inter・noise
Cambridge, USA
1986 July 21-23
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INTER-LABORATORY MEASUREMENTS OF SOUND POWER LEVELS OF THREE KINDS OF SOUND SOURCES

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Regarding the methods for determining sound power levels of noise sources, a set of Japanese Industrial Standards (JIS) are now being prepared refering to ISO 3740 series. (see, "Standardization of the method for measuring the sound power level based on the ISO 3740 series in Japan", by M.Koyasu et. al., in this meeting.) Through the drafting works for these Japanese standards which will consist of three parts including the precision, engineering and survey methods, it was needed to investigate the various measuring methods basically and examine the prescriptions in the ISO standards. Then, as an experimental study, inter-laboratory measurements of sound power levels were planned and they are now being performed with the participation of several acoustic laboratories in Japan.

In this paper, basic studies for the test sound sources and comparisons of measuring methods are presented and the results of the preliminary study for the inter-laboratory tests are reported.

BASIC STUDIES

In advance of the inter-laboratory tests, some basic studies were made in order to choose proper test sound source and to compare various kinds of measuring methods including the sound intensity the results are shown below.

For a reference sound source of loudspeaker type, B&K 4205 sound source was chosen and its sound power level (PWL) was measured by both of the precision p^2 methods and the sound intensity method. Fig.-1 shows the comparisons of the results measured by the free field p^2 method (ISO 3745) using an anechoic room, by the semi-free field p^2 method (ISO 3745) using the same anechoic room whose floor was covered with reflective board materials and by the diffuse field p^2 method (ISO 3741) using a reverberation room of $200m^3$ air volume. In these results, it can be seen that the values measured in the free field condition and the semi-free field condition are fairly in good agreement in middle and high frequencies, but obvious differences are observed in law frequencies which might

be caused by the difference of the radiation impedance. The results measured in the reverberation room are in good agreement with those measured in the semi-free field condition excluding high frequencies where the former values are slightly lower. The A-weighted PWLs measured by the three methods are markedly in good agreement.

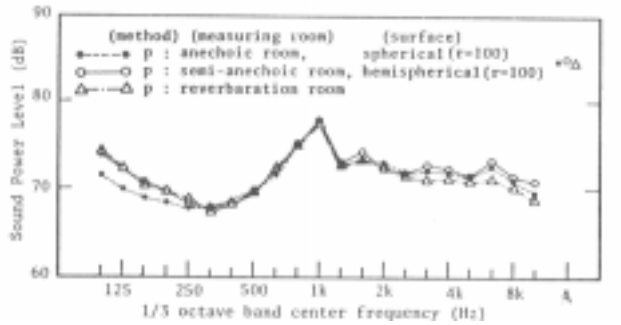

Fig.-1 Sound power levels of B&K 4205 reference source measured by various p methods

Fig.-2 shows the comparisons of the results measured in the semi-free field condition by using the sound intensity method. In these measurements, three different sound intensity measuring surfaces were chosen: a rectangular parallelepiped surface of $50\text{cm} \times 50\text{cm} \times 50\text{cm}$ which was divided into 500 segments, another rectangular surface of $30\text{cm} \times 30\text{cm} \times 30\text{cm}$ segments and a cylindrical surface of 20cm radius and 40cm height. (In the last case, automatic microphone scanning technique was used.) As a results, three kinds of PWL values measured by the sound intensity method are in good agreement, but they are a bit lower than those measured by the p^2 method.

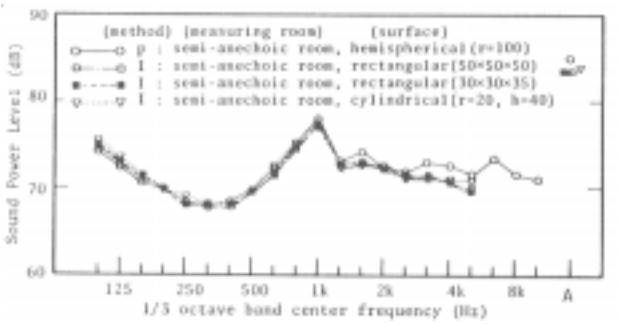

Fig.-2 Sound power levels of B&K 4205 reference source measured by sound intensity method

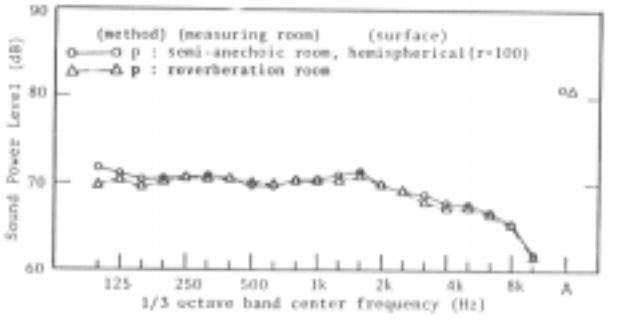

Fig.-3 Sound power levels of ILG sound source measured by two kinds of p methods

For the second sound source, another reference sound source of cetrifugal fan type (ILG) was chosen and the PWLs were measured by the semi-free field p^2 method (ISO 3745) and by the diffuse field p^2 method (ISO 3741). As shown in Fig.-3, these results are markedly in good agreement.

INTER-LABORATORY TESTS

The first stage inter-laboratory tests were performed with the participation of five acoustic laboratories in Japan.
As for the test sound sources, the following three kinds of sources of relatively small sizes were chosen.

S1: A reference sound source of loudspeaker type (B&K 4205)
S2: A reference sound source of centrifugal fan type (ILG)

S3: A portable air-compressor (0.2kw)

Concerning the measuring methods, it was promised that the free field or semi-free field measurements should be made according to JIS Z 8732 (1986) which is almost equivalent to ISO 3745, the diffuse field measurements should be made according to ISO 3741 or 3742, and sound level meters of precision class complying with JIS C 1505 which nearly corresponds to IEC pub. 651, type 0 and 1 should be used. Any laboratories do not have well designed semi-anechoic rooms, and only two laboratories carried out the semi-free field measurement by laying thick board materials on the suspended floor of the anechoic rooms. In the diffuse field measurements, the test sound sources were located in the center of the floor of the reverberation rooms. The comparisons of the measured results of octave band and A-weighted PWLs are shown below. (Besides them, 1/3 octave band PWLs were measured in these tests.)

(1) The results of SI Though this source is a reference sound source to be put on a reflective surface and has sharp directivities in the vertical section, the PWLs of free field condition were measured in the anechoic rooms. Fig.-4(a) shows the comparison of them measured by four laboratories, and it can be seen that they are in good agreement in each octave bands and A-weighted value: the maximum standard deviation is 0.7dB in 125 and 8kHz bands, and the standard deviation in the A-weighted PWL is 0.5dB. Fig.-4(b) shows the comparison of the results of semi-free field condition measured by two laboratories, and systematic differences are seen. Fig.-4(c) shows by four laboratories. In this case, a bit larger dispersions are observed in 2k and 4kHZ bands, and the standard deviation in the A-weighted PWL is 0.7dB.

(2) The results of S2 This source is an aerodynamic sound source designed as a reference sound source, and has a markedly flat freqency characteristics. Fig.-5(b) show the PWLs measured in the semi-free field condition, and the same differences as in the case of S1 are observed. Fig.-5(c) shows the PWLs measured in the reverberation rooms by four laboratories. In this case the dispersions are a bit larger than the case of S1 and some systematic differences are observed.

(3) The results of S3 This test source was chosen as an actual noise source and radiates a noise containing narrow band frequency components. The sound power and the frequency characteristics of this machine vary significantly according to the load condition. Therfore, in order to stabilize the sound radiation condition, the measurements were made under no load condition that the output valve was fully opened, and the air was exhausted out of the test rooms through a tube to avoid the effect of the exhaust noise.

Fig.-6(b) shows the PWLs of the semi-free field condition. In this case, the systematic differences are again observed. Fig.-6(c) show the comparison of the PWLs measure din the reverberation rooms by four laboratories. In these measurements, the measuring method was not unified : one laboratory took three source positioned according to ISO 3742, on the other hand, other three laboratories took only

one source position according to ISO 3741. Because of the low stability of the test source and such difference of the measuing procedure, relatively large dispersions are observed in octave band PWLs. However, the A-weighted PWLs are unexpectedly in good agreement.

CONCLUSIONS

In this paper, the preliminary basic studies for the round robin tests regarding the sound power measurements have been presented. Based on these studies, further measurements are now being made in Japan. Through these studies, the following points are to be examined:

1) the stabilities of the test sound sources,
2) the accuracy of microphone calibration,
3) the effects of test room conditions,
4) the effects of weather conditions.

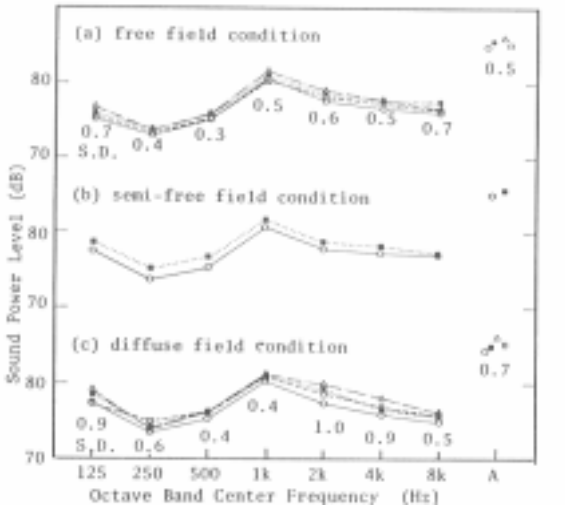

Fig.-4 Measured results for S1
(B&K 4205 reference sound source)

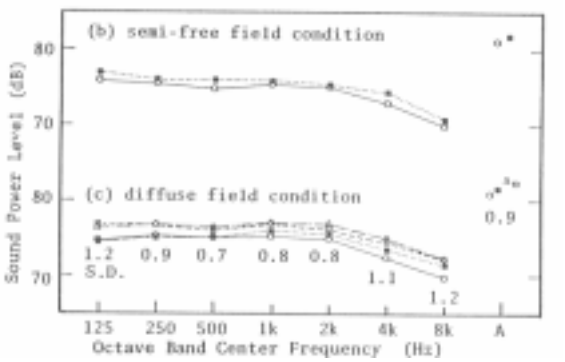

Fig.-5 Measured results for S2
(ILG reference sound source)

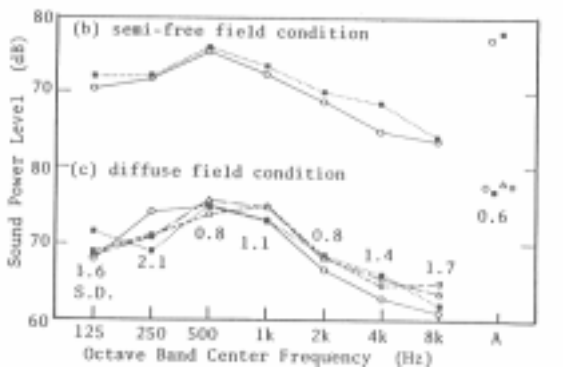

Fig.-6 Measured results for S3
(portable air - compressor)