8. Sound pressure level reduction in semi-reverberant surroundings

Question:
How effective is a screen in a semi-reverberant surrounding?

Answer:
It depends on the position of the noise source, on the screen and on the positions, in which noise reduction is required.
The sound pressure level Lp in a semi-reverberant surrounding decreases with the distance from a noise source with a sound power level Lw, according to the following equation:

$$Lp = Lw + 10\log\left(\frac{Q}{4\pi r^2} + \frac{4}{R}\right) \qquad \text{[eq.1]}$$

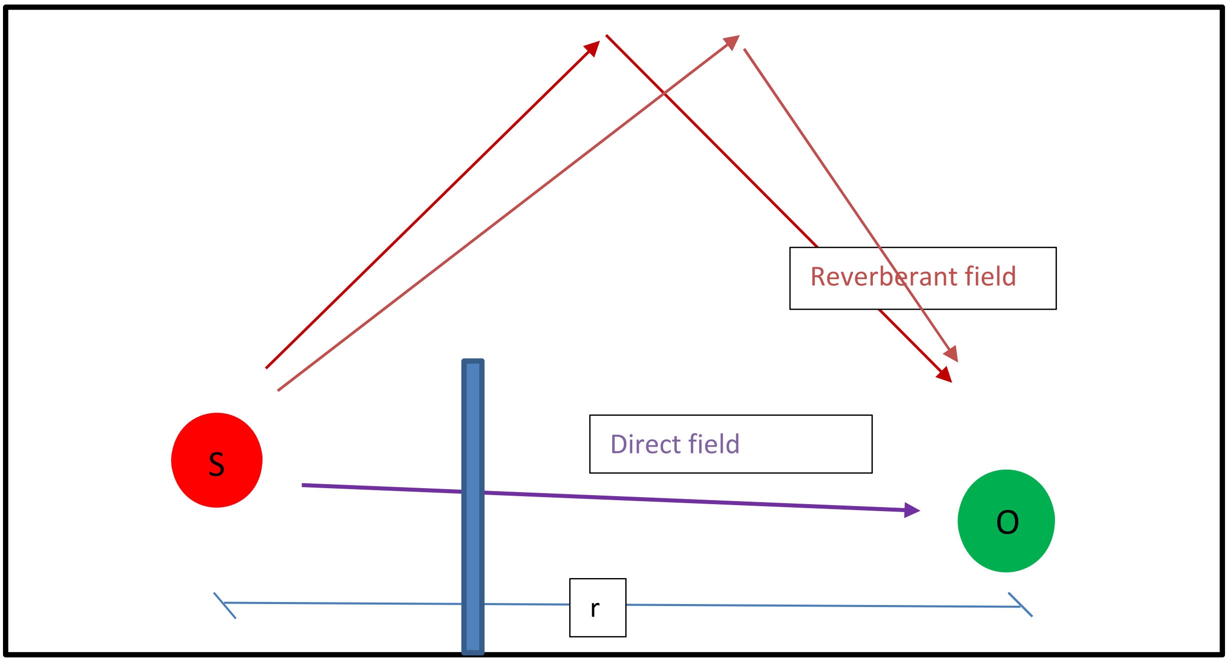
The first part in the brackets $\frac{Q}{4\pi r^2}$ represents the effect of the direct field of noise i.e. the sound waves that are produced by the noise source with a Q directivity, and reach point O at distance r without reflection. The direct sound field, from eq.1 can also be represented by the following equation:

$$Lp_{dir} = Lw - 20\log(r) - 11 + DI \qquad \text{where } DI = 10\log(Q) \qquad \text{[eq.2]}$$

The second part in the brackets of eq.1, $\frac{4}{R}$ represents the reverberant field, i.e. the sound waves that reaches point O after one or more reflections on adjacent surfaces (walls or objects) in the surroundings with a room constant “R”. This value is a function of the said adjacent surfaces of the surroundings and their sound absorption coefficient. The reverberant sound field, from eq.1 can also be represented with the following equation:

$$Lp_{rev} = Lw + 10log\left(\frac{4}{\alpha_w S}\right) \qquad \text{[eq.3]}$$

(where α_w=sound absorption of the surrounding surfaces, S= surrounding surface)



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- The sound pressure level measured in point O is the sum of the direct noise field and the reverberant field. Lp=Lpdir + Lprev
- The higher the distance "r" from the noise source, the lower the influence of the direct field
- The reverberant field doesn't change with distance, it is influenced only by the dimensions and the sound absorption properties of the surrounding surfaces.
- The critical distance (rcr) at which the two fields have the same influence, can be calculated using the following equation:
  $Q/4*pi*r^2=4/R \rightarrow rcr=0,25 * [(Q/pi)*R]^{0,5}$
- A screen is effective in noise reduction only on the direct sound field. It isn't effective on the reverberant field. So a screen will render noise reduction only in the points at a distance r<rcr from the noise source. For points at a distance r>rcr a screen will not be effective.

Example

Noise source with Lw=100 dB and positioned on the floor (i.e. Q=2)

Surrounding surfaces dimensions: 40 L x 20 W x 6 H m, and average noise absorption coefficient α_w= 0,15 → R= α_w *S /(1- α_w) = 409 m^2

$rcr=0,25*[(2/pi)*409]^{0,5}$= 4 m

<u>1st situation r<rcr</u>

Noise source and the point O are r=2 m distance from each other.

Without screen: eq.1 $Lpo=100+10*log(2/4*pi*2^2+4/409)$= 87 dB

With screen between S and O which produces DL= 5 dB on the direct field :

Eq.2 Lpdir=100-20*log(2)-5-11+3= 81 dB

Eq.3 Lprev=100+10log(4/(0,15*2320))= 81 dB

Lpos= $10*log (10^{81/10}+10^{81/10})$= 84 dB

So Lpo-Lpos =87-84= 3 dB of noise reduction

<u>2nd situation r>rcr</u>

Noise source and the point O are r=8 m distance from each other.

Without screen: eq.1 $Lpo=100+10*log(2/4*pi*8^2+4/409)$= 81 dB

With screen between S and O which produces DL= 5 dB on the direct field :

Eq.2 Lpdir=100-20*log(8)-5-11+3= 69 dB

Eq.3 Lprev=100+10log(4/(0,15*2320))= 81 dB

Lpos= $10*log (10^{69/10}+10^{81/10})$= 81 dB

So Lpo-Lpos = 81-81=0 dB of noise reduction

* for further explanations see doc. A5α