The traceability of acoustics measurement in Indonesia nowadays

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Abstract. Acoustics or sound measurement has an important role in industrial and environmental noise control, hearing health checks, and building acoustics. Therefore to ensure the acoustics measurement results, the acoustics instruments used in the measurement should be calibrated and traceable to a reference standard. Acoustics measurement traceability has been established in Indonesia, however, in the year 2019 coupler method for SLM calibration and audiometer calibration have been added to comply with the acoustic traceability needs. This paper gives a brief description of acoustics measurement traceability that is applied by the National Measurement Standard (SNSU) for Acoustics and Vibration of National Standardization Agency of Indonesia (BSN) nowadays in Indonesia.

1. Introduction

Guided by Presidential Decree of the Republic of Indonesia number 79 of 2001, the Indonesian Institute of Sciences (LIPI), specifically the Research Centre for Metrology (RCM-LIPI) was assigned as the Indonesian national metrology institute (NMI). The RCM-LIPI was responsible for managed national standards for units of measurement, including research, measurement traceability, and dissemination [1]. The RCM-LIPI has been accredited by the Indonesian accreditation body (KAN) for ISO 17025 and recognized internationally through signing the CIPM Mutual Recognition Agreement. The RCM-LIPI is also a member of the international standard organization which provides a traceable system to the International System of Units (SI), International Bureau of Weights and Measures (BIPM). The Acoustics and Vibration Metrology was one of the Sub-Division of the RCM-LIPI which was in charge to maintained acoustics and vibration standards.

Based on the Presidential Regulation of the Republic of Indonesia Number 4 of 2018, the task of implementing the scientific management of national standards for measurement units in Indonesia is transferred to the National Standardization Agency of Indonesia (BSN) [2]. The traceability of acoustics and vibration measurement is now managed by the laboratory of National Measurement Standards (SNSU) for Acoustics and Vibration. Any acoustics or sound measurement instrument has to be accurately calibrated and traceable to the national reference standards through an unbroken chain and thus traceable to international standard (SI). Calibration hierarchy is a representation of the links between the primary calibrations, the secondary calibrations, and down to the end-user [3].

This paper gives description regarding the current acoustics measurement traceability in Indonesia. The expanded uncertainty of each level of acoustics calibration is discussed. In addition, the traceability for the audiometer and audiometer calibration system is presented.
2. Acoustics standards
To realize and maintain the unit standards, the laboratory of SNSU for Acoustics and Vibration provides calibration services for acoustics measuring instruments for primary, secondary, and end-user levels. The Calibration and Measurement Capabilities (CMC) of SNSU for Acoustics has been published on Appendix – C (KCDB-BIPM).

2.1 Primary standard
The microphone primary standard, so-called laboratory standard microphone (LS) is the highest standard for acoustics traceability. The LS microphones are pressure type of microphone and have two nominal mechanical dimensions: 1 inch (LS1P) and 2 inches (LS2P). According to the standard IEC 61094-1: Specifications for laboratory standard microphone, the letter “P” indicates that the microphone has a pressure sensitivity [4].

The primary standards are calibrated by the highest possible accuracy technique that according to standard IEC 61094-2: Primary method for pressure calibration of laboratory standard microphones by the reciprocity technique. Reciprocity technique is an absolute calibration method because the calibration result is obtained without referring to a standard microphone or sound source. The method calibrates the sensitivity of the microphone (V/Pa) which is the most important parameter for the primary standards microphone [5].

SNSU for Acoustics and Vibration calibrates LS1P for the range of frequencies between 63 Hz to 8 kHz with expanded uncertainties between 0.06 dB to 0.1 dB. Meanwhile, the LS2P microphones are calibrated at the range of frequencies between 31.5 Hz to 25 kHz with expanded uncertainties between 0.06 dB to 0.17 dB. The uncertainty of measurements is estimated at a confidence level of not less than 95% with coverage factor k=2.

2.2 Secondary standard
Secondary standards for acoustics measurement are pistonphone, sound calibrator, and multifrequency sound calibrator. Pistonphone is an acoustics reference standard that operates at 250 Hz and produces a sound pressure level of 124 dB re 20 µPa. Meanwhile, the sound calibrator is a portable sound source generating sound pressure at a specified level and frequency [6], where sound calibrator produces SPL of 94 dB and 114 dB re 20 µPa at 1000 Hz. Both pistonphone and sound calibrator is used for the field verification of sound level meter. Multifrequency sound calibrator is an acoustic calibrator that produces SPL of 94 dB, 104 dB, and 114 dB, with the frequency range from 31.5 Hz to 16 kHz with 1/1 octave frequency step plus 12.5 kHz. This instrument can be used as a reference standard for sound level meter (SLM) calibration.

Pistonphone, sound calibrator, and multifrequency sound calibrator are calibrated by the absolute method or insert voltage method that is carried out without comparing the sound pressure level (SPL). The calibration method for the secondary standard is referred to as IEC 60942: Electroacoustics – Sound Calibrators [6]. The measurement uncertainty is 0.1 dB and estimated at 95% confidence level with a coverage factor k = 2.

2.3 End-user
SLM and audiometer are widely used by end-user for noise or acoustics measurement. Therefore to ensure the noise or acoustics measurement results, the acoustics instruments (SLM) used in the measurement should be calibrated and traceable to a reference standard. There are two methods to calibrate SLM, free-field and coupler method. Both methods refer to IEC 61672: Electroacoustics – Sound level meter: part 1: Specifications; part 2: Pattern evaluation tests; and part 3: Periodic tests [7-9]. LS2P is a pressure type of microphone used as a standard for the free-field method. The calibration results of LS2P are pressure sensitivity level, therefore the results need to be converted from pressure to free-field sensitivity based on the Standard IEC TS61094: Measurement Microphones - part 7: Values for the difference between free-field and pressure sensitivity levels of laboratory standard microphones [10].
For the coupler method, the multifrequency sound calibrator is used as the standard. The expanded uncertainty for a free-field method is 0.38 dB while for the coupler method is 0.4 dB to 0.8 dB. The uncertainties are estimated at 95% confidence level with a coverage factor $k = 2$ for frequencies between 63 Hz to 10 kHz.

The audiometer is a device that produces a pure tone at a specific frequency and level which is used for monitoring hearing health [11, 12]. An audiometer is calibrated by LS1P using an artificial ear as calibration media. It is calibrated at output level of 70 dB at 125 Hz, 250 Hz, 500 Hz, 750 Hz, 1000 Hz, 1500 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz. The expanded uncertainty for this measurement is 0.6 dB at 95% confidence level with a coverage factor $k = 2$. Also, the audiometer can be calibrated by using the audiometer calibration system. The system consists of SLM, sound calibrator and one-inch pressure microphone.

3. Discussion

There are some improvements regarding the measurement traceability of acoustics in Indonesia, including SLM and audiometer calibration method. A new simpler calibration method has been developed by SNSU for Acoustics and Vibration to accommodate the SLM calibration demands. This method can be applied by secondary calibration laboratories. Multifrequency acoustic calibrator which is used by the calibration laboratories as the reference standard should be traceable to the higher standard as mentioned in section 1.2. Meanwhile, the audiometer calibration method has been expanded to fulfill the calibration requirements. The improvement covers the calibration of the output level and additional specific frequencies. Furthermore, this calibration service satisfies the medical traceability needs related to hearing health check. The measurement traceability of the acoustics in Indonesia is shown in Figure 1.

![Figure 1. The measurement traceability of acoustics in Indonesia](image)

SLM calibrated by the free-field method is traceable to LS2P microphone, whereas SLM calibrated by the coupler method is traceable to the multifrequency sound calibrator. Pistonphones, sound calibrator, and multifrequency sound calibrator are traceable to the LS2P microphone. The audiometer is traceable to the LS1P microphone.
4. Conclusions
Starting from the year of 2019, Laboratory of SNSU for Acoustics and Vibration – BSN is responsible for the maintenance of traceability of national acoustics and vibration standard equipment to SI units. Primary standards, secondary standards, and end-user measuring instruments of acoustics can be calibrated in Indonesia. Some of the calibration services have been published and listed internationally in Appendix – C (KCDB)-BIPM. Some improvements regarding the measurement traceability of SLM and audiometer calibration have been made to fulfill the needs of stakeholders.

Acknowledgments
The authors thank SNSU-BSN for providing facilities that make this work possible.

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