The Current Status of AUV measurements standards at

AIST/NMIJ

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The current status of Acoustics, Ultrasound and Vibration measurement standards at AIST/NMIJ

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1. Introduction

Acoustics and Vibration Metrology Division of the NMIJ is responsible for Acoustics, Ultrasound and Vibration measurement standards in Japan. There are two sections namely, Acoustics and Ultrasonics Section, and Vibration and Hardness Section. Acoustics and Ultrasonics Section investigates on precise acoustic measurement technology including airbone ultrasound and infrasound which are related to human auditory, noise pollution and safety. The precise ultrasonic measurement techniques related mainly to medical applications including ultrasonic power and pressure standards are also developed. Vibration and Hardness Section carries out research on vibration acceleration standards, hardness standards and material impact strength standards necessary to ensure the safety and quality control of transport equipment and structures. Hardness in microstructure, advanced vibration measurements and ultrasound measurements are investigated to support next-generation industry.

2. Acoustics

NMIJ has developed calibration systems for the national standard of sound pressure in air.

- Primary calibration of pressure sensitivity level of laboratory standard microphones (LS1P & LS2P) by using the reciprocity technique. (CMC for LS1P already published)
- Primary calibration of free-field sensitivity level of laboratory standard microphones (LS1P & LS2P) by using the reciprocity technique. (CMC not published yet)
- Comparative calibration of free-field sensitivity level of working standard microphones in an anechoic chamber. (CMC not published yet)
- Comparative calibration of free-field response level of sound level meters in an anechoic chamber. (CMC not published yet)
- Comparative calibration of sound pressure level of sound calibrators. (CMC not

published yet) Now, NMIJ has been developing new acoustic standards, and they will be established within a year.

- Microphone calibration system for low frequency range (infrasound, 1 Hz to 100 Hz) by using "laser pistonphone". The purpose of this standard is the low frequency noise evaluation (**Fig.1**).
- Microphone calibration system for high frequency range (air-borne ultrasound, 20 kHz to 100 kHz) by the reciprocity technique in a small anechoic chamber. The purposes of this standard are for human safety or for testing high definition audio systems (**Fig.2**).

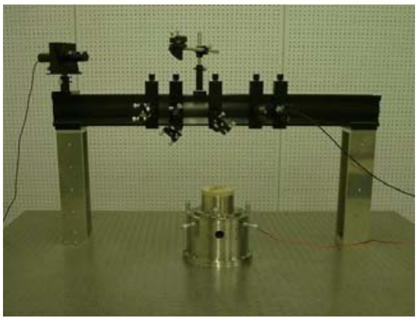

Fig.1 Calibration system by "Laser pistonphone" (under construction)

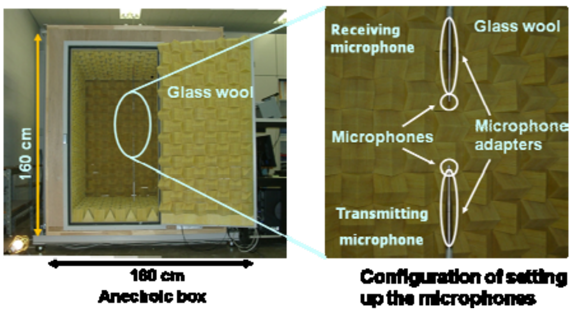

Fig.2 Small anechoic chamber for airborne ultrasound calibration

Future works for acoustics measurements

- Sound power level standard (calibration of reference sound sources)
- New reference sound source for free-field calibration of microphones

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3. Ultrasound

Hydrophone sensitivity

- The primary system for calibrating the sensitivity of the standard membrane hydrophone (CPM04, Precision Acoustic Ltd.)" using the laser interferometry method and the secondary system (comparison method) have been started since 2005. The frequency range of the hydrophone sensitivity calibration is 0.5 MHz to 20 MHz.
- The frequency range of the hydrophone sensitivity calibration is planned to be expanded up to 40 MHz by the end of 2010.
- Typical expanded uncertainties (for k=2) for primary system are 7.2 % (1 MHz), 5.3 % (5 MHz), 5.8 % (10 MHz), 6.0 % (15 MHz) and 6.6 % (20 MHz).
- Typical expanded uncertainties (for k=2) for secondary system are 7.6 % (1 MHz), 5.8 % (5 MHz), 6.4 % (10 MHz), 6.9 % (15 MHz) and 8.1 % (20 MHz).

Ultrasonic field parameters

- Recently, some of the domestic manufacturers of ultrasonic equipments requested us to measure the ultrasonic field parameters, such as I_{spta}, I_{sata}, and P_R, which are closely related to the human safely. So, we have been started the calibration service since 2006. Uncertainties of I_{spta}, I_{sata}, and P_R are, 13.3, 13.6 and 6.7 %, respectively.

Ultrasonic power

- The primary standard for ultrasonic power by using the radiation force balance method has been started since 2005.
- The frequency range is between 0.5 MHz to 20 MHz, and power range is between 1

mW to 500 mW. The power range will be expanded to 15 W (frequency range up to 5 MHz) by the end of March, 2009.

- The measurement uncertainties depend on both frequency and power. Some of the expanded uncertainties (k=2) for 100 mW are 9.0 % (0.5 MHz), 4.4 % (1 MHz), 2.6 % (5 MHz) ,4.2 % (10 MHz), 6.8 % (15 MHz) and 9.7 % (20 MHz)

Ultrasound velocity in solid (Fig.3-5)

- The standard for ultrasound velocity using a combination of a pulse-echo- overlap technique and laser ultrasound technique has been started since 2004.
- Sound velocities in a FZ single crystal silicon standard block are provided in a temperature range from 296 K to 1273 K for the purpose of NDE equipments calibration
- The relative measurement uncertainties (k=2) are 3.61×10^{-4} (296K), 5.15×10^{-4} (573K) and 6.55×10^{-4}(1273K).

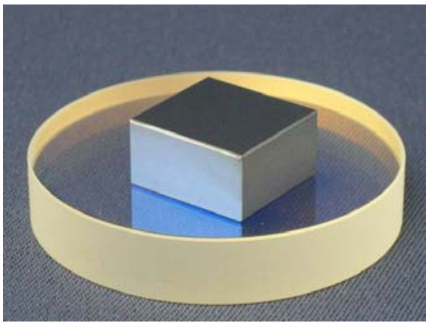

Fig.3 . FZ single crystal silicon for the reference material block of longitudinal sound velocity.

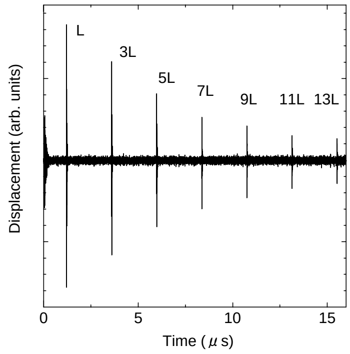

Fig.4 The multiple longitudinal echoes in the single crystal silicon along [100] direction at 296.7K.

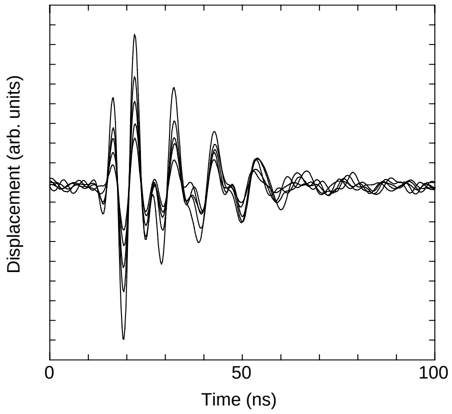

Fig.5 The overlap of the five longitudinal echoes (L, 3L, 5L, 7L and 9L).

Future work for ultrasonic measurements

We are developing ultrasonic measurement technologies for HIFU (High Intensity Focused Ultrasound).

- Calorimetric method for HIFU by using water as heating material has been developed. By this method, ultrasonic power could be measured up to 35 W. Then the measured power agreed well with those measured by RFB method.
- Quantitative measurements for cavitations generation.
- Robust, wide band and stable hydrophones for HIFU measurements by hydrothermal method (Fig. 6).

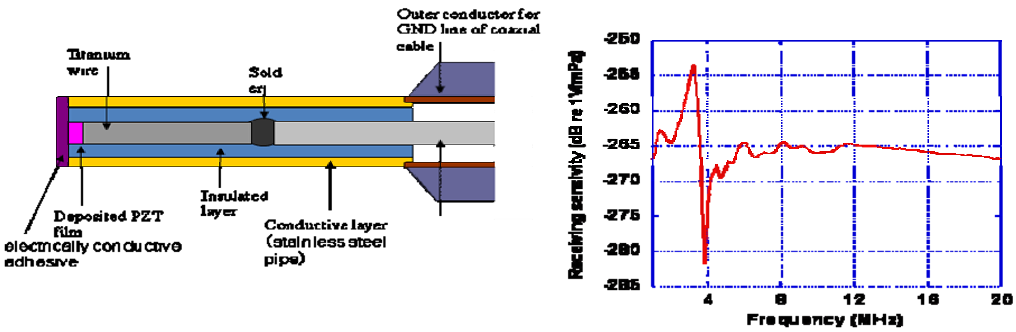

Fig. 6 Schematic figure of the needle hydrophone fabricated by the hydrothermal method and measured sensitivity (Fabricated by Toin Yokohama University, co-researcher)

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[2] Yoshimura Kazuho, Norimichi Kawashima, Shinichi Takeuchi, Takeyoshi Uchida, Masahiro Yoshioka, Tsuneo Kikuchi, Minoru Kurosawa, " Trial Fabrication of Needle-Type Hydrophone with Taper-Type Structure using Hydrothermally Synthesized Lead Zirconate Titanate", Japanese Journal of Applied PhysicsVol.47, No.5, 2008, pp.4215-4219.

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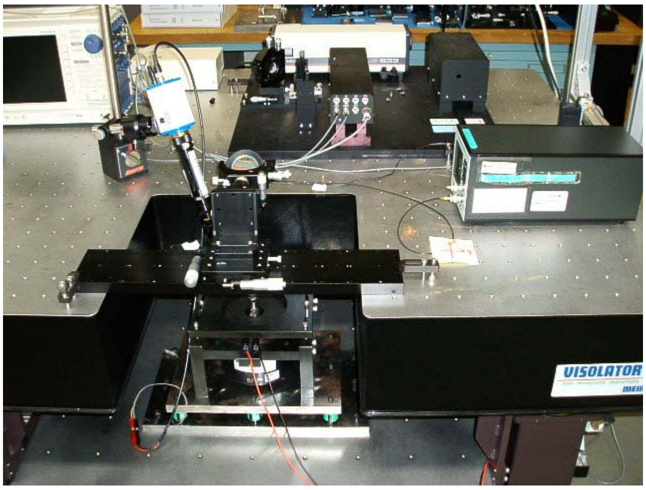
4. Vibration and acceleration standards

4.1 Established systems of vibration standards

There are four calibration systems for vibration standard in frequency range from 0.1 Hz to 10 kHz. All of the systems are developed by NMIJ and are in compliance with ISO 16063-11 (Methods for the calibration of vibration and shock pick-ups. Part 11: Primary vibration calibration by laser interferometry). Calibration cervices are under operation in compliance with ISO 17025. All calibration systems and procedures are reviewed by the peer from other NMI in 2007.

System I: 0.1 Hz to 2 Hz

System II: 1 Hz to 200 Hz

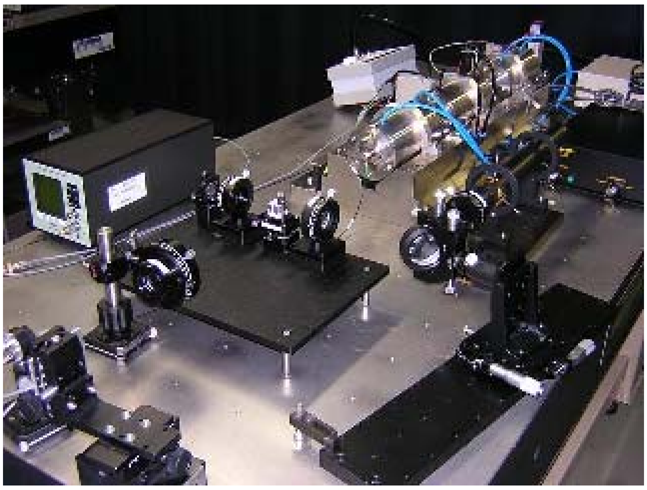


System III: 20 Hz to 5 kHz

System IV: 5 kHz to 10 kHz

4.2 Shock acceleration standard under development

Shock acceleration standard (200 m/s to 5000 m/s) is under development. The system employs air-born cylinder for supporting anvil which generates shock acceleration and laser interferometer for measuring acceleration[1].

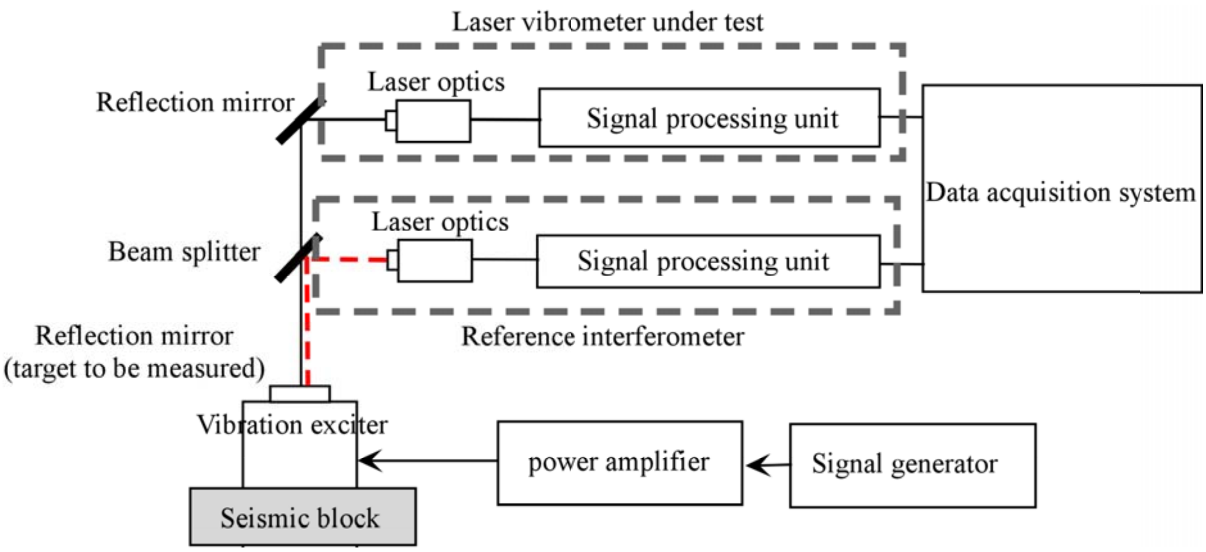


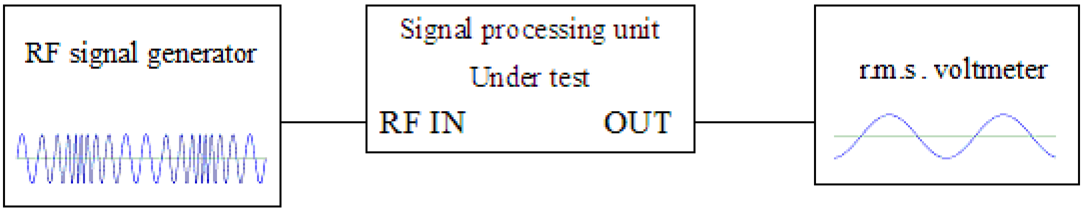
Shock acceleration calibration system

4.3 Other research activities

4.3.1 LDV calibration method

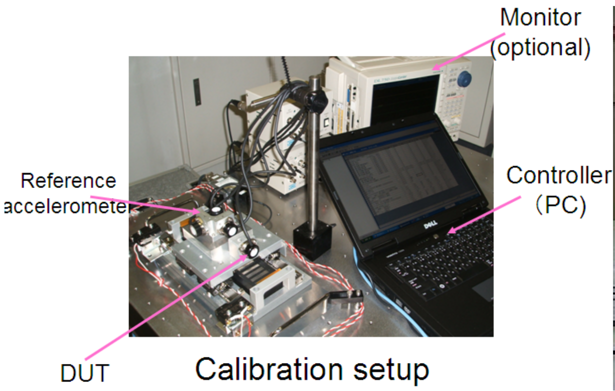
Non-contact vibrometer such as laser Doppler vibrometer (LDV) becomes popular equipment in industry. However, calibration method for LDV is under discussion in ISO [2]. With this regard, NMIJ developed LDV calibration methodology by evaluating demodulator unit of LDV. Some commercial LDVs were evaluated by the method and good calibration results were obtained [3].





4.3.2 Transportable calibration system for on-site calibration

Turn around time for calibration directly affects to the cost in industry. Short turn around time or on-site calibration is highly requested. Transportable calibration system for vibration transducer (shaker and controller) and transportable calibration system for charge amplifier (gain and phase-shift) are developed. The systems forward calibration data via internet [4].



Calibration system for vibration transducer

Calibration system for charge amplifier

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