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Using the interpolation in the DIN EN ISO 17201-1

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ABSTRACT

Since 2005 the Standard ISO 17201-1 is used for the prediction of shooting noise. In this time the standard has been applied to many measurements. While it is working well for most of the measurements, some measurements leaded to unreasonable results by adopting the interpolation method of the standard. This is documented by some artificial directivity pattern. Some solutions are discussed like changing the criteria for the validation of a measured directivity pattern and using other interpolation schemes.

Keywords: interpolation method, ISO 17201-1 I-INCE Classification of Subjects Number(s): 76.1

1. INTRODUCTION

The DIN EN ISO 17201-1 (1) is often used in the prediction of shooting noise since it has been published in 2005. In this standard specification a directivity pattern is defined by an interpolation between the measuring points at discrete angles. These measuring points are used as sampling points in a cosine interpolation. This method now is being used in the sound prediction program “Propper” (2, 3, 5) for several years. During this usage we found that the interpolation method is working well for most of the measurements, but for some it leads to unreasonable results.

2. THE INTERPOLATION METHOD OF THE ISO 17201-1

2.1 Samples

To illustrate the interpolation scheme, different artificial signals were created and analyzed. The following figures show two artificial sample directivity patterns. All directivity pattern used in this publication are supposed to be rotational symmetrical directivity pattern; so only the angles from 0° to 180° are given.

Table 1 – sample artificial directivity pattern (level range)

angle	pattern 1	pattern 2
0°	90 dB	90 dB
30°	89 dB	60 dB
60°	87 dB	60 dB
90°	84 dB	60 dB
120°	80 dB	60 dB
150°	75 dB	60 dB
180°	73 dB	60 dB

By applying these values to the interpolation method we get:

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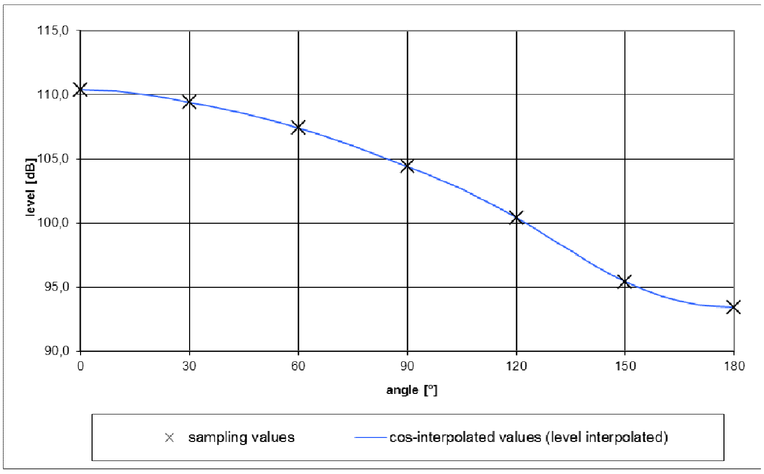

Figure 1 – interpolated directivity pattern for pattern 1

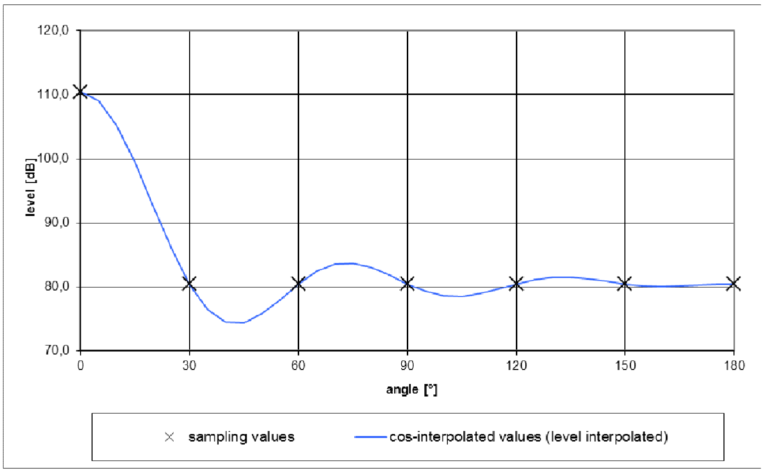

Figure 2 – interpolated directivity pattern for pattern 2

The figures show that for a smooth directivity pattern (no.1) the interpolated values are located between the neighboring sampling values. For a directivity pattern with a sharp increase (or decrease) in one measured angle the interpolated directivity pattern will “swing” around the other sampling points. In this theoretical pattern with an increase of 30 dB in 0° the swinging effect yields to an amplitude of about 5 dB near the other sampling points. This effect can be found for other angular resolutions too (fig. 3).

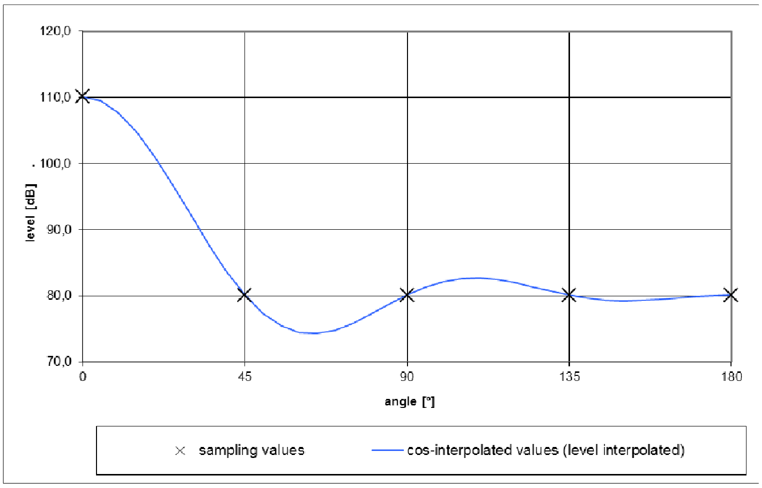

Figure 3 – interpolated directivity pattern for pattern 2 with an angle resolution of 45°

With the lower angle resolution in fig. 3 the overshooting effect is higher: at 65° a value of -17.6 dB is achieved whereas the value at the sampling points is -11.8 dB. This results in an overshoot value of 5.8 dB.

The interpolations above are done in the level range. The ISO 17201-1 also defines an interpolation to the linear energy range and compares this result with the interpolation in the level range. Therefor we need to transform the level values in the corresponding linear values:

Table 2 – sample artificial directivity pattern (linear range)

angle	pattern 1	pattern 2
0°	0.1000 J	0.1000 J
30°	0.0793 J	0.0001 J
60°	0.0500 J	0.0001 J
90°	0.0250 J	0.0001 J
120°	0.0100 J	0.0001 J
150°	0.0032 J	0.0001 J
180°	0.0020 J	0.0001 J

By applying the cosine-interpolation scheme to the linear values this lead to:

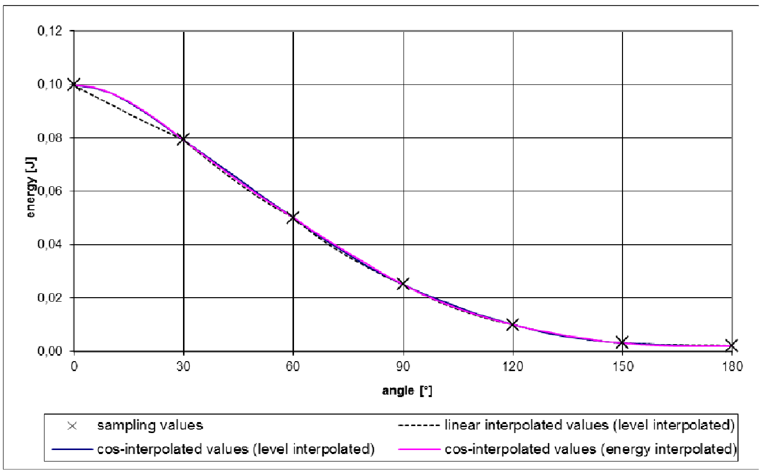

Figure 4 – interpolated directivity pattern for pattern 1 (linear values)

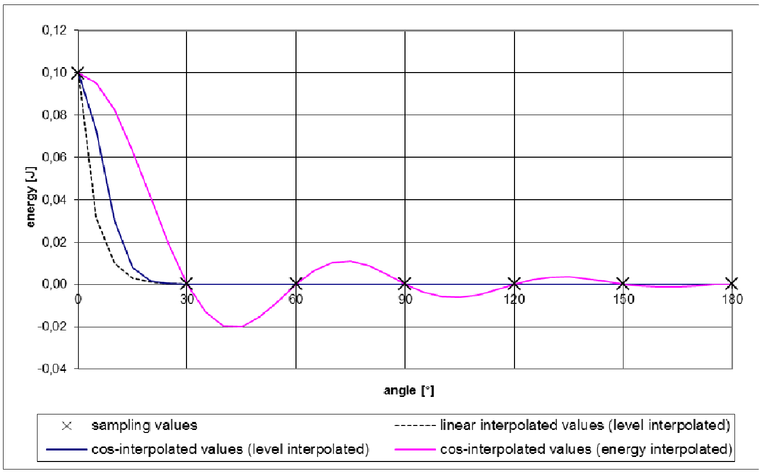

Figure 5 – interpolated directivity pattern for pattern 2 (linear values)

Figure 5 shows that the interpolated values not only overshoot the sampling values but also reach negative values. Physical this means that in that angular range where the values are negative there is acoustical energy floating to the source. This might be possible for some special cases, but for a directivity pattern of a weapon an angular range with negative acoustical energy is unlikely. Therefore it is reasonable to define the interpolation in a way that the minimum values of the measured sampling angles are not overshoot. At least the interpolation has to make sure that the overshooting values don't reach negative values. For sure, this is an extreme case, but it is just to explain the effect.

By converting the energy values back to levels, this leads to fig. 6:

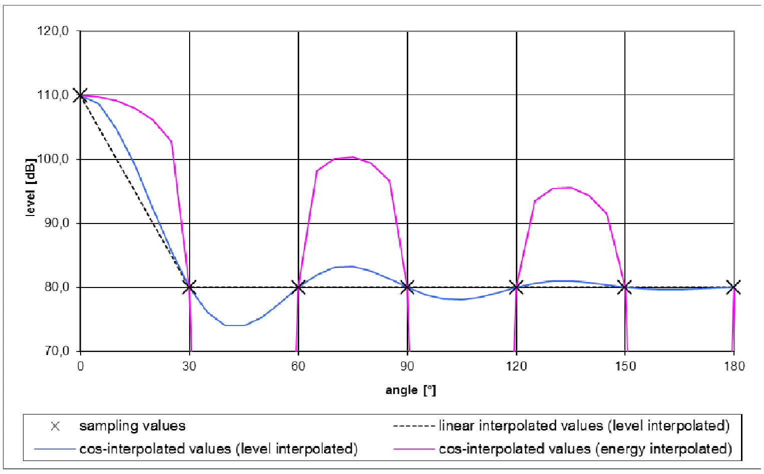

Figure 5 – interpolated directivity pattern for pattern 2 (level values)

It is obvious that a directivity pattern of that shape is much better represented by a linear interpolation compared to the both cosine interpolations.

2.2 Other interpolation schemes

The ISO 17201-1 only proposes the cosine interpolation; other interpolation schemes are allowed to be used. Therefore table 3 shows other interpolation schemes and their effects to the interpolated function:

Table 3 – sample artificial directivity pattern (linear range)

interpolation method	continuous	differentiable	overshoot	Negative values
linear interpolation (level domain)	yes	no	no	no
linear interpolation (linear domain)	yes	no	no	no
spline interpolation (level domain)	yes	no	yes	no
spline interpolation (linear domain)	yes	no	yes	yes
Cos-interpolation (level domain)	yes	yes	yes	no
Cos-interpolation (linear domain)	yes	yes	yes	yes

To avoid negative values for the interpolated energy, a higher angular resolution can be used, but we have to keep in mind that this is just to avoid an effect of the interpolation method, even if the lower resolution would be sufficient. Therefore it might be reasonable to use another interpolation scheme like the linear interpolation for directivity pattern with a strong directivity to avoid the effect of overshooting and negative values.

Using another interpolation scheme has an influence on the criterion of the ISO 17201-1 to decide whether a measured directivity pattern is valid or not.

2.3 The criterion for a valid angular resolution in the ISO 17201-1

The ISO 17201-1 defines the difference between the interpolated angular source energy distribution level $L_q(\alpha)$ and the source energy calculated from the interpolated angular source energy distribution $S_q(\alpha)$ to be the criterion to decide, if the number of measured angular directions is considered to be sufficient. This is defined to be true when the difference between both values is below 0.4 dB.

Beside the question, whether an interpolation scheme with overshootings like shown above can yield to meaningful results, this criterion might not the best one for special cases.

If the effects of overshooting occurs in an angular range with lower angular source energy, the ranges with higher angular source energy will dominate both source energy levels that are used to rate the measured directivity pattern.

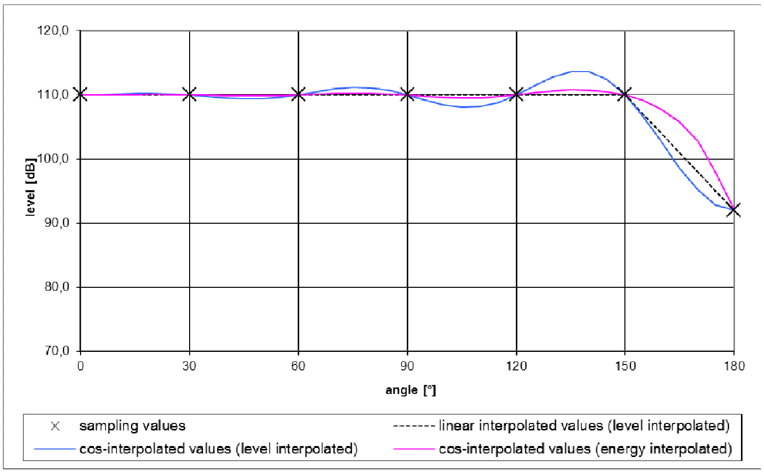

Figure 6 – interpolated directivity pattern for pattern 3 (linear values)

The directivity pattern from fig. 6 lead to a difference between both source energy levels of 0.3 dB and is therefore supposed to be valid. The differences between the three interpolations shown in fig. 6 are up to 10 dB. Using the simple linear interpolation might lead to more plausible results as using the cosine-interpolation.

In prediction sound from weapons with the ISO 17201-1 scenarios are possible, that only one small angular range can dominate the immission levels. If this happens, the predicted immission levels will have a great uncertainty. A solution might be the (additional) requirement, that by increasing the angular range by 2 and interpolate the new source energy distribution the difference between both curves has not to extend a certain wanted difference for all angles.

3. CONCLUSIONS

The ISO 17201-1 defines an interpolation scheme for the measurements of directivity pattern. During the last years the standard is used with several weapon measurements. For most measurements it is a practical standard with reasonable results. But in some cases the interpolation yields to results that are not sensible. The effect that is responsible for this has been identified and an approach is done, how this effect can be avoided.

The criterion for the validation of the used angular resolution has been discussed and it could be shown, that for some special directivity pattern in spite of the fulfilled criterion the immission values for different interpolations can yield to differences up to 10 dB. A new criterion was defined which has to be proved in the future.

ACKNOWLEDGEMENTS

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