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REMARKS ON THE TRUE VALUE OF THE SOUND POWER LEVEL

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1. INTRODUCTION

Since there is the possibility of determining the true sound power level of noise sources by the use of the intensity technique, the systematic deviations of results achieved by other methods should be discussed. The method using sound pressure level measurements on an enveloping surface over a reflecting plane needs special consideration.

This method includes an environmental correction which received noteworthy attention in a recently accomplished national round robin [1,2,3].

2. DEFINITIONS

From the beginning, the standard on sound power level determination of machinery by sound pressure level measurements in situ with engineering accuracy [4,5] yielded the following formula for the average environmental correction K_2:

$$K_2 = \overline{L}'^{RSS}_p + L^M_S - L^{RSS}_{Wcal} \tag{1}$$

with

$\overline{L}'^{RSS}_p$ the uncorrected average sound pressure level on the actual measurement surface S^M for the machine under test produced by the reference sound source (RSS) under the environmental conditions of the machinery in situ and suitably low background noise level

$$L_S^M = 10 \lg \frac{S^M}{S_o}$$

L_{Wcal}^{RSS} the calibrated or true sound power level of the RSS

Since the distances of the measurement surfaces are usually low compared with machinery dimensions and wavelengths of interest, this definition of the environmental correction K_2 contains the bias given by insufficiencies of sound pressure level measurements in a nearfield. These relations between the pure environmental influence and the nearfield bias, which is a combination of angular and impedance bias, can be shown by fictitious or real experiments.

If one measures the sound pressure level on the same measurement surface of a real machine in situ as well as under free field conditions, the difference between the average sound pressure levels shows the pure influence of the environment

$$K_{2u}^M = \overline{L}_p^{M,is} - \overline{L}_p^{M,ff} \quad (2)$$

with indices "is" for in situ and "ff" for free field.

M	h/d				M	h/d			
l / b / h	1	2	4	RSS*	l / b / h	1	2	4	RSS*
					0.25/0.25/ 1	-	-	1.6	1.6
					0.5 / 0.5 / 1	-	1.3	2.1	1.2
1/1/1	1.1	1.9	2.4	1.0					
2/1/1	1.4	2.1	2.5	1.1	2 / 2 / 1	1.7	2.2	2.7	0.9
4/1/1	1.6	2.3	2.9	1.4	4 / 4 / 1	2.1	2.6	3.3	1.1
8/1/1	1.9	2.6	3.3	1.8	8 / 8 / 1	2.6	3.3	4.2	2.0
16/1/1	2.1	2.7	3.6	2.2	16 /16 /1	3.3	4.2	5.1	3.1

Table 1
Angular correction K_{2W} for sound power determination by sound pressure level measurements on an enveloping surface.
- for parallelepiped shaped machine surface (M) with equally distributed incoherent sources
- for a reference sound source (RSS) positioned on the floor in the center of the ground plan of the machine-related measurement surface

for different ratios l/b/h and h/d with l length, b width, h height of the machine and d distance of the enveloping measurement surface.

* average for measurement surfaces related to ratios h/d from 1 to 4; the angle corrections for the different ratios h/d differ by less than 0.2 dB

If one determines the correction K_2, Eq. (1), under free field conditions and not in situ, the result will be a sufficient approximation of the angular bias and partly the impedance bias for machines as small as the reference sound source. For larger machinery the computation of the angular bias has been shown in [6] presuming that the impedance bias for measuring distances of 1 m is important only beneath 100 Hz and independent of dimensions and shape of the source. The numerical results of [6] have been arranged to give a rough overview in table 1.

The magnitudes of the angular bias proved to be not negligible. In addition the principally preferable orthogonal surfaces cannot overcome the fact that sound pressure level measurements consider the sum of vector magnitudes only and not the complete properties of the intensity vectors of differently positioned partial sources.

3. EXPERIMENTS

As shown in [7] some extreme source-room configurations have been used to test the application of angular corrections according to [6].

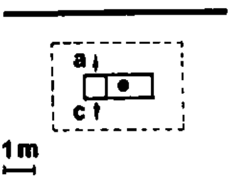

Fig. 1
Floor plan of model machine and 1 m distance measurement surface in front of reflecting wall in a hemianechoic room
a, c radiation directions of the single active panel in the model machine (gearbox)
• position of RSS on machine

Because of the larger dimensions 2.25 m x 0.75 m x 1.6 m, see Fig. 1, compared to the small sources dealt with in [3], the angular bias should be corrected according to [6] with the equation for

$$K_2^M \approx 10\lg(10^{0.1K_{2u}^{RSS}} + 10^{0.1K_{2w}^M} - 1) \qquad (3)$$

In the same way results for K_{2u}^M according to Eq. 2 have been corrected to:

$$K_2^M = 10\lg(10^{0.1K_{2u}^M} + 10^{0.1K_{2w}^M} - 1) \qquad (4)$$

Fig. 2 shows some results accomplished with averages of five sound pressure level measurements on 14 microphone positions for each configuration.

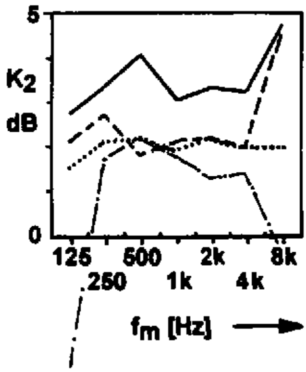

Fig. 2
Comparison of environmental corrections K_2 for the source-room configurations of Fig. 1
—·— K_2 acc. to Eq. 2 and [5]
.... K_2^M acc. to Eq. 3
—— K_2^M acc. to Eqs. 2 & 4 for radiation directions 'a'
- - - - and 'c'

4. DISCUSSION

Angular corrections according to [6] seem to improve the determination of the environmental bias as the main obstacle to finding the true sound power level by use of sound pressure level measurements. In Fig. 2 this is true in the octave-band center frequencies 250 Hz to 4 KHz for the source-room configuration 'c', without interaction with the reflecting wall, but not for its strong influence in configuration 'a'.

Similar results have been discussed for large vertically directional sources beneath different ceilings in [8]. In these cases there are no practical solutions available. For horizontallly directional sources of medium size a temporary absorbent lining of reflecting surfaces near the partial sources of the machinery can be proposed after some successful experiments [9].

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