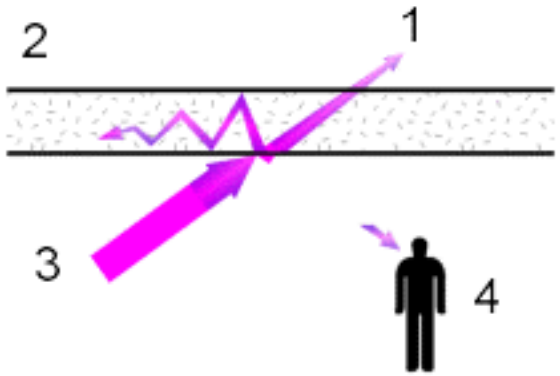
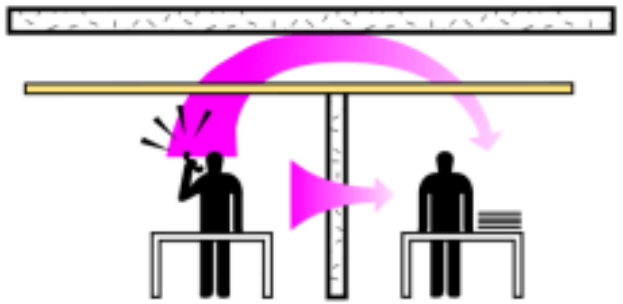
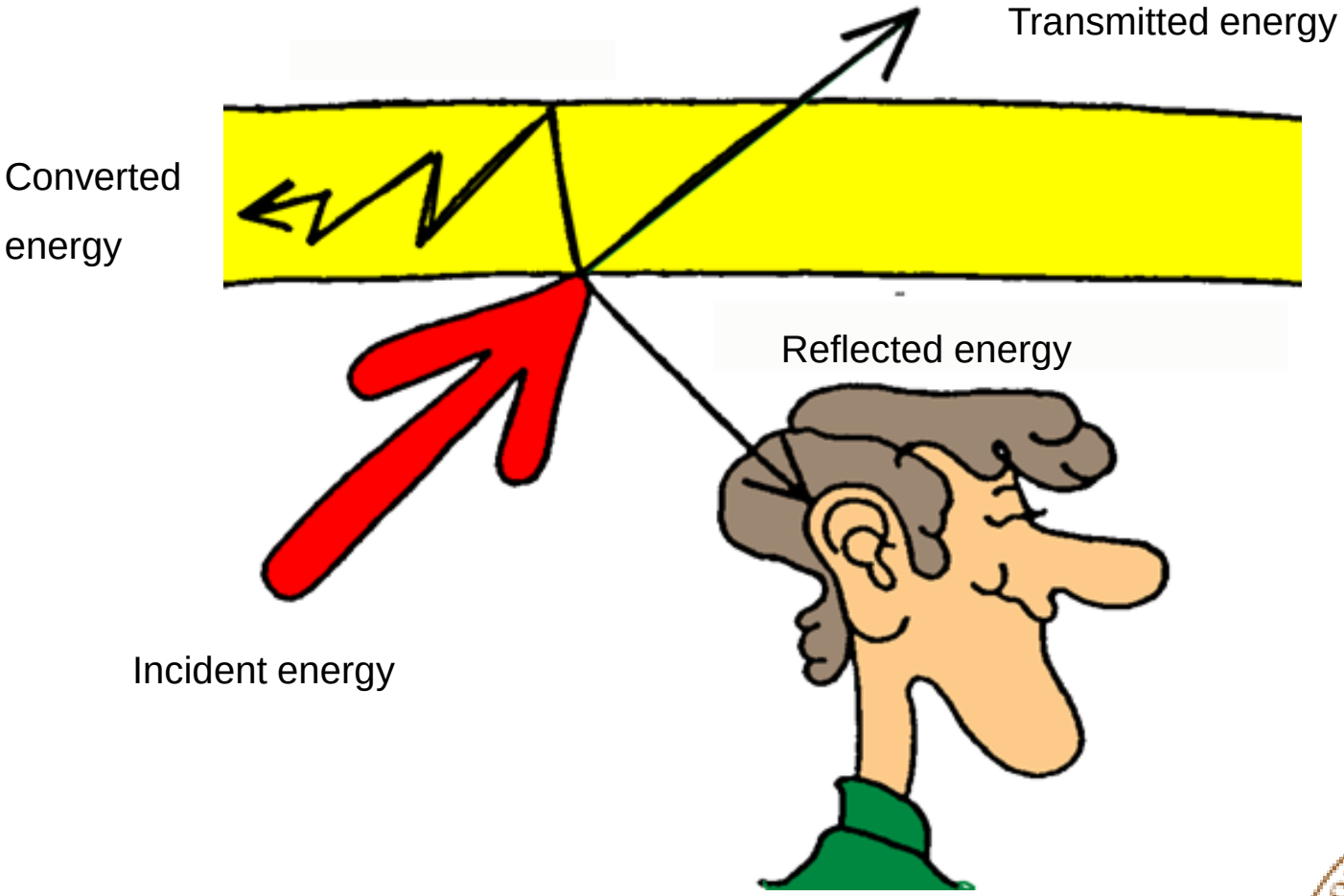
Sound Absorption and Sound Insulation





Sound absorption



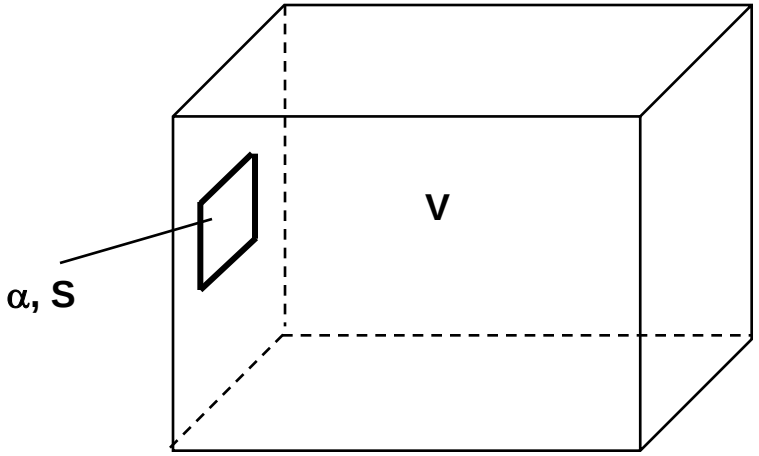
Absorption coefficient

$$\alpha = \frac{\text{converted + transmitted energy}}{\text{incident energy}}$$

Absorption - Reverberation

Sabine

$$T = 0.16\left(\frac{V}{\alpha S}\right)$$

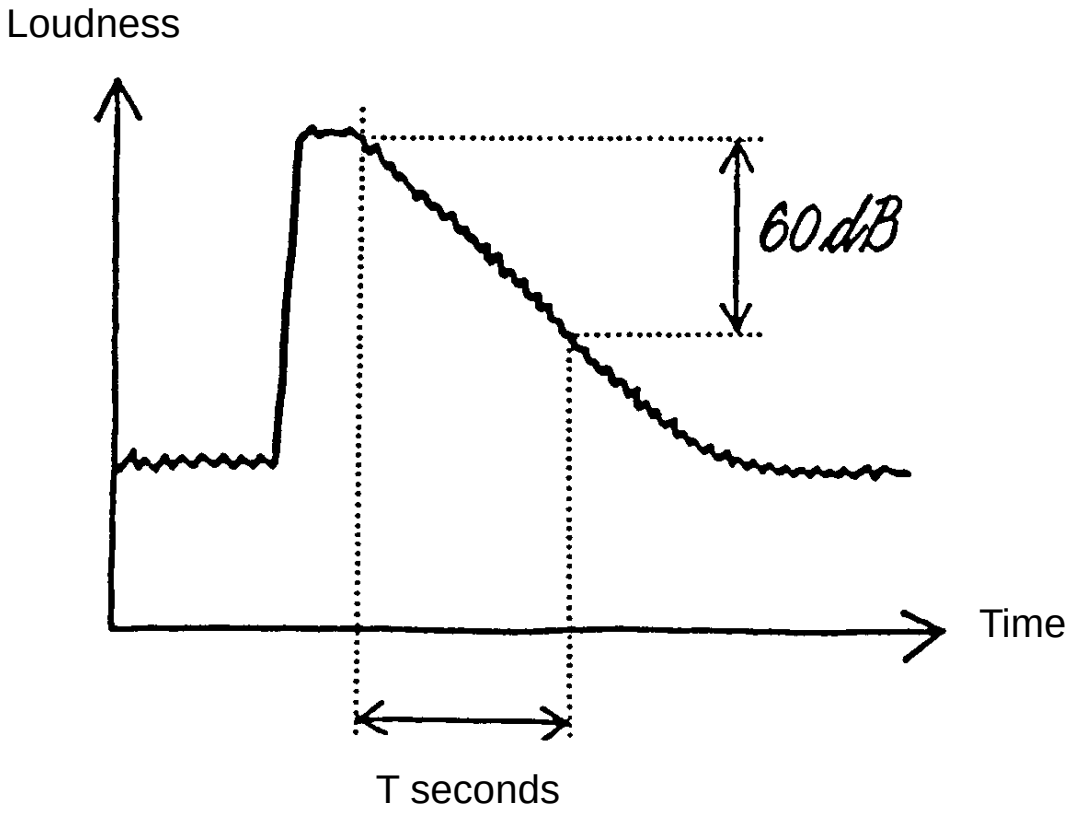


Large room volume → long reverberation

High absorption factor → short reverberation

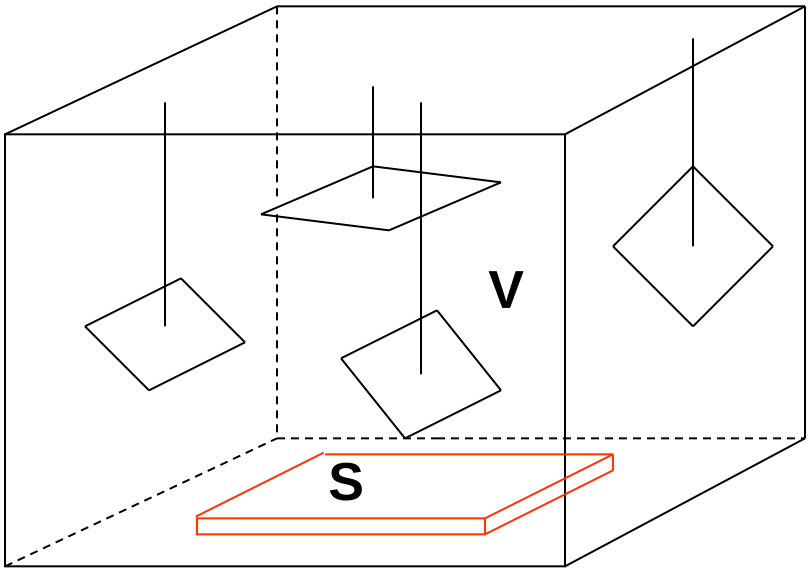
Large absorption area → short reverberation

Reverberation time



Measurement of absorption factor

The room method EN ISO 354



Reverberation chamber

$$A = 0.16V\left(\frac{1}{T_{with}} - \frac{1}{T_{without}}\right)$$

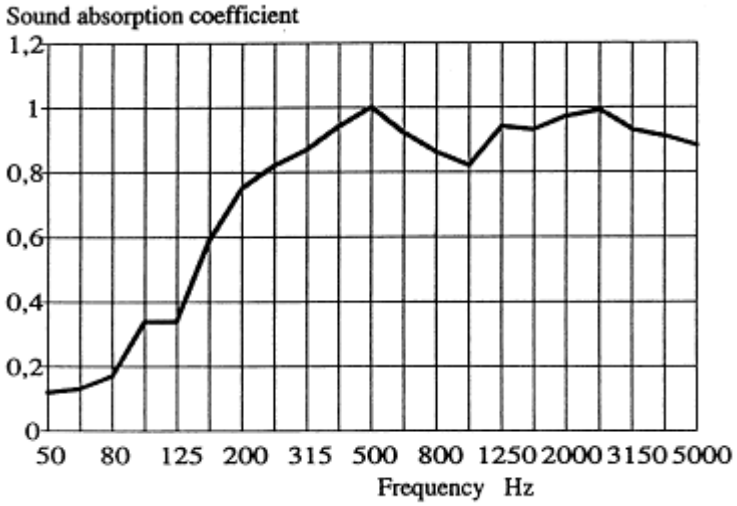
A=equivalent absorption area, m^2

V= room volume, m^3

absorption factor

A = A/S

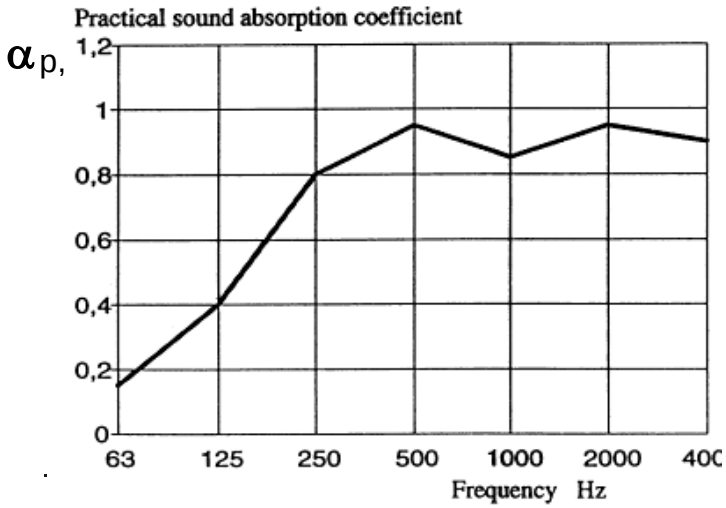
Ecophon ceiling Akutex T Gedina edge A



Thickness: 20 mm
Panel size: 1192x592 mm

Frequency	Curve 1
50	0.12
63	0.13
80	0.17
100	0.34
125	0.34
160	0.59
200	0.75
250	0.82
315	0.87
400	0.94
500	1.00
630	0.92
800	0.86
1000	0.82
1250	0.94
1600	0.93
2000	0.97
2500	0.99
3150	0.93
4000	0.91
5000	0.88

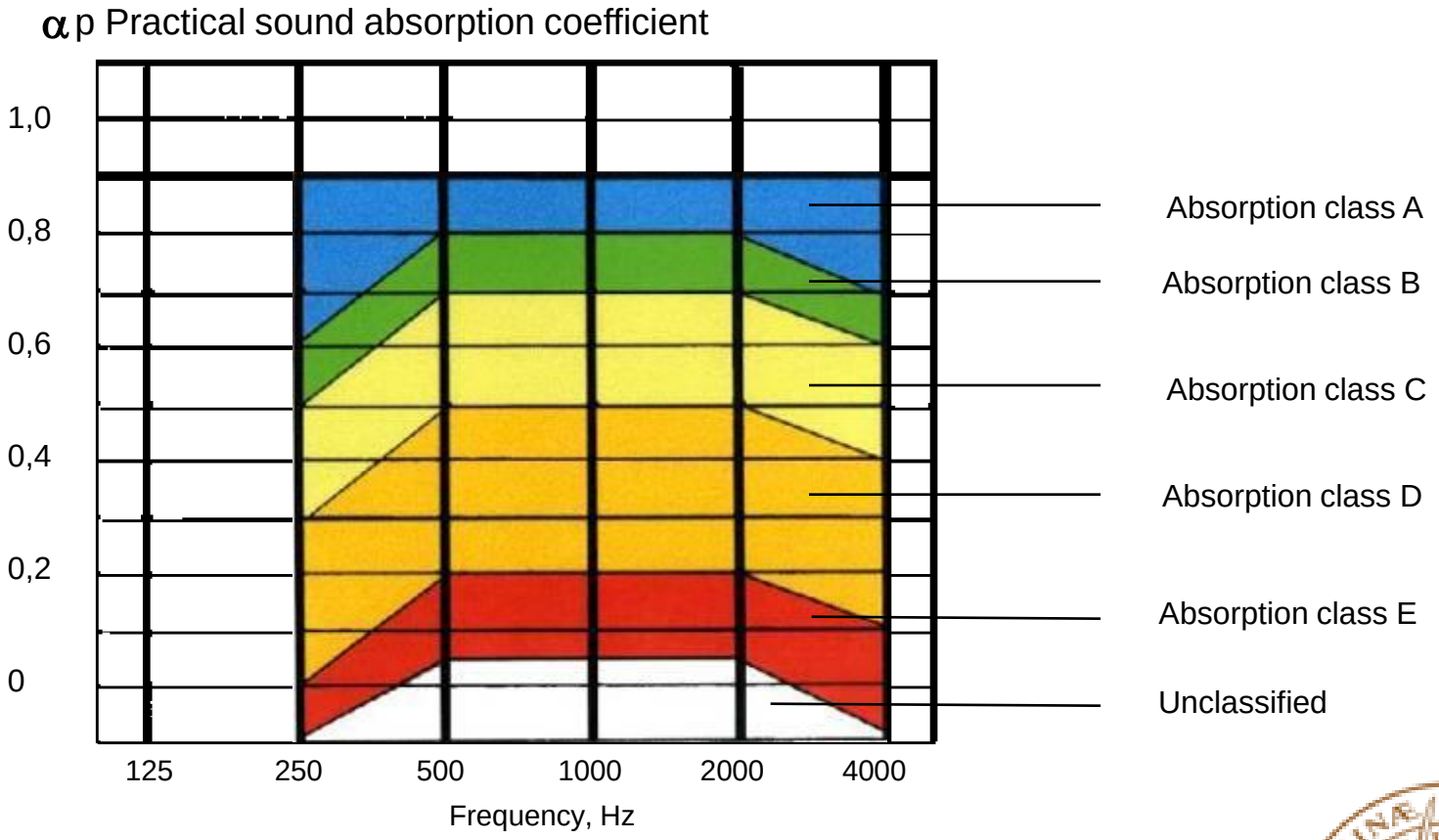
Ecophon ceiling Akutex T Gedina edge A



Thickness: 20 mm
Panel size: 1192x592 mm

Frequency	Curve 1
63	0.15
125	0.40
250	0.80
500	0.95
1000	0.85
2000	0.95
4000	0.90

Classification of sound absorbers EN-ISO 11654

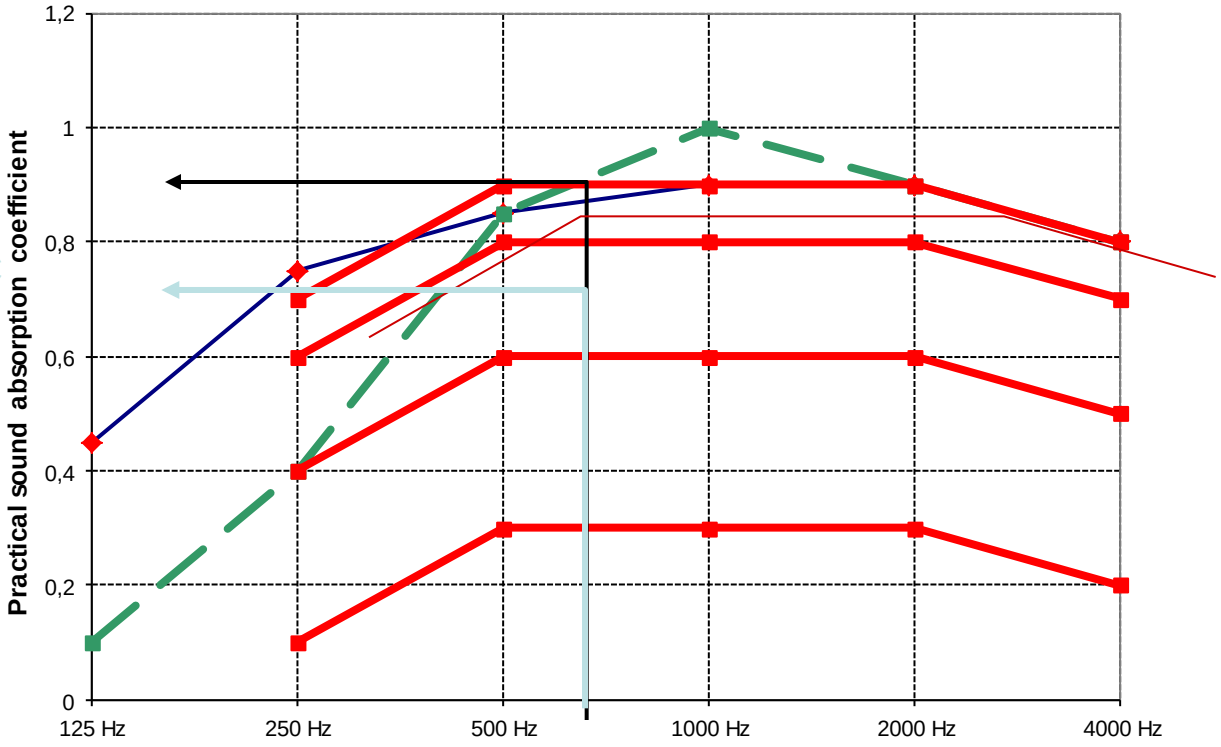


Practical absorption coefficient and classification

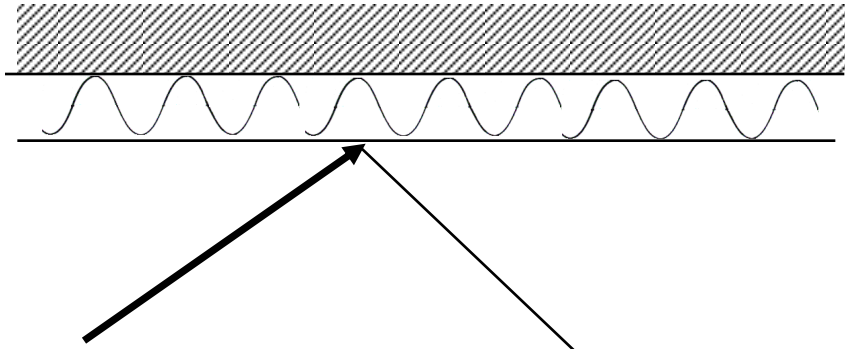
Weighted absorption coefficient, α_w

$\alpha_w = 0{,}9$, class A

$\alpha_w = 0{,}7$, class C



Reflected sound



$$\Delta L = 10 \cdot \log(1-\alpha)$$

At absorption class	The reflected sound is reduced by
D	1-4 dB
C	4-7 dB
B	7-10 dB
A	10-20 dB

Absorbers

1. Porous absorbers

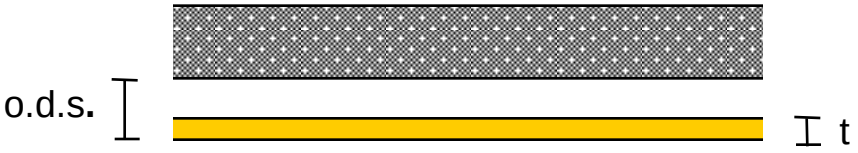
(mineral wool products, porous fibreboard products, foam plastic, fabric, felt etc)

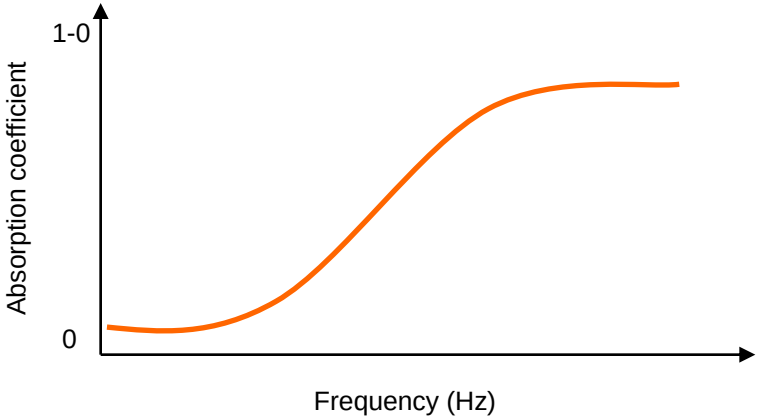
2. Resonance absorbers

a) Cavity absorbers (Helmholtz absorbers)

b) Membrane absorbers

Porous absorbers - Important parameters

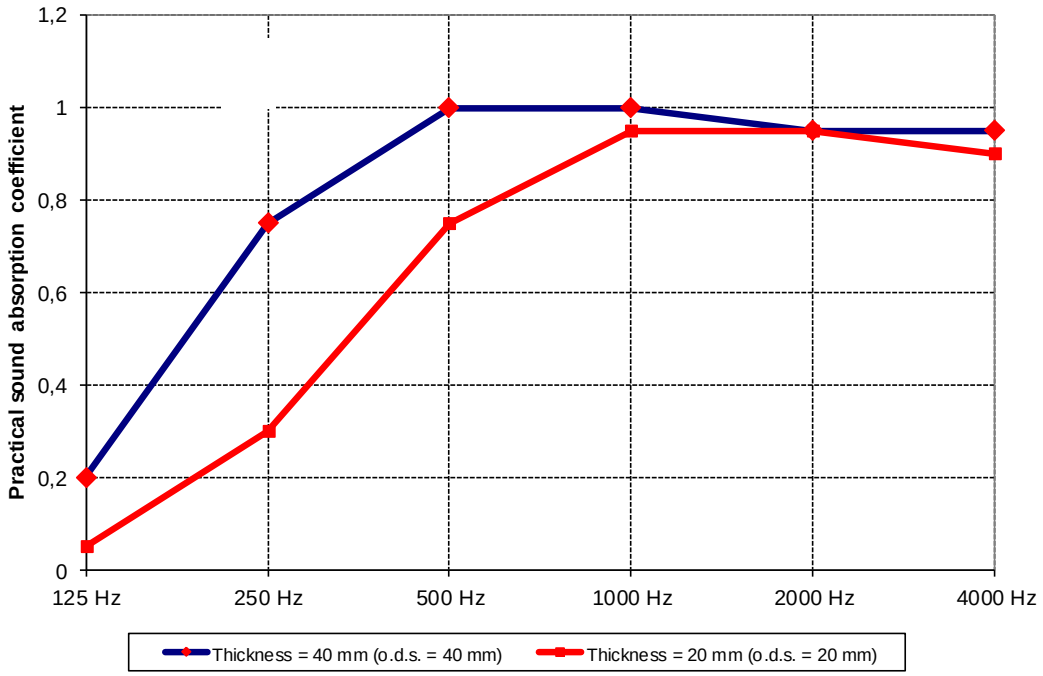




- Surface (layer)
- Material
- Thickness
- Overall depth of system (o.d.s.)

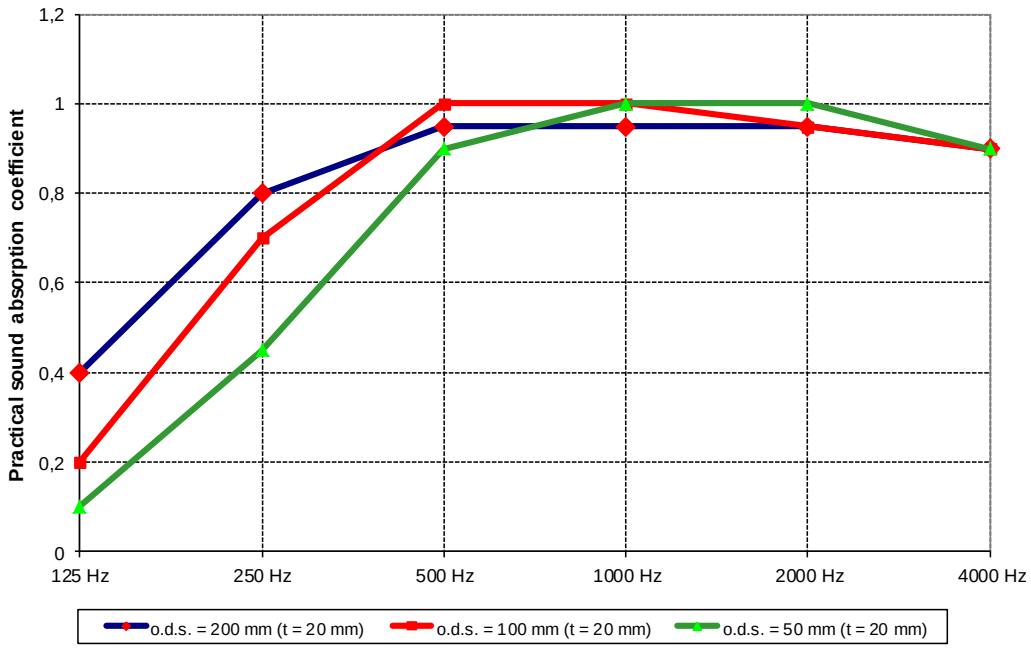
Absorption coefficient

- various thickness small overall depth of system

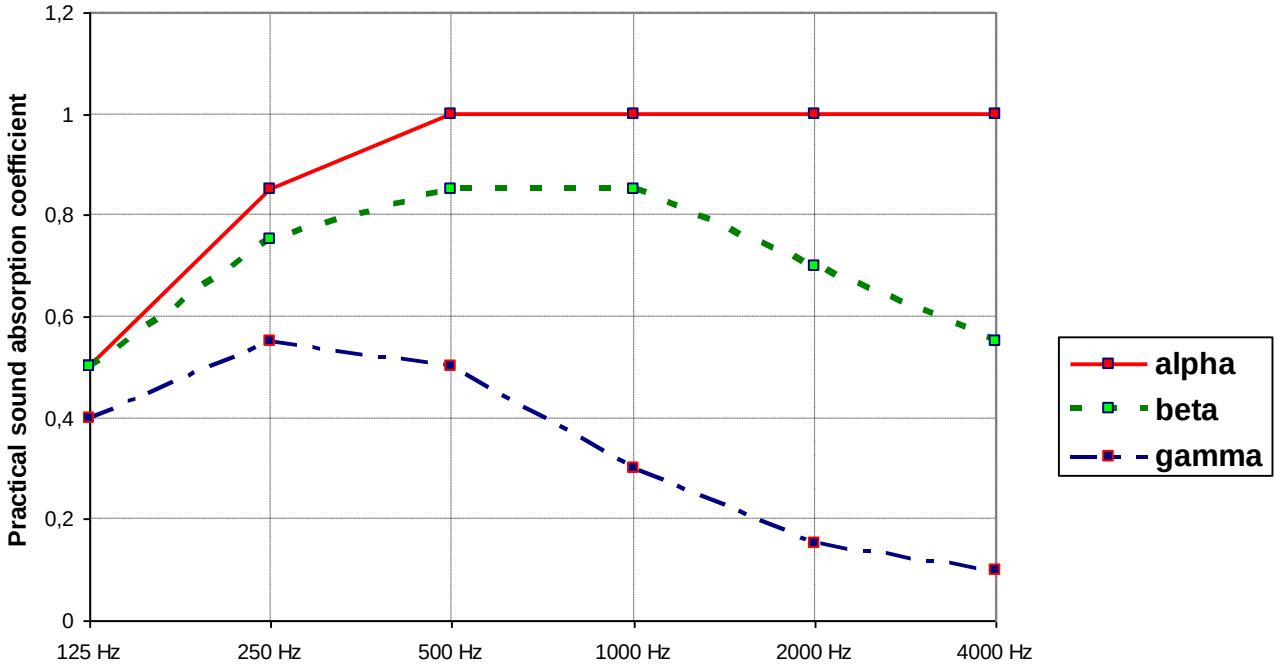


Absorption coefficient

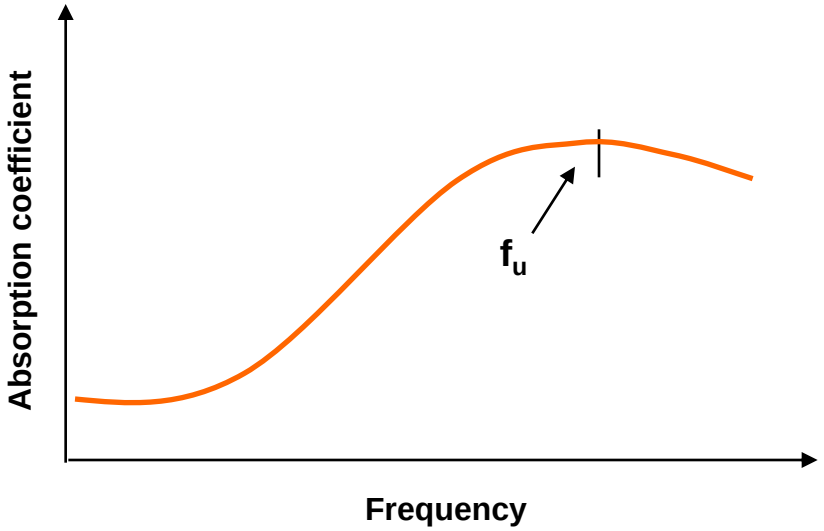
- various overall depth of system



Master A, o.d.s. 200 mm



Surface layer - upper frequency limit

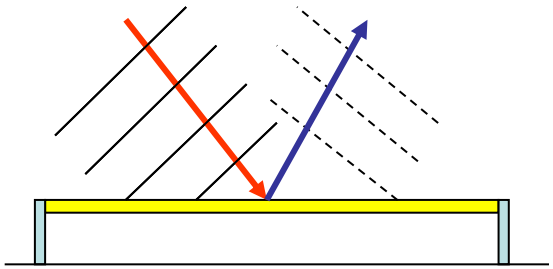


$f_u \approx 4000$ Hz

radius (mm)	perforation (%)
0.1	1
0.5	2
1.5	3

FHU - Acoustic specification

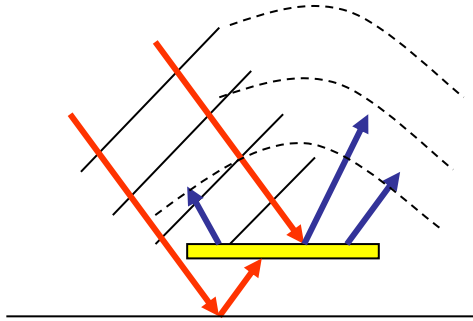
Absorbent ceiling



Absorption factor (ISO 354)

$$\alpha = \frac{A}{S}$$

FHU – free hanging unit

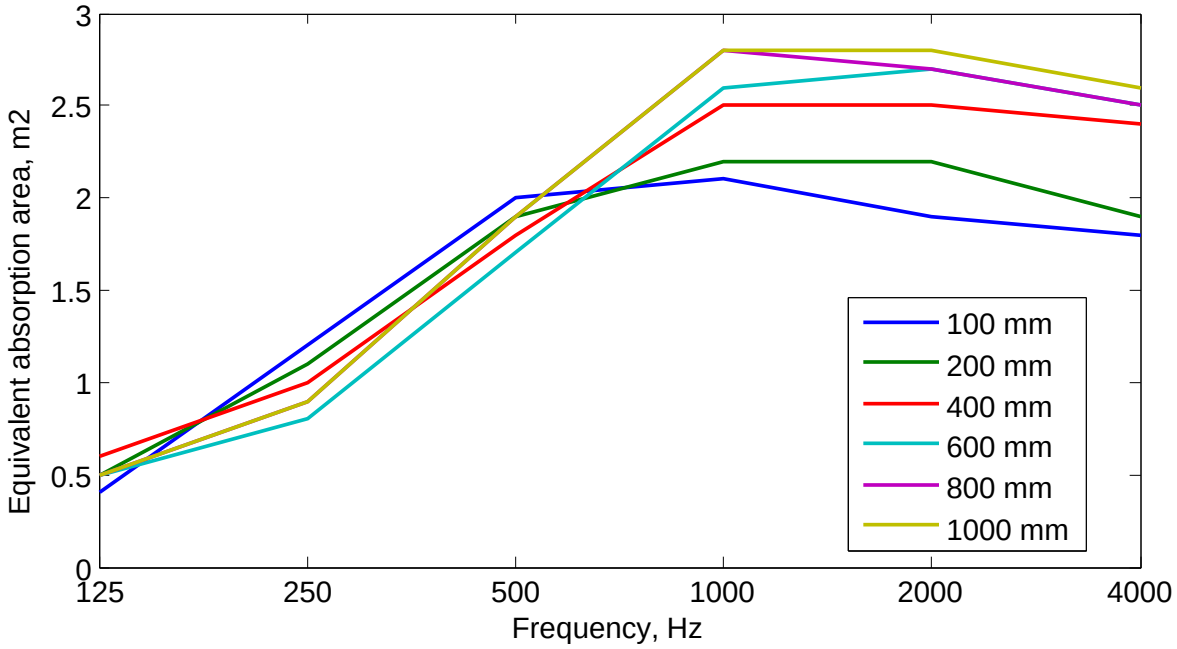


S ?

Equivalent absorption area (ISO 354)

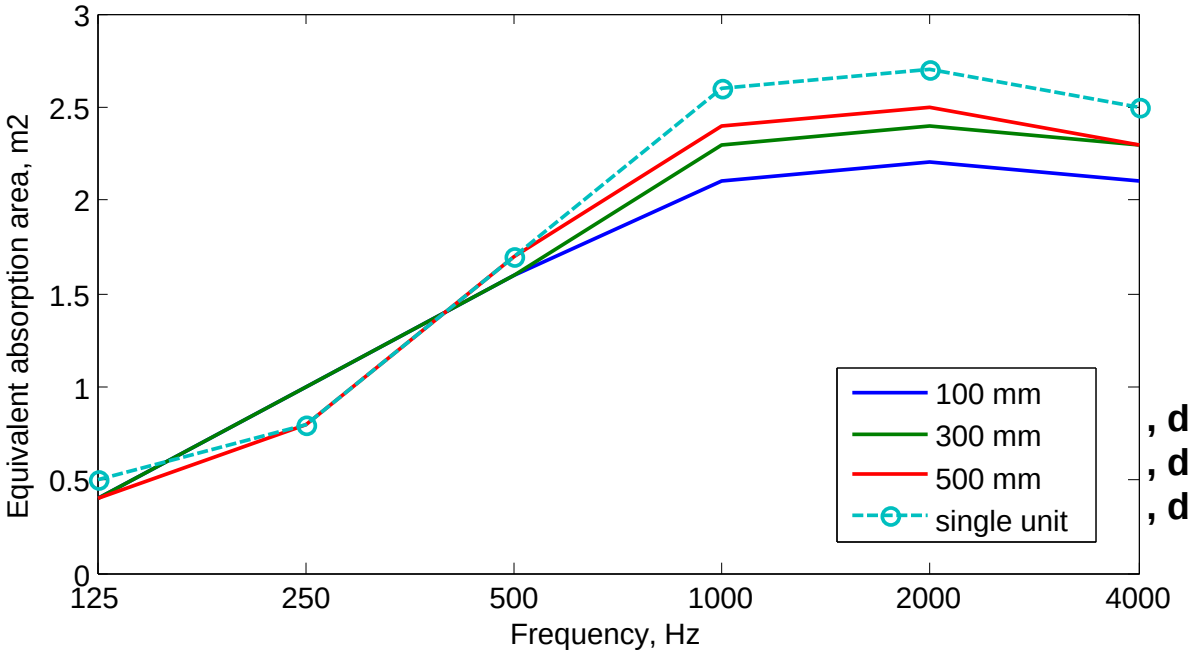
A (m^2)

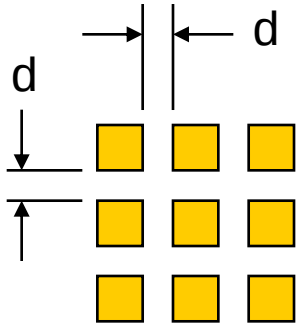
Master Solo S (1200x1200), single unit for various o.d.s.



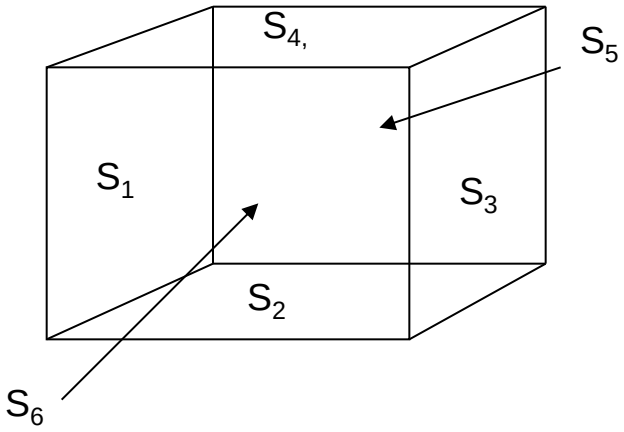
Master Solo S, array with 9 panels 1200 x 1200,

- 600 mm o.d.s., for various distances d





Calculation of reverberation time



Sabine's formula:

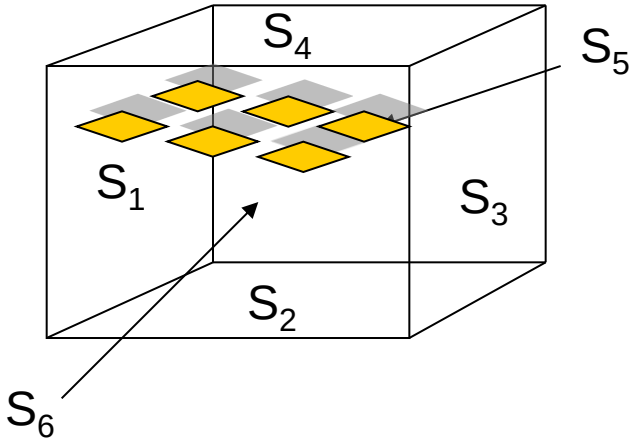
T = 0.16·V/A

V = volume, m^3

A = equivalent absorption area, m^2

$$A=\alpha_1 \cdot S_1 + \alpha_2 \cdot S_2 + \alpha_3 \cdot S_3 + \alpha_4 \cdot S_4 + \alpha_5 \cdot S_5 + \alpha_6 \cdot S_6$$

Calculation of reverberation time: FHU added



Sabine's formula:

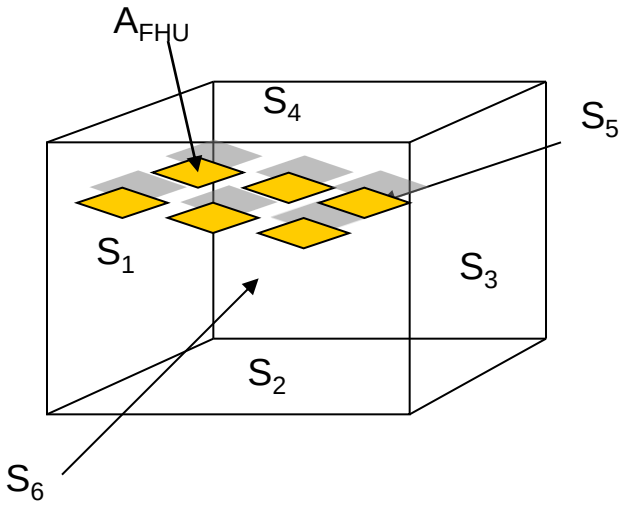
T = 0.16·V/A

V = volume, m^3

A = equivalent absorption area, m^2

$$A=\alpha_1 \cdot S_1 + \alpha_2 \cdot S_2 + \alpha_3 \cdot S_3 + \alpha_4 \cdot S_4 + \alpha_5 \cdot S_5 + \alpha_6 \cdot S_6 \quad \mathbf{+ 6 \cdot A_{FHU}}$$

Calculation of sound pressure level decrease with FHU



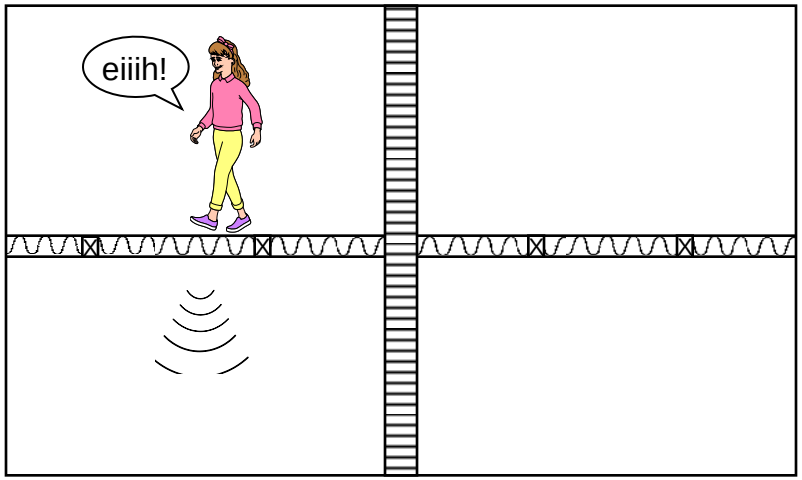
$$\Delta L = 10 \cdot \log\left(\frac{A_0 + A}{A_0}\right)$$

$A_0 = \alpha_1 \cdot S_1 + \alpha_2 \cdot S_2 + \alpha_3 \cdot S_3 + \alpha_4 \cdot S_4 + \alpha_5 \cdot S_5 + \alpha_6 \cdot S_6$

$A = 6 \cdot A_{FHU}$

Sound insulation

Different sound sources demands different sound insulation

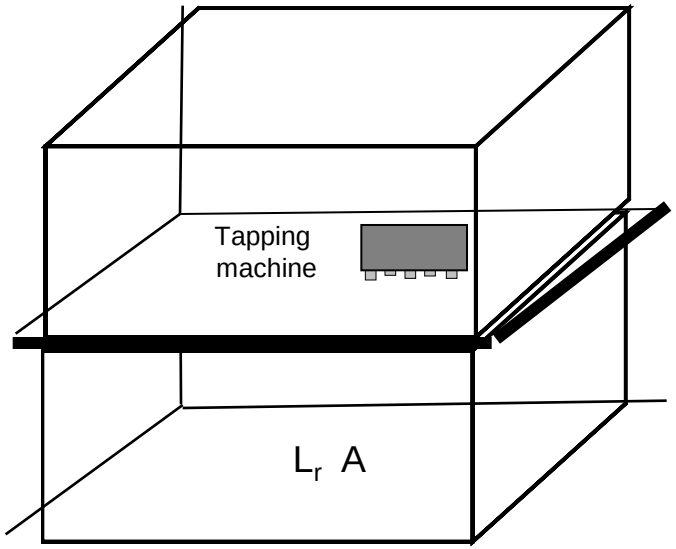


Sound sources spectral and temporal characteristics

- Speech
- Footstep
- Music
- Installation
- Traffic

Impact sound

- definition and measurement procedures



L_r: Sound pressure level receiving room
A: Equivalent absorption area

Impact sound transmission

$L_n = L_r + 10 \log (A/10)$ (dB)

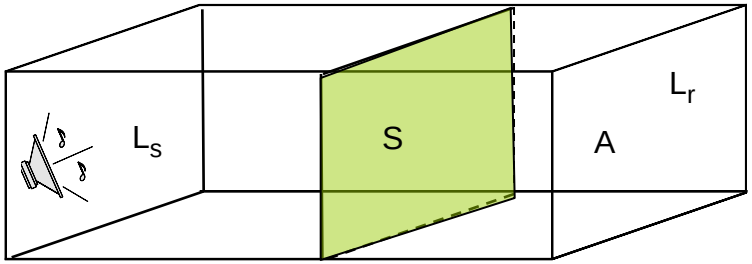
High L_n → high impact sound transmission

Low L_n → low impact sound transmission

L'_n denotes a field value

Tapping machine

Airborne sound, definition and measurement procedures



Sound reduction

$R = L_s - L_r - 10 \log(A/S)$ (dB)

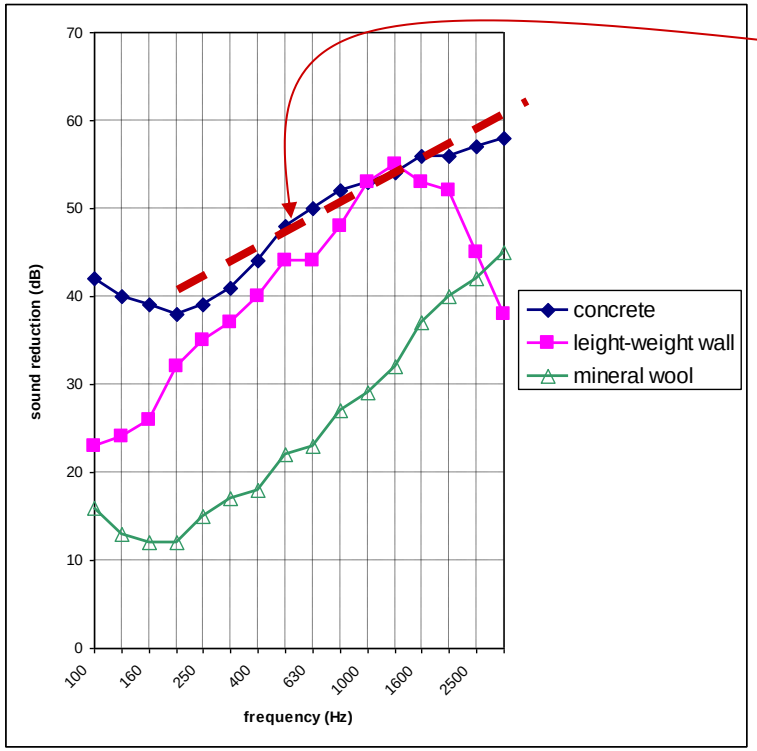
High R ⟶ High sound insulation

Low R ⟶ Low sound insulation

L_s: Sound pressure level sending room
L_r: Sound pressure level receiving room
A: Equivalent absorption area
S: Area separating wall

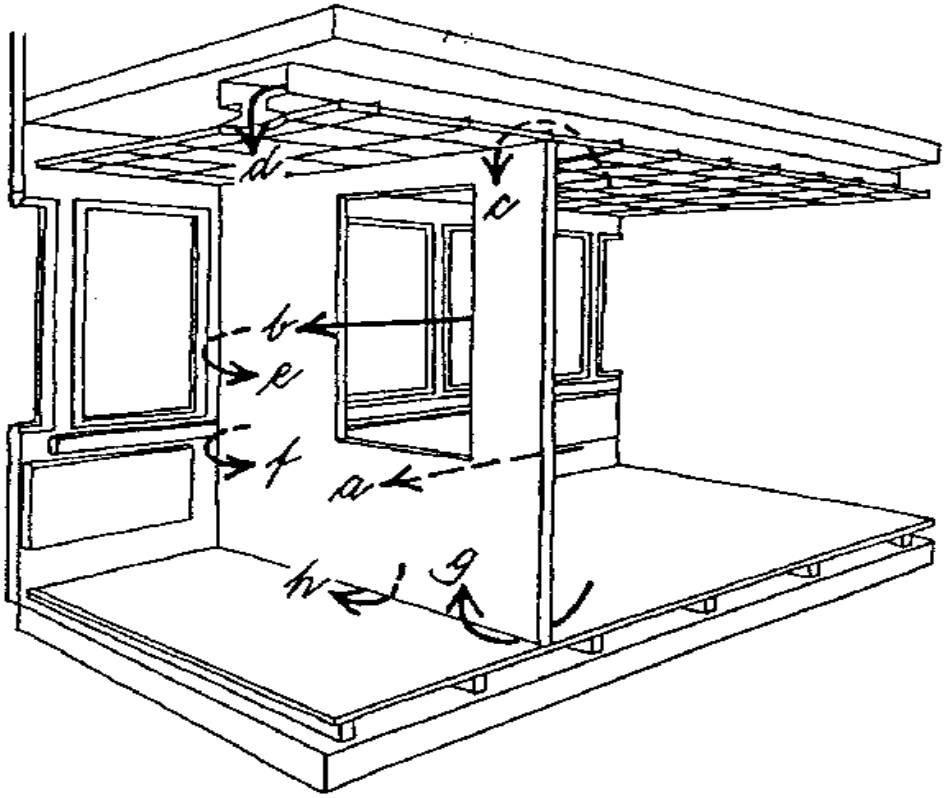
R' denotes a field value

Airborne sound insulation

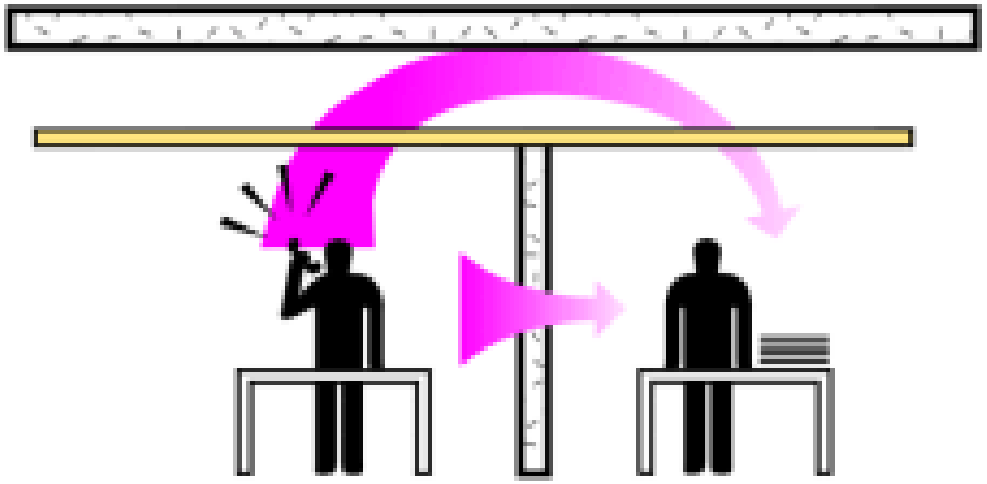


Mass law
6 dB/octave
Doubled weight leads to 6 dB increased insulation

Sound transmission paths

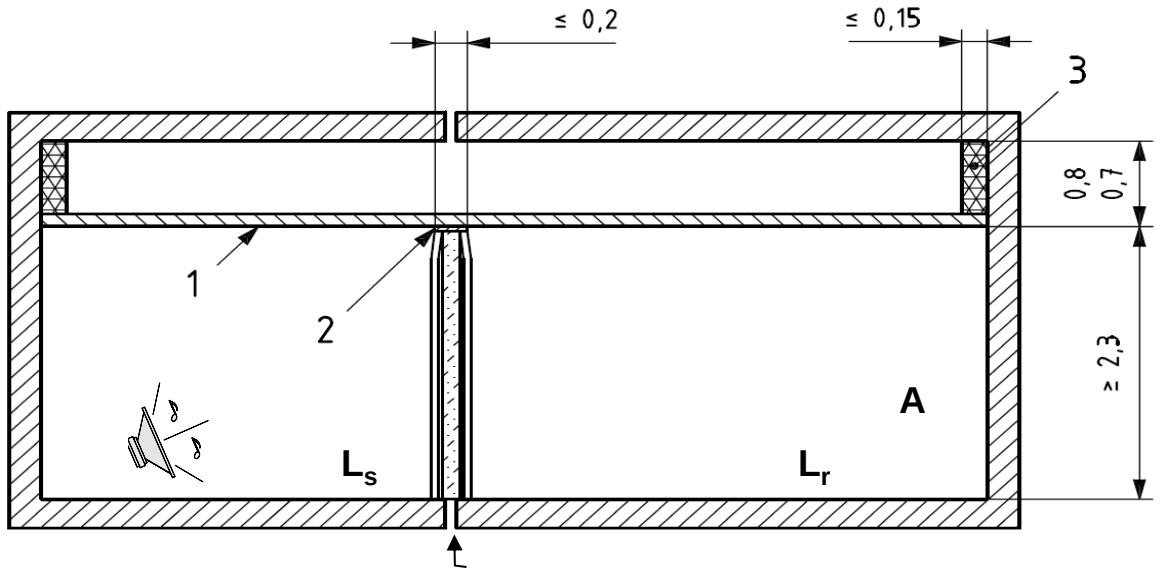


Room-to-room airborne sound insulation of a suspended ceiling with a plenum above



El ce

Definition and measurement procedure



1 suspended ceiling

2 flexible material

3 absorbing material

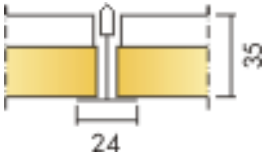
vibration break

$D_{n,f} = L_s - L_r - 10 \log(A/A_0)$ $A_0 = 10\ m^2$ (dB)

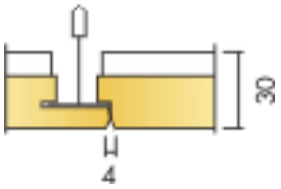
Ecophon Combison™

Sound insulation plus sound absorption

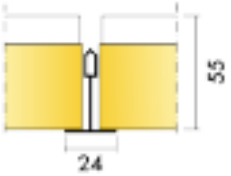
Combison Uno A



$D_{n,f,w}$ 40 dB

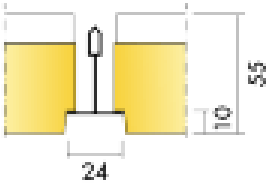


$D_{n,f,w}$ 42 dB



$D_{n,f,w}$ 41 dB

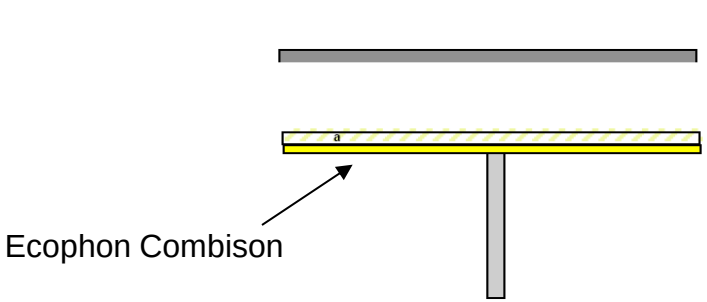
Combison Uno D



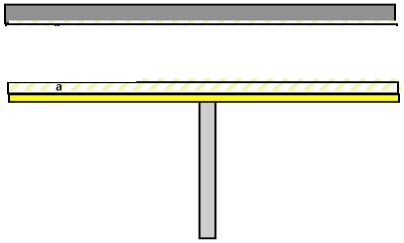
$D_{n,f,w}$ 40 dB

The effect of additional absorbers

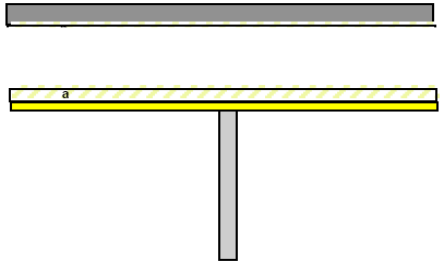
Example: Increase in sound reduction in laboratory



Combison XR 600 mm on each side of the partition

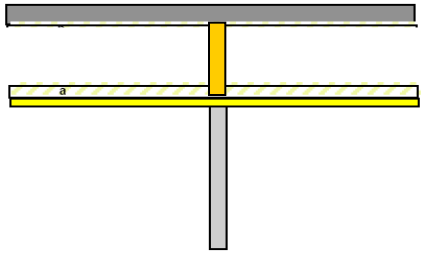


about 3 dB



about 6 dB

Combison XR all over the suspended ceiling

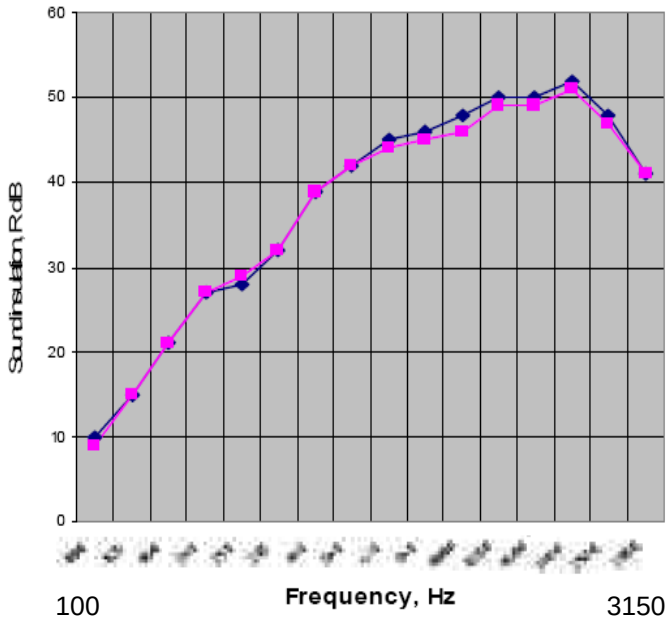


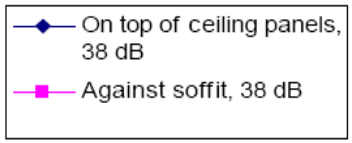
about 6-12 dB

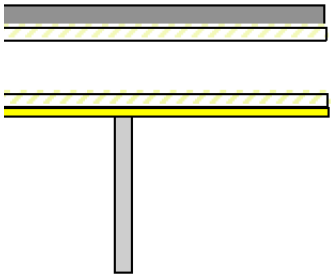
Combison Barrier over the partition

How does the location of the absorbers influence sound insulation?

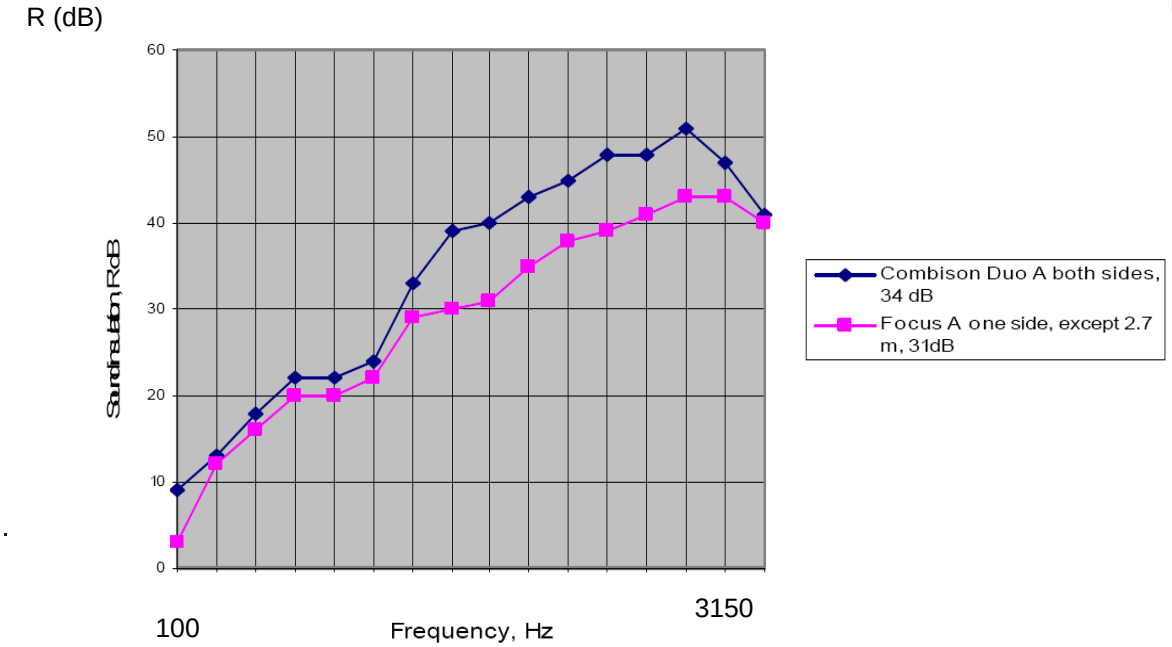
R (dB)

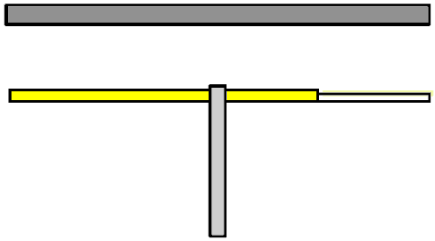




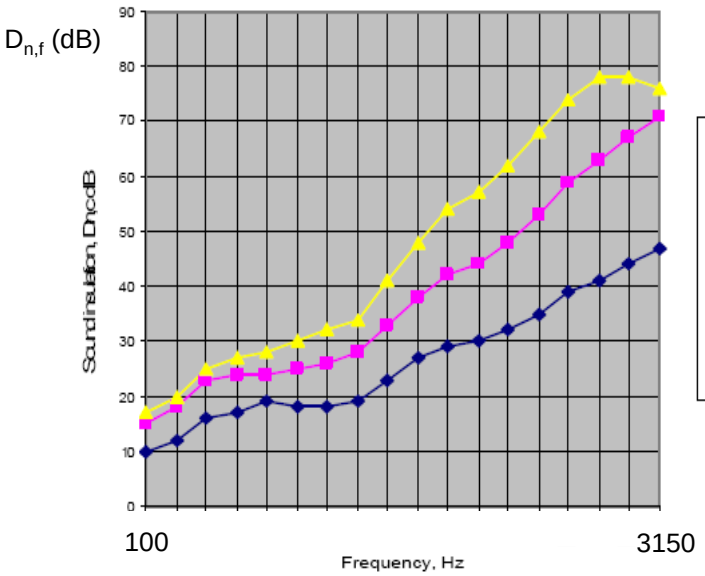


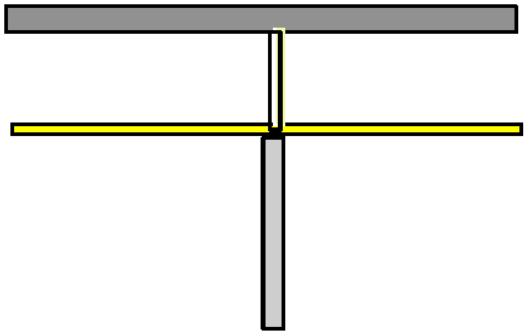
What happens when different panels are mixed in a ceiling?





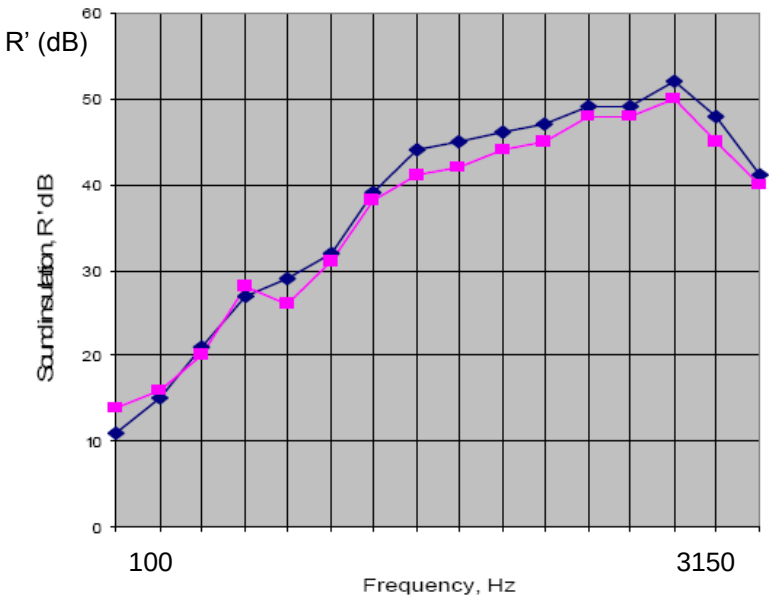
The effect of barriers

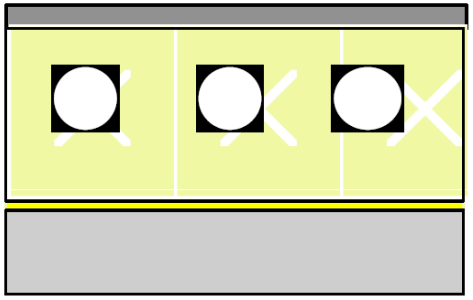




Influence of ducts and gaps

15% openings in the barrier showed a reduction of sound insulation by 1 dB for a $D_{n,f,w}$ = 40 dB





Combison Barrier only, 38 dB

Barrier w ith 3 ducts and 6.5 % gaps, 38 dB