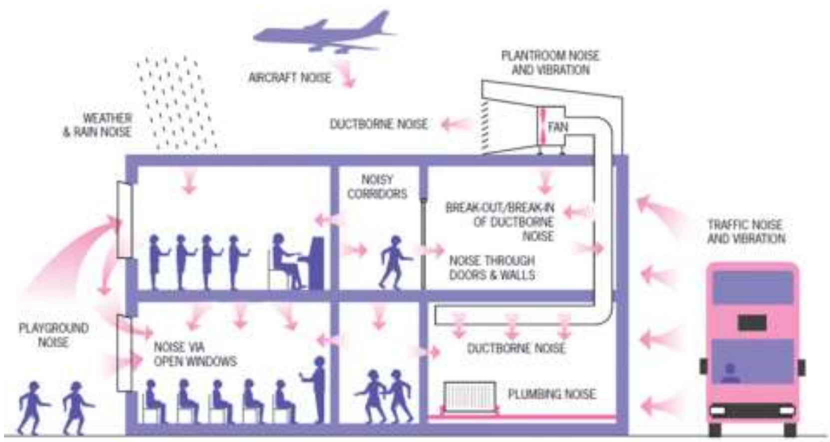
# Building Noise Control




# Noise reduction

- Reduction of noise generation <u>at the source</u>
- Reduction of <u>noise transmission </u>from point to point
- Reduction of noise <u>at the receiver</u>

# The role of absorption

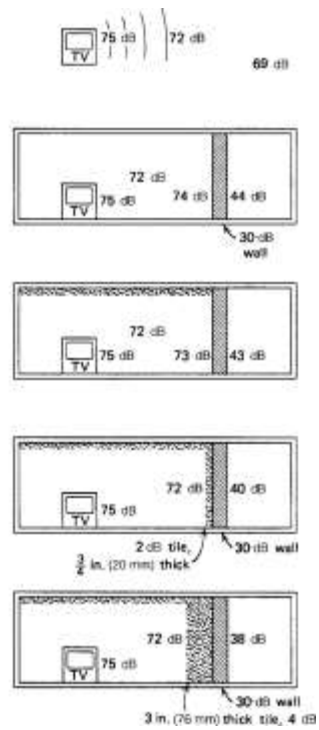
(a) TV set in free space produces 75-dB sound level, which drops 6 dB for each doubling of distance. Attenuation by inverse square law (see Eq 17-5).

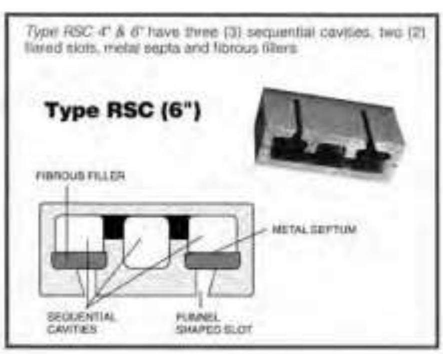
(b) TV still produces 75 dB. In the free field, sound drops to 72 dB but builds up to 74 dB at the wall due to reverberant field reinforcement (see Fig 18.7). Wall attenuation is 30 dB. Sound on other side of the wall is 74 − 30 = 44 dB.

(c) Acoustic tile ceiling acts to reduce room reverberant field. Free field is extended. Level at wall is 73 dB. Level in second space is 73 − 30 = 43 dB.

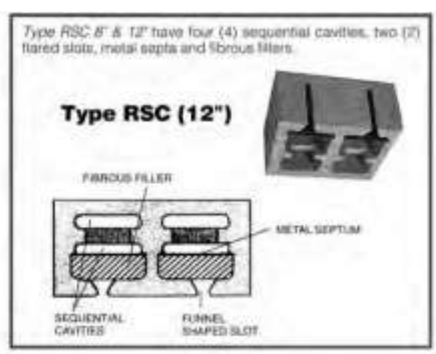
(d) Entire room is acoustically treated, effectively eliminating reverberant field. Room is "dead." Level on second side of wall is 72 dB less acoustic tile loss, less wall loss (that is, 72 − 2 − 30 = 40 dB).

(e) Add another 2½ in. of acoustic wall treatment. Room is "dead." Level at wall 72 dB. Level in second space = 72 − 4 − 30 = 38 dB.




(a)




(b)

**Sound Absorption Coefficients — Type RSC**

| Size | Type | Surface | Exposed Slots/ Cavities | FREQUENCY – Hertz 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | NRC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6" | RSC | PAINTED | 2/3 | .48 | .70 | .93 | 1.14 | 1.05 | .97 | .91 | .84 | .75 | .76 | .77 | .70 | .67 | .68 | .56 | .51 | .59 | .85 |
| 8" | RSC | PAINTED | 2/4 | .48 | .85 | 1.17 | .99 | .90 | .88 | .98 | .79 | .62 | .58 | .60 | .61 | .70 | .69 | .70 | .64 | .51 | .80 |
| 12" | RSC | PAINTED | 2/4 | .57 | * | * | .76 | * | * | 1.09 | * | * | .94 | * | * | .54 | * | * | .59 | * | .85 |

(c)

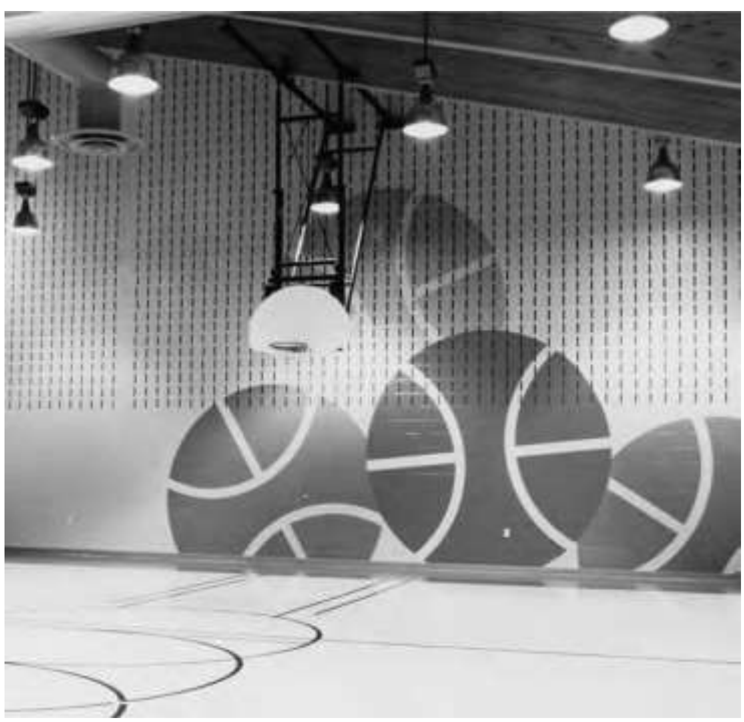
# Noise reduction by absorption

$$NR = 10 \log \frac{\sum A_2}{\sum A_1} \qquad (18.14)$$

where

$NR$ = noise reduction, dB
$\sum A_2$ = total absorption, final condition
$\sum A_1$ = total absorption, initial condition

| | 500 Hz | | 2000 Hz | |
|---|---|---|---|---|
| ***SPL for:*** | ***5 m*** | ***10 m*** | ***5 m*** | ***10 m*** |
| (a) Original room | 84.1 | 84.0 | 81.1 | 81.0 |
| (b) Double $\bar{\alpha}$ | 81.0 | 80.8 | 78.0 | 77.8 |
| (c) Quadruple $\bar{\alpha}$ | 77.7 | 77.3 | 74.7 | 74.3 |



# absorption techniques are useful and effective for:

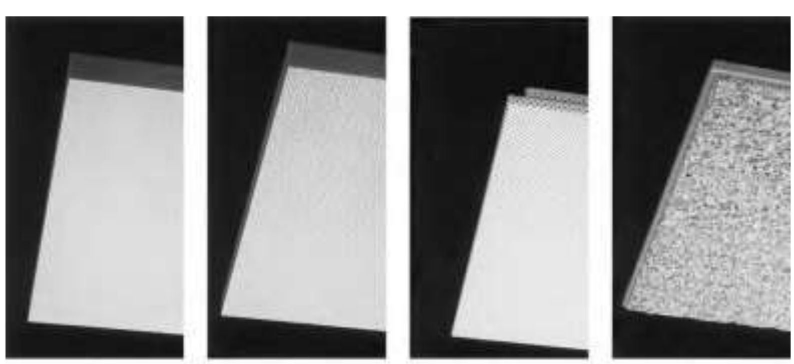
1. change room reverberation characteristics.
2. In spaces with distributed noise sources such as offices, schools, restaurants, and machine shops.
3. In spaces with hard surfaces and little absorptive content.
4. Where listeners are in the reverberant field.

(No amount of absorptive material can reduce intensity levels in the free field.)

## ABSORPTIVE MATERIALS

***<u>1. Acoustic tile</u>***

Tile materials are generally mineral fiber or faced fiberglass, with noise reduction coefficient(NRC) ratings in the range of 0.45 to 0.75 for mineral fiber tiles and up to 0.95 for fiberglass



(a) (b) (c) (d)

## 2. ***Perforated metal-faced units***

## 3. ***Acoustic panels***

are made of treated wood fibers, bonded with an inorganic cement binder

NRC ratings range from 0.40 to 0.70

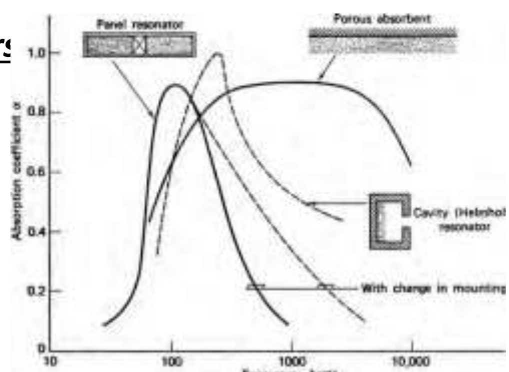
## ***4. Acoustic plaster***

## ***5. Sound blocks, baffles, and hanging panels***

## ***6. Wall panels***

consist of a wood or metal backing on which is mounted a mineral fiber or fiberglass substrate and a fabric covering. NRC coefficients vary from 0.5 for direct-mounted 1-in. mineral fiber substrate to as high as 0.85 for strip mounted 1½-in. (38 mm) fiberglass substrate panels

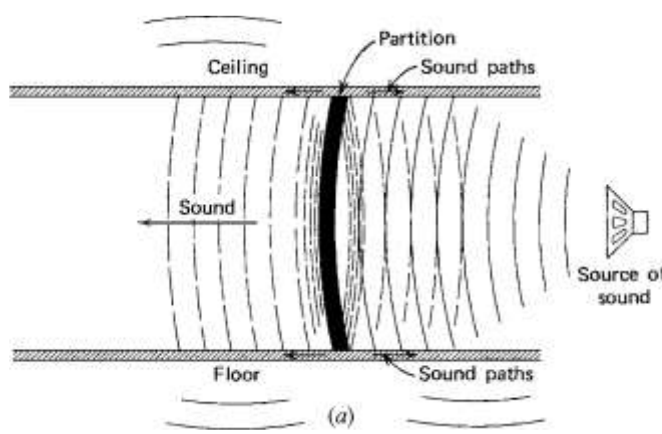
## ***7. Resonator sound absorbers***

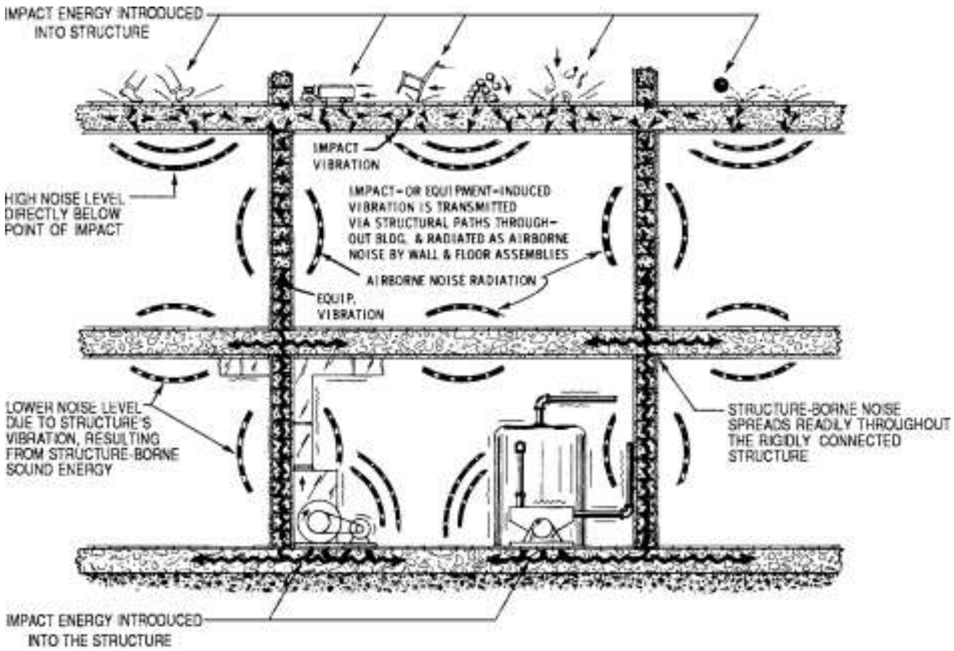



***8. Carpeting and drapery***

# SOUND INSULATION

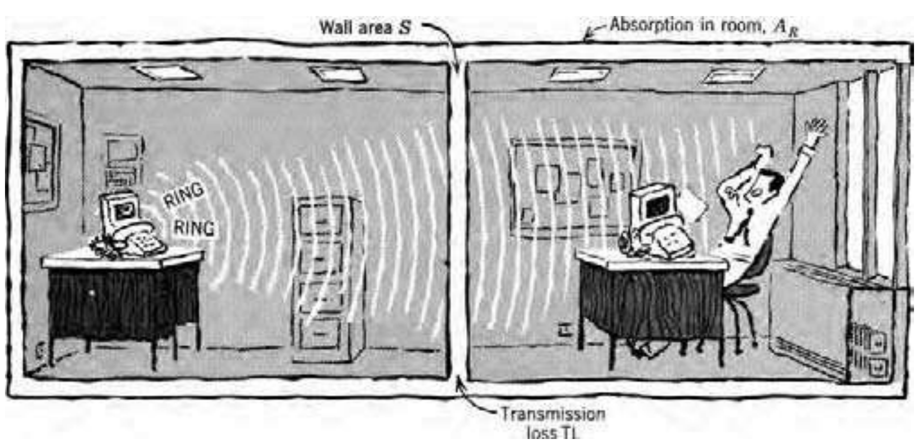
- **AIRBORNE AND STRUCTUREBORNE SOUND**






(b)

# TRANSMISSION LOSS AND NOISE REDUCTION



$$NR = IL_{room\ 1} - IL_{room\ 2} \qquad (19.2)$$

and is related to the TL of the barrier by the expression

$$NR = TL - 10 \log \frac{S}{A_R} \qquad (19.3)$$

where

$NR$ = noise reduction, dB

$TL$ = barrier transmission loss, dB

$S$ = area of the barrier, ft$^2$ (m$^2$)

$A_R$ = total absorption of the *receiving* room, sabins, ft$^2$ (m$^2$)

1. For a live receiving room,

$$NR = TL - 1 \text{ dB}$$

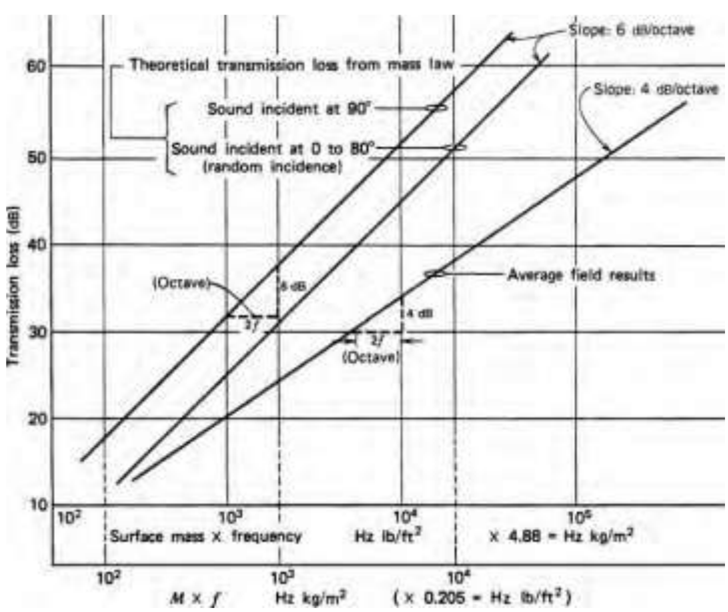
2. For a medium receiving room,

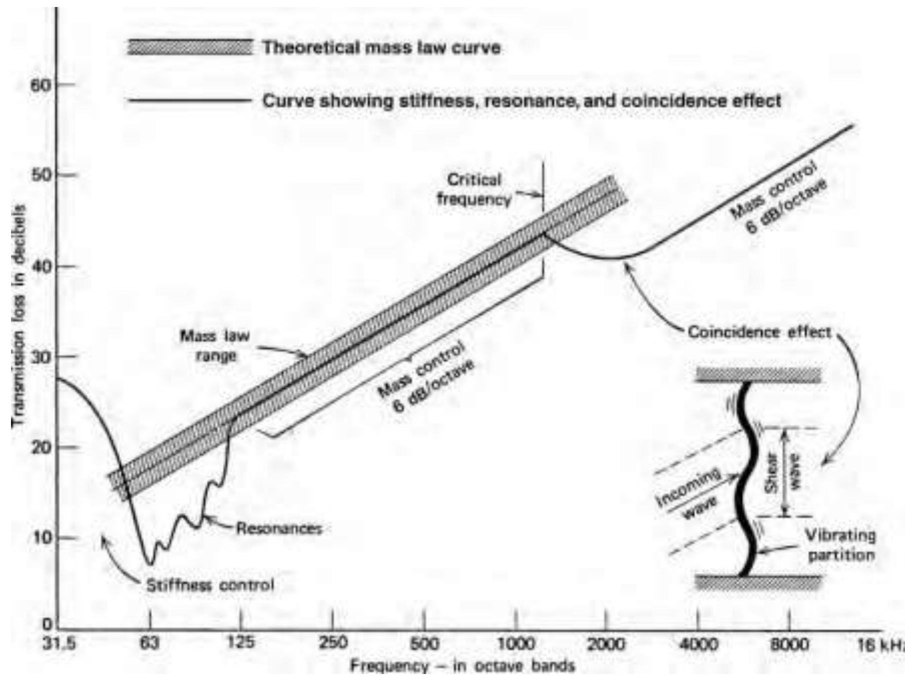
$$NR = TL + 4 \text{ dB}$$

3. For a dead receiving room,

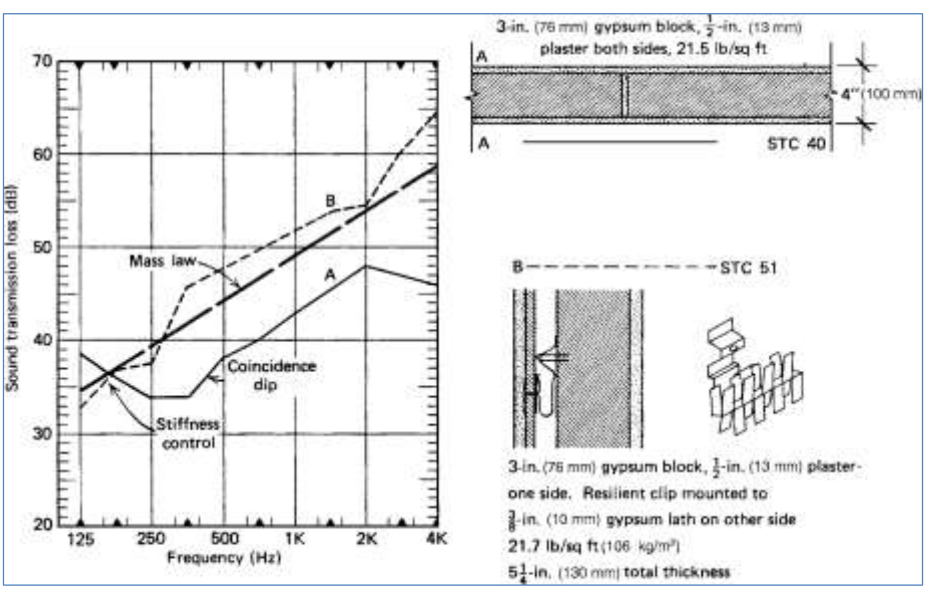
$$NR = TL + 7 \text{ dB}$$

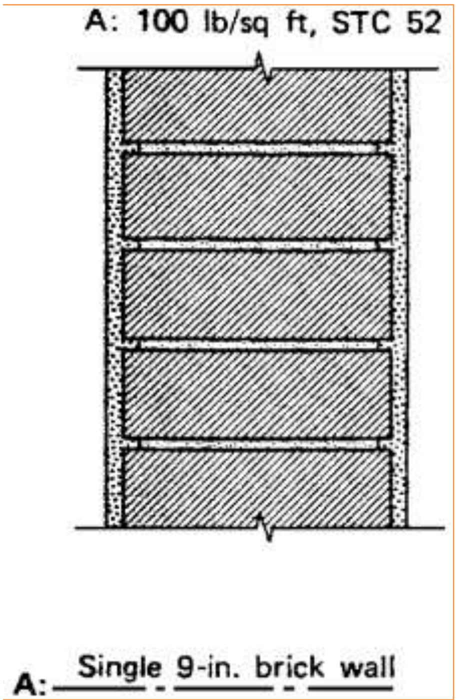
# TL and BARRIER MASS

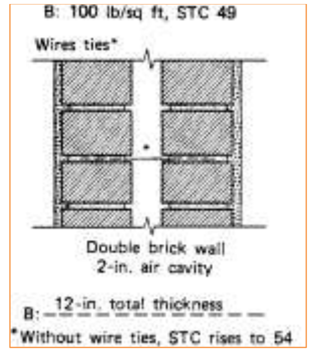


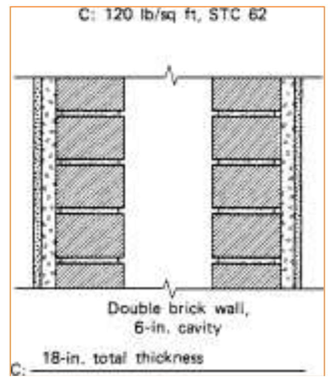


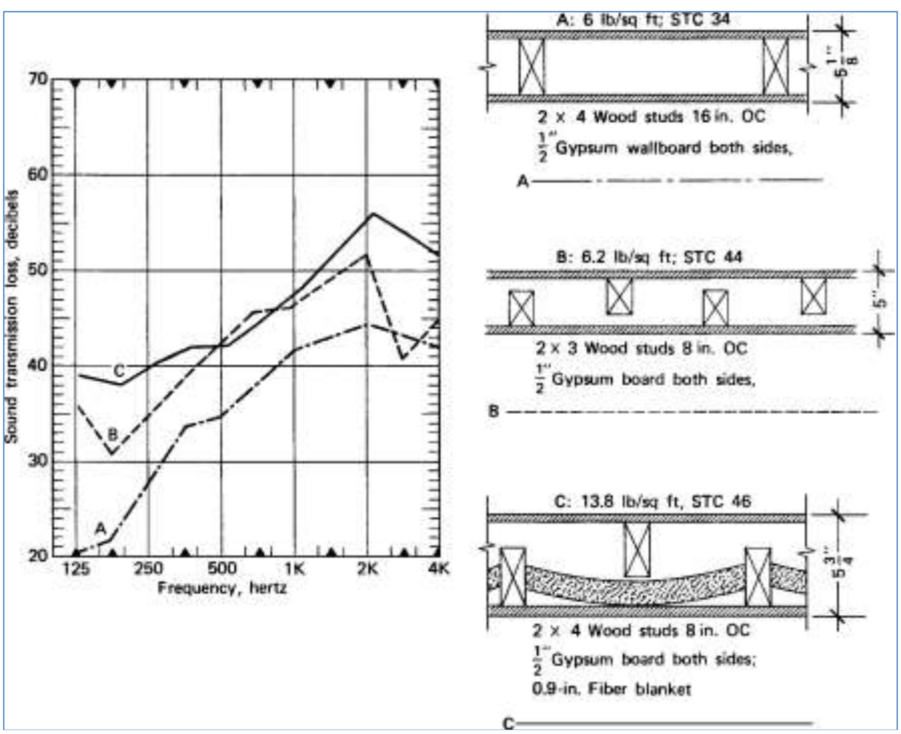

# COMPOUND BARRIERS (CAVITY WALLS)



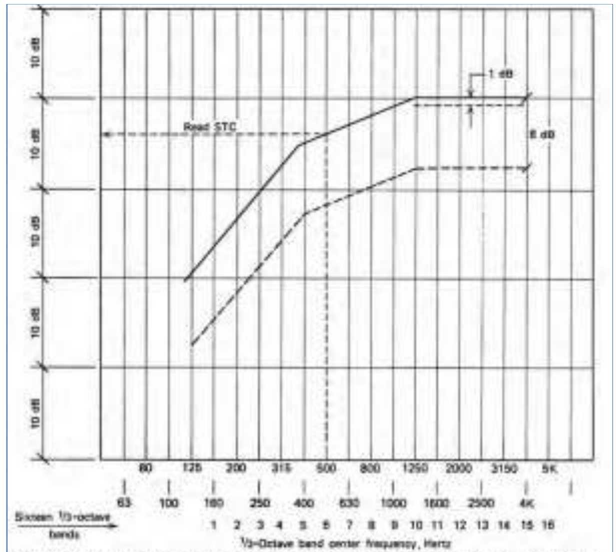

A: 100 lb/sq ft, STC 52
A: Single 9-in. brick wall


B: 100 lb/sq ft, STC 49
Wires ties*
Double brick wall
2-in. air cavity
B: 12-in. total thickness
*Without wire ties, STC rises to 54


C: 120 lb/sq ft, STC 62
Double brick wall,
6-in. cavity
C: 18-in. total thickness


Sound transmission loss, decibels
70
60
50
40
30
20
125
250
500
1K
2K
4K
Frequency, hertz
A
B
C
A: 6 lb/sq ft; STC 34
2 × 4 Wood studs 16 in. OC
1/2" Gypsum wallboard both sides,
A
B: 6.2 lb/sq ft; STC 44
5"
2 × 3 Wood studs 8 in. OC
1/2" Gypsum board both sides,
B
C: 13.8 lb/sq ft, STC 46
2 × 4 Wood studs 8 in. OC
1/2" Gypsum board both sides;
0.9-in. Fiber blanket
C

# SOUND TRANSMISSION CLASS - STC




The STC is determined by comparison with a transparent overlay of this graph on which the STC contour is drawn. The STC contour is shifted vertically, relative to the test curve, until some of the measured TL values for the test specimen fall below those of the STC contour (the solid line) and the following conditions are fulfilled:

1. The sum of the deficiencies (i.e., the deviations below the contour) shall not be greater than 32 dB.
2. The maximum deficiency at a single test point shall not exceed 8 dB [the broken (dashed) line beneath the STC contour].

When the contour is adjusted to the highest value (in integral dB) that meets the above requirements, the sound transmission class for the specimen is the TL value corresponding to the intersection of the contour and the 500-Hz ordinate.

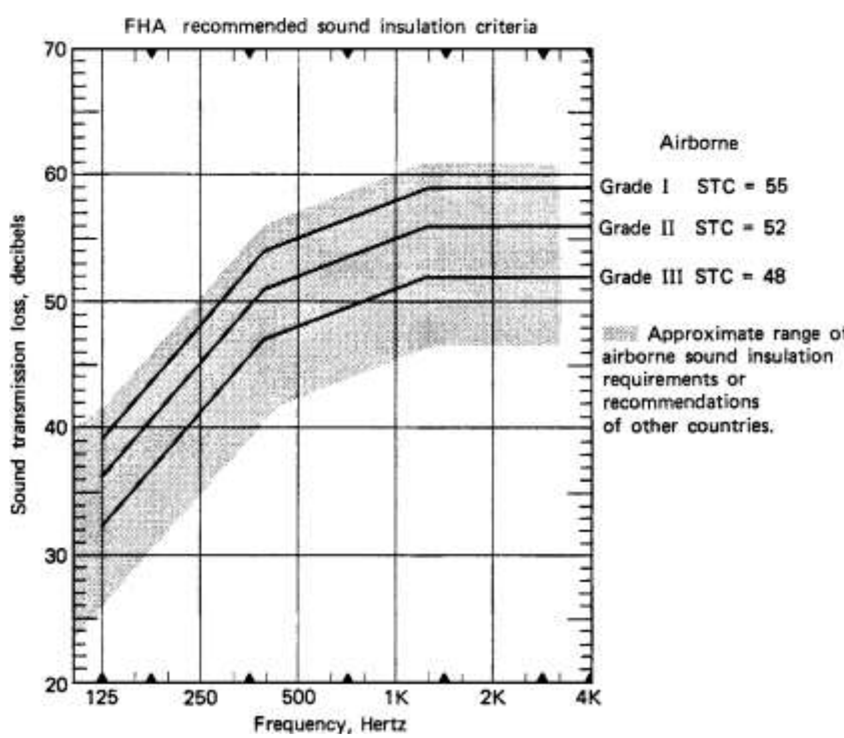


**TABLE 19.1 Improvements in STC Rating of Stud[a] Partitions[b]**

| Description | STC[c] |
|---|---|
| Basic partition: single wood studs, 16 in. (406 mm) on centers, ½-in. (13-mm) gypsum board on both sides, air cavity | 35 |
| Add to basic partition | |
| Double gypsum board, one side | +2 |
| Double gypsum board, both sides | +4 |
| Single-thickness absorbent material in air cavity | +3 |
| Double-thickness insulation | +6 |
| Resilient channel supports for gypsum board | +5 |
| Staggered studs | +9 |
| Double studs | +13 |

[a]For application to metal stud partitions, use adders as in note b, but begin with STC = 40 for a 3⅝-in. (92-mm) basic partition.

[b]When using two improvements, add an additional +2; for three improvements, add +3.

*Example:* Improvements to 35 STC basic partition:

| | |
|---|---|
| Staggered wood studs | +9 |
| Double gypsum board, one side | +2 |
| Single-thickness insulation | +3 |
| Adder (3 improvements) | +3 |
| Total | +17 |
| Total STC | 35 + 17 = 52 |

[c]The STC figures are conservative. Other sources list the same constructions with 1 to 5 points higher STC.

**TABLE 19.2 STC Ratings of Masonry Walls**

| Description | STC[a] |
|---|---|
| 4-in. (102-mm) lightweight[b] hollow block | 36 |
| 4 in. (102-mm) dense hollow block | 38 |
| 6-in. (152-mm) lightweight hollow block | 41 |
| 6-in. (152-mm) dense hollow block | 43 |
| 8-in. (203-mm) lightweight hollow block | 46 |
| 8-in. (203-mm) dense hollow block | 48 |
| 12-in. (305-mm) lightweight hollow block | 51 |
| 12-in. (305-mm) dense hollow block | 53 |
| 4-in. (102-mm) brick | 41 |
| 6-in. (152-mm) brick | 45 |
| 8-in. (203-mm) brick | 49 |
| 12-in. (305-mm) brick | 54 |
| 6-in. (152-mm) solid concrete | 47 |
| 8-in. (203-mm) solid concrete | 50 |
| 10-in. (254-mm) solid concrete | 53 |
| 12-in. (305-mm) solid concrete | 56 |

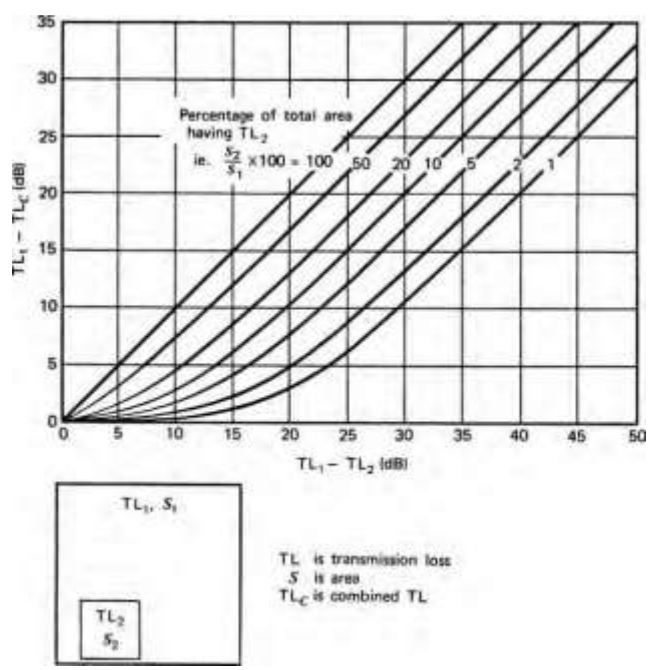
[a]See note c, Table 19.1.

[b]All ratings of lightweight block assume sealing with paint. Note that this reduces absorption.

Modifications

| | |
|---|---|
| Add sand to cores of hollow blocks | +3 |
| Add plaster to one side | +2 |
| Add plaster to both sides | +4 |
| Add furring strips, lath and plaster: | |
| One side | +6 |
| Two sides | +10 |
| Add plaster via resilient mounting: | |
| One side | +10 |
| Two sides | +15 |

# COMPOSITE WALLS AND LEAKS



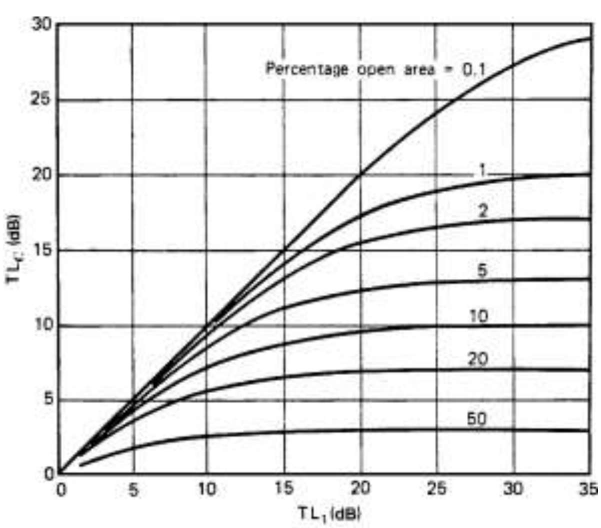
# DOORS AND WINDOWS

**TABLE 19.3 Typical STC Values for Doors**

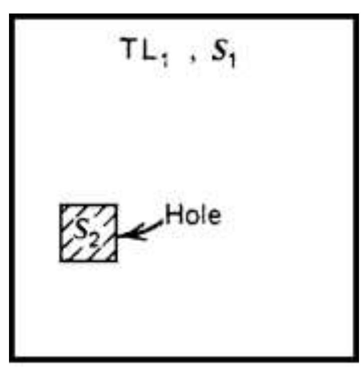
| Door Construction | STC |
|---|---|
| Louvered door | 15 |
| Any door, 2-in. (51-mm) undercut | 17 |
| 1½-in. (38-mm) hollow core door, no gasketing | 22 |
| 1½-in. (38-mm) hollow core door, gaskets and drop closure | 25 |
| 1¾-in. (45-mm) solid wood door, no gasketing | 30 |
| 1¾-in. (45-mm) solid wood door, gaskets and drop closure | 35 |
| Two hollow core doors, gasketed all around, with sound lock | 45 |
| Two solid core doors, gasketed all around, with sound lock | 55 |
| Special commercial construction, with lead lining and full sealing | 45–65 |

**TABLE 19.4 Typical STC Values for Windows**

| Window Construction | STC |
|---|---|
| Operable wood sash, ⅛-in. (3.2-mm) glass, unsealed | 23 |
| Operable wood sash, ¼-in. (6.4-mm) glass, unsealed | 25 |
| Operable wood sash, ¼-in. (6.4-mm) glass, gasketed | 30 |
| Operable wood sash, laminated glass, unsealed | 28 |
| Operable wood sash, double-glazed, ⅛-in. (3.2-mm) panes, ⅜-in. (9.5-mm) air space, gasketed | 29 |
| Fixed sash, double ⅛-in. (3.2-mm) panes, 3-in. (76-mm) air space, gasketed | 44 |
| Fixed sash, double ⅛-in. (3.2-mm) panes, 4-in. (102-mm) air space, gasketed | 48 |




(a)

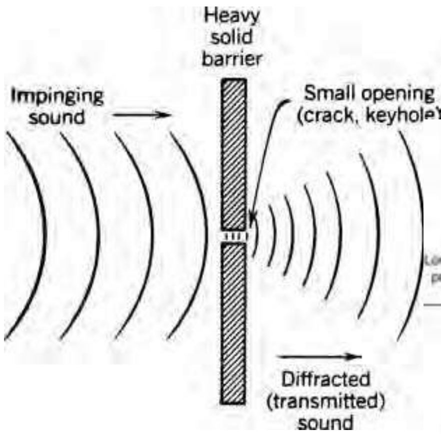


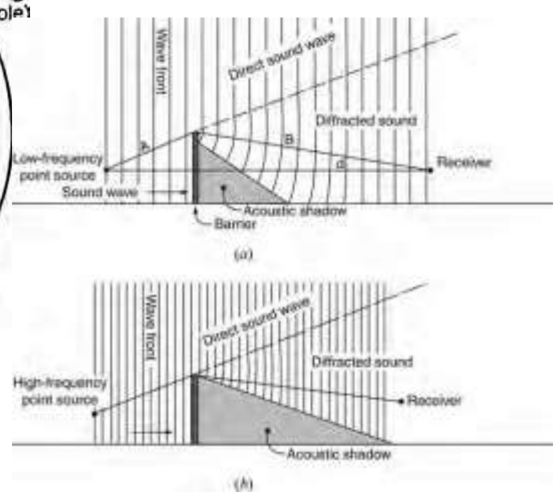

TL is transmission loss
$S$ is area
$TL_C$ is combined TL

% open area
$= S_2/S_1 \times 100$

(b)

# Diffraction and sound shadow




# STRUCTURE-BORNE NOISE

Structure-borne noise is at least as serious a problem as airborne noise for the following reasons:

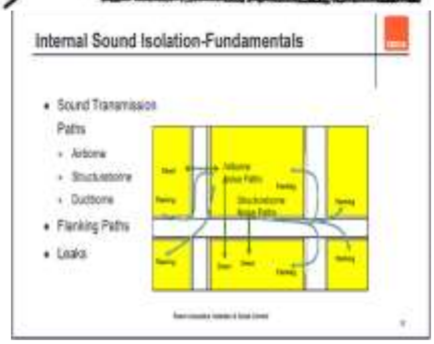
1. There is no air cushion between the source and the structure; thus, high-intensity energy is introduced into the structure, through which it travels with minimum attenuation and at great speed.
2. Sound, once introduced into the structure, is attenuated well only by discontinuities in the structure. Since the structure must have structural integrity to carry the loads, discontinuities of the type that will stop noise are complex and expensive.
3. The entire structure constitutes a network of parallel paths for sound. Therefore, partial solutions are useless, since sound will find flanking paths. The entire structure must be soundproofed to yield good results.
4. Unlike the case of airborne noise, additional mass does not usually block structure-borne noise, particularly in long spans where a floor can act as a diaphragm, thereby improving the structure-to-air noise transfer efficiency (like a drum).
5. The increasing use of exposed structural ceilings eliminates the attenuation that can be introduced by a plenum above a hung ceiling. This is particularly bad, since most structure-borne noise is carried by floor structures (rather than walls), which radiate sound up and down

# Structure borne noise

Why its important

1. No air and no attenuation … the attenuation can be done by non continuous structure
2. Mass law does not work
3. More problems in floors

and ceiling more than in walls

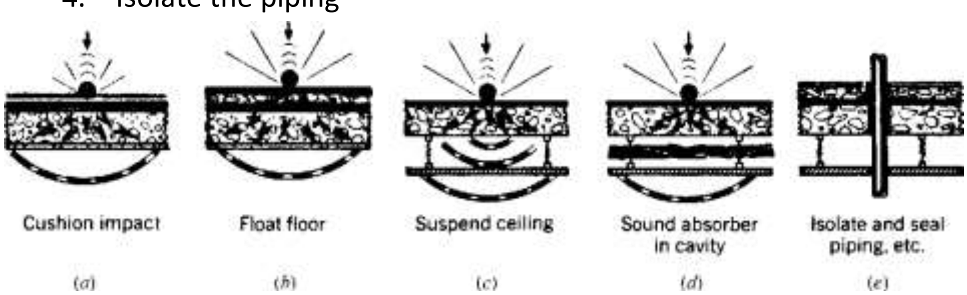




# Impact noise control

How to control impact noise

- The best way is preventing it
- And minimizing it through

1. Cushion the impact (floor tile or rubber, carpeting)
2. Float the floor ( rubber or metal wool pads, blankets, spring metal)
3. Suspend the ceiling and use an absorber in the cavity
4. Isolate the piping



## **Improving IIC**

- (3-mm) linoleum or rubber tile 4 ± 1
- (6-mm) cork tile 10 ± 2
- Low-pile carpet on fiber pad 12 ± 2
- Low-pile carpet on foam rubber pad 18 ± 3
- High-pile carpet on foam rubber pad 24 ± 3

**TABLE 19.13 Recommended STC for Partitions; Specific Occupancies**

| | *Wall, Partition, or Panel Between* | | *Sound Insulation Requirement: Background Level in Room Being Considered* | |
|---|---|---|---|---|
| **Type of Occupancy** | **Room Being Considered** and | **Adjacent Area** | **Quiet** | **Normal** |
| Normal school buildings without extraordinary or unusual activities or requirements | Classrooms | Adjacent classrooms | STC 42 | STC 40 |
| | | Corridor or public areas | STC 40 | STC 38 |
| | | Kitchen and dining areas | STC 50 | STC 47 |
| | | Shops | STC 50 | STC 47 |
| | | Recreation areas | STC 45 | STC 42 |
| | | Music rooms | STC 55 | STC 50 |
| | | Mechanical equipment rooms | STC 50 | STC 45 |
| | | Toilet areas | STC 45 | STC 42 |
| | Music practice rooms | Adjacent practice rooms | STC 55 | STC 50 |
| | | Corridor and public areas | STC 45 | STC 42 |
| Executive areas, doctors' suites; confidential privacy requirements | Office | Adjacent offices | STC 50 | STC 45 |
| | | General office areas | STC 48 | STC 45 |
| | | Corridor or lobby | STC 45 | STC 42 |
| | | Washrooms and toilet areas | STC 50 | STC 47 |
| Normal office; normal privacy requirements; any occupancy using rooms for group meetings | Office | Adjacent offices | STC 40 | STC 38 |
| | | Corridor, lobby, exterior | STC 40 | STC 38 |
| | | Washrooms, kitchen, dining | STC 42 | STC 40 |
| | Conference rooms | Other conference rooms | STC 45 | STC 42 |
| | | Adjacent offices | STC 45 | STC 42 |
| | | Corridor or lobby | STC 42 | STC 40 |
| | | Exterior of building | STC 40 | STC 38 |
| | | Kitchen and dining areas | STC 45 | STC 42 |
| Large offices, drafting areas, banking floors, etc. | Large general office areas | Corridors, lobby, exterior | STC 38 | STC 35 |
| | | Data-processing area | STC 40 | STC 38 |
| | | Kitchen and dining areas | STC 40 | STC 38 |
| Motels and urban hotels. Hospitals and dormitories | Bedrooms | Adjacent bedrooms[a] | STC 52 | STC 50 |
| | | Bathroom[a] | STC 50 | STC 45 |
| | | Living rooms[a] | STC 45 | STC 42 |
| | | Dining areas | STC 45 | STC 42 |
| | | Corridor, lobby, or public spaces | STC 45 | STC 42 |

**TABLE 19.14 Criteria for Airborne Sound Insulation of Partitions between Dwelling Units**

| *Partition Function between Dwellings* | | | |
|---|---|---|---|
| **Apt. A** | | **Apt. B** | **Grade II STC** |
| Bedroom | to | Bedroom | 52 |
| Living room | to | Bedroom[a] | 54 |
| Kitchen[b] | to | Bedroom[a] | 55 |
| Bathroom | to | Bedroom[a] | 56 |
| Corridor | to | Bedroom[a,c] | 52 |
| Living room | to | Living room | 52 |
| Kitchen[b] | to | Living room[a] | 52 |
| Bathroom | to | Living room | 54 |
| Corridor | to | Living room[a,c,d] | 52 |
| Kitchen | to | Kitchen[e] | 50 |
| Bathroom | to | Kitchen | 52 |
| Corridor | to | Kitchen[a,c,d] | 52 |
| Bathroom | to | Bathroom | 50 |
| Corridor | to | Bathroom[a,c] | 48 |

**TABLE 19.15 Criteria for Airborne and Impact Sound Insulation of Floor-Ceiling Assemblies between Dwelling Units**

| *Assembly Function between Dwellings* | | | *Grade II* | |
|---|---|---|---|---|
| **Apt. A** | | **Apt. B** | **STC** | **IIC** |
| Bedroom | Above | Bedroom | 52 | 52 |
| Living room | Above | Bedroom[a] | 54 | 57 |
| Kitchen[b] | Above | Bedroom[a,c] | 55 | 62 |
| Family room | Above | Bedroom[a,d] | 56 | 62 |
| Corridor | Above | Bedroom[a] | 52 | 62 |
| Bedroom | Above | Living room[e] | 54 | 52 |
| Living room | Above | Living room | 52 | 52 |
| Kitchen | Above | Living room[a,c] | 52 | 57 |
| Family room | Above | Living room[a,d] | 54 | 60 |
| Corridor | Above | Living room[a] | 52 | 57 |
| Bedroom | Above | Kitchen[c,e] | 55 | 50 |
| Living room | Above | Kitchen[c,e] | 52 | 52 |
| Kitchen | Above | Kitchen[c] | 50 | 52 |
| Bathroom | Above | Kitchen[a,c] | 52 | 52 |
| Family room | Above | Kitchen[a,c,d] | 52 | 58 |
| Corridor | Above | Kitchen[a,c] | 48 | 52 |
| Bedroom | Above | Family room[e] | 56 | 48 |
| Living room | Above | Family room[e] | 54 | 50 |
| Kitchen | Above | Family room[e] | 52 | 52 |
| Bathroom | Above | Bathroom[c] | 50 | 50 |
| Corridor | Above | Corridor | 48 | 48 |

**Impact insulation class**