POLITECNICO DI MILANO



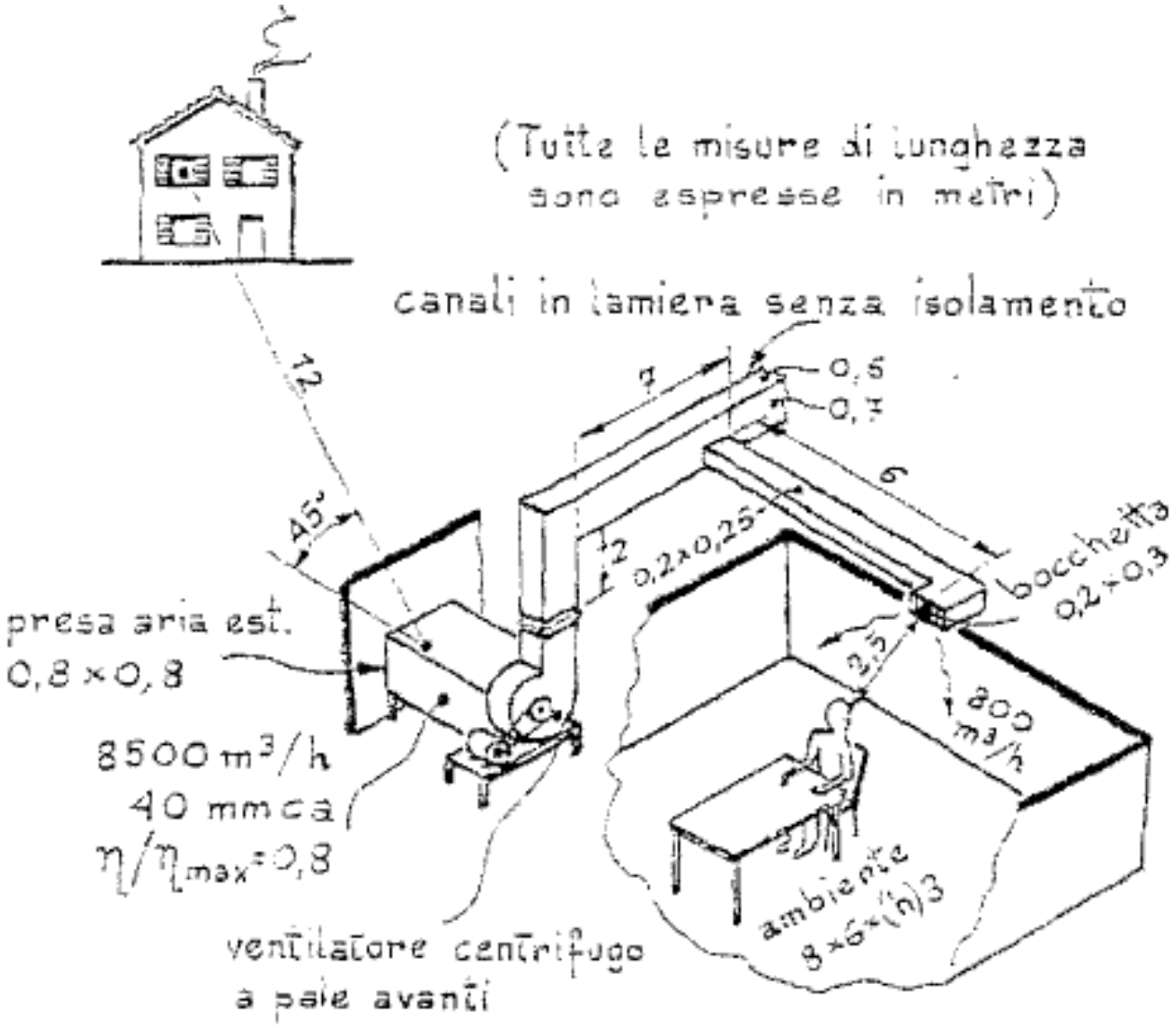


Exercise: Noise in HVAC systems

Prof. Livio Mazzarella

Ing. Maria Cairoli
Dipartimento di Energia

DATI


(Tutte le misure di lunghezza sono espresse in metri)
canali in lamiera senza isolamento
12
45°
7
0,5
0,7
6
2
0,2×0,25
bocchetta 0,2×0,3
presa aria est. 0,8×0,8
8500 m³/h
40 mmca
η/η max = 0,8
ventilatore centrifugo a pale avanti
2,5
800 m³/h
ambiente 9×6×(h)3

1. Calculation of the sound pressure level on the internal receiver relative to the air flow inlet only (person at 2.5 m from the delivery outlet).
2. Calculation of the sound pressure level on the external receiver (window of the house facing the air handling unit)
3. Check that the sound pressure level on the building window is not higher than the NR40 criterion.
4. Define the spectral characteristics of an attenuator filter on the intake that ensures compliance with the NR40 criterion

Calculation 1

1) It is calculated the spectral distribution of the sound power of the "noise generator", the fan, known Q, p and the type of fan

$$L_W = 41 + 10 \cdot \log_{10}(Q) + 20 \cdot \log_{10}(p) \quad [\text{dB}]$$

Q portata [m^3/h]

p pressione mandata [mm H_2O]

Fan Type	Correction factors for octave bands							
	63	125	250	500	1000	2000	4000	8000
Centrifugal - backward curved blades	- 4	- 6	- 9	- 11	- 13	- 16	- 19	- 22
Centrifugal - forward curved blades	- 2	- 6	- 13	- 18	- 19	- 22	- 25	- 30
Centrifugal - radial blades	- 3	- 5	- 11	- 12	- 15	- 20	- 23	- 26
Axial	- 7	- 9	- 7	- 7	- 8	- 11	- 16	- 18

2) It is determined the portion of the spectral sound power directed towards the internal environment (fan inlet) in [dB] (linear)

It is defined the portion of the spectral sound power directed towards the internal environment (fan inlet) in [dB] (linear) $\Delta L_w = -3$ dB

The spectral distribution at the inlet is determined as:
$L_{w,inlet} = L_{w,fan} + \Delta L_w$

3) The spectral attenuations in [dB] are determined in the distribution channel due to its extension, size, the presence of curves and branches (flow reductions)

Attenuation dB/m

Rapporto *P/S* [1/m]	63 Hz	125 Hz	250 Hz e oltre
maggiore di 12	0	0,9	0,3
tra 12 e 5	0,9	0,3	0,3
minore di 5	0,3	0,3	0,3

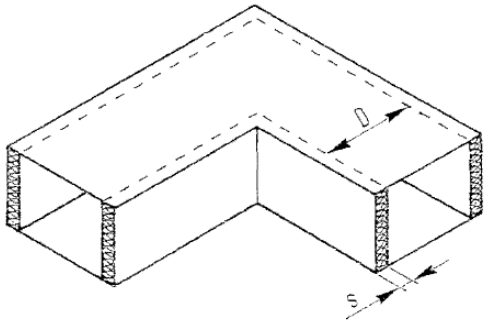
P: perimetro della sezione retta del condotto
S: area della sezione retta del condotto.

P is the perimeter of the section of the duct

S is the area of the section

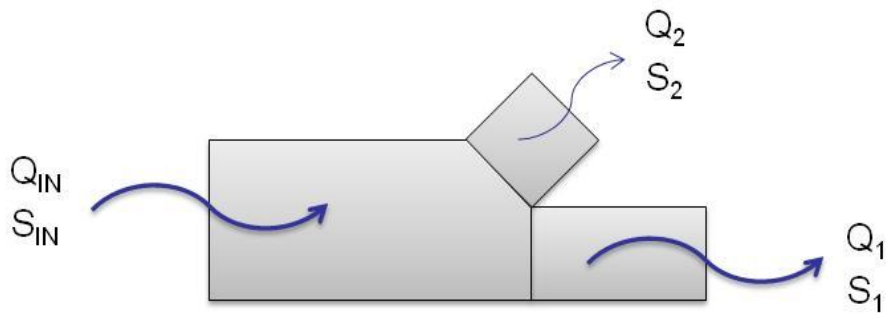
3) The spectral attenuations in [dB] are determined in the distribution channel due to its extension, size, the presence of curves and branches (flow reductions)

Diameter	Center frequency in octave bands [Hz]							
[m]	63	125	250	500	1000	2000	4000	8000
Square elbows without turning vanes								
0,15-0,30	0	0	1	4	6	6	4	3
0,30-0,60	0	0	4	6	6	4	3	2
0,60-1,2	1	3	6	7	4	3	3	3
Square elbows with turning vanes								
0,15-0,30	0	0	0	2	3	4	3	3
0,30-0,60	0	0	2	3	4	3	3	3
0,60-1,2	0	1	4	4	3	3	3	3
Round elbows								
0,15-0,30	0	0	0	0	1	2	3	3
0,30-0,60	0	0	0	1	2	3	3	3
0,60-1,2	0	0	1	2	3	3	3	3
D: diameter of the duct with circular section or dimension in the plane of curvature in the ducts of rectangular section								



3) The spectral attenuations in [dB] are determined in the distribution channel due to its extension, size, the presence of curves and branches (flow reductions)

$$\Delta L_W = 10 \cdot \log_{10}\left(\frac{Q_1}{Q_{IN}}\right)$$



4) The spectral attenuations are determined in [dB] by terminal reflection at the emission in the room

To be significant, there must be a section of an rectilinear duct at least 3-5 average diameters and there is no diffuser or grid at the outlet.

This is not our case: it does not apply.

5) It is calculated the spectral sound power in [dB] injected into the room from the emission point as the spectral sound power emitted by the fan plus all the spectral attenuations (<0) along the duct.

$$L_{w,D} = L_{w,F} + \Delta L_w$$

6) The spectrum of the sound pressure at the receiver in [dB] is determined according to the spectral sound power emitted by the nozzle, by means of the propagation law in a reverberant environment.

$$L_p = L_{W,boc} + 10 \cdot \log_{10}\left(\frac{Q}{4\pi r^2} + \frac{4}{R}\right) \qquad R = \frac{S_T \cdot \bar{\alpha}}{1 - \bar{\alpha}}$$

If the absorption coefficients are not known, there is a semiempirical relation for furnished environments of «normal characteristics»:

V = volume [m^3] , f= frequency [Hz], r= distance[m],

$$L_p = L_{W,boc} - 5 \cdot \log_{10}(V) - 3 \cdot \log_{10}(f) - 10 \cdot \log_{10}(r) + 12 \quad [\text{dB}]$$

7) Sound pressure leve evaluated in [dBA].

$$L_{P(A)} = L_P + A \quad [\text{dB(A)}]$$

$$L_P = L_{P(A)} - A \quad [\text{dB}]$$

Freq. Hz	Correzione per ottenere i dB(A) A
63	-26.2
125	-16.1
250	-8.6
500	-3.2
1000	0
2000	1.2
4000	1.0
8000	-1.1

Calculation 2

1) It is determined the portion of the spectral sound power directed towards the external environment (fan suction) in [dB] (linear)

It is defined the portion of the spectral sound power directed towards the external environment (fan inlet) in [dB] (linear) $\Delta Lw = -3$ dB

The spectral distribution at the inlet is determined as:

$$Lw,inlet = Lw,fan + \Delta Lw$$

2) The spectral attenuations in [dB] are determined in the distribution channel due to its extension, size, the presence of curves and branches (flow reductions)

NEGLIGIBLE

3) The directivity factor is determined and the directivity index relative to the direction between the external air intake (sound source)

Curve A

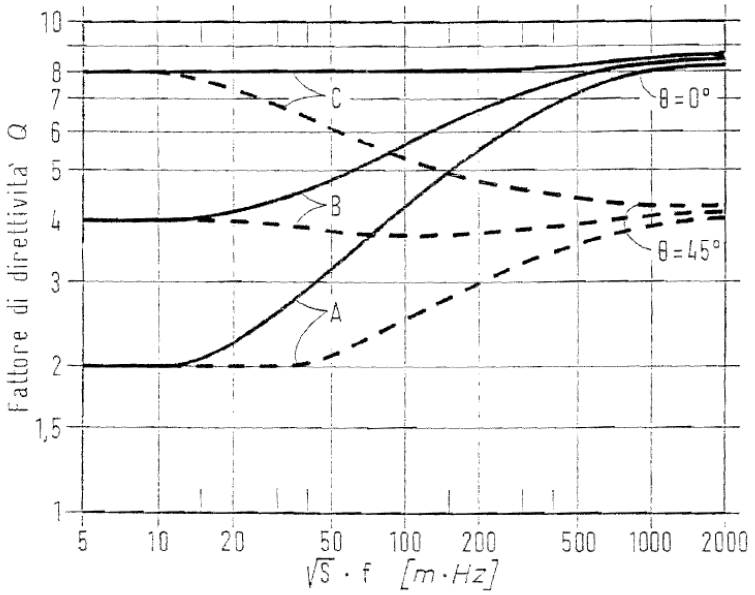


Fig. I.3-6 - Fattori di direttività dei terminali d'ambiente:
f : frequenza; S: area della sezione retta del raccordo: θ: angolo tra la direzione considerata e la normale alla superficie di sbocco del terminale.
A: terminale al centro di una parete.
B: terminale in prossimità dell'incontro di due pareti.
C: terminale in prossimità degli angoli dell'ambiente.

4) The directivity index DI [dB] is determined

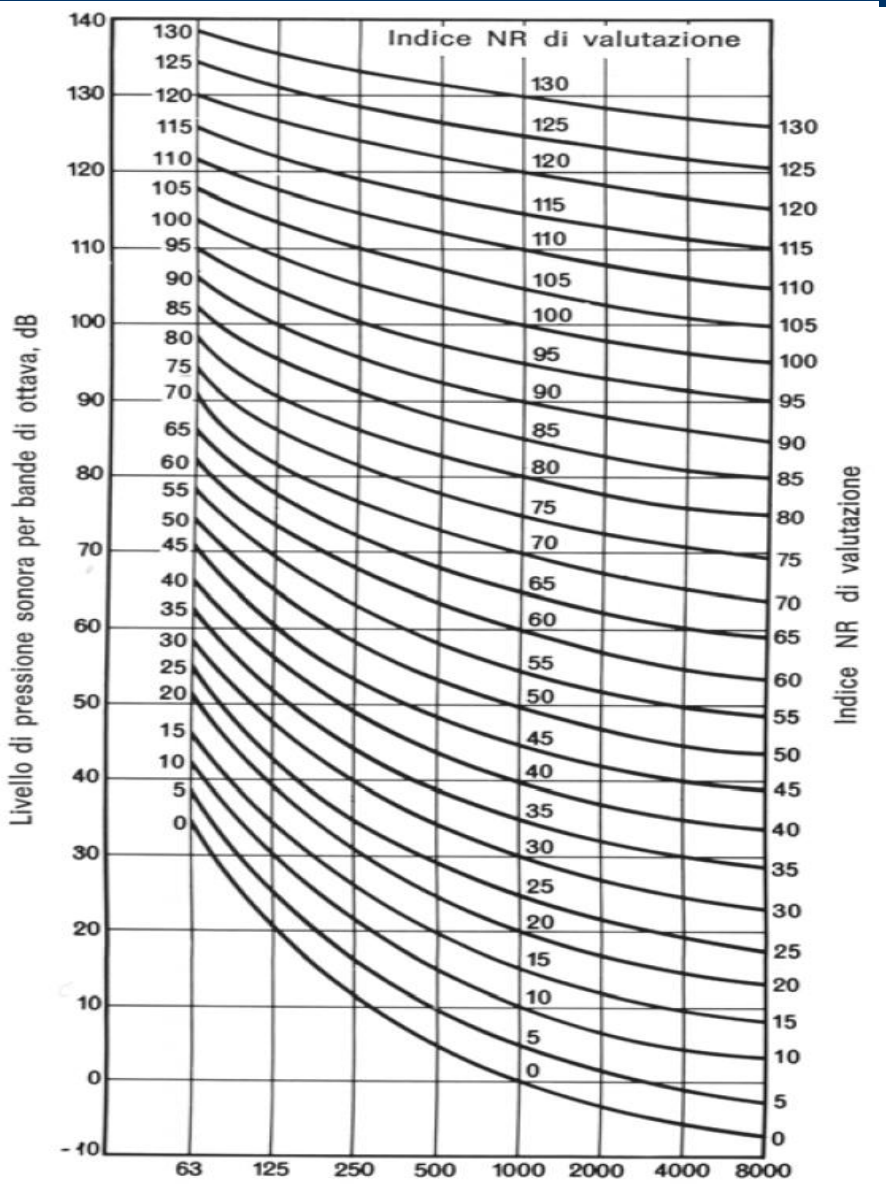
$$DI = 10 \cdot \log_{10}(Q) \qquad [\mathrm{dB}]$$

Sequenza di calcolo obbiettivo 2

6) The spectrum of the sound pressure at the receiver in [dB] is determined by the propagation law in free field.

$$L_p = \left(L_{w,vent} + \sum \Delta L_w\right) - 20 \cdot \log_{10}(r) - 11 + DI$$

7) The spectrum of sound pressure is compared to the receiver in [dB] with the limit value required by the criterion NR = 40. If the difference is positive also for a frequency band it is necessary to introduce an appropriate attenuator filter on the suction.



8) The spectrum of the minimum attenuation in [dB] is determined, which the attenuator filter must perform to achieve compliance with the NR40 criterion.

A difference of 3 dB is added to the difference between Lp on the window plane and Criterion NR40.