echeverría-Villagómez

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1. Vibrations Group recent developments.

Peer review.

Measurement capabilities for the calibration of accelerometers by sinusoidal and shock methods were reviewed during December 2004 in a peer review performed by Dr Hans J. von Martens. Update of CENAM´s AUV CMC´s for Appendix C of the MRA, in sensitivity and phase, is in progress. Measurement capabilities have been improved.

Calibration of accelerometers and laser vibrometers.

Low frequency (2 Hz to 50 Hz). The calibration system shown in figure 1 was improved by optimizing interferometric setups, acquisition systems and processing algorithms. Overall results were evaluated by the calibration of several types of standard accelerometers periodically.

Figure 1.1. Low frequency accelerometer calibration system.

Middle range (50 Hz to 5 kHz). Satisfactory results for calibration of phase shift were obtained by implementation of quadrature Michelson intrferometers, within the low and middle frequency range

Shock. The shock calibration system was declared officially as a national standard during September 2005, validated measurement capabilities go from 50 m/s^2 to 5000 m/s^2 with uncertainty of 1%. The phase unwrapping method was implemented successfully in accordance with ISO 16063-13:2001, additionally the time interval method was also implemented. Figure 1.2 shows the mechanical excitation system. Comparison results between time interval and phase unwrapping methods are shown in figure 1.3.

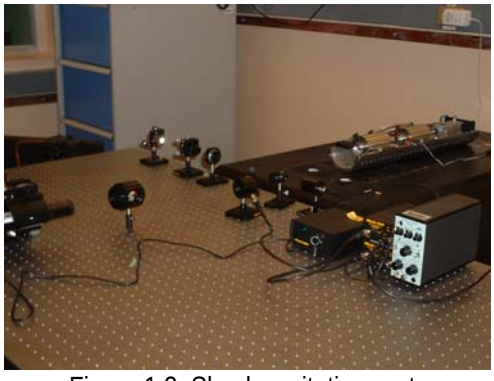


Figure 1.2. Shock excitation system.

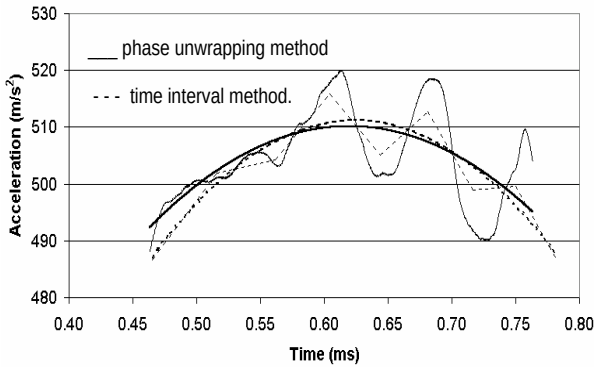


Figure 1.3. Phase unwrapping an time interval results.

Calibration of velocity transducers.

A linear velocity system for calibration of optical velocity transducers, figure 1.4, is under development. Measurement capabilities are in the range of 5 km/h to 200 km/h, currently a laser velocimeter is used as a reference and a laser interferometer is under development. This system gives support mainly to automotive applications.

Figure 1.4. Linear velocity system for calibration of optical velocity transducers.

Current comparisons.

Measurements of SIM.AUV.V-K1.1 bilateral comparison between INMETRO and CENAM, of two double ended standard accelerometers were finished successfully, draft A is in progress. This comparison was performed in the range of 40 Hz to 5 kHz.

Angular vibration.

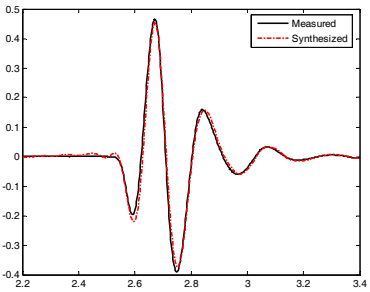
Implementation of a measurement system for angular vibration will be carried on during the 2007, a reference system is expected to be developed during the next years. This system will give support to angular vibration measurements performed in testing for new product developments in the industry.

2. Ultrasound Group recent developments.

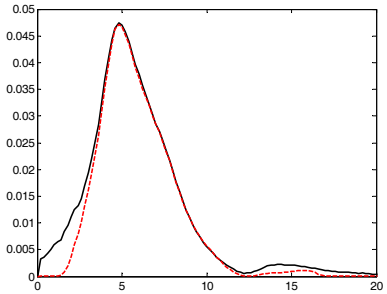
As part of the work carried out by Dr. Ana Lilia López Sánchez during her Ph. D. at Iowa State University in the USA, ultrasonic models and measurements were used to characterize ultrasonic measurement systems and a number of measurement elements. Ultrasonic measurement models for predicting the response from reference reflectors are described in her Ph. D thesis, including a new ultrasonic measurement model recently developed to simulate the ultrasonic response of an infinitely long cylindrical cavity. The reference reflectors considered include spherical pores, flat-bottom holes and side-drilled holes, which commonly are used in nondestructive evaluation studies. These reflectors were employed in a series of modeling/experimental studies to assess where approximate and more exact scattering models are needed and to estimate the significance of beam variations over the reflector surface. Model-based simulated flaw responses were compared to experimentally determined flaw responses.

A new model-based method for simultaneously determining the impedance and sensitivity of commercial ultrasonic immersion transducers was developed based on a pulse-echo setup and relies only on electrical measurements. It is demonstrated that sensitivities obtained with this new method agree well with the sensitivities obtained using a more complex three-transducer method originally developed for lower-frequency acoustic transducers that has been used in many previous studies.

The influence of the pulser/receiver settings on the transducer electrical impedance and sensitivity was also discussed. Cabling effects present are compensated for in the new pulse-echo method. It was shown that by combining the system transfer function with models of the acoustic/elastic process present in a measurement system it is possible to accurately simulate the output voltage of the entire ultrasonic measurement system.



time



frequency

Figure 2.1 Synthesized (dashed-dotted line) and directly measured (solid line) output voltage signal of an ultrasonic pitch-catch measurement system. Figure 2.2 Synthesized (dashed-dotted line) and deconvolved (solid line) system transfer function versus frequency; for a pulser energy setting of 1 and damping setting of 7.

On the other hand, there are no accredited laboratories in Mexico to whom ask for the calibration of hydrophones. Calibration needs of users at the industrial sector have put some pressure on the ultrasound group at CENAM to establish hydrophone calibration capabilities. The main objective was to determine voltage free field sensitivity and/or free field sensitivity level for a receptor hydrophone. Comparison and reciprocity methods were successfully implemented. Experimental results from the calibrations with different cable lengths, using three signal conditioners with distinct electrical specifications, show that large deviations because of a capacitance change may arise during a hydrophone calibration. As already reported in the literature, hydrophones alignment, duration and waveform of signals used as well as sound speed have also been taken into account. Hydrophone calibrations are being performed in the frequency range of 10 kHz to 100 KHz, work is being done at frequencies lower than 3 kHz. Prony methods are being considered to solve and avoid measurement restrictions due to water tank dimensions.

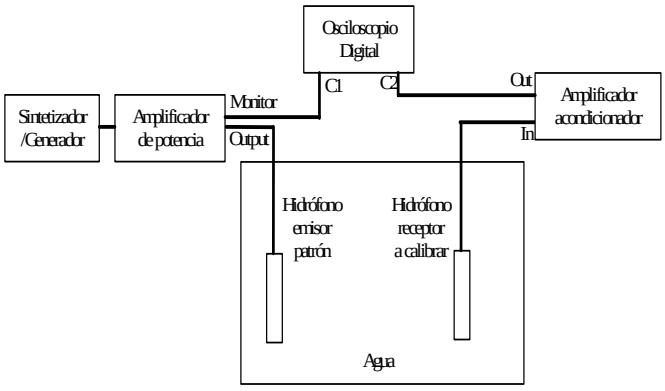


Figure 2.3 Measurement chain for a hydrophone calibration by comparison.

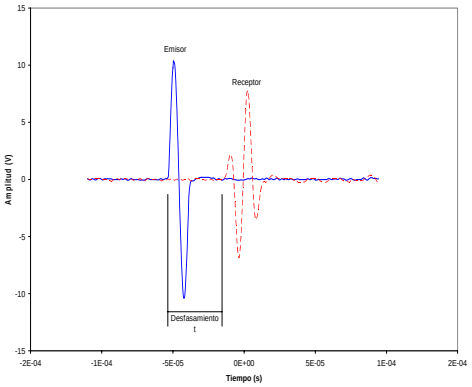


Figure 2.4 Hidrophone signals.

Our ultrasound group is currently working on projects regarding the characterization of medical ultrasound equipment and acoustic microscopy for non-destructive testing of industrial components.

A project to conform an Iberoamerican Net for Medical Ultrasound Metrology (Red Iberoamericana de Metrología en Ultrasonido Médico, RedIMUM) is being worked out, representatives from metrology institutes such as CEM-Spain, INMETRO-Brazil, INTI-Argentina, LATU-Uruguay, ICIMAF-Cuba and CENAM-México have already confirmed their participation.

One of its objectives being to contribute to the different medical protection programs in the field of medical ultrasound. A number of ultrasound equipment have been recalled recently by the FDA because of malfunctions and the associated possibilities of representing a potential risk to a patient (www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfRES/res.cfm). For instance, situations where "*Due to a problem with calibration, the device can produce up to 50% elevated acoustic output and up to 2 degrees higher surface temperature*", in our opinion, remark the need of giving more attention to the traceability of medical ultrasound devices available in the market. Local health institutes are being advice to review how their medical equipments are being calibrated or if they are indeed calibrated at all. Some institutes have disregarded this issue until recently.

The Iberoamerican Net for Medical Ultrasound Metrology (RedIMUM) is aiming to establish a more robust infrastructure on medical ultrasound metrology in each of the participating countries from which safer and better ultrasound therapies and diagnostics might be eventually available. In general, measurement equipment for industrial applications is being calibrated; however measurement equipment for medical applications is not, at least not in the case of ultrasound devices used in the region. Manufacturers take care of the so-called calibration but it is not clear if calibrations comply with ISO/IEC 17025 requisites.

3. Acoustics Group recent developments.

Peer review.

Prof Knud Rasmussen, representing the Danish Primary Laboratory on Acoustics (DPLA), Denmark performed a peer review of CENAM´s acoustics and ultrasound capabilities. This peer review was done during Jan 25th to Feb.2nd of 2005. Prof. Rasmussen pointed out some areas on which further work was needed to improve the current measurement capabilities. As a result an update of the acoustics CMCs listed in the appendix C is in progress.

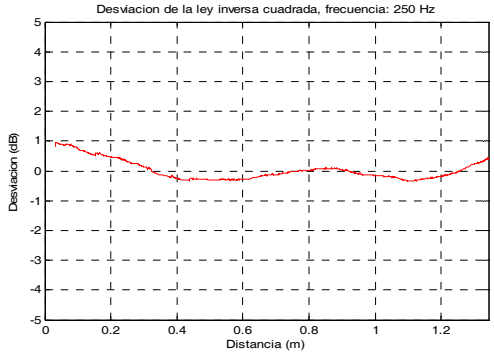


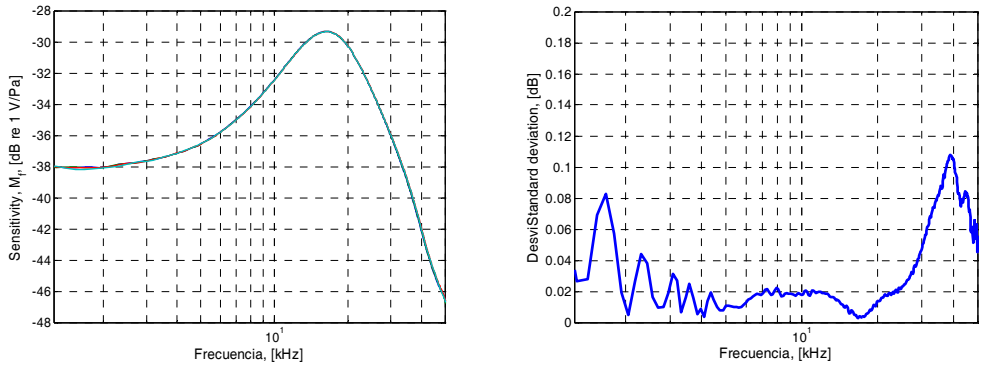
Figure 3.1: Pressure deviations from the inverse square at 250 Hz.

Free field measurements.

An anechoic chamber has been built at CENAM with lower cut frequency at 250 Hz and upper cut frequency at 50 kHz. The Acoustic Insulation of the chamber, background noise and the deviation from the inverse distance law had been measured. As an example the pressure deviations at 250 Hz are shown in figure 3.1.

Free-field reciprocity calibration of condenser microphones.

The calibration in free-field of condenser microphones using reciprocity has been developed. This system is being considered to form a National Standard and all the procedures had been done for achieving this. Our measurements have a repeatability with a standard deviation of 0,02 dB in the frequency range of 3kHz to 20 kHz. Some polarization problems with the microphones have been detected and are under study.
The uncertainty budget has been revised and the influence of some variables has been tested using a Monte Carlo technique.



(a) (b)

Figure 3.2: Preliminary results for free-field sensitivity calibrations. (a) measurements, (b) standard deviation.

Comparisons.

CCAUV.A-K3. The final report have been sent to all participants and approved. Dr. Vicente Cutanda Henríquez who left CENAM in December, 2004; kindly continued working on this report until the final version.

SIM.AUV.A-K1. Comparison of calibration laboratory standard LS1P microphones. Participants: (NRC, NIST, CENAM, INMETRO, INTI). Draft B is currently under revision.

SIM.AUV.A-S1. Comparison of pistonphone acoustical calibrators. Draft A has been approved, currently Draft B is under revision.

SIM A&V Seminar.
In December, 2005; CENAM´s A&V personnel prepared the Seminar “Introduction to the Legal Metrology for Noise and Vibration”. The seminar was given at the SuperIntendencia de Industria y Comercio (Bogota, Colombia) where several representatives of Andin countries attended the seminar. This seminar was also transmitted via IP to Colombia and the Latin-America region. For the first time in this kind of SIM events, live lectures were combined with remote links to Laboratories of Acoustics and Vibration at CENAM.