Status Report to the 7th Meeting of CCAUV 2010 in the Field of Acoustics, Ultrasonics & Vibration at NIM (China)

1 INTRODUCTION

At NIM, Mechanics & Acoustics Division is responsible for research, establishment and maintenance of national measurement standards in the field of AUV. Two labs, namely Acoustics & Ultrasonics Lab and Vibration & Shock Lab, are involved in all the research and development projects as well as calibration tasks in AUV.

Acoustics & Ultrasonics Lab is responsible for realization and dissemination of the units, and the associated scales, of sound pressure, sound power mainly in air and water medium. Over the last several decades, the lab has established several calibration standards for measurements of electro-acoustics and ultrasound. They can carry out accurate calibration of transducers, measuring instruments over wide measurement ranges.

Vibration & Shock Lab is responsible for realization and dissemination of the units, and the associated scales, of acceleration and derived motion quantities of solid bodies. Over the last three decades, the lab has established 6 national primary standards for measurements of vibration and shock. They can carry out accurate calibration of transducers, measuring chains, measuring instruments and laser vibrometers for translational motion quantities over wide measurement ranges.

2 ACCREDITATION

The Acoustics & Ultrasonics Lab and the Vibration & Shock Lab were re-assessed by China's National Accreditation System (CNAS) in August, 2010. Since it was a full re-assessment of the labs in a period of 5 years, a peer reviewer, Dr. Hyu-Sang Kwon from KRISS, was invited as a technical assessor in the field of AUV. As part of the conclusion, the scope of accreditation was extended in the field of acoustics, vibration and /shock.

In the field of acoustics, the lab added the low frequency microphone calibration capability from 10 Hz to 16 Hz for LS1. The uncertainty is 0.1 dB (k=2).

In the field of ultrasonics, the lab modified the ultrasound power measurement capabilities from at discrete frequency points to certain frequency range. And the lab added the high frequency range measurement capabilities from 5 MHz to 11 MHz with the power range from 3 mW to 100 mW.

In the field of vibration, the lab added the primary phase shift calibration capability from 0.1 Hz to 10 kHz and expanded the frequency range for primary calibration of sensitivity magnitude to include frequencies from 0.1 Hz to 0.4 Hz and from 10 kHz to 20 kHz. In addition, the primary calibration capability of laser vibrometers from 0.1 Hz to 20 kHz was added. For the complex sensitivity calibration of comparison method, the capability was recognized from 1 Hz to 10 kHz.

In the field of shock, the lab extended the low limit of acceleration from 400 m/s^2 to 50 m/s^2. The uncertainty was improved from 2% to 1% (k=2) for acceleration less than 20000 m/s^2 and from 5% to 2% (k=2) for acceleration within the range from 20000 m/s^2 to 100000 m/s^2.

3 ACOUSTICS & ULTRASONICS

3.1 ACOUSTICS

Coupler reciprocity calibration system for LS microphone.

The coupler reciprocity calibration system for LS microphone is based on PULSE and the low frequency is extended to 2 Hz. The uncertainty is about 0.30 dB（k =2）at 2 Hz. A big bottle is connected with the acoustic isolation chamber to reduce the heat effect at low frequency.

Free field reciprocity calibration system for LS microphone.

Free field reciprocity calibrations system is completed in 2010. The apparatus is supplied by B&K and the software is from DFM. Not only LS1 microphone but also LS2 microphone can be calibrated. With the SSR and time selective technology the effect of reflective wave is reduced. The uncertainty for LS1microhone is，1 kHz-5 kHz, 0.10 dB; 6.3 kHz-12.5 kHz, 0.12 dB; 16 kHz，0.14 dB; 20 kHz，0.16 dB.

LS2 microphone (*k*=2),1 kHz-6.3 kHz,0.10 dB; 8 kHz-12.5 kHz,0.12 dB;16 kHz-20 kHz,0.14 dB; 25 kHz,0.16 dB; 25 kHz -31.5 kHz,0.20 dB;40 kHz,0.22 dB;51 kHz,0.38 dB.

WS microphone calibration system

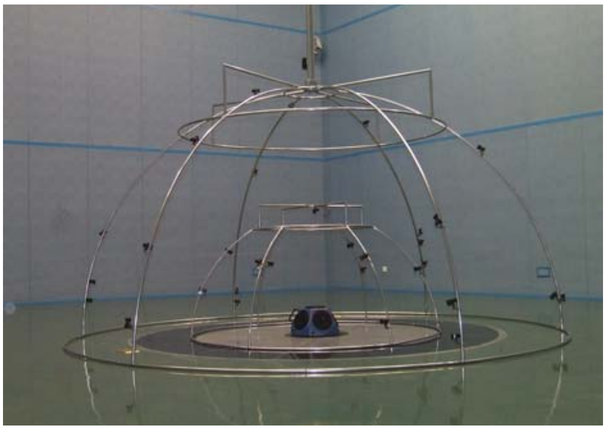
WS microphone calibration system is B&K 9721. Frequency response of WS microphones is calibrated with electrostatic actuator and the sensitivity at reference frequency point is obtained by the comparison method with an active coupler. With a special adapter the phase response of microphone pair could also be calibrated.

Audiometric Zero Level of Air Conduction and Bone Conduction

The Primary Standard for Audiometric Zero Level of Air Conduction was set up in 1973 and used to realize the sound pressure sensitivity of audiometric frequencies. Its frequency range is from 50 Hz to 10000 Hz which covers human's hearing range and its measurement uncertainty is *U*=1.0 dB (*k*=3). The Primary Standard for Audiometric Zero Level of Bone Conduction was set up in 1984 and used to realize the force sensitivity of audiometric frequencies. Its frequency range is from 250 Hz to 8000 Hz and its measurement uncertainty is *U*=1.5 dB (*k*=3).

Standard Equipment for Sound Power Measurement

The Standard Equipment for Sound Power Measurement was set up in 1988 and was renovated in new semi-anechoic room in 2009. This standard can measure sound power by two methods, 20-fixed-point method and coaxial circular method. The measurement deviation is no more than 0.9 dB from 50 Hz to 20000 Hz.



3.2 ULTRASONICS

Ultrasound Power Standard

Two ultrasound power standards based on radiation force balance method were firstly setup in the 1980s, one for milli-watt level and the other one for watt level. In 2007, the setup is renovated. More accurate balance, voltage measurement with the thermal converters, reflective and absorptive targets are adopted in the standards. These standards can measure the ultrasound power from several milliwatt to about 20 watt with the frequency range from 1 MHz to above 20 MHz.

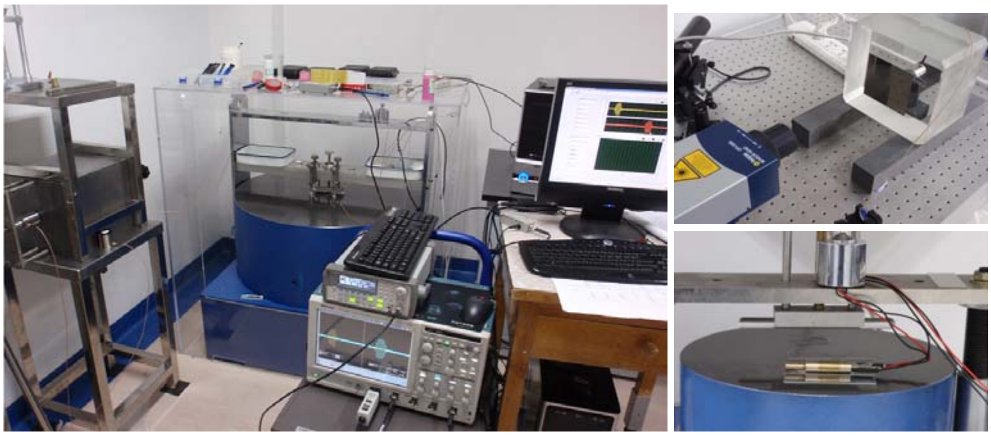
High Frequency Hydrophone Calibration Standard

Hydrophone calibration standard based on reciprocity methods are set up in 2008. High frequency needle and membrane hydrophone with the frequency range from 0.5 MHz to 15 MHz can be calibrated. The uncertainty level is similar to the uncertainty level in the IEC 62127-2-2007, with the typical uncertainty at 15 MHz is about 15%.

Besides, based on this standard, it can implement large area ultrasound field scanning and mapping.

Acoustic Emission sensor calibration system

In 2009, the Acoustic emission sensor reciprocity calibration system both for surface wave and longitudinal wave and the secondly calibration system were completed. From 100 kHz to 1 MHz, the uncertainty of the systems is less than 16% (*k*=2). Optical methods and capacitance reference transducer are now being constructed.



4 VIBRATION & SHOCK

4.1 VIBRATION

Ultra low frequency vibration standard from 0.01 Hz to 40 Hz

This device is a research product of a National Scientific Infrastructure Platform Project – 'Building of National ULF Standard Vibration Device' and the project has successfully completed in December, 2009. The sine-approximation method (homodyne version) with dynamic successive phase unwrapping algorithm and second recombination algorithm as the core is successfully applied to ULF vibration system. Equipped with a Homodyne quadrature laser interferometer and 4-channel synchronous data acquisition card, the ULF vibration standard can perform measurements of complex sensitivity of accelerometers accurately. The maximum peak-to-peak displacement is 1000 mm for horizontal exciter and 100mm for vertical exciter.

Low frequency vibration standard from 0.1 Hz to 120 Hz

National low frequency vibration standard mainly consists of two vibration exciters (one horizontal and the other vertical), a modified Michelson interferometer, signal conditioning & acquisition system, and a computer. Homodyne sine-approximation method (SAM) has been implemented for the calibration of complex sensitivity of accelerometers. When supplied with radio counter and voltmeter, it can also perform calibration in accordance with Fringe Counting Method (FCM) as laid out in ISO 16063-11. Its calibration frequency range is from 0.1 Hz to

120 Hz and maximum acceleration applied is 30m/s^2. The maximum peak-to-peak displacement is 40 mm for vertical exciter.

Medium frequency vibration standard from 10 Hz to 800 Hz (version1) and from 10 Hz to 10 kHz (version2)

National medium frequency vibration standard mainly consists of a vertical moving-coil electrodynamic exciter, a heterodyne interferometer, signal conditioning & acquisition system and a computer. Heterodyne SAM and Time Interval Analysis method (TIA) has been implemented for the calibration of complex sensitivity of accelerometers. When supplied with radio counter and voltmeter, it can also perform calibration in accordance with FCM (to 800 Hz). Its calibration frequency range is from 10 Hz to 10 kHz and maximum acceleration applied is 300m/s^2.

High frequency vibration standard from 2 kHz to 50 kHz

National high frequency vibration standard mainly consists of a vertical piezoelectric vibration exciters, a heterodyne interferometer, signal conditioning &

acquisition system and a computer. Heterodyne SAM and TIA has been implemented for the calibration of complex sensitivity of accelerometers. Its calibration frequency range is from 2 kHz to 50 kHz. The maximum displacement is 500 nm and maximum acceleration applied is 10000m/s^2.

4.2 SHOCK

Low-g Shock standard from 50 m/s^2 to 20000m/s^2

National low-g shock acceleration standard mainly consists of a low-g Hopkinson bar as shock exciter, a heterodyne laser interferometer, signal conditioning & acquisition system and a computer. It is an implementation of ISO 16063-13 and can calibrate the complex shock sensitivity of accelerometers.

High-g Shock standard from 20000 m/s^2 to 100000m/s^2

The setup of national high-g shock acceleration standard is similar to low-g shock standard, but with a high-g Hopkinson bar as shock exciter. It is also the implementation of ISO 16063-13 and can calibrate the complex shock sensitivity of accelerometers at high acceleration level with small expanded uncertainty of 2% (k=2) from 20000 m/s^2 to 100000 m/s^2. The actual acceleration high limit of shock pulse is up to 7.5×10^6 m/s^2 with time duration of 0.25 us though the uncertainty increases.

5 COMPARISONS

5.1 ACOUSTICS & ULTRASONICS

In 2009, the Acoustics & Ultrasonics Lab participated in the APMP.AUV.A-S1 supplementary comparison on multi-frequency sound calibrator piloted by NIMT,Thailand, The artefact consists of a Bruel & Kjaer type 4226 multifunction acoustic calibrator.

The Acoustics & Ultrasonics Lab also takes part in the CCAUV.U-K3 key comparison piloted by PTB in 2010. Till now, we have finished the comparison and reported the data to the pilot laboratory.

5.2 VIBRATION & SHOCK

The Vibration & Shock Lab piloted an APMP key comparison in vibration, AMPM.AUV.V-K1.2. This is the third comparison of vibration acceleration within the Asia Pacific Metrology Program to include two national laboratories, the KIM-LIPI (Indonesia) and the NPLI (India). The pilot laboratory was used to link the results to the CCAUV.V-K1 comparison. The accelerations varied from 10 m/s^2 to 200 m/s^2 over the frequency range from 40 Hz to 5 kHz. The results were approved by CCAUV, published in BIPM website and *Metrologia Technical Supplement*, which demonstrates the good agreement with the key comparison reference value and each other, within the expanded uncertainties claimed.

The Vibration & Shock Lab, as one of the three delegate members from APMP, participates in the on-going international key comparison in vibration, CCAUV.V-K2 and will finish its measurement of complex sensitivity in due course.

The Vibration & Shock Lab has been making preparation for piloting an APMP key comparison in low frequency vibration, proposed AMPM.AUV.V-K2, within a possible frequency range of 0.1 Hz to 20 Hz. Questionnaires for artefacts and participants were sent out to APMP members, technical issues were discussed among them, and candidate of comparison standard was monitored by the lab, in the term of its stability. The necessity of this suggested comparison was proved by the intensive interests from other 6 members in APMP with NMISA's willingness as co-pilot lab.

6 REGIONAL ACTIVITIES

The Acoustics & Ultrasonics Lab manufactured and sent ultrasound power transducer to NMIA for the measurement of ultrasound power in 2009, during the APMP TCAUV meeting period.

The Vibration & Shock Lab welcomed its colleague in vibration from CMS/ITRI Taiwan, in NIM's Changping research campus in September 2009. During the technical visit, the vibration expert from CMS and the lab staff had in-depth discussion in the area of vibration calibration technology.

Technical exchange activity with vibration experts from Tokyo Measurement Company took place in August, 2010. The environmental vibration test technique and the scientific evaluation of its influence on precise metrological measurements were discussed. Some on-site measurements of environmental vibration in the precise measurement labs were carried out in NIM's Changping research campus.

7 PUBLICATIONS

7.1 ACOUSTICS & ULTRASONICS

[1] YANG Ping, ZHU Haijiang 2010 Influence of Transducer Focus Position and Signal Length in Backscatter Coefficient Measurement for Blood Mimicking Fluid

(in English) 2010 IEEE 502-505

[2] CAO Yuwen, ZHU Haijiang, YANG Ping 2010 Ultrasonic Time of Flight Diffraction Defect Recognition based on Edge Detection (in English) 2010 IEEE 318-321

[3] ZHONG Bo, XU Huan, SUN Qingsheng, HE Longbiao 2010 An automatic calibration system for frequency weighting functions of sound level meter (in English) *IEEE International Conference on Mechatronics and Automation (ICMA)* 401-405

[4] YANG Ping and ZHU Haijiang 2010 Measurement of Ultrasonic Backscatter Coefficient in Tissue-Mimicking Material (in Chinese) *ACTA ELECTRONICA SINICA* 38 (5) 998-1001

[5] YANG Ping 2010 Calibration application of the blood velocity for the B mode diagnostic equipment (in Chinese) *Measurement Technology* 2010 (002) 39-42

[6] YANG Ping, BIAN Wenping, ZHU Yan, 2010 Characteristic Study of the Focus of Ultrasonic Phased Linear Array System (in Chinese) *ACTA METROLOGICA SINICA* 31(1) 32-35

[7] LI Ying and ZHONG Bo 2010 Design and Implementation of Pure-tone Signal Generator in Audiometer (in Chinese) *Computer Measurement & Control* 18(3) 721-722

[8] HE Long-biao, XU Huan, NIU Feng, etc. 2010 Study on the Measurement of the Front Cavity Volume of the Laboratory Standard Microphone (in Chinese) *ACTA METROLOGICA SINICA* 2010 31(2) 97-100

[9] HE Long-biao, ZHONG Bo, XU Huan, etc. 2010 Measurement of Front Cavity Depth of Laboratory Standard Microphone by Optical Method (in Chinese) *ACTA METROLOGICA SINICA* 31(3) 249-253

[10] HE Longbiao, LI Luming, WU Minsheng 2010 The acoustic characteristics of high frequency modulated arc and its application in welding structure refinement (in Chinese) *Applied Acoustics* 29(3) 222-226

7.2 VIBRATION & SHOCK

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[3] Chenguang Cai, Yang Liu, Yanan Han, Quayle Chen, Antti Salo, Leon Xu 2009 FEA Based Design Optimization of Exciting Sensitivity for Micromachined Piezoelectric Transducer (in English) *EuroSimE 2009 10th IEEE international*

conference on Thermal, Mechanical and Multiphysics Simulation and Experiments in Micro-Electronics and Micro-Systems

[4] YU Mei 2010 Research Review on Measurement and Evaluation Methods of Environmental Vibration for Precision Instruments (in Chinese) *Journal of Vibration and Shock* 29(8) 214-216

[5] LIU Aidong, YU Mei and MA Mingde 2010 Development of the Low-frequency Vibration Standard Combination (in Chinese) *ACTA METROLOGICA SINICA* 31(3) 238-240

[6] HU Hongbo 2010 Application of Virtual Instrument Technology for Shock Testing (in Chinese) *Measurement Technology* 430(6) 22-24

[7] YU Mei 2009 Research and Application on the Vibration Isolation Technique of the vibration standard devices (in Chinese) *ACTA METROLOGICA SINICA* 30(4) 328-331

[8] LIU Aidong and YU Mei 2009 Study and Implementation of the Auto-calibration System of Vibration (in Chinese) *ACTA METROLOGICA SINICA* 30(2) 141-143

[9] YU Mei, YANG Lifeng, LIU Aidong and ZUO Aibin 2009 Application Research on the Laser Vibrometer in Calibration of Vibration Standard Devices (in Chinese) *Measurement Technology* 414(2) 52-55

[10] HU Hongbo and YU Mei 2009 Study of Velocity Feedback Control for the Standard of National Low-Frequency Vibration Exciter (in Chinese) *Measurement Technology* 414(2) 20-22