Noise level pressure

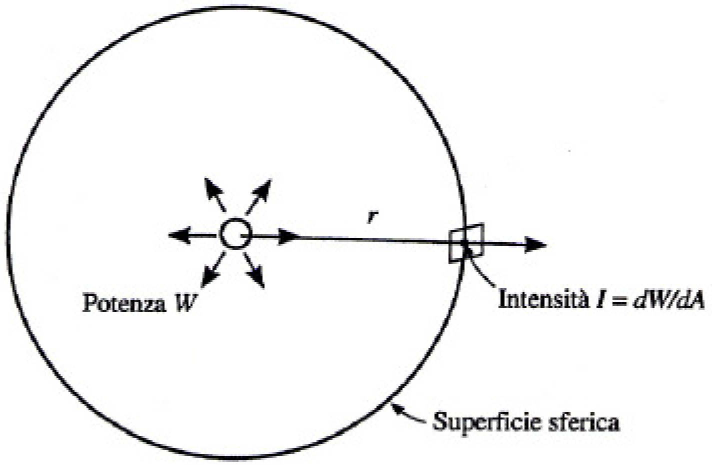
Subjects

1. Theory of the punctiform source.

2. Rule ISO 3744.

3. Excel file for the calculation at different distances accordingly to the dimensions of the unit.

Theory of the punctiform source

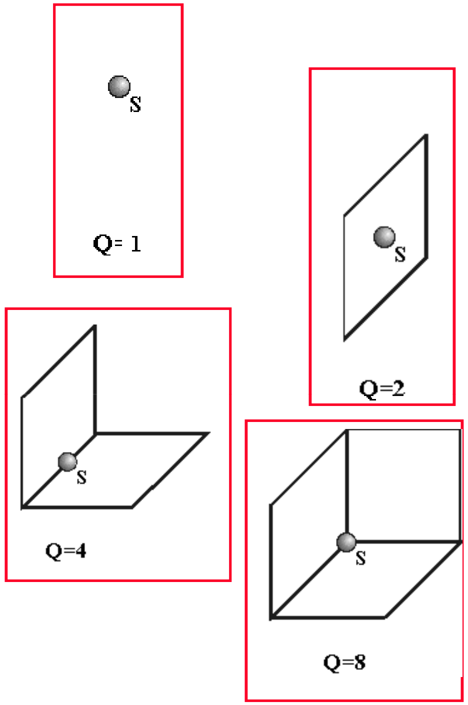


The punctiform source irradiates noise through spherical waves that spread without finding obstacles.

If the source irradiates sound power W with regular intensity in all directions:

$$I = \frac{W}{4\,\pi\,r^2}$$

Theory of the punctiform source



The limitation in considering the source suspended on air is then removed through the directionality factor Q so defined:

“ Ratio between the sound intensity at any point distance from the source and the sound intensity that should have been in the same point in case the source would have irradiated uniformly ”

Practically Q is the inverse of the sphere portion from whose center is uttered noise from the punctiform source (ex. Q = 8 -> acoustic propagation at 1/8 of sphere).

$$I = Q \frac{W}{4 \pi r^2}$$

Theory of the punctiform source

References sound intensity and sound power :

$$I_0 = \frac{W_0}{A_0}$$

Ao = Surface of the portion of the irradiated sphere

Wo = 10^-12 [W]

Io = 10^-12 [W/m2]

In general:

- The “level” of a generic size is defined as the common logarithm of the ratio between the value of the size in question and its reference value. In this way is obtained the value “Bel” of the level of that size. It is usual to refer to the tenth part of the “Bel” -> then the value is “DECIBEL” simply multiplying x 10.

Theory of the punctiform source

$$L_W = 10 \log \frac{W}{W_0}$$

W = 10^-12 [W]	->	Lw = 0 [dB(A)]	Threshold of the human hearing

In correspondence of the pain threshold the acoustic power perceived by the human hearing is:

W = 100 [W]	->	Lw = 140 [dB(A)]	Threshold of the pain

$$Lp = 10 \log \frac{p^2}{p_0^2}$$

p = this is the effective pressure of the considered sound

p_0 = this is the effective pressure of reference as 2 x 10^-4 [μ bar]

$$I = p_e^2/(\rho_0 \, c)$$

p = this is the effective pressure of the considered sound

ρ_0 = this is the density of the equipment where the sound spreads

c = the speed of the sound propagation in the equipment

$$L_p = 10 \log \frac{p_e^2}{p_0^2} = 20 \log \frac{p_e}{p_0} \cong L_I = 10 \log \frac{I}{I_0}$$

$$I = \frac{W}{4 \pi r^2}$$

$$10 \log \frac{I}{I_0} = 10 \log \frac{W}{W_0} - 10 \log \frac{4 \pi r^2}{A_0} + 10 \log Q$$

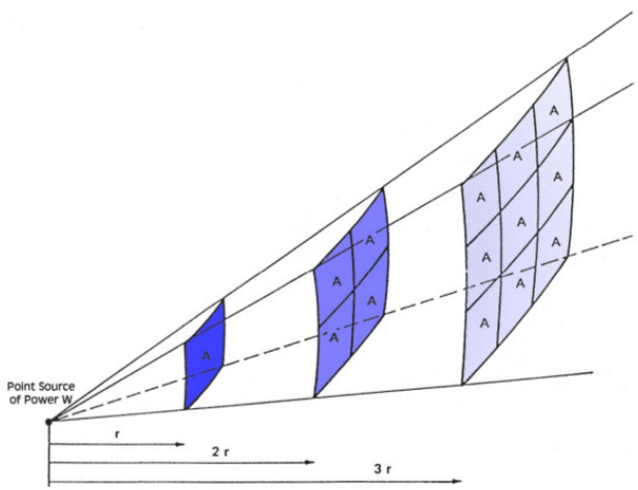
I_0 = Intensity of reference as 10^-12 [W/m2]

Theory of the punctiform source

$$L_p \cong L_W - 20 \log r' + ID - 11$$

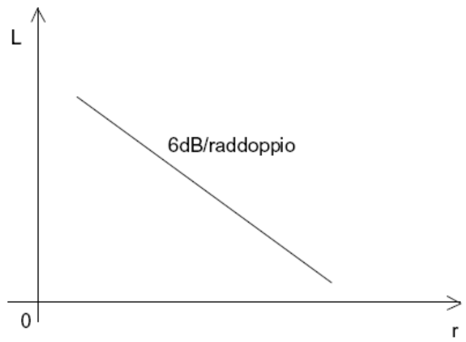
$$ID = 10 \log Q$$

Con Q = 2	->	$L_W = L_p + 20 \log r + 8$	con r = 10 [m]	->	$L_W = L_p + 28$
Con Q = 1	->	$L_W = L_p + 20 \log r + 11$	con r = 10 [m]	->	$L_W = L_p + 31$



Propagazione del suono da una sorgente puntiforme –

In campo libero per una sorgente puntiforme la relazione tra livello e raddoppio della distanza è lineare.



Legge di decadimento del livello al raddoppio della distanza–

Nella realtà il campo di propagazione non è mai completamente libero ma si ha tutta una serie di fattori che aumentano o diminuiscono il livello del suono, primo fra tutti è il terreno.

Teoria della sorgente puntiforme

Following the theory of the sound emission in a free field of a punctiform source, the procedure that determines the noise level of a refrigerating equipment is:

1.Through laboratory tests or theoric evaluations in relation to the sound emission of the single sound sources (ex. Compressors) of a unit, and of the acoustic attenuations of other components (ex. panels), is defined a certain average value of the noise pressure level in free field Lp, at a certain distance from the unit;

2.The sound power level Lw is evaluated inverting the the formula in the red square; this means that it is not considered the dimensional impact that the sound source produces in the acoustic field.

As example:

- To evaluate the Lw from the Lp in free field at 1 m unit distance, it is necessary to increase the Lp of:

  11 dBA in case of propagation in full sphere (Q=1, hanging source),
  8 dBA in case of propagation in ½ sphere (Q=2, source laying on a surface);

- To evaluate the Lw from the Lp in free field at 10 m unit distance, it is necessary to increase the Lp of :

  31 dBA in case of propagation in full sphere (Q=1, hanging source),
  28 dBA in case of propagation in ½ sphere (Q=2, source laying on a surface

The reduction or the increase of the Lp in free field, from a X distance to another Y from the unit, has to be calculated by deducing before the Lw from the Lp at X meters (see. point 2), and then obtaining the Lp at the new distance (Y); alternatively it is possible to apply the following formula, coming from that of the red square:

$$L_{p1} - L_{p2} = 20 \log \frac{r_2}{r_1}$$

In case of double distance from the punctiform source, the reduction of Lp is of 6 dBA.

ISO 3744

ISO 3744

This is the rule used to determine the sound power level measuring the sound pressure level in free field uttered by a noise source non-punctiform, lied on a surface that reflects acoustically.

ISO 3744 specifies a methodology to measure the sound pressure levels on a surface of measure that envelops the same source, and the calculation of the sound power level that the source utters.

The application field of ISO 3744 is given by the following surroundings:

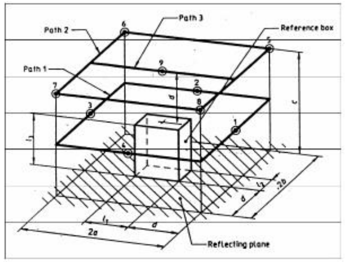
1.A test room made of a reflecting floor and of the conditions as above described (ex. a room with surfaces very sound-proofing);
2.An external area, flat and reflecting, without obstacles, so that the testing correction K_2, evaluated accordingly to the appendix A of rule ISO 3744 and referred to the influence of the obstcles that cause reflexions and of the acoustic waves uttered, is under 2 dB (ex. a large square enoughly big);
3.A closed surrounding where the acoustic field contribution result as slight than that of the acoustic field direct (ex. an industrial place of huge dimensions).

The source had to be then placed on a reflecting floor, distant form obstacles as walls and cealings that can reflect the sound waves over them.

Then ISO 3744 considers by default a propagation of acoustic waves at directionality factor Q=2 (1/2 spheric propagation).

ISO 3744

Practically the sound source is then envelopped by a surface that can be parallelepiped or half spheric.



The distance of the surface of measure of the unit has to be preferably of 1 mt and anyway at least 0,25. The measuring points have to be, for units with compact dimensions, at least 9 (at the centre of the 5 surfaces that surrounds the unit and at the 4 upper apex of the parallelepiped).

$$L_p' = 10\log\frac{1}{N}\sum_{i=1}^{N}10^{0.1Li}$$

Average sound pressure level on the measure surface

K2 = Correction factor related to the surroundings reflections

$$Lp_f = L_p' - K_1 - K_2$$

K1 = Correction factor related to the bottom noise

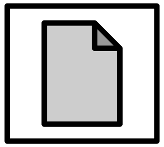
The sound power level of the unit (Lw), expressed in dB, is given by:

S = Measure surface in m2
So= Unit surface in m2

$$L_W = L_{Pf} + 10\log\frac{S}{S_0}$$

File for the calculation

The file of calculation: “From Lw to Lp at various distances in free field (accordingly to ISO 3744).xls”



Input data:

1. The overhaul dimensions of the refrigeration equipment for that it is necessary to get the noise data, in terms of length height and width of the unit;
2. The average sound power level Lw uttered by the unit;

Output data through: $L_W = L_{pf} + 10 \log \frac{S}{S_0}$

1.The surface of the parallelepiped of measure accordingly to ISO 3744, that envelops the refrigerating unit, calculated at a certain distance from 1 m to 10 m, step 1 m ;

2.The sound pressure in a free field at a certain distance X from the non-punctiform source, that goes from 1 m to 10 m, from the sound power level that characterize this source;

3.The difference between the power level and and the sound pressure in free field, for each distance that goes from 1 m to 10 m;

Differences between Punctiform method and ISO 3744

1. The difference between the power level and the sound pressure level in free field at 1 m of distance from the unit is 19.5 dBA in case of propagation in ½ sphere (Q=2, source laying on a surface), against the 8 dBA that should have come applying the theory of the sound emission of a punctiform source, always in case of propagation in ½ sphere (Q=2, source laying on a surface);

2. The difference between the power level and the sound pressure level in free field at 10 m of distance from the same unit is 32 dBA in case of propagation in ½ sphere (Q=2, source laying on a surface), against the 28 dBA that should have come applying the theory of the sound emission of a punctiform source, always in case of propagation in ½ sphere (Q=2, source laying on a surface);

3. The reduction of the Lp in free field, passing from a distance of 2 m to a distance of 4 m from the unit, is -3.5 dB, against -6.0 dBA that should have been calculated applying the theory of the sound emission of a punctiform source;

The mnemonic rule of the reduction -6 dBA at the doubling of the distance from the sound source is no more true in case of real sources, then non-punctiform.