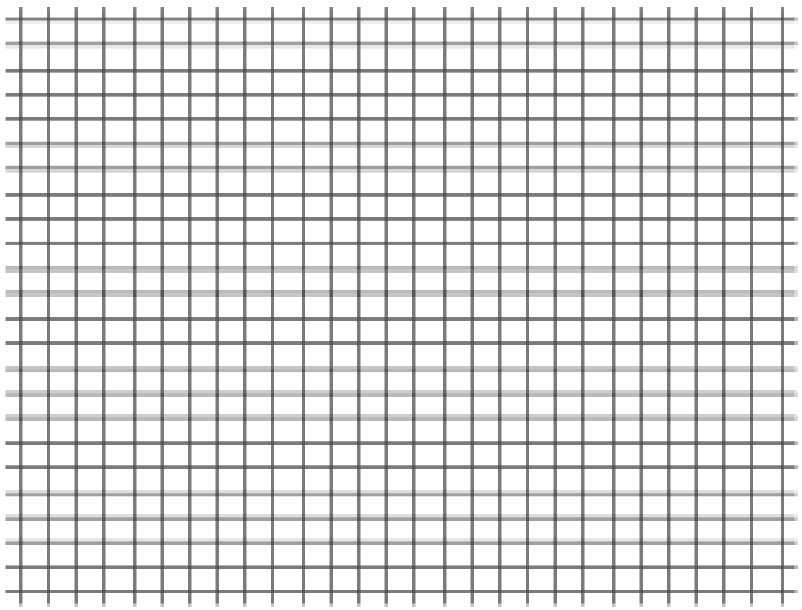
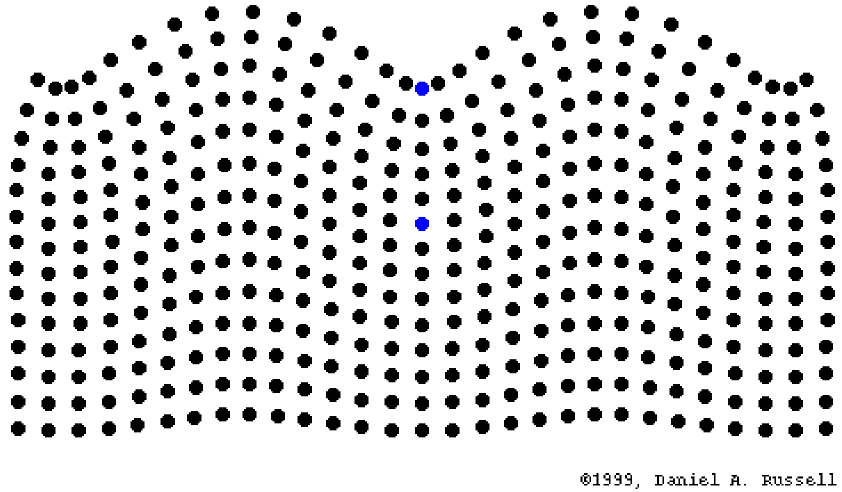
بسمه تعالی

کنترل صدا

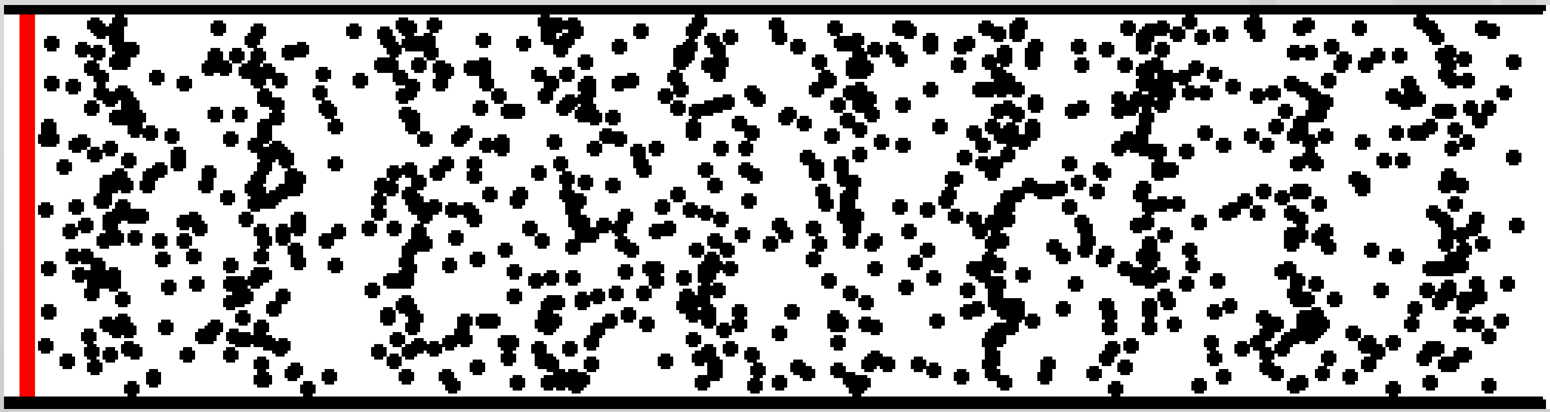
روح اله حاجی زاده

مقدمه





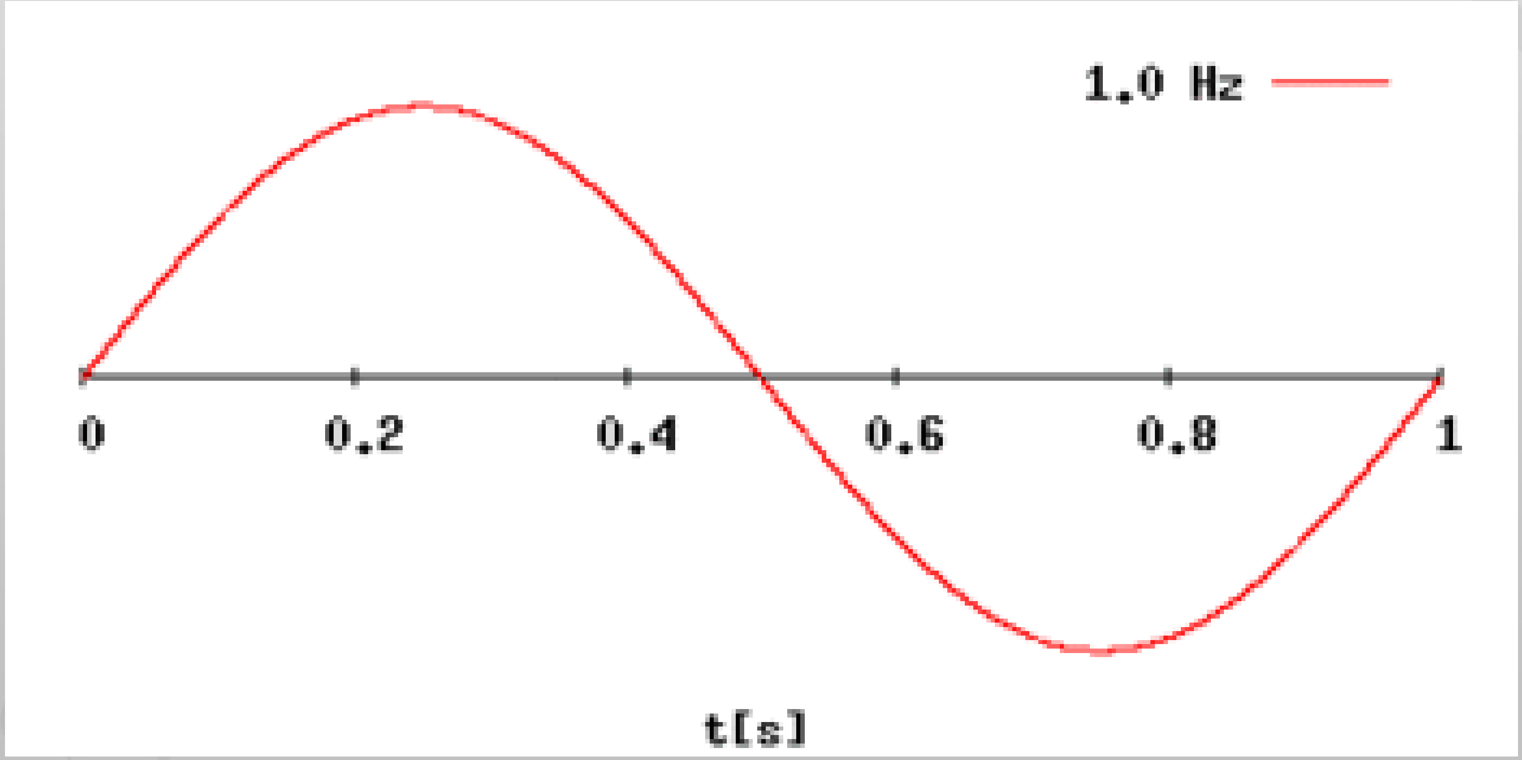
موج طولی

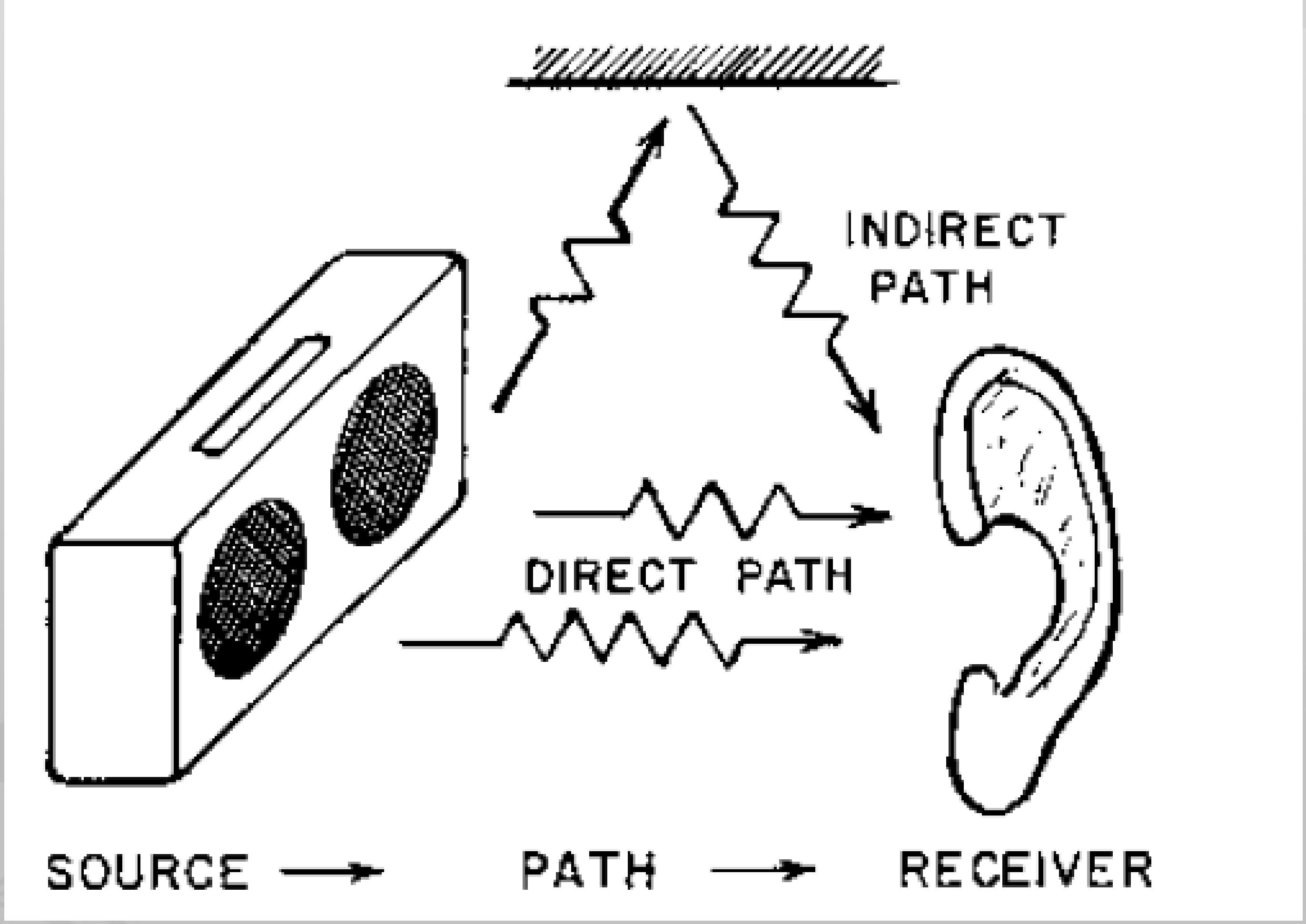


مشخصه های موج صوتی

- فرکانس
- دوره یا تناوب(period)
- طول موج(wavelength)
- دامنه(amplitude)

مقایسه فرکانس پایین و بالا




INDIRECT
PATH
DIRECT PATH
SOURCE
PATH
RECEIVER

PRINCIPLES OF NOISE CONTROL

1. The source of the sound
2. The path through which the sound travels
3. The receiver of the sound

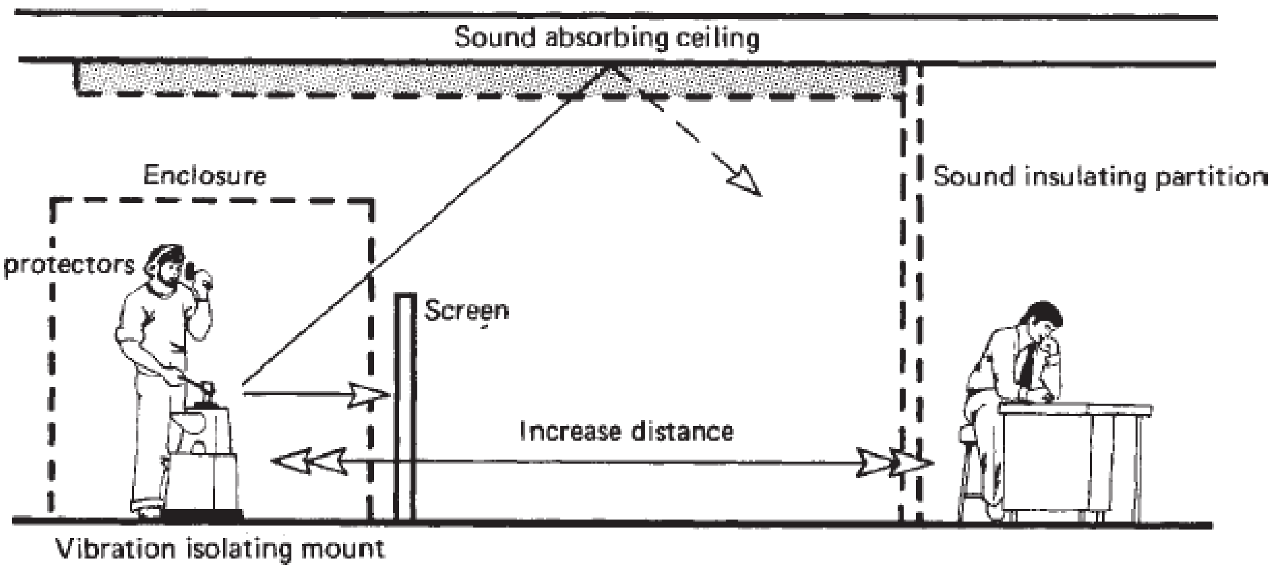


Figure 3. Typical noise control procedures

Noise Control at the Source

- ✓ انتخاب صحیح دستگاه
- ✓ نصب کاهش دهنده های صدا
- ✓ تغییر در اجزاء و کار دستگاه
- ✓ محصورسازی

Noise Control in the Transmission Path

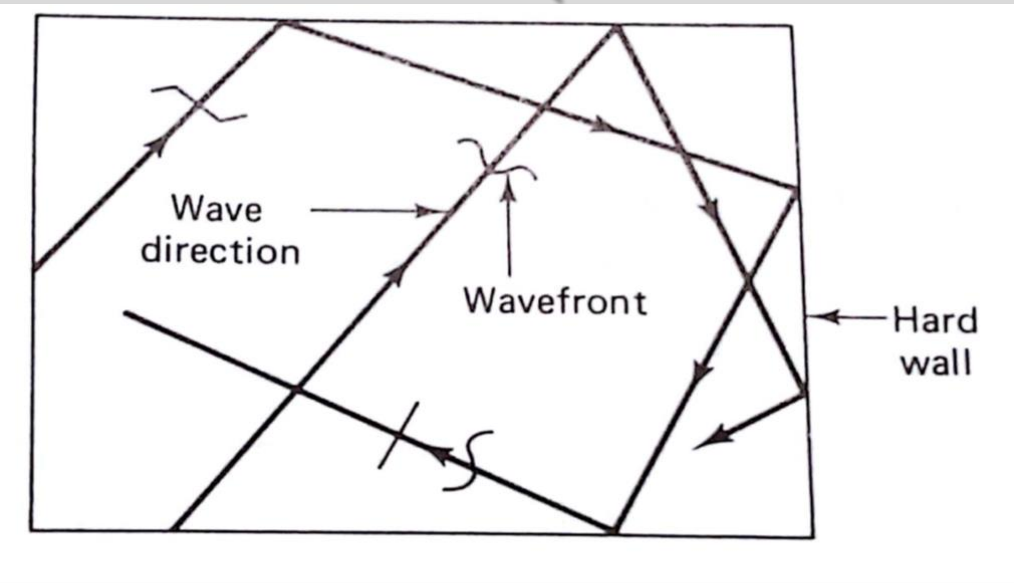
۱:جاذب های صوت
۲:جدا کردن منابع پر صدا
۳:جداسازی بخش های پرصدا از سایر بخش ها
۴:عایق های صوتی
۵: کنترل فعال صدا

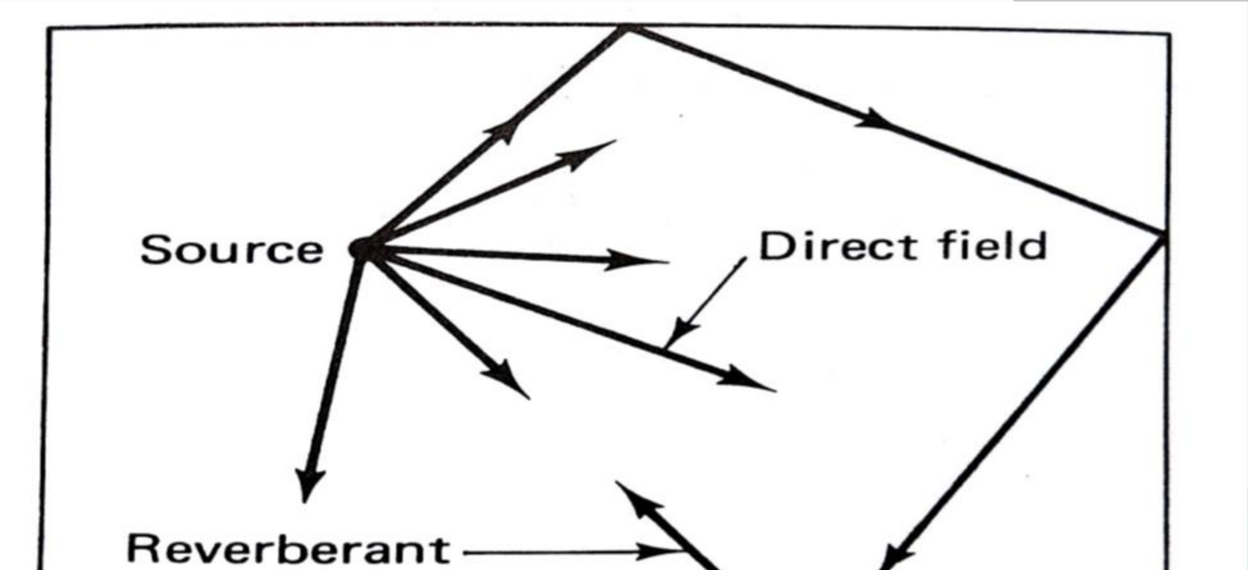
Noise Control at the Receiver

تفاوت جاذب و عایق صوتی؟

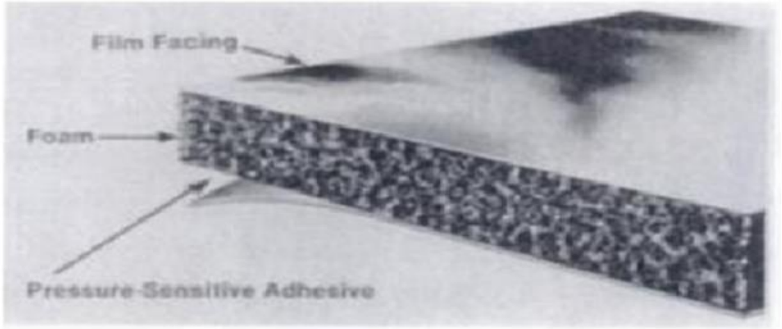
شما صدای من را چند بار می شنوید؟

SOUND-ABSORBING (مواد جاذب صدا) MATERIALS

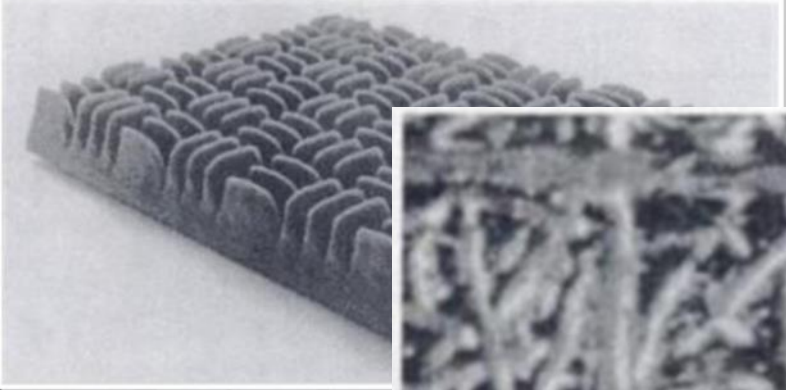


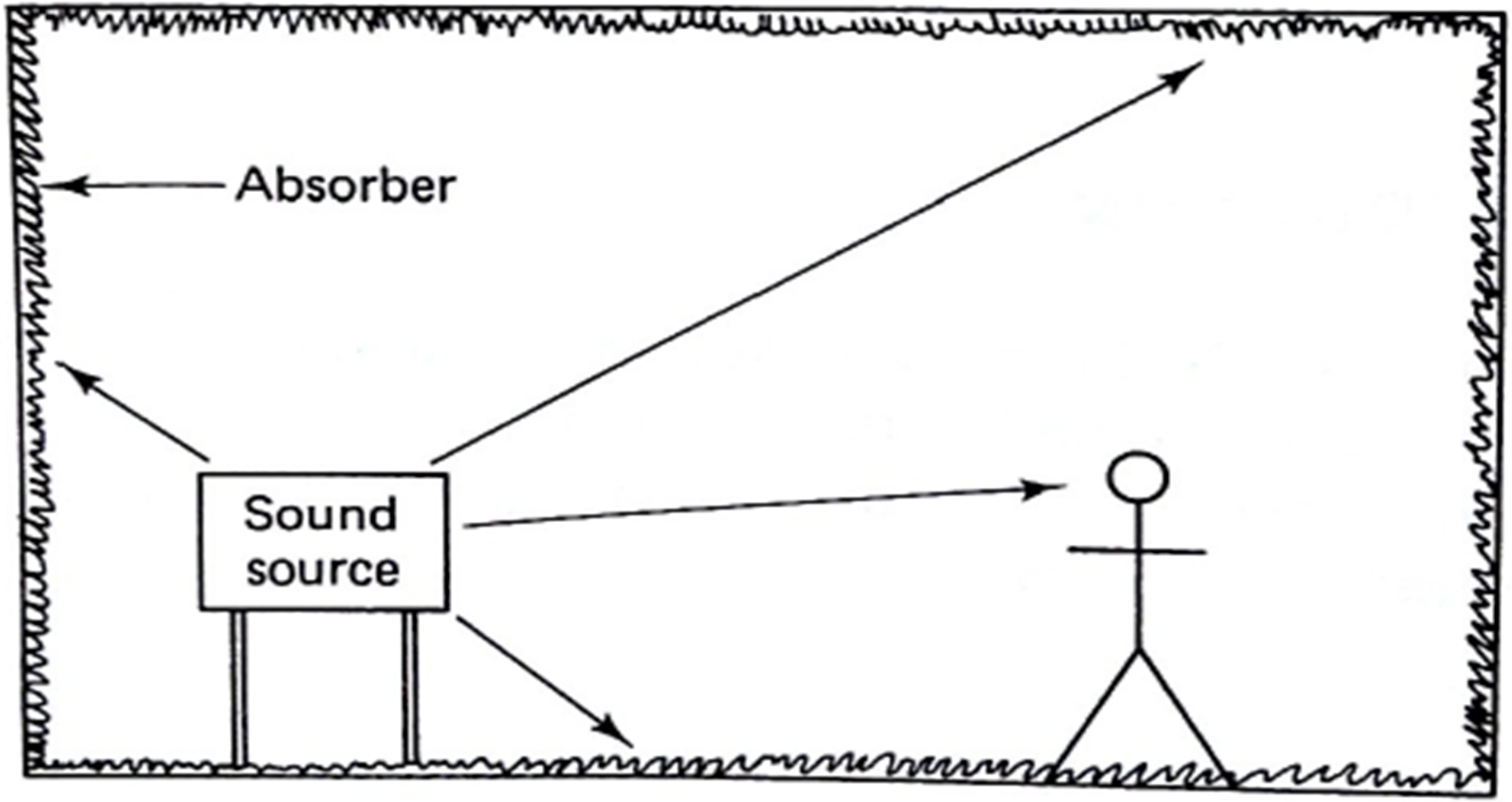


مواد جاذب صدا (SOUND-ABSORBING MATERIALS)



(a)




Absorber
Sound source

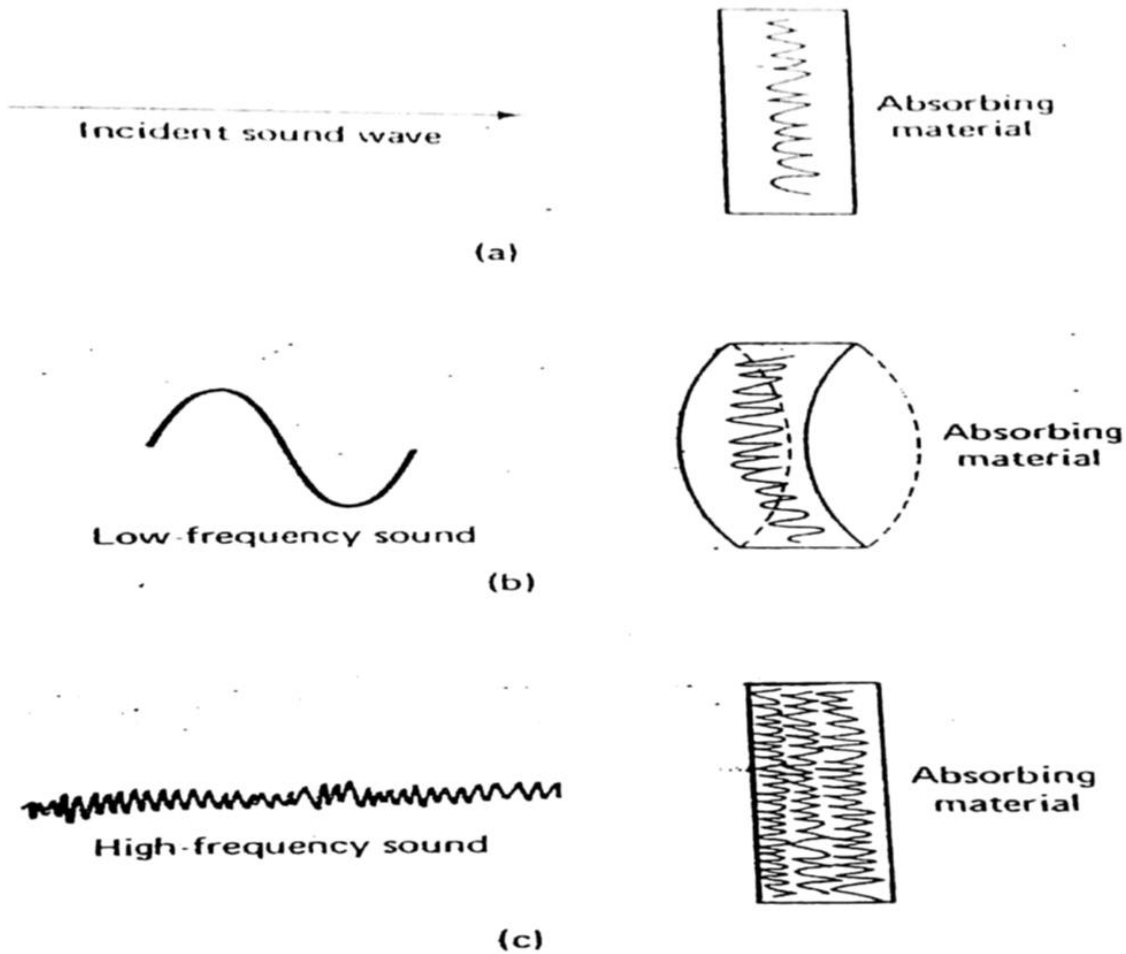


FIGURE 8.2 *Material performance as a function of incident sound wave frequency: (a) experimental configuration (material unexcited); (b) exaggerated motion of the material due to low-frequency excitation; (c) high-frequency excitation*

نحوه ارزیابی جاذب های سطحی

۱:ویژگی های ثابت اتاق
۲:زمان بازآوایی
۳:سطح موثر جاذب

نحوه بکارگیری جاذب های سطحی با استفاده از ویژگی های ثابت اتاق

$$R = \frac{S\bar{\alpha}}{1-\bar{\alpha}}$$

This expression may be converted to "level" form by taking $\log_{10}$ of both sides and multiplying through by 10:

$$L_p = L_W + 10\log_{10}\left(\frac{4}{R} + \frac{Q}{4\pi r^2}\right) + 10\log_{10}\left(\frac{\rho_o c W_{ref}}{p_{ref}^2}\right) \qquad (7\text{-}17)$$

↑ [reverberant sound field] ↑ [direct sound field]

As discussed in Sec. 5.1, the value of the last term in Eq. (7-17) for air at 101.3 kPa and 300K is 0.1 dB. The final form for the expression for the steady-state sound pressure level in a room may be written as follows:

$$L_p = L_W + 10\log_{10}\left(\frac{4}{R} + \frac{Q}{4\pi r^2}\right) + 0.1 \qquad (7\text{-}18)$$

افزایش سطح

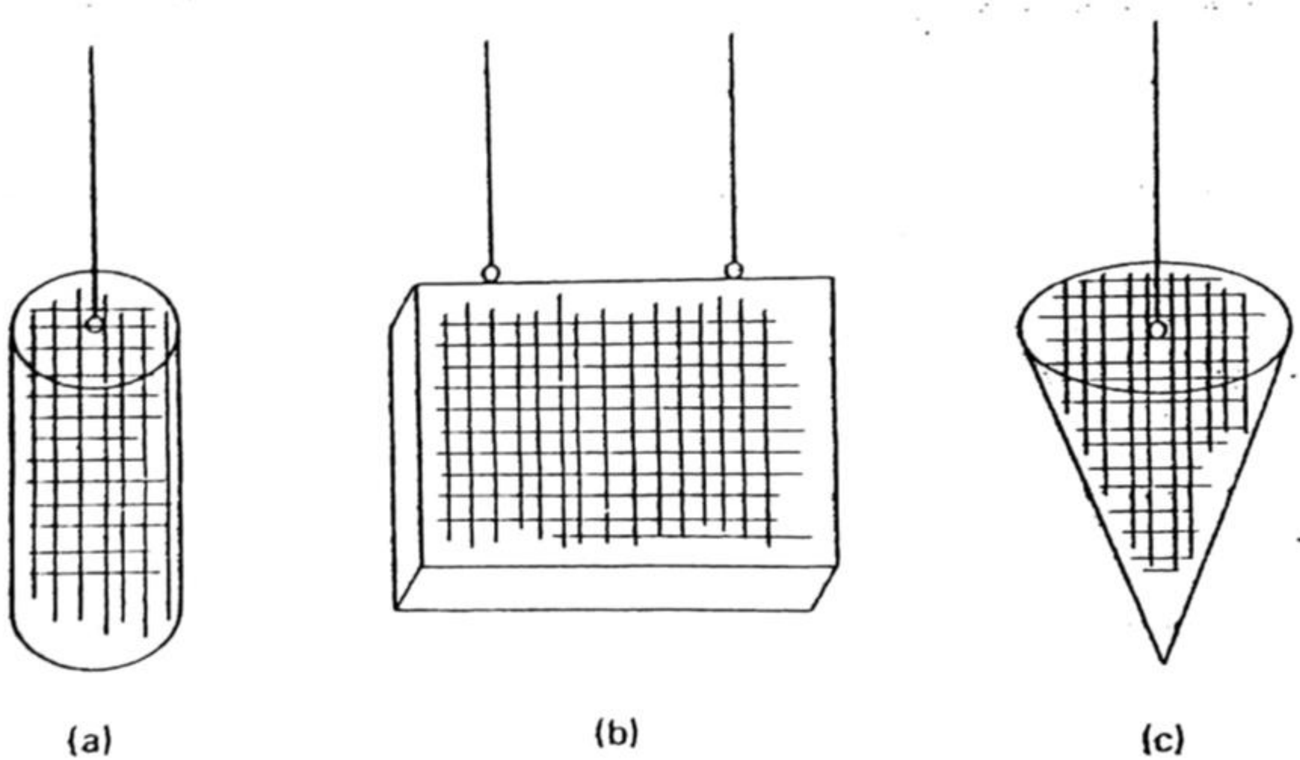
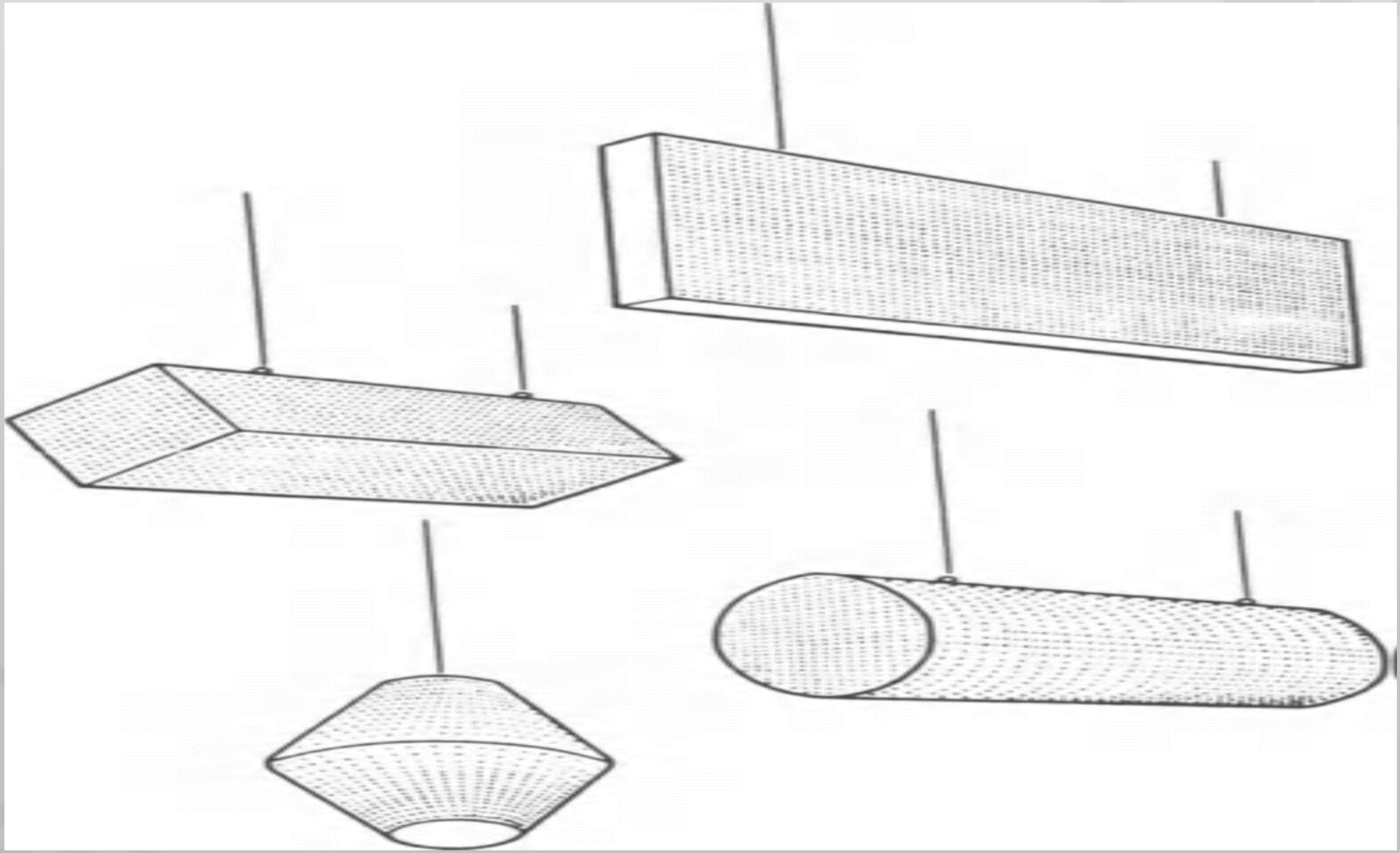


FIGURE 8.4 *Some typical space absorbers*



مینه سوتا

نحوه بکارگیری جاذب های سطحی با استفاده از زمان بازآوایی

$$LP = LW - 10\log V + 10\log T + 14$$

$$T_{60} = \frac{0.049V}{A} \quad [s] \qquad (9.2)$$

where

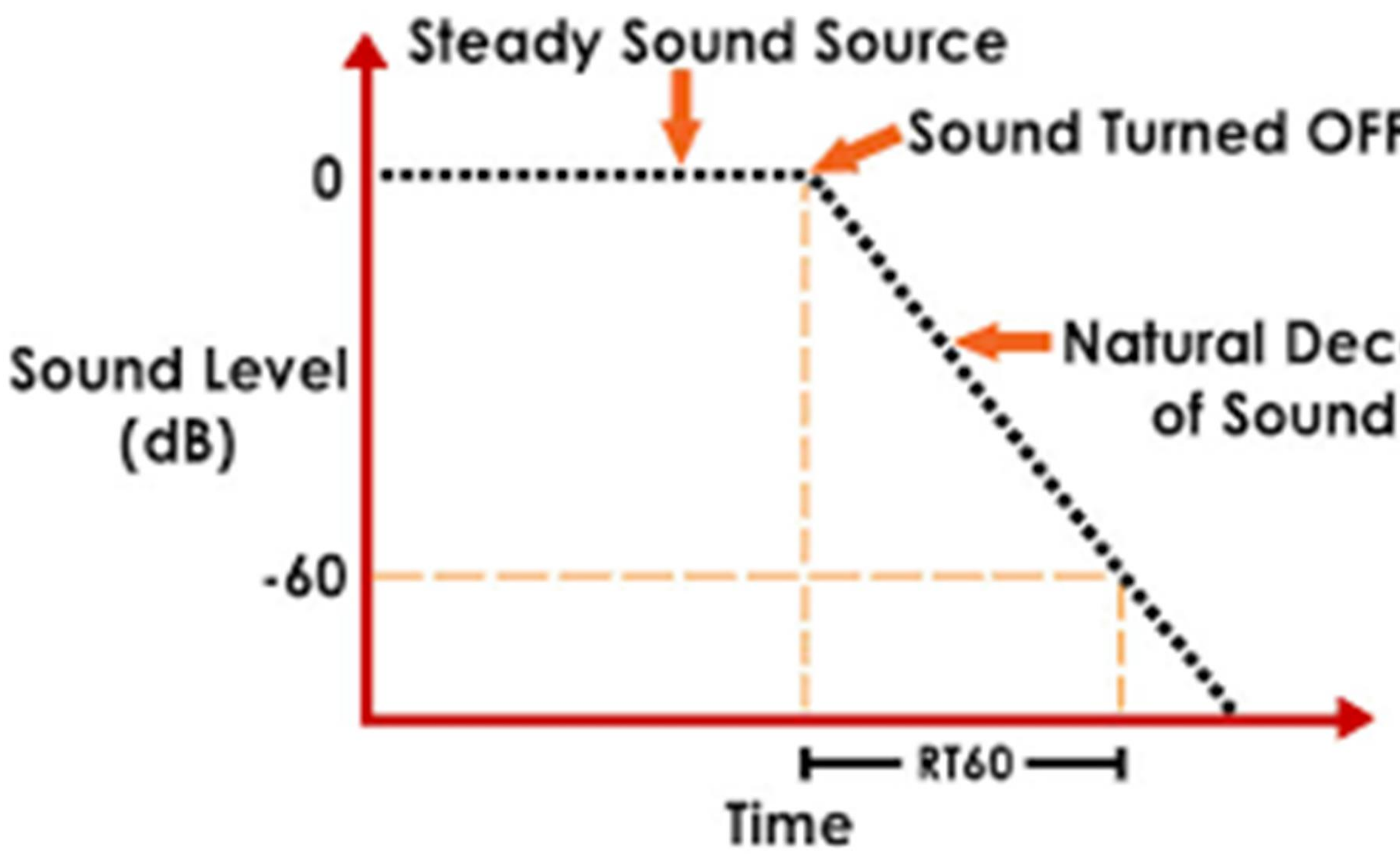
V = room volume (ft^3 or m^3)

A = total room absorption (ft^2 or m^2)

or, in metric units,

$$T = \frac{0.161V}{A} \quad [s] \qquad (9.3)$$

reverberation time



چرا زمان بازآوایی اهمیت بیشتری در نحوه ارزیابی عملکرد آکوستیک دارد؟

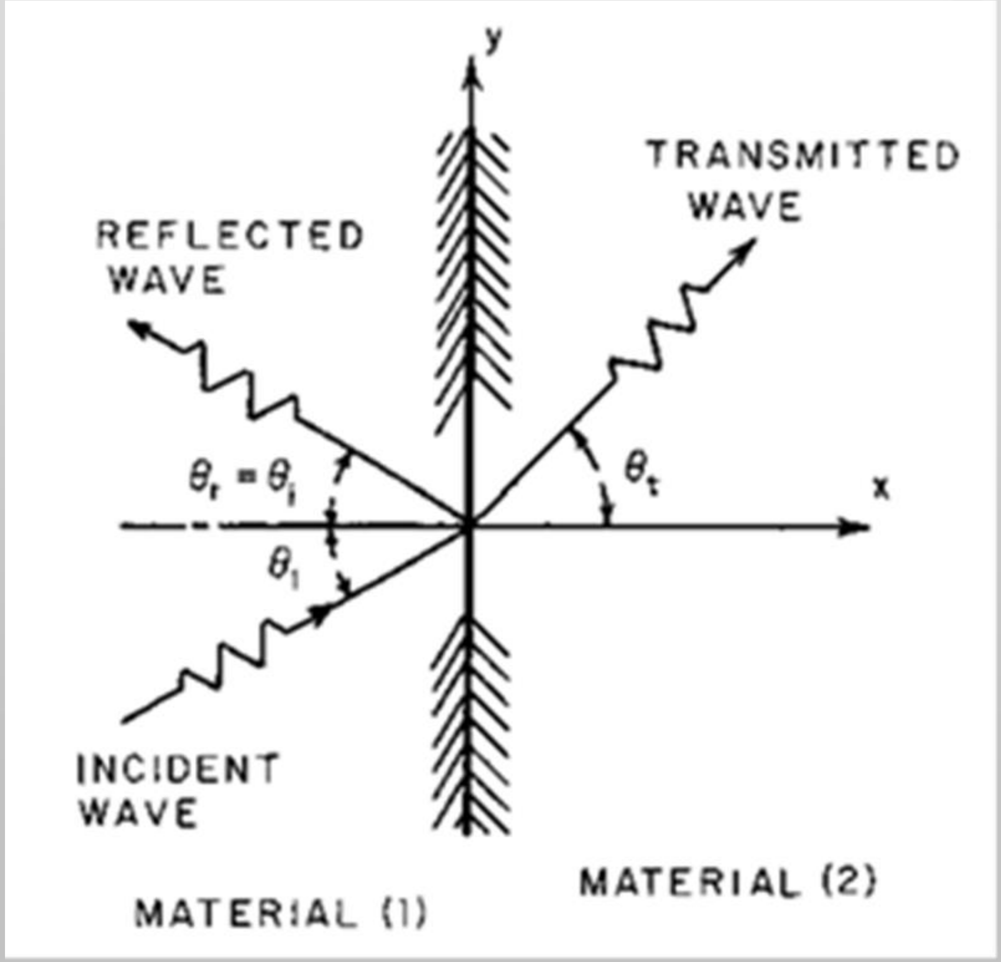
میانگین زمان بازآوایی در محیط های مختلف

نوع فضا	میانگین زمان بازآوایی به ثانیه در فرکانس های ۵۰۰، ۱۰۰۰، ۲۰۰۰
ساختمان های مسکونی	۱/۵ ثانیه
اتاق مهمان	۰/۸
سالن انتظار	۱
راهروها	۱/۲
آزمایشگاه ها	۱/۲
کلاس درس نظری در شرایط خالی	۱
راهرو، راه پله، کارگاه ها	۱/۵
اتاق های بخش بستری، مراقبت های ویژه، جراحی، اتاق زایمان	۱/۲
اتاقهاي اداري، مراكز كامپيوتري، سالن عمومي بانكها	۱/۲

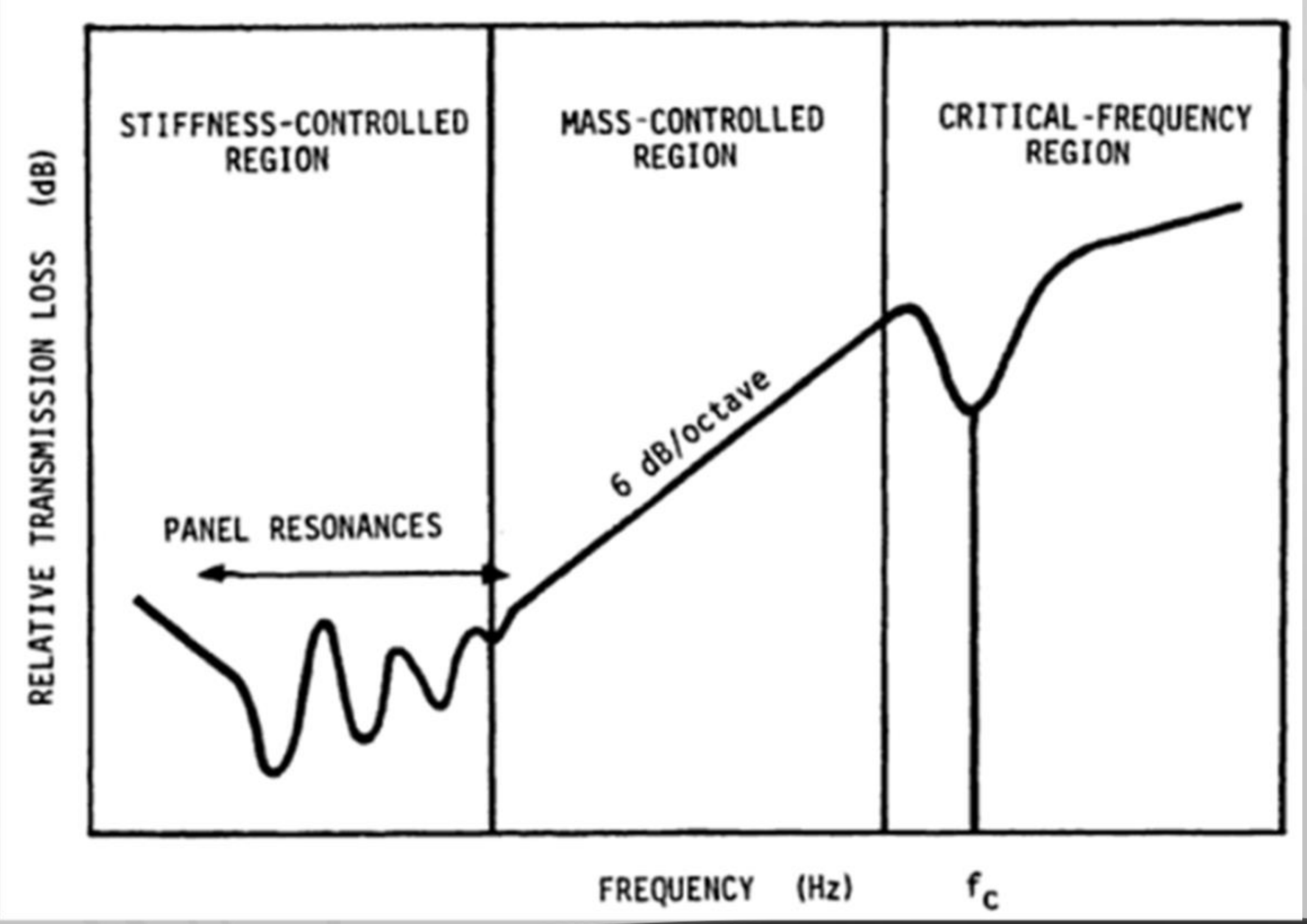
نحوه به کارگیری جاذب های سطحی با استفاده از نسبت سطح موثر جاذب

$$\Delta L_P = 10\log\left[1 + \frac{S\,\overline{\alpha_a}}{S\,\overline{\alpha_i}}\right]$$

عایق های صوتی



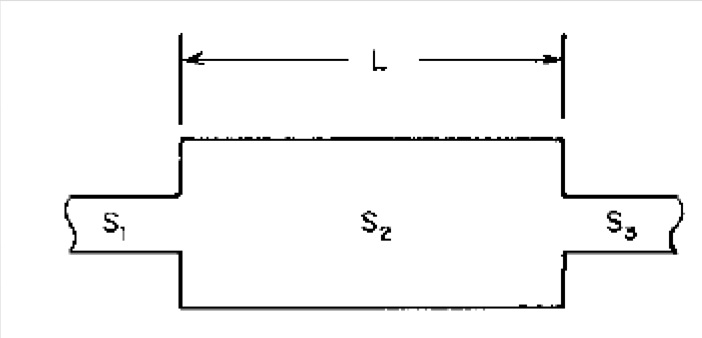
عایق های صوتی



Silencer

- EXPANSION CHAMBER MUFFLERS
- DISSIPATIVE MUFFLERS

EXPANSION CHAMBER MUFFLERS



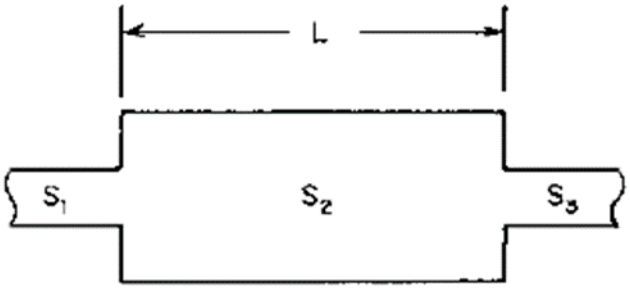
$$Z_1/Z_3 = Z_{A1}/Z_{A3} = S_3/S_1 \equiv \nu$$

$$Z_1/Z_2 = Z_{A1}/Z_{A2} = S_2/S_1 \equiv m$$

$$\frac{Z_2}{Z_3} = \frac{Z_{A2}}{Z_{A3}} = \frac{S_3}{S_2} = \frac{S_3/S_1}{S_2/S_1} = \frac{\nu}{m}$$

$$\frac{1}{a_t} = \frac{(1+\nu)^2 + [(m-\nu/m)^2 - (1-\nu)^2]\sin^2(kL)}{4\nu}$$

$$TL = 10\log\frac{1}{a_t}$$



$$Z_1/Z_3 = Z_{A1}/Z_{A3} = S_3/S_1 \equiv \nu$$

$$Z_1/Z_2 = Z_{A1}/Z_{A2} = S_2/S_1 \equiv m$$

$$\frac{Z_2}{Z_3} = \frac{Z_{A2}}{Z_{A3}} = \frac{S_3}{S_2} = \frac{S_3/S_1}{S_2/S_1} = \frac{\nu}{m}$$

For the special case in which the inlet tube and the outlet tube have the same cross-sectional area, $\nu = S_3/S_1 = 1$, Eq. (8-128) reduces to the following expression:

$$1/a_t = 1 + \tfrac{1}{4}(m - 1/m)^2 \sin^2(kL) \qquad (8\text{-}129)$$

The transmission loss obtained from Eq. (8-129) is plotted in Fig. 8-15.

It is noted from Eq. (8-128) that the transmission loss is a maximum for the frequencies corresponding to the following condition:

$$kL = \frac{2\pi f_o L}{c} = (n - \tfrac{1}{2})\pi \qquad (n = 1, 2, 3, \ldots) \qquad (8\text{-}130)$$

$$f_o = \frac{(n - \frac{1}{2})c}{2L} \qquad (n = 1, 2, 3, \ldots) \qquad\qquad L = \frac{(n - \frac{1}{2})c}{2f_o} \qquad (n = 1, 2, 3, \ldots)$$

For the special case of $\nu = 1$, the maximum transmission loss expression is as follows:

$$(1/a_t)_{max} = 1 + \tfrac{1}{4}(m - 1/m)^2 \qquad (8\text{-}133)$$

We also observe that the transmission loss is a minimum for the frequencies corresponding to the following condition:

$$kL = n\pi \qquad (n = 1, 2, 3, \ldots) \qquad (8\text{-}134)$$

$$f_p = \frac{nc}{2L} \qquad (n = 1, 2, 3, \ldots) \qquad (8\text{-}135)$$

The minimum transmission loss expression is as follows:

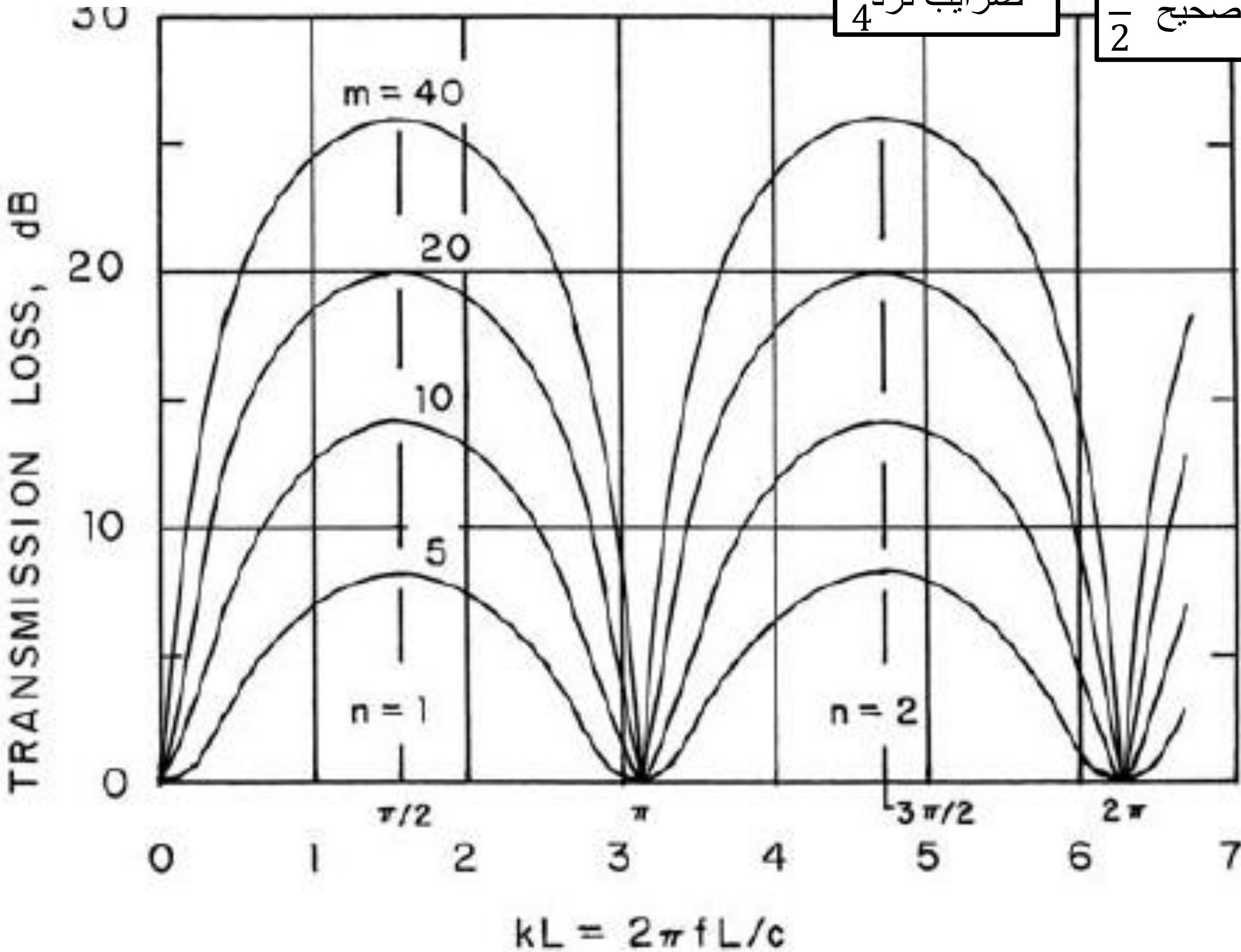
$$\left(\frac{1}{a_t}\right)_{min} = \frac{(1 + \nu)^2}{4\nu} \qquad (8\text{-}136)$$

For the special case of $\nu = 1$, $(1/a_t)_{min} = 1$ and $TL_{min} = 0$ dB.

$$Z_1/Z_2 = Z_{A1}/Z_{A2} = S_2/S_1 \equiv m$$

ضرایب فرد $\frac{\lambda}{4}$

ضرایب صحیح $\frac{\lambda}{2}$



8.5.2 Design Procedure for Single-Expansion Chamber Mufflers

If the same parameters are given or known as in the case of the side-branch muffler design given in Sec. 8.4.2, we may develop a similar design procedure for the expansion chamber muffler with a single expansion volume.

D1. The resonant frequency (or center frequency) for the optimum expansion chamber muffler is the arithmetic average of the low and high operational frequencies, f_1 and f_2, of the muffler:

$$f_o = \tfrac{1}{2}(f_1 + f_2) \tag{8-137}$$

D2. The optimum length of the expansion chamber corresponds to the situation in which the transmission loss is maximized at the center or resonant frequency, as given by Eq. (8-131):

$$L = \frac{(n - \frac{1}{2})c}{2f_o} \qquad (n = 1, 2, 3, \ldots) \tag{8-138}$$

D3. The value of the integer n may be estimated by satisfying the following condition:

$$k_2 L - k_1 L \approx \tfrac{1}{2}\pi \tag{8-139}$$

If we substitute for the expansion chamber length from Eq. (8-138), the following expression is obtained for the approximate value of the integer n:

$$n \approx \tfrac{1}{2} + \frac{f_o}{2(f_2 - f_1)} \tag{8-140}$$

تعیین طول بهینه مافلر انبساطی

$$f_o = \frac{1}{2}(f_1 + f_2)$$

$$L = \frac{(n - \frac{1}{2})c}{2f_o} \qquad (n = 1, 2, 3, \ldots)$$

Example 8-8. A cylindrical air conditioning duct has a diameter of 250 mm (9.84 in). The fluid flowing in the duct is air at 10°C (50°F) and 105 kPa (15.23 psia), for which the sonic velocity $c = 337.3$ m/s (1107 ft/sec) and the density $\rho_o = 1.292\ \text{kg/m}^3$ ($0.0807\ \text{lb}_m/\text{ft}^3$). It is desired to design a single expansion chamber muffler that has a minimum transmission loss of 6 dB for the frequency range between 177 Hz and 354 Hz.

The center frequency for the muffler may be determined from Eq. (8-137):

$$f_o = \tfrac{1}{2}(f_1 + f_2)$$

$$f_o = \tfrac{1}{2}(177 + 354) = 265.5\ \text{Hz}$$

The estimated value of the integer n may be found from Eq. (8-140):

$$n \approx \tfrac{1}{2} + \frac{f_o}{2(f_2 - f_1)}$$

$$n \approx \tfrac{1}{2} + \frac{(265.5)}{(2)(354 - 177)} = 1.25$$

We could possibly use either $n = 1$ or $n = 2$.

Let us check the results when using $n = 2$ first. The length of the muffler is found from Eq. (8-138):

$$L = \frac{(n - \frac{1}{2})c}{2f_o} \qquad (n = 1, 2, 3, \ldots)$$

$$L = \frac{(2 - \frac{1}{2})(337.3)}{(2)(265.5)} = 0.953\ \text{m}\ (37.5\ \text{in})$$

At the lower frequency (177 Hz) in the operational range for the muffler, we find the following value for $k_1 L = 2\pi f_1 L/c$:

$$kL = \frac{2\pi f_o L}{c} = (n - \tfrac{1}{2})\pi$$

$$k_1 L = \frac{(2\pi)(177)(0.953)}{(337.3)} = 3.1416\ \text{rad} = \pi\ \text{rad}$$

As shown by Eq. (8-134), the transmission loss for $\nu = 1$ and $kL = \pi$ is TL = 0, so the value of $n = 2$ cannot be used.

Let us try the other possibility, $n = 1$. The required muffler length is found from Eq. (8-138):

$$L = \frac{(n - \frac{1}{2})c}{2 f_o} \qquad (n = 1, 2, 3, \ldots)$$

$$L = \frac{(1 - \frac{1}{2})(337.3)}{(2)(265.5)} = 0.318\,\text{m} = 318\,\text{mm (12.50 in)}$$

$$kL = \frac{2\pi f_o L}{c} = (n - \tfrac{1}{2})\pi$$

For the lower frequency, f_1, we find the following value for the parameter $k_1 L$:

$$k_1 L = \frac{(2\pi)(177)(0.318)}{(337.3)} = 1.0472\,\text{rad} = \tfrac{1}{3}\pi\,\text{rad} = 60^\circ$$

The sound power transmission coefficient (or the reciprocal) at the lower frequency corresponds to the minimum design transmission loss:

$$\text{TL}_{\text{min}} = 6\,\text{dB} = 10\log_{10}(1/a_t)$$

$$1/a_t = 10^{0.60} = 3.981$$

The required size of the expansion chamber may be found from Eq. (8-129):

$$1/a_t = 3.981 = 1 + \tfrac{1}{4}(m - 1/m)^2 \sin^2(\pi/3)$$

$$Z_1/Z_2 = Z_{A1}/Z_{A2} = S_2/S_1 \equiv m$$

$$m - 1/m = \frac{(2)(\sqrt{2.981})}{\sin(60^\circ)} = 3.9874$$

$$m^2 - 3.9874m - 1 = 0$$

If we solve for the area ratio, we obtain the following value:

$$m = 1.9937 + [(1.9937)^2 + 1]^{1/2} = 4.224 = S_2/S_1 = (D_2/D_1)^2$$

The required expansion chamber diameter is as follows:

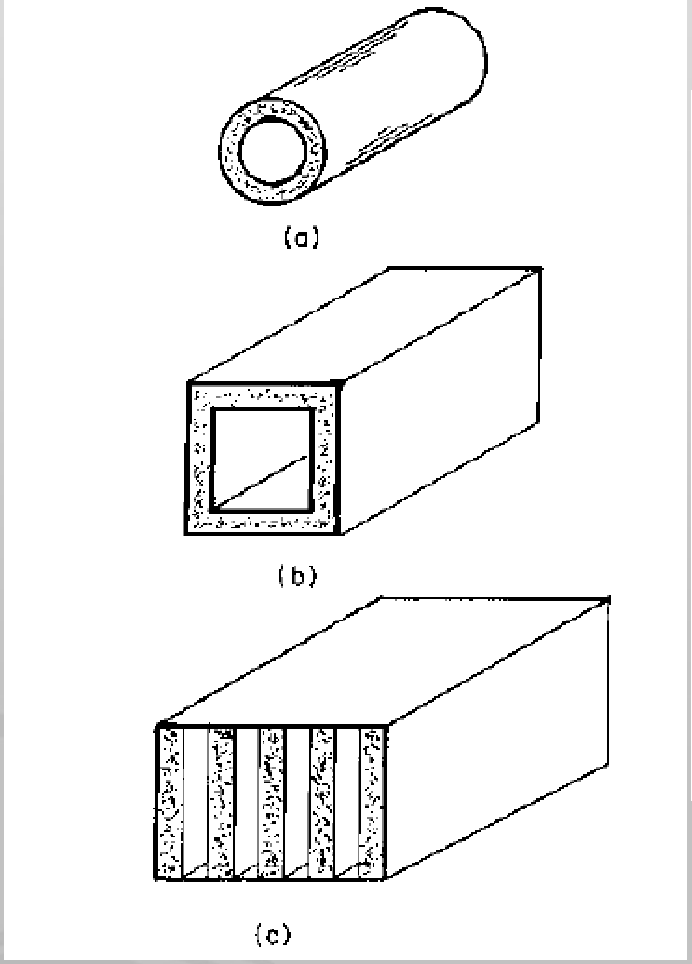
$$D_2 = (250)(4.224)^{1/2} = 514\,\text{mm (20.2 in)}$$

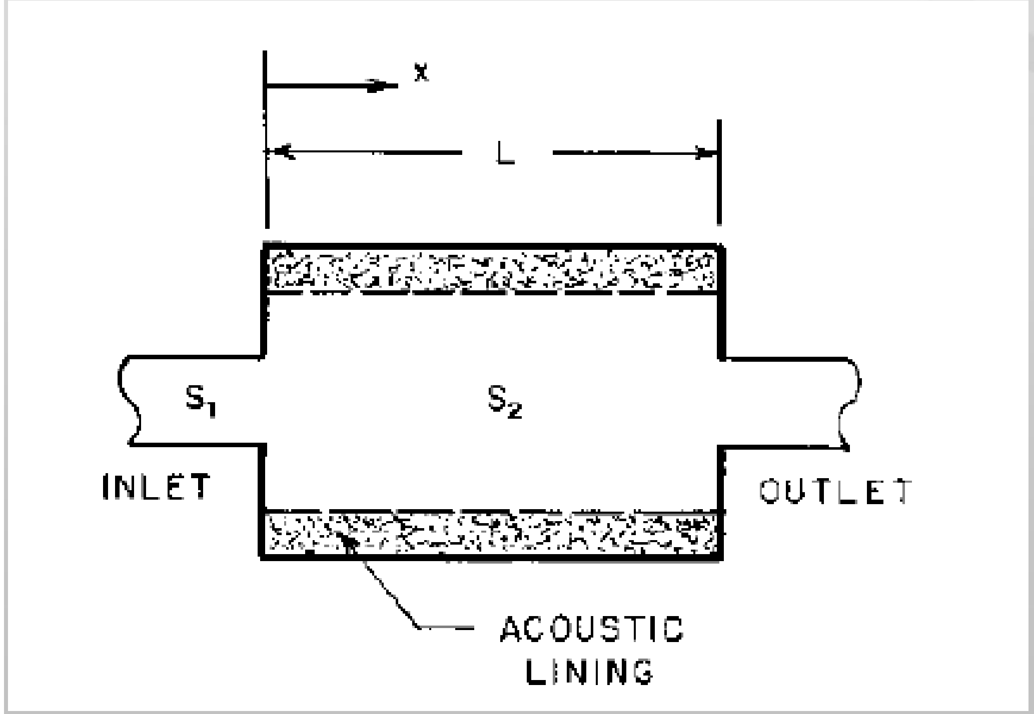
The maximum transmission loss for the muffler occurs at the center frequency, $f_o = 265.5$ Hz. The value is determined from Eq. (8-133):

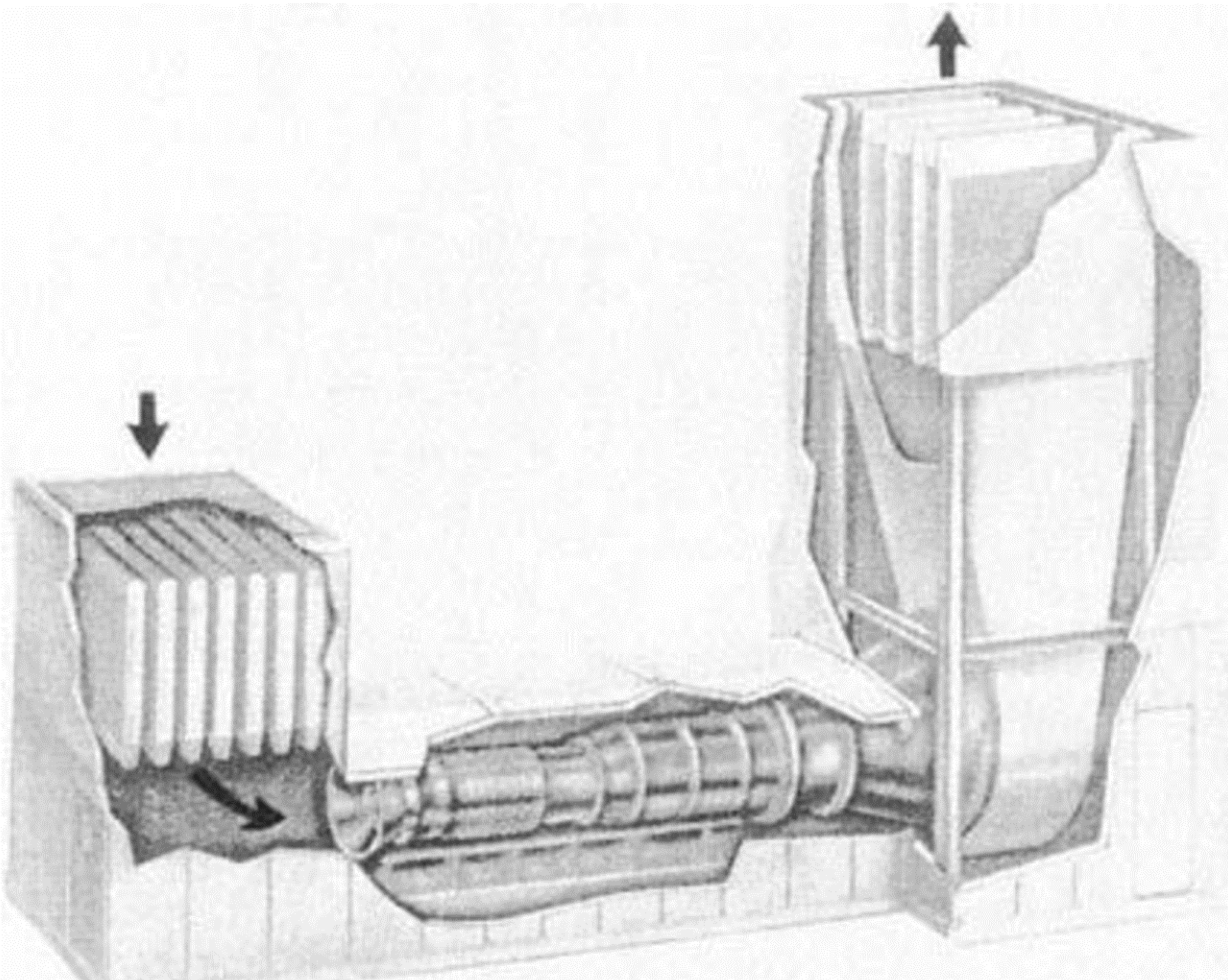
$$(1/a_t)_{\text{max}} = 1 + \tfrac{1}{4}[4.224 - (1/4.224)^2] = 4.975$$

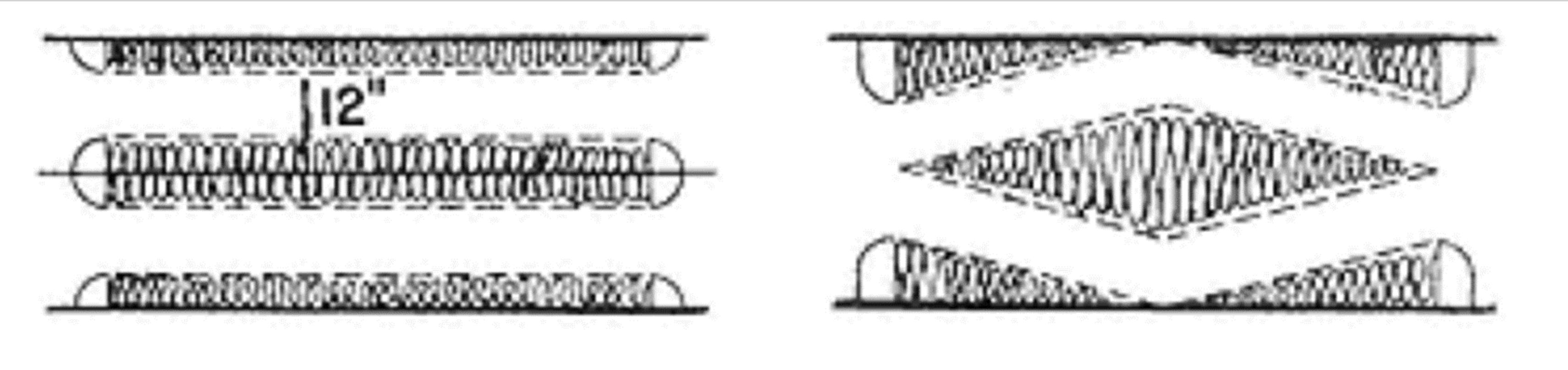
$$\text{TL}_{\text{max}} = 10\log_{10}(4.975) = 7.0\,\text{dB}$$

DISSIPATIVE MUFFLERS








12"

$$1/a_t = \frac{1}{4}\,e^{2\sigma L}[1 + \frac{1}{2}(m + 1/m)]^2$$

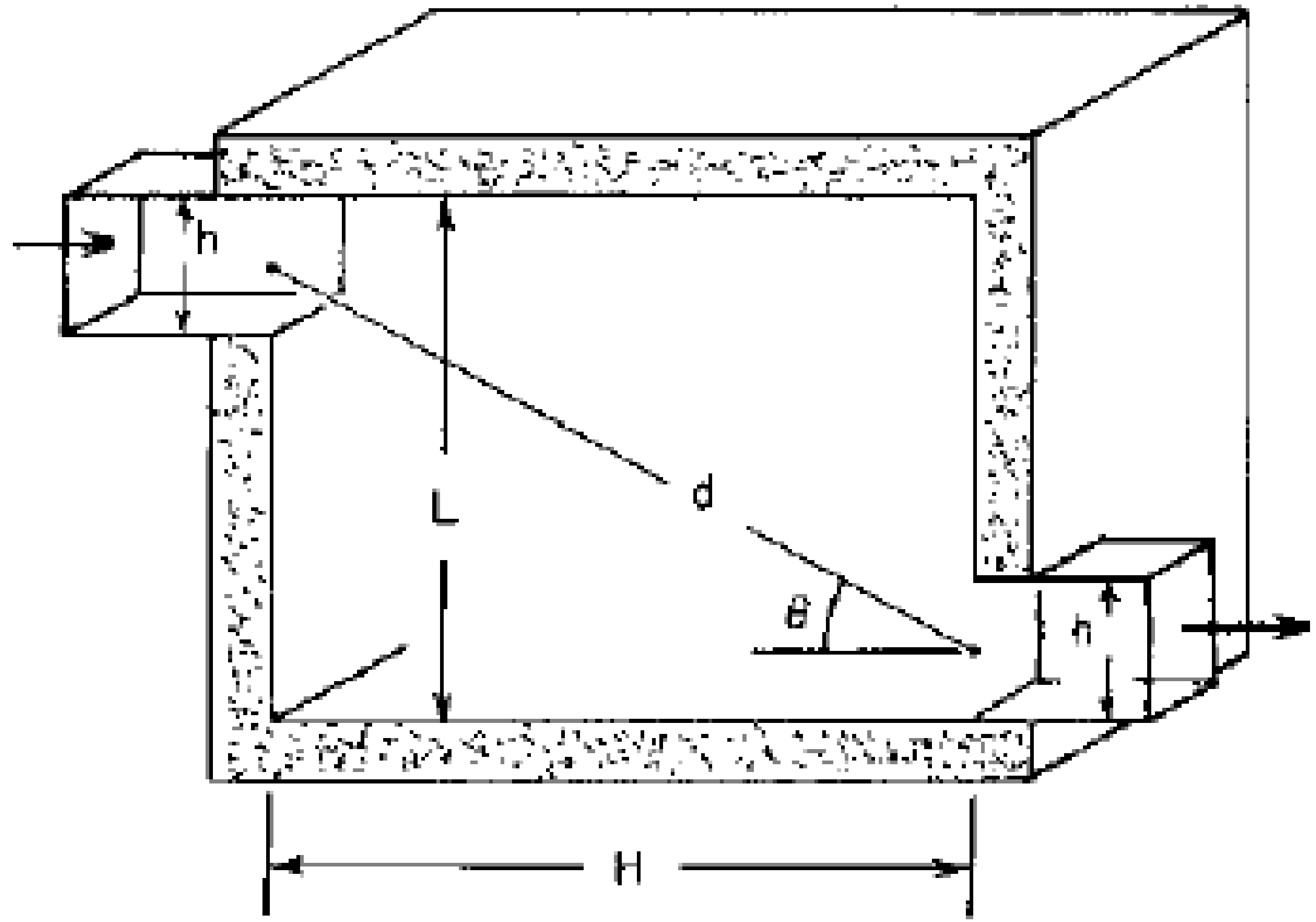
$$TL = 8.6859\sigma L + 20\log_{10}[\frac{1}{2} + \frac{1}{4}(m + 1/m)]$$

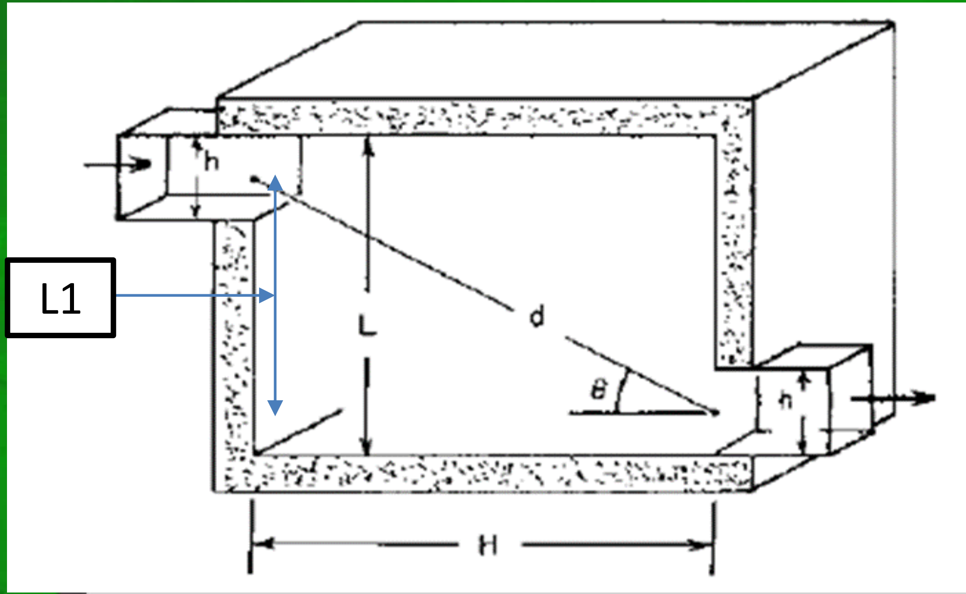
attenuation coefficient

Material	c_L, m/s	ρ_w, kg/m^3	$M_S f_c$, Hz-kg/m^2	η	E, GPa	σ
Aluminum (2014)	5,420	2,800	34,090	0.001	73.1	0.33
Brass (red)	3,710	8,710	155,200	0.001	103.4	0.37
Brick	3,800	1,800	31,250	0.015	25.0	0.20
Chipboard	675	750	73,400	0.020	0.340	0.08
Concrete	2,960	2,400	50,200	0.020	20.7	0.13
Glass	5,450	2,500	30,300	0.0013	71.0	0.21
Granite	4,413	2,690	40,270	0.001	48.3	0.28
Gypsum board	6,790	650	6,320	0.018	29.5	0.13
Lead	1,206	11,300	819,000	0.015	13.8	0.40
Lexan™	1,450	1,200	54,650	0.015	2.12	0.40
Marble	4,600	2,800	40,200	0.001	55.2	0.26
Masonry block (6 in)	3,120	1,100	23,300	0.007	10.6	0.10
Plaster	4,550	1,700	24,700	0.005	32.0	0.30
Plexiglas™	2,035	1,150	37,300	0.020	4.00	0.40
Plywood	3,100	600	12,780	0.030	4.86	0.40
Polyethylene	765	935	80,700	0.010	0.48	0.35
Pyrex	5,350	2,300	28,400	0.004	62.0	0.24
Rubber (hard)	1,700	950	36,900	0.080	2.30	0.40
Steel (C1020)	5,100	7,700	99,700	0.0013	200.0	0.27
Wood (oak)	3,860	770	11,900	0.008	11.2	0.15
Wood (pine)	4,680	640	8,160	0.020	13.7	0.15

[a] c_L is the longitudinal speed of sound; ρ_w is the material density; $M_S = \rho_w h$ = surface density; f_c is the critical or wave coincidence frequency, η is the damping coefficient; E is Young's modulus; and σ is Poisson's ratio.

PLENUM CHAMBERS





$$a_t = \frac{W_{out}}{W_{in}} = \frac{S_o Q \cos\theta}{4\pi d^2} + \frac{S_o}{R} \quad (8\text{-}195)$$

The transmission loss for the chamber is given by the following expression:

$$TL = 10 \log_{10}(1/a_t) \quad (8\text{-}196)$$

$$R = \frac{S\bar{\alpha}}{1 - \bar{\alpha}} \quad (8\text{-}190)$$

The surface area S is the total surface area of the chamber, including the lined surface area S_L and the area of each opening S_o:

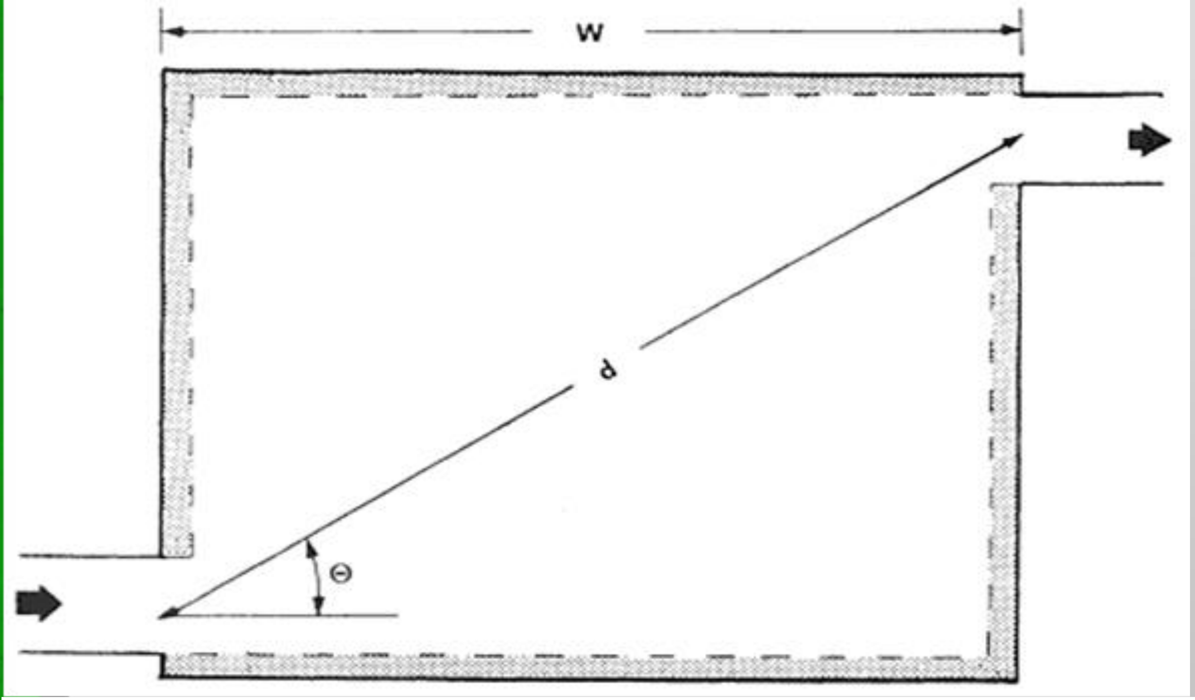
$$S = S_L + 2S_o \quad (8\text{-}191)$$

The average surface absorption coefficient $\bar{\alpha}$ may be determined from the following expression, assuming that the absorption coefficient for the openings is unity:

$$\bar{\alpha} = \frac{\bar{\alpha}_L S_L + 2S_o}{S} \quad (8\text{-}192)$$

$$\cos\theta = L_1/d$$

روش دوم

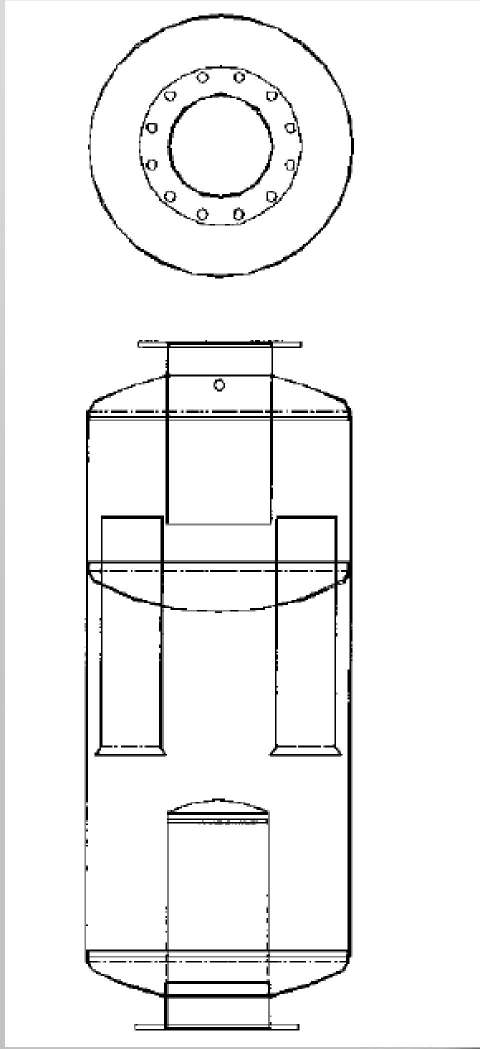


$$Attenuation = 10\log\left(\frac{1}{S_e\left[\cos(\theta)/2\pi d^2 + (1-\alpha)/\alpha S_W\right]}\right) = -10\log\left[S_e\left(\frac{\cos\theta}{2\pi d^2} + \frac{1-\alpha}{\alpha S_W}\right)\right] \quad dB$$

$$\cos\theta = W/d$$

$$Total\ attenuation = (3N + A_o)$$

COMMERCIAL SILENCERS



با تشکر از توجه شما