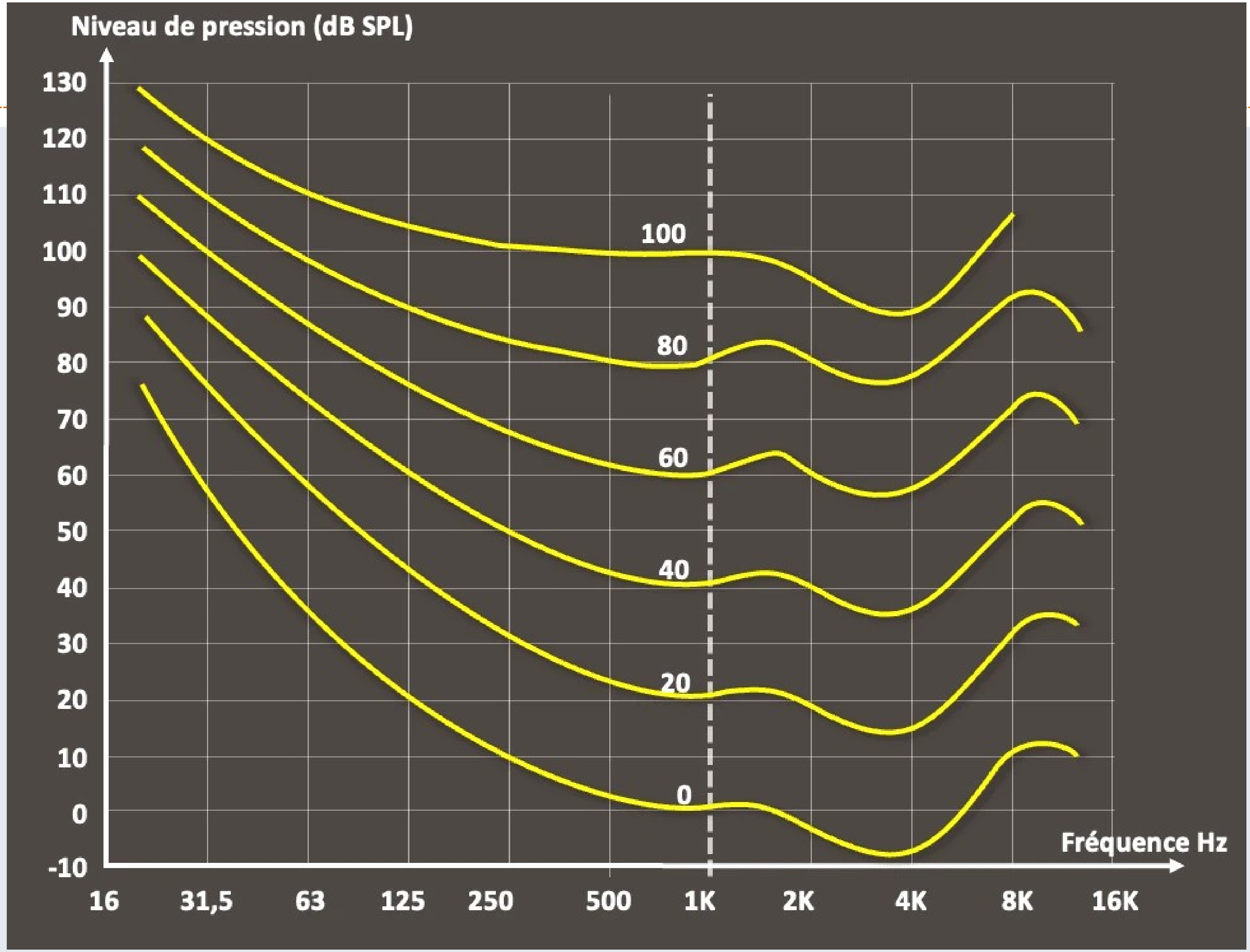
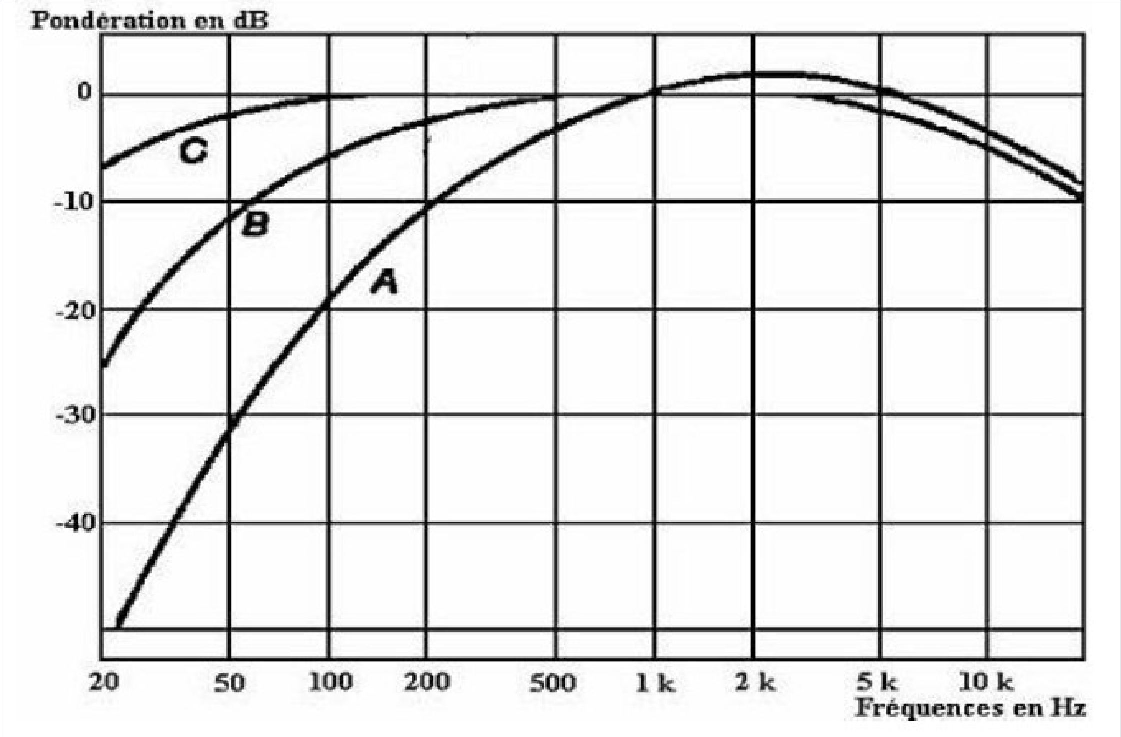
Chapter II
SOUND PROPAGATION IN FREE FIELD



Niveau de pression (dB SPL)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
100
80
60
40
20
0
Fréquence Hz
16
31,5
63
125
250
500
1K
2K
4K
8K
16K

Weighted sound levels

Weighting coefficients are used to take into account the sensitivity of the human ear as a function of frequency.In this case, the sound level is expressed in dB(A) or dBA when the A-weighting curve is applied.



- A-weighting is normally used when the overall unweighted sound level is below 55 dB.
- B-weighting is normally used when the overall unweighted sound level is between 55 and 85 dB
- C-weighting is normally used when the overall unweighted sound level is above 85 dB.

Example:

Consider the octave-band spectrum of road traffic noise.

The sound levels are weighted according to A-weighting. The overall noise level is obtained by summing the weighted levels, resulting in 86 dB(A).

1	Fréquences (Hz)	125	250	500	1000	2000	4000	dB(A)
2	Niveau L en dB	80	80	80	80	80	80	
3	Pondération (A) en dB	- 16	- 9	- 3	0	+ 1	+ 1	
4	Niveau L pondéré (A)	64	71	77	80	81	81	86

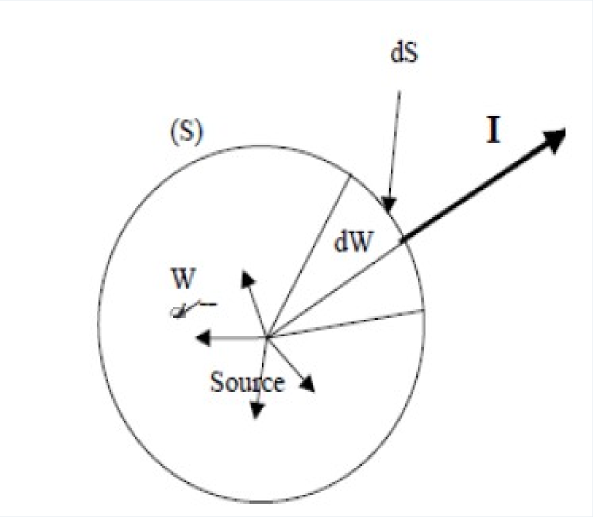
Omnidirectional point source

When the source is an omnidirectional point source, it generates spherical waves. In other words, at any given instant, every point located on a sphere centered on the source undergoes the same motion, and the acoustic intensity I is identical at every point on the sphere of radius r

$$I = \frac{dW}{dS} = cte$$

$$W = \int_S I.\, dS = 4\pi r^2 . I$$

$$I = \frac{W}{4\pi r^2} \quad (w/m^2)$$



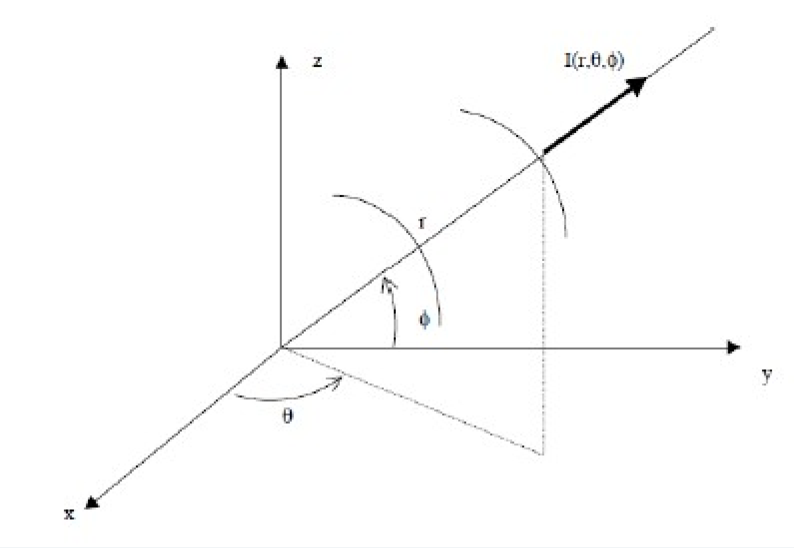
W: the power emitted by the sound source, in watts (W), r: the distance between the source and the measurement point (radius of the sphere)

Directional point source

When the source is a directional point source, the emitted power is not uniformly distributed around the sound source.

A directivity factor Q(θ,φ)Q(\theta, \phi)Q(θ,φ) is defined as the ratio of the intensity delivered by the directional source at a point M to the intensity provided by an omnidirectional point source,

$$Q(\theta,\varphi) = \frac{I_M(r,\theta,\varphi)}{I} = \frac{I_M(r,\theta,\varphi)}{\frac{W}{4\pi r^2}}$$



In this case, the acoustic intensity of the sound wave is equal to

$$I_M = \frac{Q.W}{4\pi r^2} \quad (w/m^2)$$

The sound wave intensity level is equal to:

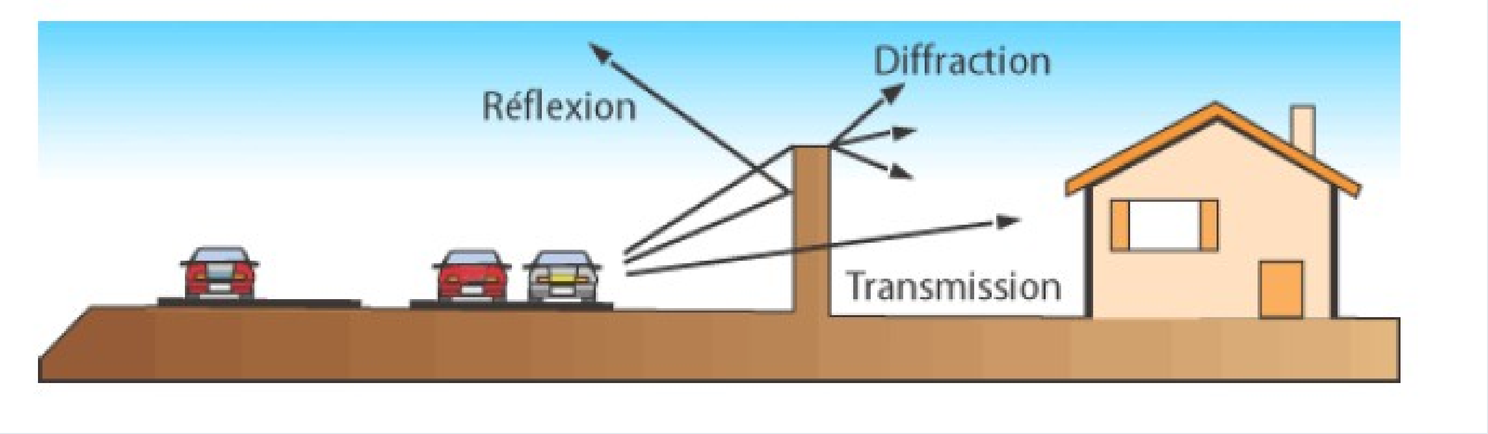
$$L_I = L_W + 10\log\frac{Q(\theta,\varphi)}{4\pi r^2} \quad (dB)$$

Noise Reduction in Free-Field Propagation

When outdoors, the main measure to take is to place one or more barriers between the emitting source S and the receiving point R. The effectiveness of the barrier depends on the frequency as well as its positioning.

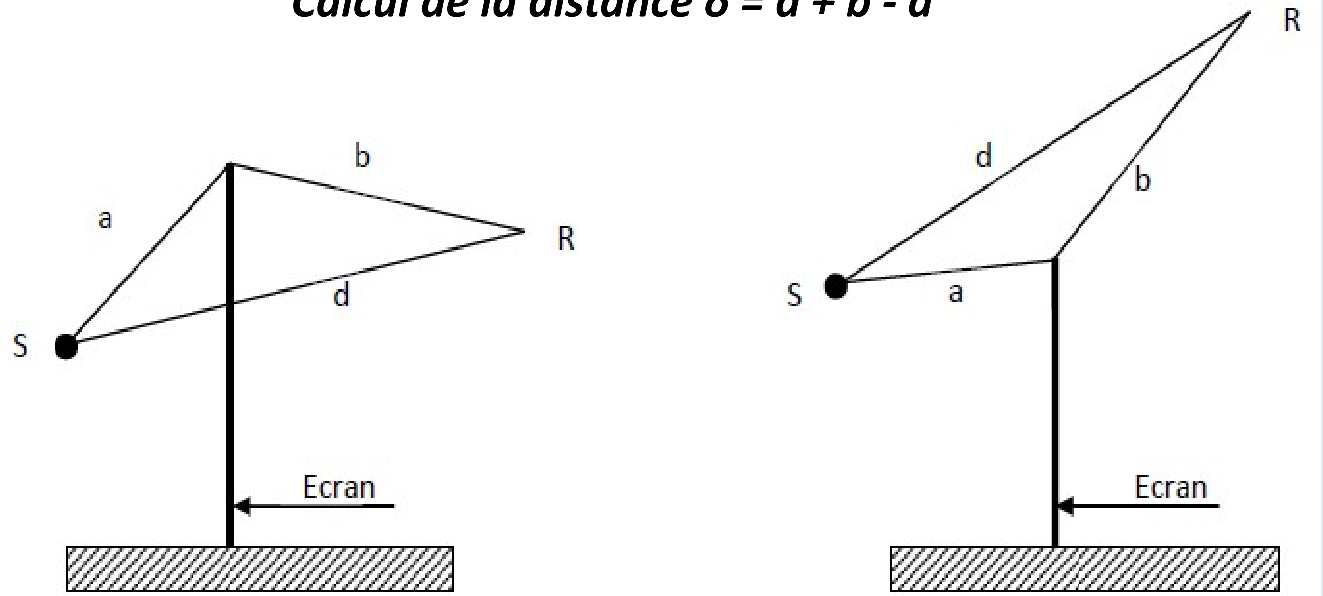
Attenuation due to barriers

The barrier attenuation, Î”L, is defined as the difference between the sound level at point R in the absence of the barrier and the level in the presence of the barrier.



When the sound wave propagates toward the receiver, it encounters the barrier. Part of this sound wave: 1) is transmitted through the barrier ;2) is absorbed by the barrier, 3)is reflected by the barrier, 4) is diffracted around the edges of the barrier

Calcul de la distance δ = a + b - d



The noise attenuation, ΔL, provided by a barrier depends on the Fresnel number N,

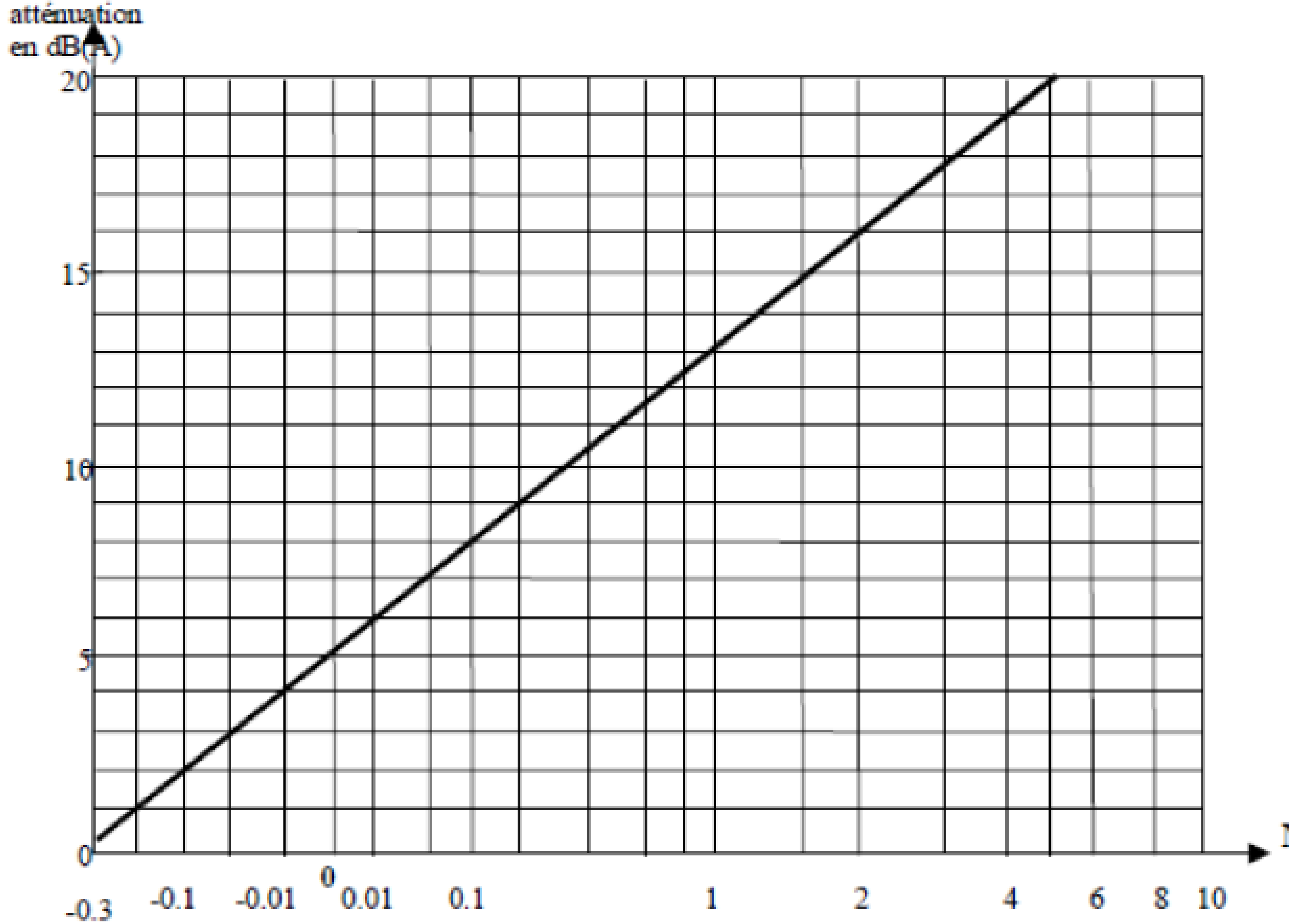
which is equal to:

$$N = \frac{2\delta}{\lambda}$$

Where:

δ: the difference between the shortest path from S to R via the barrier and the direct path d (δ = a + b − d)

λ: the wavelength in meters (m)



Maekawa's chart for determining the attenuation ΔL

Atmospheric attenuation

Atmospheric attenuation is related to the energy exchanges that occur between the sound wave and its propagation medium.

$$I_r = \frac{Q(\theta,\varphi).W}{4\pi r^2} e^{-mr}$$

Where m is the atmospheric absorption coefficient.

$$L_I = L_W + 10log\frac{Q(\theta,\varphi)}{4\pi r^2} - \alpha_m r$$

Where: $\alpha_m = 4.34$ m in dB/m

The atmospheric attenuation coefficient depends on the temperature of the propagation medium and on the frequency.