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THE LOCAL ENVIRONMENTAL CORRECTION FOR EMISSION SOUND PRESSURE MEASUREMENTS TO BECOME A STANDARDIZED METHOD

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1. DETERMINATION OF THE LOCAL ENVIRONMENTAL CORRECTION K_3

The method of the local environmental correction (K_3) for a position (j) in the vicinity of a source has been based on the assumption for an ordinary room with a directional source that the particular sound pressure level $L'_{j=k}$ at a specified position k may be imagined as a superposition of

- the sound pressure level of the diffuse field L_{diff} produced by the total sound power of the source which is only dependent on the equivalent absorption area (A in m^3)

$$L'_j = L_W - 10 \lg (4/A) \qquad 1)$$

- the sound pressure level in the free field $L_{j=k}$ produced by the sound energy radiated in the direction of the respective position k.

This superposition may be written as

$$L'_{j=k} = 10 \lg (10^{0.1L_{j=k}} + 10^{0.1L_{diff}}) \qquad 2)$$

or also

$$L_{j=k} = L'_{j=k} + 10 \lg (1 - 10^{0.1L_{diff}}/10^{0.1L'_{j=k}}) \qquad 2a)$$

As the sound power L_W can be calculated from N sound pressure level measurements L'_i on a measuring surface S (in m^2), added by L_S and corrected by the measuring surface related or average environmental correction K_2, the following applies:

$$L_W = \overline{L'}_i + L_S - K_2 \quad \text{with} \qquad 3)$$

$$\overline{L'} = 10 \lg \Sigma(10^{0.1L'_i})/N; \quad L_S = 10 \lg S; \quad K_2 = 10 \lg (1 + 4S/A).$$

A position related or local environmental correction K_3 may be defined as

$$K_3 = L'_{j=k} - L_{j=k} \qquad 4)$$

and using equation 1, 2 and 4, K_3 can be written as

$$K_3 = -10 \lg [1-(1/(1+A/4S)\cdot 10^{0.1(\overline{L'}_i - L'_{j=k})}] \qquad 5)$$

Using the reference source method for determining the average environmental correction K_2, equation 2) may be written as follows:

$$K_3 = -10 \lg [1-(1-10^{-0.1K_2})\cdot 10^{0.1(\overline{L'}_i - L'_{j=k})}] \qquad 6)$$

To facilitate the determination of the local environmental correction K_3 the diagram of figure 1 as shown in Probst [1] and Sehrndt, Lazarus, Probst [2] should be used.

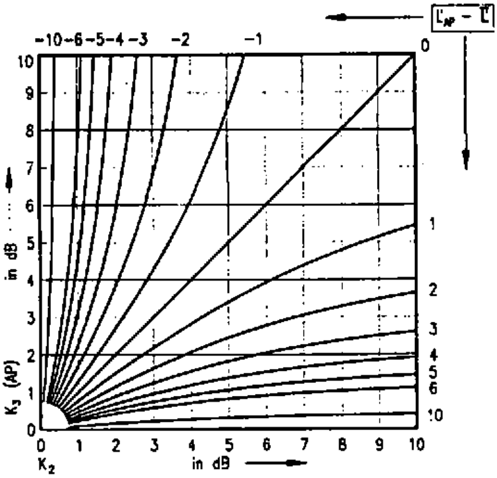

Fig. 1

Diagram for the determination of K_3 at the position (j = k = AP) with

$L'_j - \overline{L'_i} = L'_{AP} - \overline{L'_i}$

K_2 from ISO 3744

Because of doubts in the precision of the method its use - and the diagrams - are limited to $K_3 \leq 7$. This could be inconvenient especially for the determination of emission sound pressure levels at specified positions near large machinery. The sensitivity of equation 5 or 6 against deviations from the true value of the difference $\overline{L'_i} - L'_{j=k}$ and its relation to the value of K_2 will be shown by some experiments. Nevertheless the K_3-method is to be preferred to the use of the average environmental correction K_2 for single position measurements.

In the following experiments the specified position (j) lies on the measurement surface (i), therefore is i = j.

2. EXPERIMENTS

First investigations of the possibilities to apply the local environmental correction included rooms with average environmental corrections K_2 ranging from 0.1 to 2.7 dB as shown by Sehrndt, Lazarus, Probst [2]. In the meantime experiments have been carried out in rooms with K_2 larger than 1.0 dB and with the same model source, a tapping machine in an asymmetrical housing, producing distinct directivity, Fig. 2.

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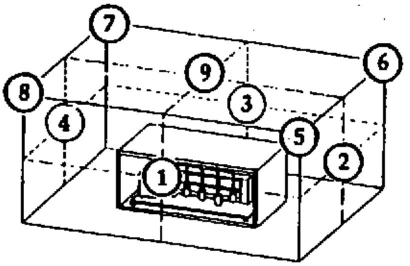

Fig. 2

Model machine with main radiation direction to microphone position 1; measuring distance 1 m from Probst [1]

The differences of the sound pressure levels L'_i of the positions 1, 2 and 3 determined in different rooms versus the levels L_i of the same positions in an hemianechoic room are shown in table 1 as $K_{3meas} = L'_i - L_i$. Table 3 shows the mesured K_{3meas}, the difference $L'_i - \overline{L'_i}$, used as basis for the calulation of K_3 following equation (6) and fig. 1 and K_3.

Table 1: Average of the measured sound pressure level ($\overline{L'_i}$) on the measuring surface; differences (K_{3meas}) of single position levels L'_i measured in different rooms versus the levels L_i in an hemianechoic room for the model machine of Fig. 2 (tapping machine partly enclosed); measuring distance 1 m, averaging time 30 s; difference $L'_i - \overline{L'_i}$; K_3 calculated from $L'_i - \overline{L'_i}$ with equation (6); (K2 see Table 2)

Room No.	$\overline{L'_i}$ in dB	$K_{3meas.}$ in dB			$L'_i - \overline{L'_i}$ in dB			K_3 in dB		
		MP 1	MP 2	MP 3	MP 1	MP 2	MP 3	MP 1	MP 2	MP 3
1	104.0	.3	4.3	6.6	5.6	−2.8	−5.1	.3	2.5	5.8
2	106.2	−1.1	8.9	12.5	2.0	−.4	−1.4	1.6	3.2	4.7
3	104.3	.7	3.8	7.5	5.7	−3.6	−4.5	.3	4.3	6.4
4	106.2	1.7	7.3	11.0	3.8	−2.0	−2.9	.7	6.1	10.0
5.	105.3	.2	6.6	10.1	4.2	−1.8	−2.9	.7	4.0	6.4
6	102.6	.1	1.8	6.0	6.8	−3.9	−4.3	.2	3.5	4.1

Since the standard proposal limits the calculation of local environmental correction K_3 to 7 dB, doubts may arise if some of the results for position 2 and most of position 3 could be corrected according to the standard. To determine the accuracy of the K_3-method, Table 2 shows the differences between environmental corrections determined according to the reverberation time method and the proposed calculation procedure according to equation (6) and the true value $K_{3\ meas}$.

Table 2: Differences between environmental corrections determined according to the reverberation time method (K_2) and the calculation procedure (K_3) and the true value K_{3meas}. Model machine of Fig. 2

			K_2–$K_{3meas.}$ in dB			K_3–$K_{3meas.}$ in dB		
No.	room lxbxh in m	K_2 in dB	MP 1	MP 2	MP 3	MP 1	MP 2	MP 3
1	28x20x6	1.1	.8	–3.2	–5.5	0	–1.8	–.8
2	26x8x4	2.8	3.9	–6.1	–9.7	2.7	–5.7	–7.8
3	22x25x6	1.4	.7	–2.4	–6.1	–.4	.5	–1.1
4	15x12x6	2.8	1.1	–4.5	–8.2	–1.0	–1.2	–1.0
5	26x10x6	2.2	2.0	–4.4	–7.9	.5	–2.6	–3.7
6	36x18x8	1.1	1.0	–.7	–4.9	.1	1.7	–1.9

For the positions 1 and 2 an advantage of the K_3 method is clearly shown, but for position 3 the limits of the method are becoming obvious, even then, the K_3-method shows better agreement than the K_2-method. Therefore further experiments have been started, with the aim to show the application for relative large machines. The model source consists of an asymmetrical hood into which a loudspeaker radiates broad-band pink noise, Fig. 3

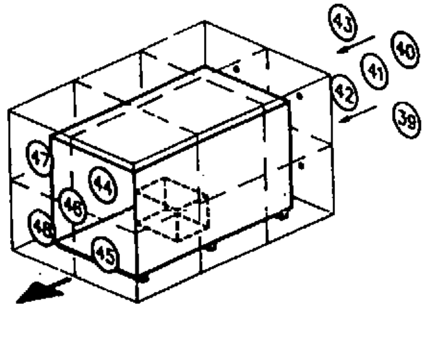

Fig. 3
Model machine with main radiation direction to the five microphone positions 44 to 48 (microphone area 1), measuring distance 0.2 m. Microphone positions 39 to 43 on the opposite side (microphone area 3; comparable with position 3 of a nine positions parallelepiped)

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Table 3: Sound pressure level measurements L_i, L'_i in octave bands in different rooms, i.e. free field (FF), reverberant (RR) with 9.0m x 6.9m x 3.9 m and small (SR) with 4.5m x 2.5m x 2.5m, averaged over 5 positions in the measuring areas (MA) 1 and 3, together with corrections K_{3meas}, K_2 and K_3 in dB, K_3 calculated from L_i-L'_i with equation 6. Model machine of Fig. 3 (loudspeaker partly enclosed), measuring distance 0.2 m (K_3 is not calculated for MA3 because of its high values).

			octave band with center frequency in Hz						
MA	room	L or K in dB	125	250	500	1k	2k	4k	8k
1	FF	L_i	85.4	83.9	84.3	80.8	79.5	80.6	83.2
	RR	L'_i	89.6	87.0	86.2	82.6	80.1	81.6	83.6
	RR	$\bar{L}'_i$	86.3	84.0	81.9	78.3	74.4	75.0	75.2
	SR	L'_i	85.5	86.8	86.2	82.4	80.7	81.6	83.7
	SR	$\bar{L}'_i$	82.8	82.9	81.5	77.4	74.8	75.6	76.7
	RR	$K_{3meas.}$	4.2	3.1	1.9	1.8	.6	1.0	.4
	RR	K_3	2.2	2.3	1.6	1.6	1.0	.7	.3
	SR	$K_{3meas.}$	.1	2.9	1.9	1.6	1.2	1.0	.5
	SR	K_3	2.6	1.9	1.5	1.3	1.0	.9	.7
3	FF	L_i	69.5	69.0	63.1	56.4	54.7	56.4	49.5
	RR	L'_i	86.5	83.9	80.8	76.7	71.8	71.2	67.7
	SR	L'_i	81.4	80.5	78.1	74.2	71.0	71.1	70.5
	RR	$K_{3meas.}$	17.0	14.9	17.7	20.3	17.1	14.8	18.2
	SR	$K_{3meas.}$	11.9	11.5	15.0	17.8	16.3	14.7	21.0
all	RR	K_2	8.1	7.6	7.9	7.7	6.7	5.1	3.2
	SR	K_2	8.3	8.9	8.5	7.2	6.7	6.5	6.0

Whereas experiments with different measuring distances have been finished, the results for d = 0.2 m should be shown here. For comparison, positions 1 and 3 are replaced by an area of five positions according to the standard rule of ISO-3744 [3] not to choose measuring subsurfaces of larger dimensions than three times the measuring distance. The results of the sound pressure level measurements are shown in table 3 together with the correction K_{3meas}, K_3 and the average environmental correction K_2.

Table 3 shows that the term "large machine" depends more on the relation of its dimensions to the dimensions of the surrounding room than on the relation to human or so-called "absolute" dimensions.

Other configurations, mainly a model machine operating in front of an reflecting wall in an otherwise free-field surrounding, are under investigation.

3. DISCUSSION

The results show that the calculation procedure proposed for the local environmental correction K_3-method is most suitable to determine the corrected sound pressure level at a specified position, especially for regions in the main radiation direction of a "large" machine. In relation to the directivity height of the machine, K_3 can be smaller or larger than the average environmental correction K_2, thus providing values which are more true than those of K_2. The results show that apporximate methods for K_3 which do not consider information on the directivity systematically deviate from the true value. The term "large" machine considers only the relations between the dimensions of the machine, the measuring surface and the room, but not the "absolute" dimensions. Because in case of "large" machines the environmental correction K_2 is large, the calculation procedure for the local environmental correction K_3 has tight limits in the minimum radiation area of a source.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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