Investigation on the traceable calibration of sensors for monitoring the seismic activities based on the international metrology system

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Sensors to monitor the seismic activity, such as broadband seismic sensors and infrasound sensors based on the micro-barometer are the special types of vibration and acoustic sensor having high sensitivity and covering extremely low frequency. Traditionally, the calibration of such instruments has been separately operated from the international metrology system and the method of calibration is not traceable from the International System of Units (SI). Recently, Comprehensive Nuclear Test Ban Treaty Organization (CTVTO) has mentioned about the necessity of connection of the seismic measurement area to international metrology system. This is because the reliability assurance become more important due to the increase of seismic activities and extension of the international monitoring system (IMS) operated by various independent institutes and countries. Lately, the ISO standard for calibrating the seismic sensor has been published [ISO 16063-42; ISO 16063-43; ISO 16063-45], however these methods are limited to the comparison and in-situ method therefore the reference based on the absolute calibration having the traceability to SI unit is essential.

In this study, the potential primary calibration methods for the seismic sensor and infrasound sensor are investigated with the consideration of traceability to the international metrology system. For the seismic sensor, it is a special type of vibration sensor with high sensitivity for low frequency therefore the primary calibration method for vibration measurement can be applied for the calibration of seismic sensors. Here, the method based on the interferometer [ISO 16063-11] was applied to calibrate the sensitivity of broadband seismic sensors, Streckeisen STS-2 and STS-2.5. The homodyne laser interferometer with quadrature output was applied and displacement as a function of time was estimated by the sine approximation method. To excite the system down to 0.1 Hz, the long-stroke excitation system (SPEKTRA APS-600) was employed. With this system, the absolute sensitivity calibration of seismometer was conducted for 0.1 Hz –20 Hz range.

The standard of sound-in-air measurement is based on the laboratory standard (LS) microphone [IEC 61094-1] and the primary method for calibration is based on the reciprocity method [IEC 61064-2]. This approach is quite reliable and precise however only applicable to LS microphone. Therefore, the calibration of infrasound sensor can be done by comparison with the LS microphone. However, this approach has several limitations especially for non-audible frequency range, such as low signal-to-noise ratio. The method called laser pistonphone which measure the volume change directly by using the laser interferometer, similar to the vibration was propose as a potential method to overcome this problem. Here, the primary calibration method based on the reciprocity and the laser pistonphone were applied to the calibration of infrasound region down to 2 Hz and the feasibility of these method was investigated. Also, the calibration of infrasound sensor was conducted by the comparison method with the calibrated LS microphone.

As a result, the primary calibration methods for monitoring the seismic activity are investigated and the traceability chain is proposed for these types of sensors.

Keywords: Calibration, traceability, seismic sensor, infrasound sensor

