The relevance of the peak sound pressure level to the assessment of industrial workplaces

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Introduction

In addition to determination of the daily noise exposure level $L_{EX,8h}$, assessment of noise exposure at workplaces in accordance with EU Directive 2003/10/EC [1] may require measurement of the C-weighted peak sound pressure level L_{Cpeak}. At the majority of workplaces, the daily noise exposure level $L_{EX,8h}$ is the deciding quantity for assessment, and forms the basis upon which high-noise areas are marked, hearing protectors selected, and decisions taken regarding preventive hearing checks. Only at workplaces exhibiting extremely high impulsive sound events and peak sound pressure levels L_{Cpeak} of 135 dB and higher need the additional sound parameter of this peak level be considered.

The present paper explains this sound parameter and provides a list of example relevant workplaces exhibiting high peak sound pressure levels. This list may be used as a reference for companies in determining whether such extreme impulsive noise exposure may occur at their workplaces.

Sound exposure parameters

The daily noise exposure level $L_{EX,8h}$ is a suitable quantity for describing the hazard to human hearing presented by many years' exposure to noise. It is determined by measurement of the noise exposure L_{Aeq} for a representative shift (duration T_e) and normalized to the reference duration T_0 of 8 h.

$$L_{EX,8h} = L_{Aeq,Te} + 10 \lg (T_e / T_0) \text{ dB(A)} \qquad (1)$$

where:
$L_{Aeq,Te}$ – Equivalent continuous sound level for the shift

The procedure is described in detail in ISO 9612 [2], which has been fully revised in recent years.

The C-weighted peak sound pressure level L_{Cpeak} corresponds to the absolute peak (crest) value of a sound pulse, and is used as a quantity describing the mechanical exposure of human hearing to a discrete noise event. By limitation of the peak sound pressure level, extremely high discrete sound pulses are to be prevented from causing acute damage to the hearing (blast injuries).

Figure 1 shows the recording of the C-weighted peak sound pressure value p_{Cpeak} for a sound signal in comparison with the corresponding sound pressure signals p_C with the time weightings "F" (fast) and "S" (slow). The peak sound pressure can be read off directly as the peak (crest) value of a corresponding oscillographic recording, whereas the time-weighted signals are obtained from the respective rms values of the sound pressure in consideration of the defined time weighting, "F" or "S".

The corresponding levels L_p are obtained in the form of the logarithms of these values in accordance with the following formula:

$$L_p = 10 \lg (p/p_0)^2 \text{ dB} \qquad (2)$$

where:
p_0 = 20 µPa – Reference value

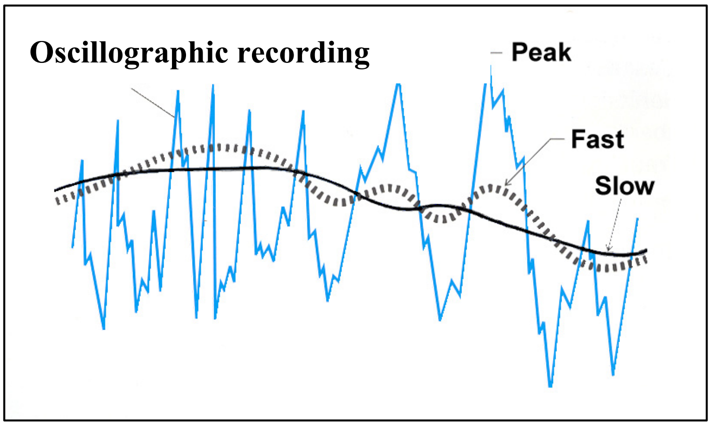

Figure 1: Sound pressure signal in the time weightings "F", "S" and "Peak"

For a constant discrete tone, the peak sound pressure level L_{Cpeak} is 3 dB higher than the rms values in the time weightings "F" and "S" (3 dB corresponds to the relationship between peak value and rms value). In the case of impulsive noises, however, substantially higher differences arise between the peak sound pressure level L_{Cpeak} and the time-weighted rms value, as illustrated by the examples in the following section.

Examples of workplace noise with high peak sound pressure level

Table 1 lists examples of workplace noise with high peak sound pressure levels. Besides the C-weighted peak sound-pressure level, the table also contains the corresponding maximum sound pressure levels in the "F" (fast) and "I" (impulse) time weightings. In addition, the A-weighted equivalent continuous sound pressure level L_{Aeq} of the noise in question is stated, and where applicable also the single-event sound pressure level L_{AE} (normalized to reference time interval of 1 s) for a discrete noise pulse. Note that these values are largely random spot measurements, and that substantially different values may be obtained under different operating conditions or for other machines of the relevant type.

For the purpose of comparison, **Table 2 and 3** show the corresponding results for certain weaponry and blasting and for selected everyday noise events.

Source of noise	Sound pressure level [dB] L_{Cpeak}	L_{AImax}	L_{AFmax}	L_{Aeq}	L_{AE}
Bottling plant	120	105	101	92	–
Impact drilling machine	123	110	109	106	–
Rotary hammer	118 126	100 110	99 108	96 100	–
Pneumatic gun nailor	127 130	104 108	102 105	– 91	94 97
Bolt-firing tool	130 149	108 126	104 122	–	96 112
Straightening work - flat bar (4mm strong) - stainless steel container	 134 140	 114 126	 111 123	 96 107	 103 115
Dropping of heavy steel profiles	136	127	125	–	120
Guillotine shears (cut operation and falling steel plate)	138	120	115	–	107
Punching presses	115 129	102 118	97 113	91 101	
Forging hammer 750 kg 10 t	 144 144	 126 126	 118 122	 100 113	 110 115
Pile-driving work (drive-hammer) - Driving of crash-barriers - Driving of pipes	 140 139 142	 118 120 121	 115 117 118	 104 108 110	 – –

Table 1: Examples of industrial noises with high sound pressure peaks

Source of noise	Sound pressure level [dB] L_{Cpeak}	L_{AImax}	L_{AFmax}	L_{Aeq}	L_{AE}
Blasting in quarries (at a distance of 50 m)	133	105	101	–	98
Avalanche blasting (2,5 kg, at a distance of 20 m)	155	122	117	–	110
Pistol, Walther OSP (ammunition 9x19)	162 162	133 139	127 133	–	121 126
Rifle, FN in shooting tunnel (ammunition 7.62x51)	161	144	139	–	130
Artillery (106 mm recoil-free projectile)	178	151	145	–	136

Table 2: Examples of noise bursts caused by blasting and weaponry

Source of noise	Sound pressure level [dB] L_{Cpeak}	L_{AImax}	L_{AFmax}	L_{Aeq}	L_{AE}
Clapping the hands (at a distance of 0.3 m)	121 135	104 115	99 109	– –	91 101
Slamming of a car door (at a distance of 0.3 m)	125 135	99 102	95 97	– –	88 91
Bursting of a balloon (at a distance of 1 m)	138 145	117 121	112 116	– –	104 108
Drums	131	113	109	101	–

Table 3: Examples of noise bursts caused by everyday noises

These results show that the peak sound pressure level L_{Cpeak} may lie approximately 15 to 30 dB above the maximum "I"-weighted sound pressure level L_{AImax}. The shorter the pulses, the greater the difference.

The results also show that the action values L_{Cpeak} of 135 dB and 137 dB are reached at very few industrial workplaces. Attainment of the limit must be anticipated for example during extreme straightening work, the dropping of heavy steel plates or steel profiles, on forging hammers, and during pile-driving. But there are also high peak levels in many other situations of our daily life, e.g. the bursting of a ballon.

The single-event sound pressure level L_{AE} calculated for a sound pulse and the number N of such pulses in the course of a working shift can be used for calculation of the noise exposure level $L_{EX,8h}$, when no additional noise exposure caused by other work has to be taken into consideration:

$$L_{EX,8h} = 10 \cdot \lg\left[\frac{1}{28800}\left(N \cdot 10^{0,1 \cdot L_{AE}}\right)\right] \text{ dB} \qquad (3)$$

where:
N - Number of events
L_{AE} - Single-event sound pressure level

Conversely, it is also possible to calculate the number of pulses of a certain type (L_{AE}) that are required to reach the respective noise exposure levels $L_{EX,8h}$ of 80 or 85 dB (action values). This relationship is shown diagrammatically in **Figure 2**, where you can find different fields of noise exposure level as a function of the single-event sound pressure level L_{AE} and the number of pulses. This figure shows for example that in the case of a forging hammer with a single-event level L_{AE} of 115 dB, as few as 10 such events give rise to a noise exposure level of 80 dB(A). And one single burst from a large-calibre weapon may cause the same noise exposure level.

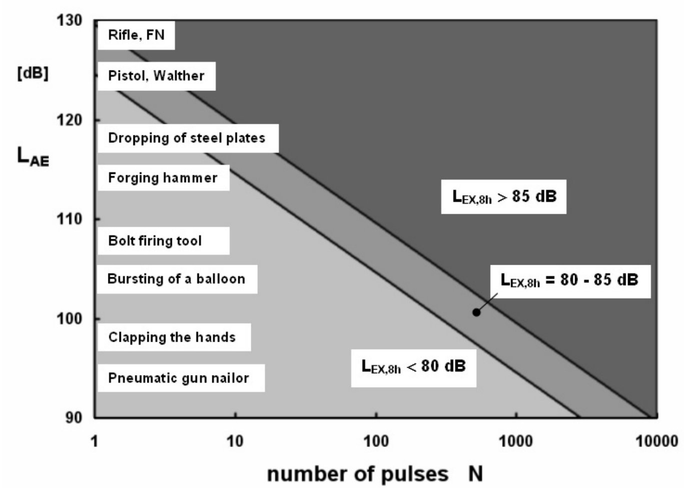

Figure 2: Relationship of single-event sound pressure level L_{AE}, number of pulses and noise exposure level $L_{EX,8h}$

For the majority of workplaces exhibiting high peak sound pressure levels L_{Cpeak} in excess of 135 dB, summation of the noise exposure over a working shift will yield daily noise exposure levels $L_{EX,8h}$ equating to the action values of 80/85 dB(A) and higher. In a small number cases only the action value for the peak sound pressure level will be attained, for example in cases where only a small number of extremely high noise pulses are generated at an otherwise very quiet workplace.

In all cases involving such extremely high impulsive noise exposure, the C-weighted peak sound pressure level provides useful information supplementary to the noise exposure level. Note here that the maximum permissible exposure value L_{Cpeak} of 140 dB set out in EU Directive 2003/10/EC (137 dB in Germany) is approximately 20 dB below the critical range at which, in accordance with existing knowledge, immediate damage to the hearing (acoustic trauma) must be anticipated as a result of a single event (refer for example to VDI 2058-2 [3]). Provided the maximum permissible peak sound pressure level L_{Cpeak} of 140 dB is observed, there should be no risk of acute hearing damage caused by a single noise pulse.

References

[1] DIRECTIVE 2003/10/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)

[2] ISO/DIS 9612: Acoustics – Determination of occupational noise exposure – Engineering method. (2007)

[3] VDI 2058 Blatt 2: Beurteilung von Lärm hinsichtlich Gehörgefährdung. (Juni 1998)