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The Acoustic Performance of The Building Envelope

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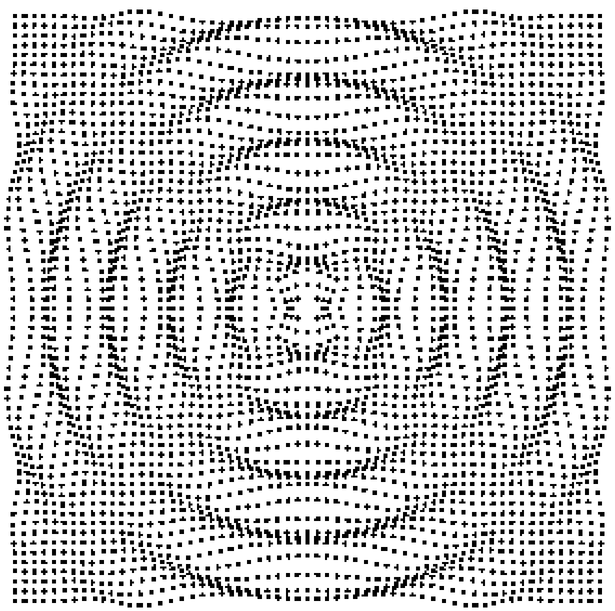
Outline

- Fundamentals of Acoustics
- Single Number Ratings
- Acoustic Performance of Windows
- Composite Acoustic Performance of the Building Envelope

What is Sound?

- Sound is defined as a mechanical disturbance in an elastic medium that can be detected by the human ear.
- The medium can be gas, liquid or solid.



Source: www.acs.psu.edu

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How do we describe sound?

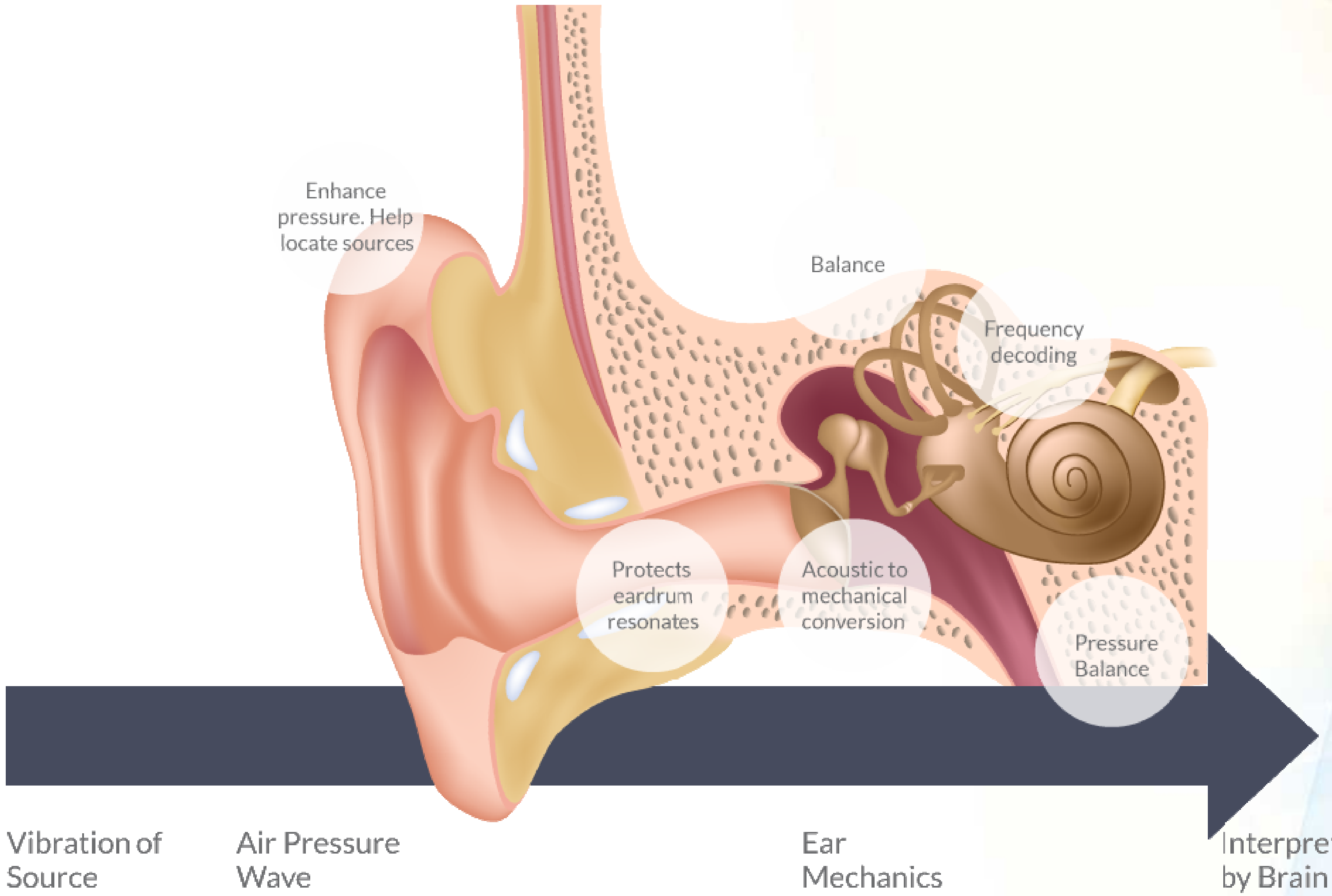
Sound generally described using:

Magnitude – “Levels”

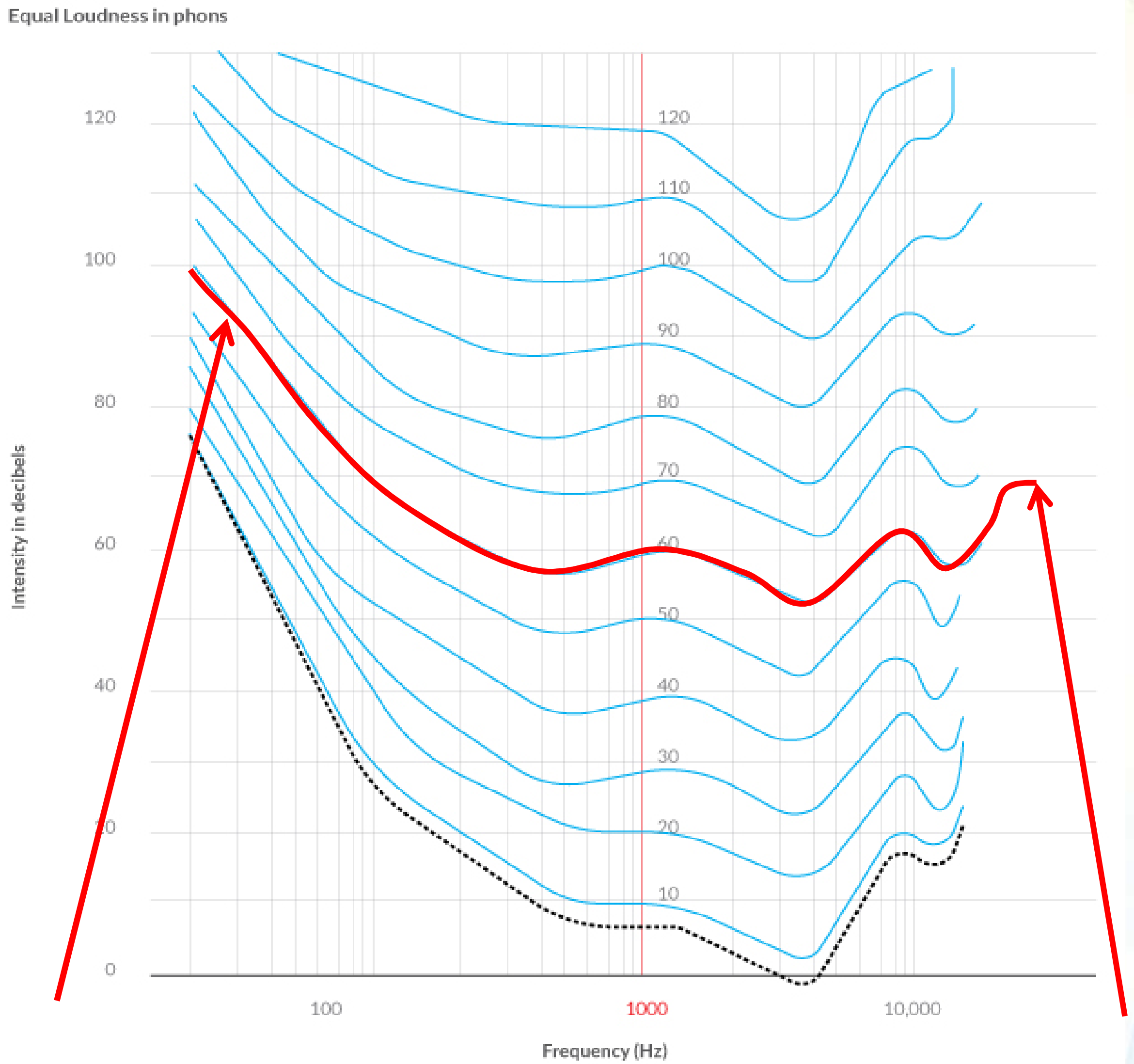
Frequency – “Pitch”

Sound level drops with distance from source

Human Hearing

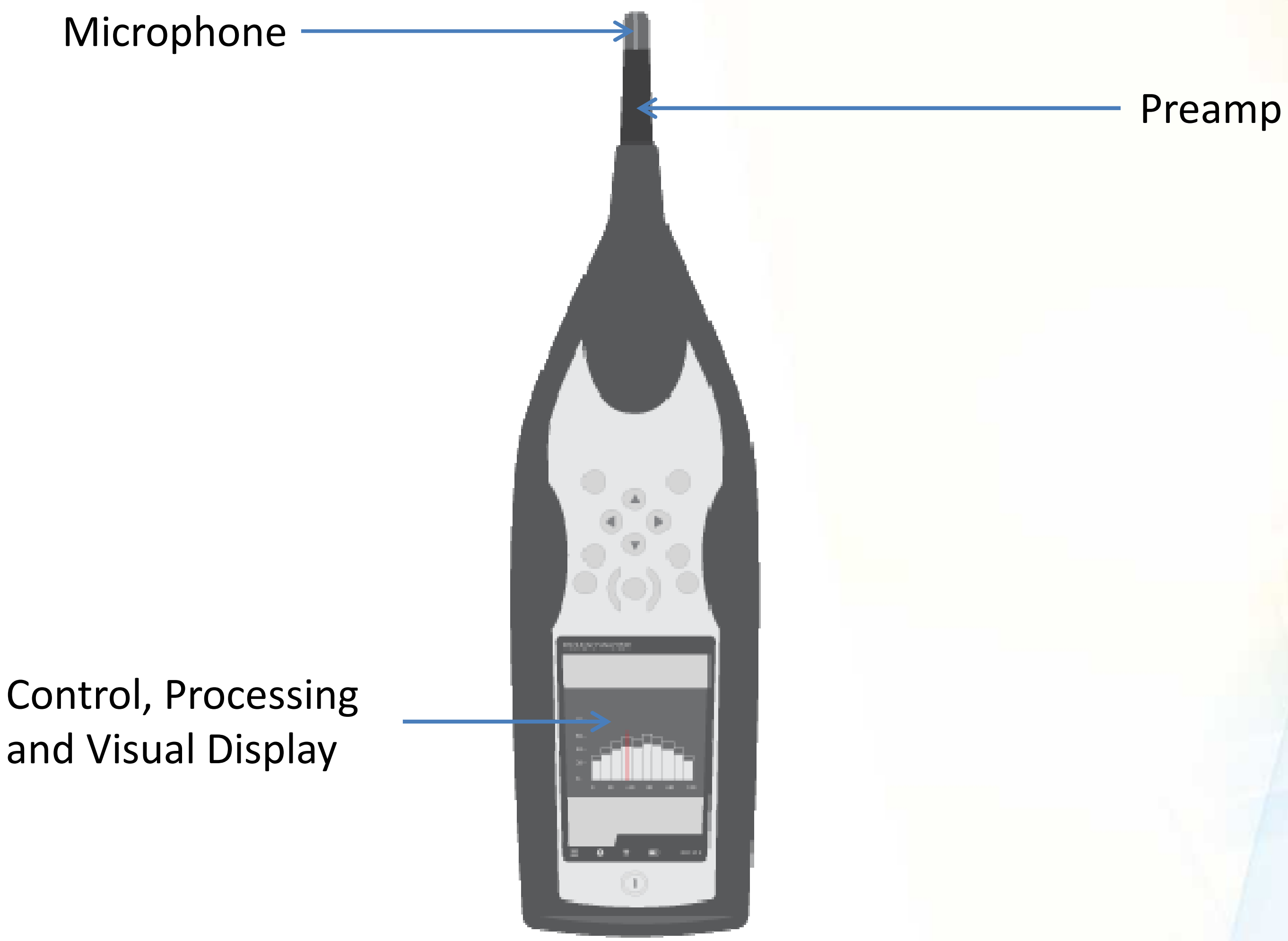


Equal Loudness Curves



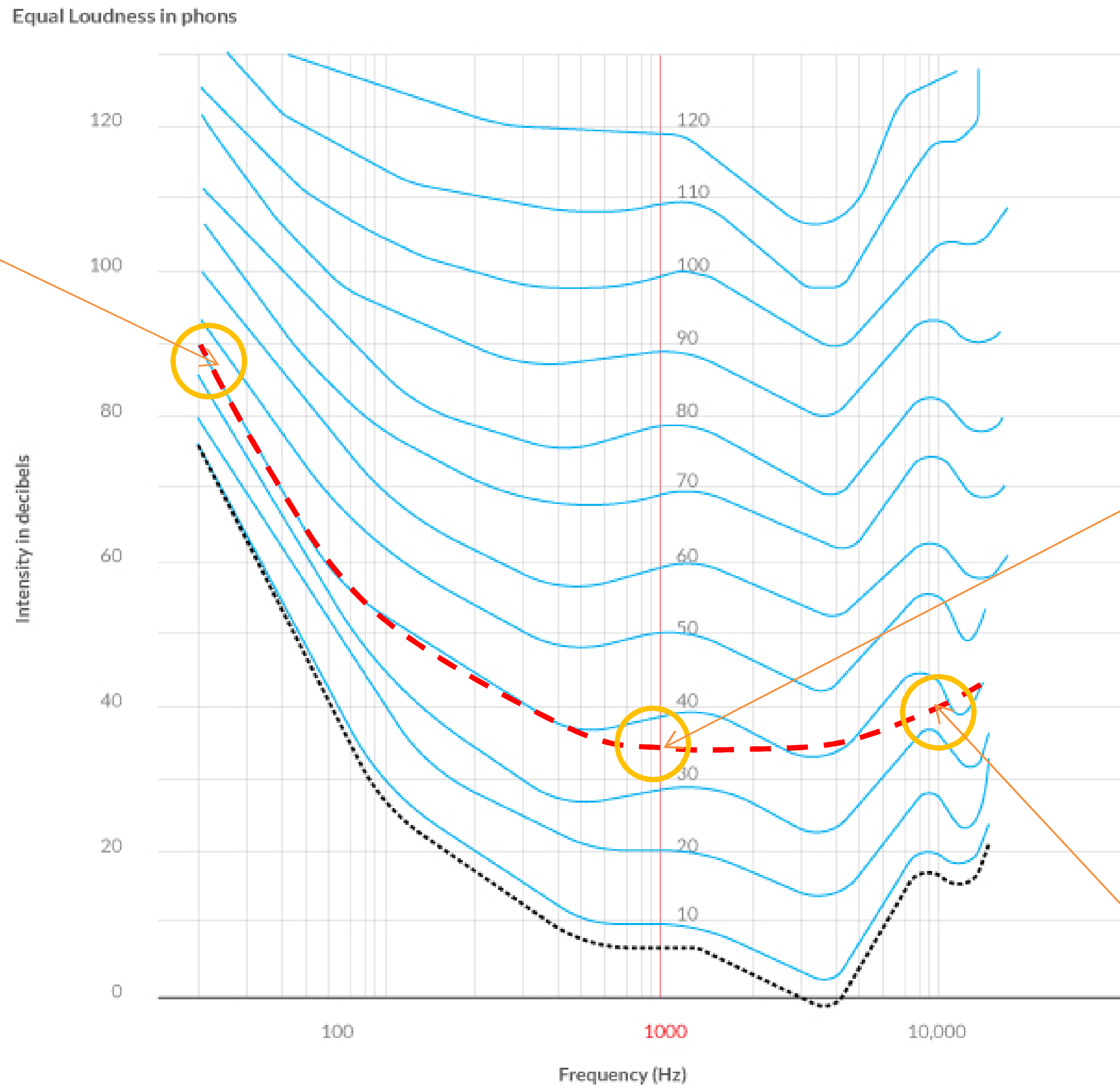
Our ears are less sensitive to low frequencies and high frequencies

How do we measure sound?



A-Weighting Curve

63.4 dB discount

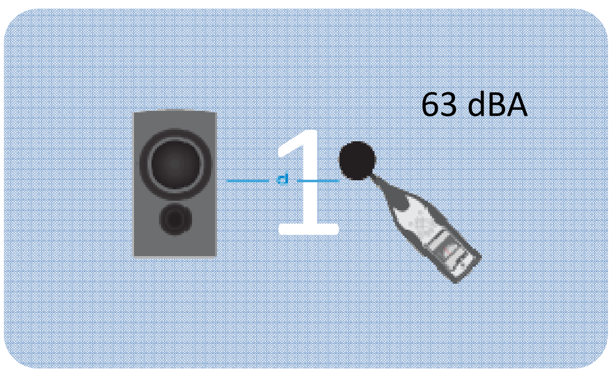


0 dB discount

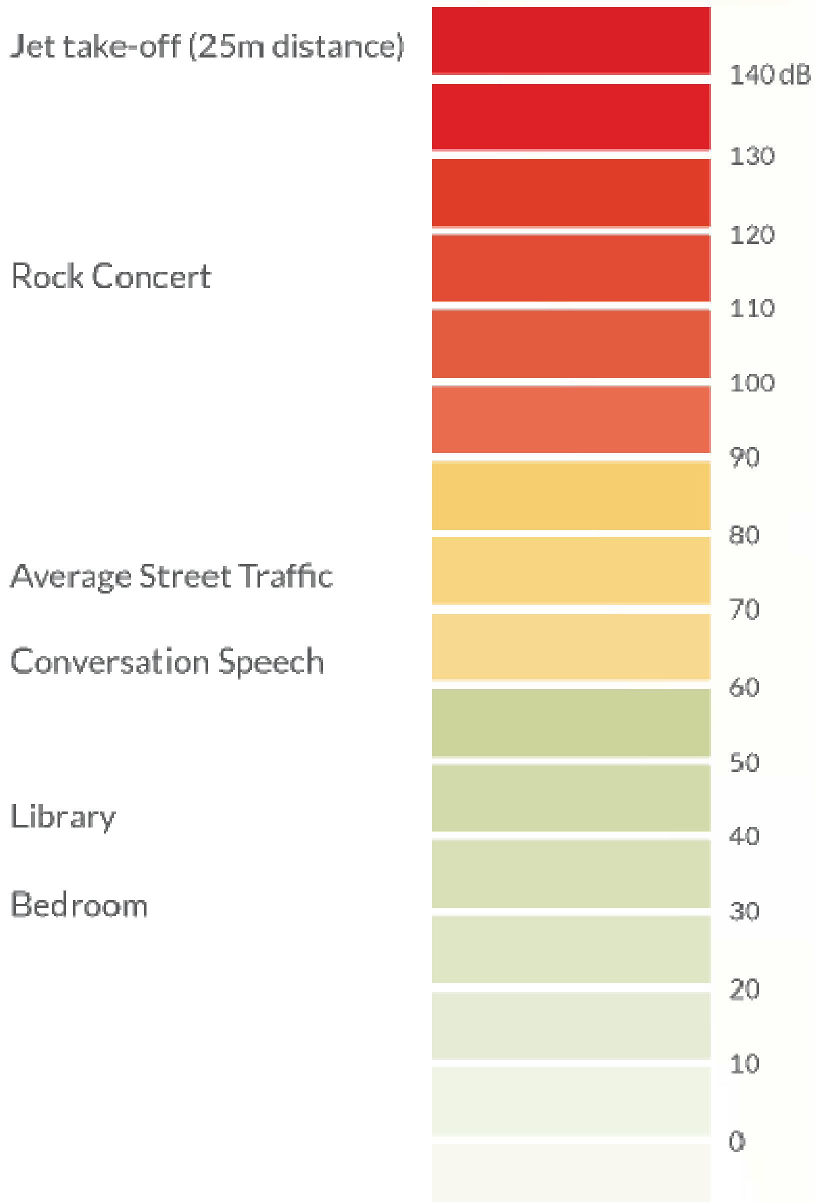
2.5 dB discount

Levels and the Decibel

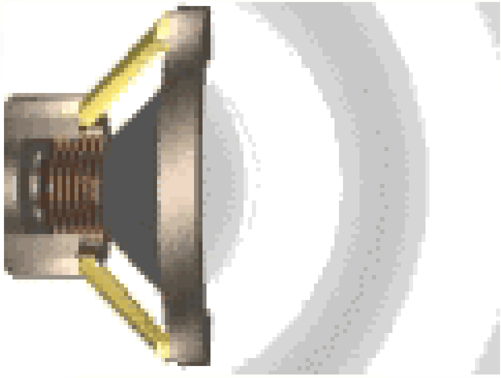
- The decibel (dB) is used to describe the ratio between two "power-like" quantities.
- A doubling of sound power/energy equates to a 3 dB increase in sound pressure level. This is just noticeable.
- Range of human hearing is 0 dB to 120 dB Sound Pressure Level



Example Sound Levels



Frequency



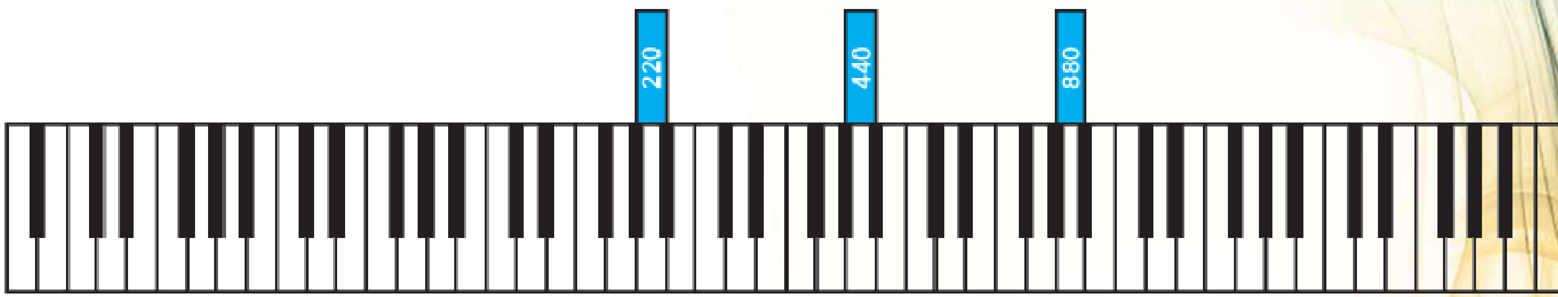
125 cycles per second

or

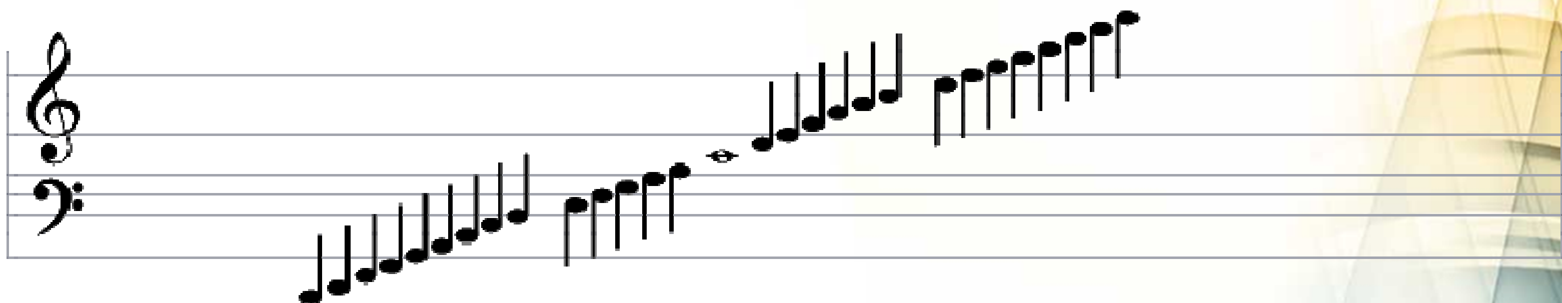
125 Hertz (Hz)

Frequency for Musicians

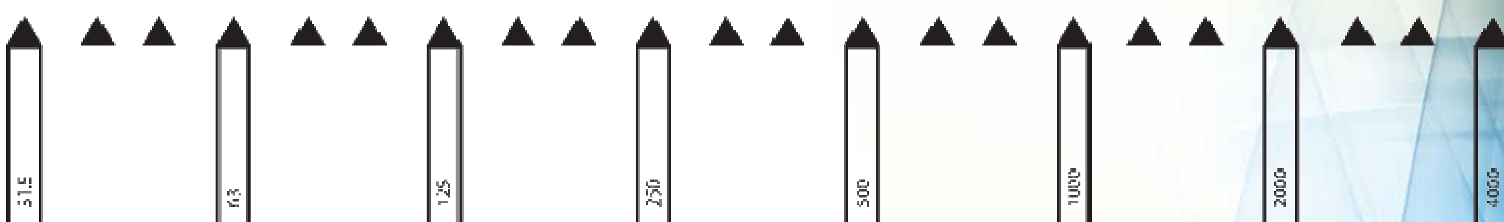
Each octave higher doubles in frequency



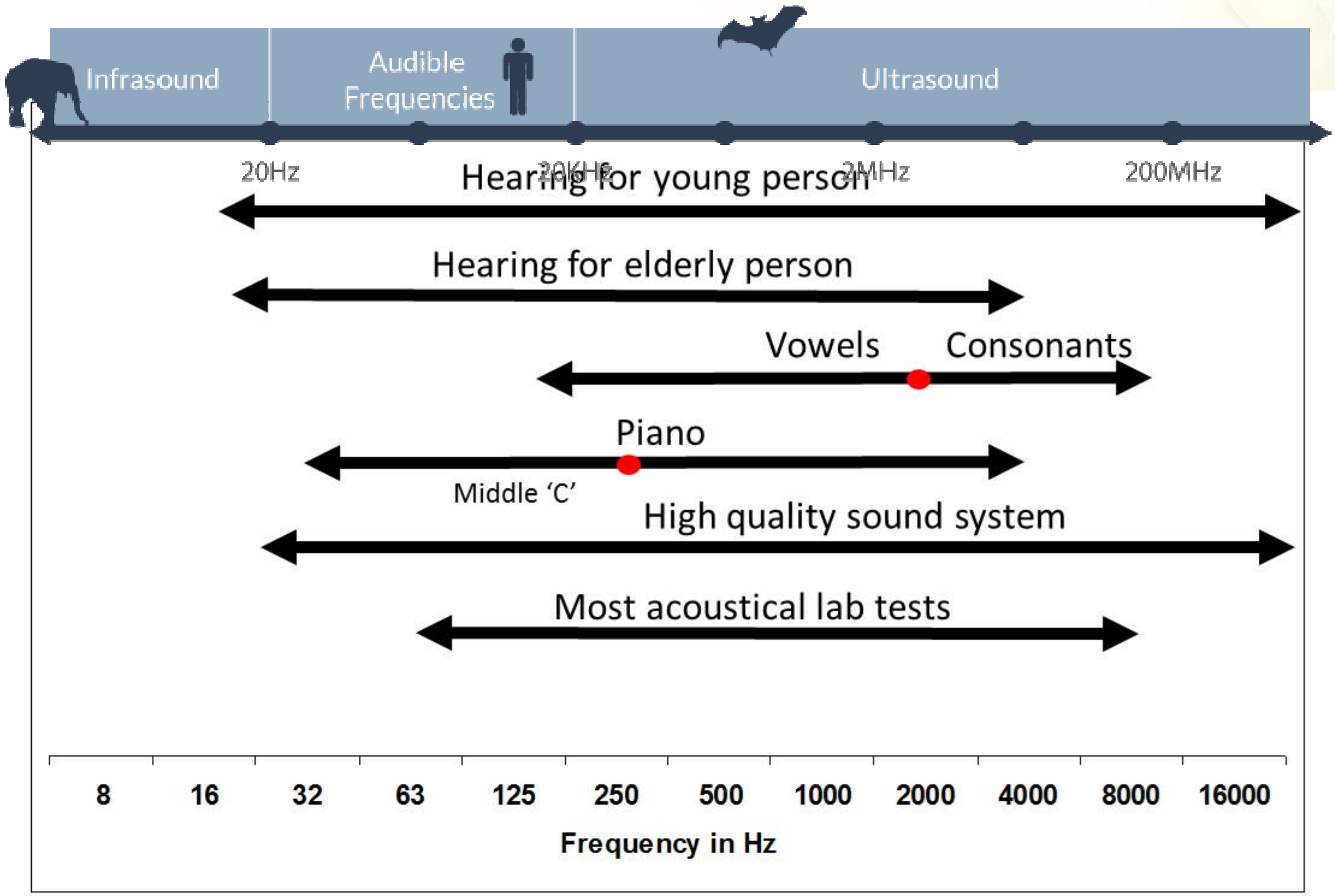
A musical scale corresponds to a logarithmic frequency scale

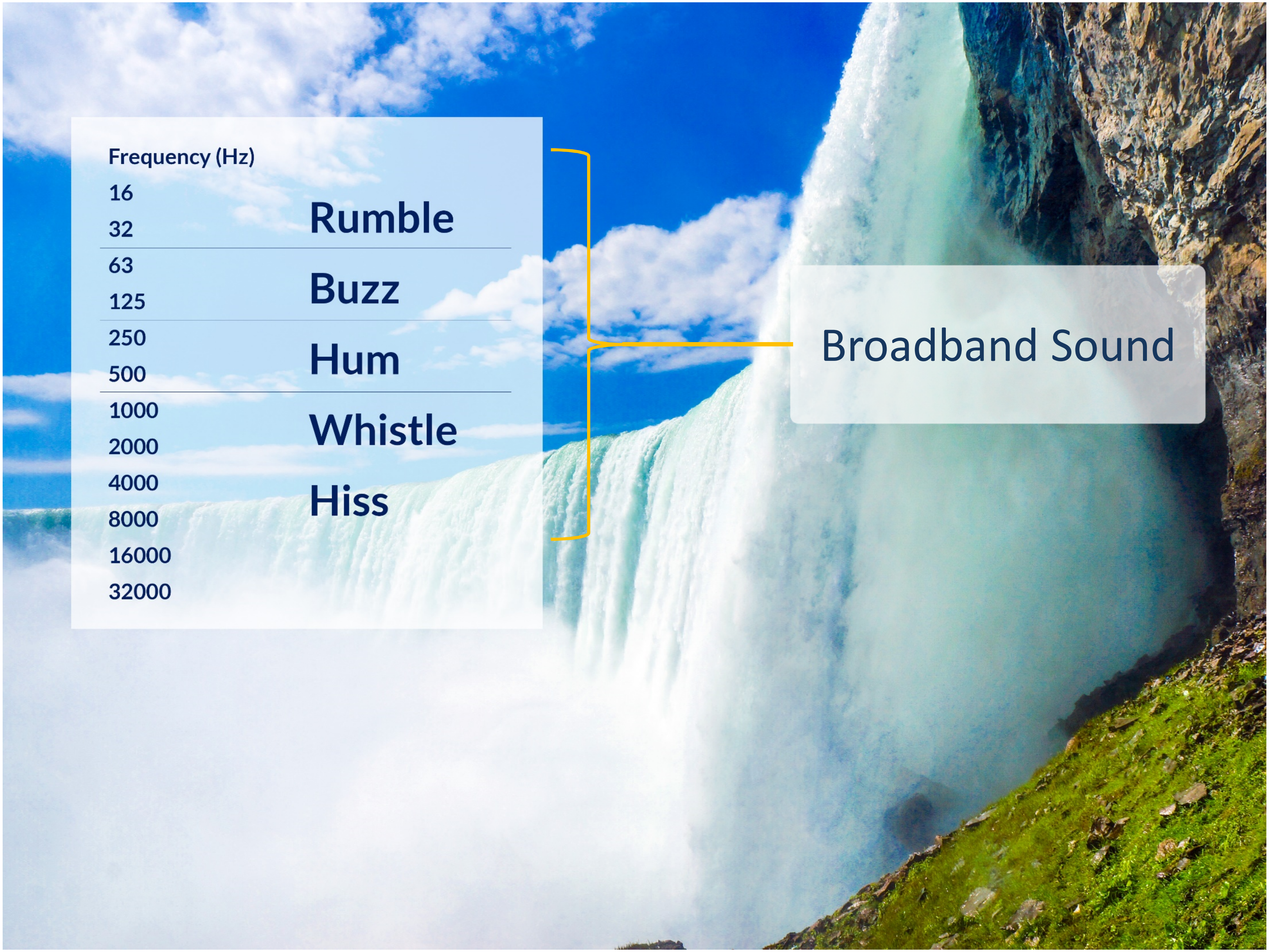


Acoustical measurements are presented in octave or 1/3 octave bands



Frequency Range and Audibility



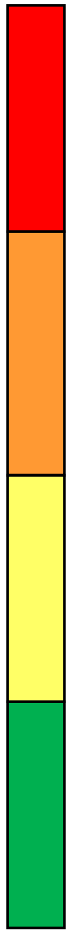


Frequency (Hz)
16
32
Rumble
63
125
Buzz
250
500
Hum
1000
2000
Whistle
4000
Hiss
8000
16000
32000
Broadband Sound

Noise and The Building Envelope

Façade Noise Exposure

24 Hour Equivalent Façade Noise Level



Unacceptable

Specialty construction required

75 dBA

Normally Unacceptable

Requires upgraded exterior façade construction

55 dBA

Normally Acceptable

Requires standard residential façade construction .

45 dBA

Acceptable

Noise exposure both indoors and outdoors is unobtrusive.

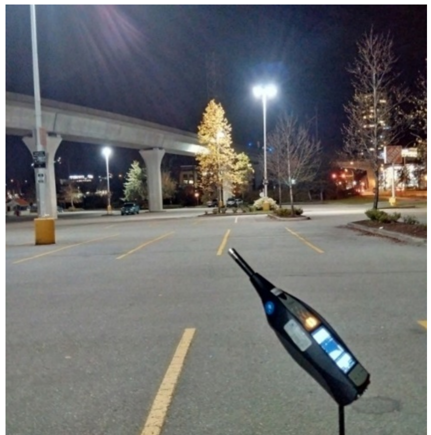
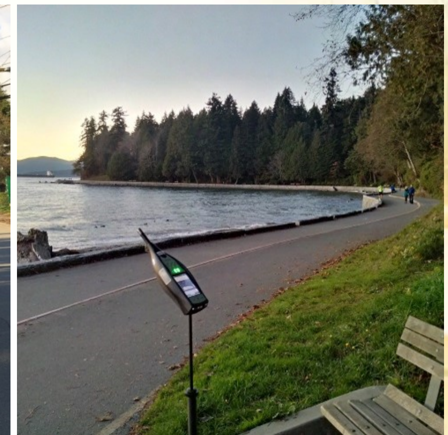
Reference: CMHC Road and Rail Noise: Effects on Housing (1981)

CMHC Indoor Residential Noise Criteria

Room	Max Sound Level (24 hour Leq)
Bedroom	35
Living Room, Dining Room, Family Room	40
Kitchens, Bathrooms, Hallways	45

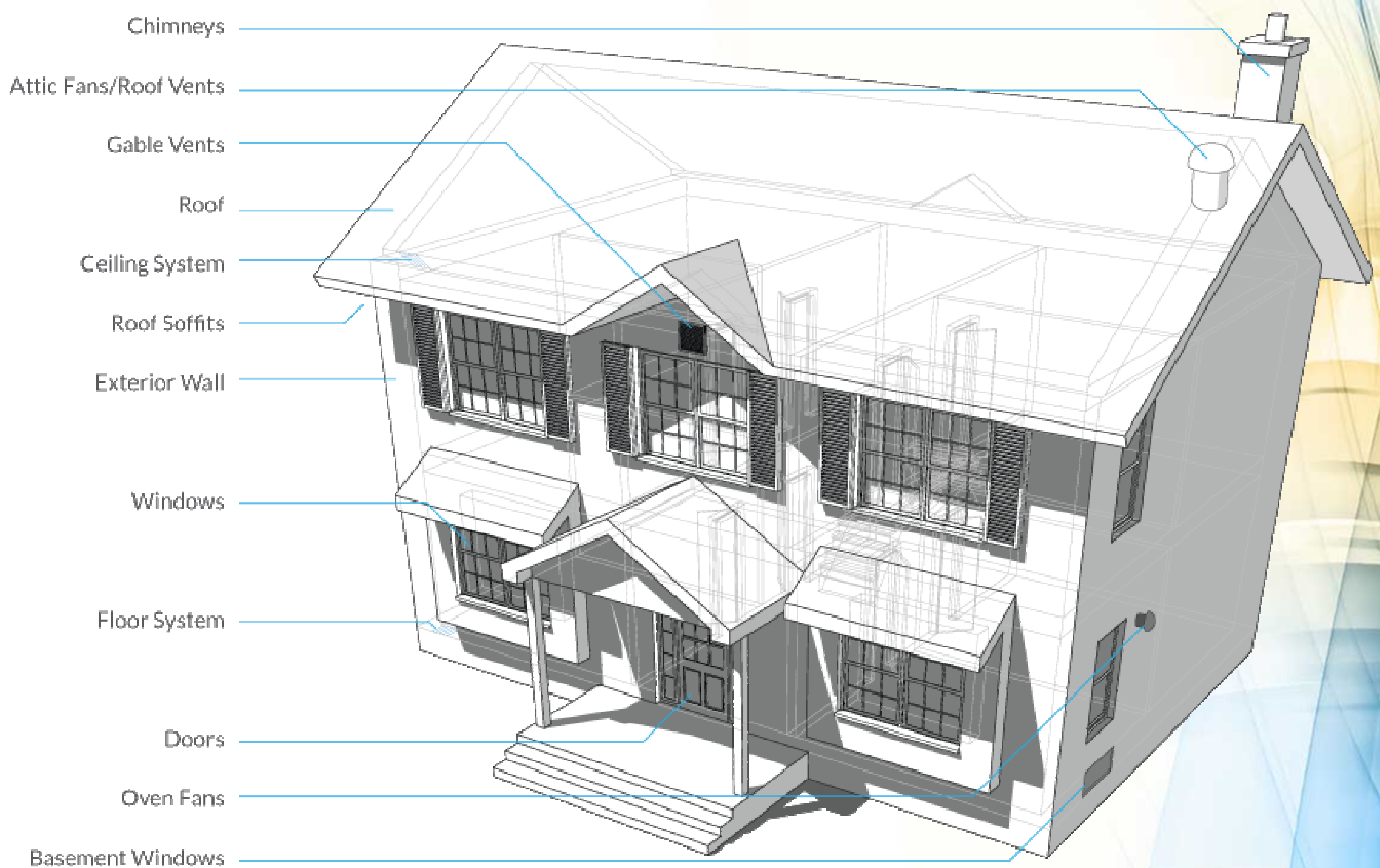
! Municipal criteria may differ

Typical Façade Noise Levels

Broadway/Cambie	Skytrain	Residential Road off SE Marine Drive	Stanley Park
			
83 dBA Sirens; 71 dBA	67 dBA	63 dBA	56 dBA

Unacceptable	Normally Unacceptable	Normally Acceptable	Acceptable
24 Hour Equivalent Façade Noise Level	75 dBA	55 dBA	45 dBA

Façade Sound Transmission Paths



Sound Transmission Loss

Sound Transmission Loss (TL) is a measurement of the sound isolation of a building element, such as a window, door or wall partition.

Single Number Ratings - STC/OITC

- Based on sound transmission loss (TL) data in accordance with ASTM E90

- Weighted average of the performance of the assembly.

Lost detail and generalized assumptions

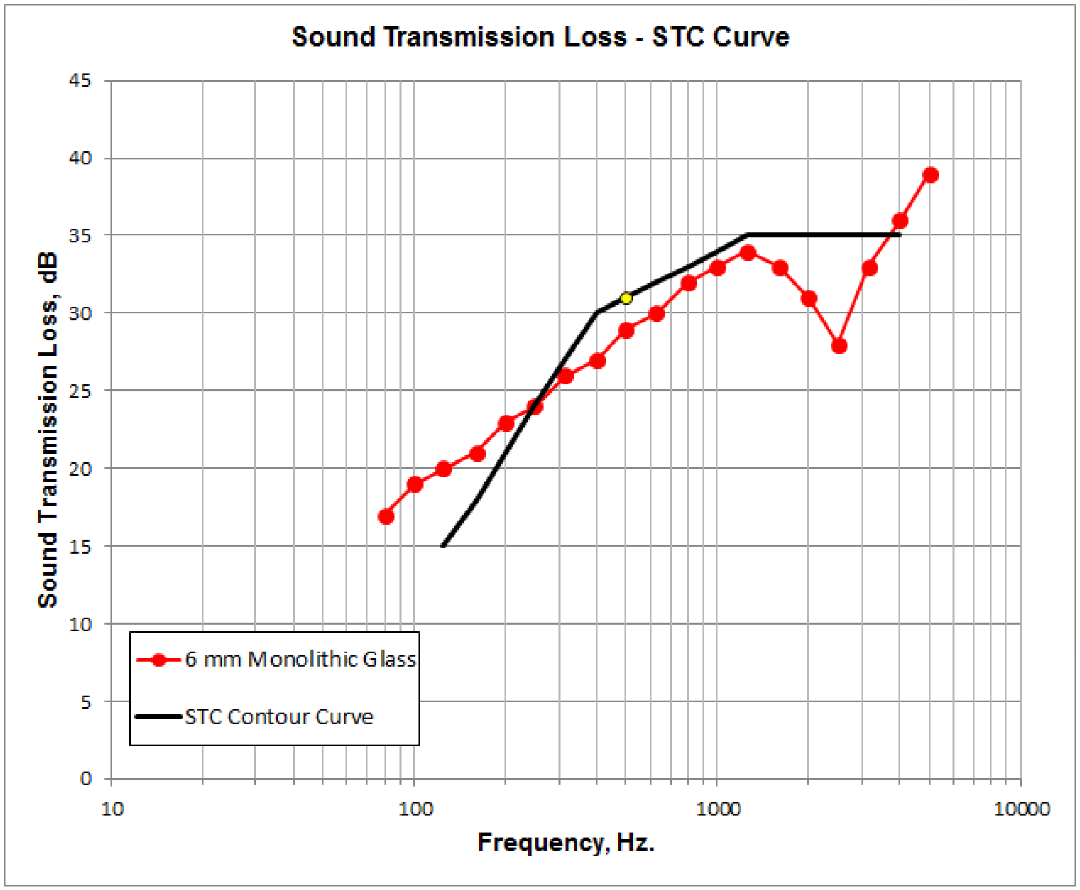
Useful for preliminary selection, but inadequate **where acoustical ratings are critical.**

Single Number Ratings - STC

STC : Sound Transmission Class Rating system

- Appropriate for indoor partitions where reduction in "standard household noise" is required.
- Standard household noise refers to **live speech, radio and television music and speech, vacuum cleaner noise and air conditioning noise** in offices and buildings
- Does not account for subwoofer noise transfer!

STC Contour



The sum of the deficiencies (the deviations below the contour curve) shall not be greater than 32dB

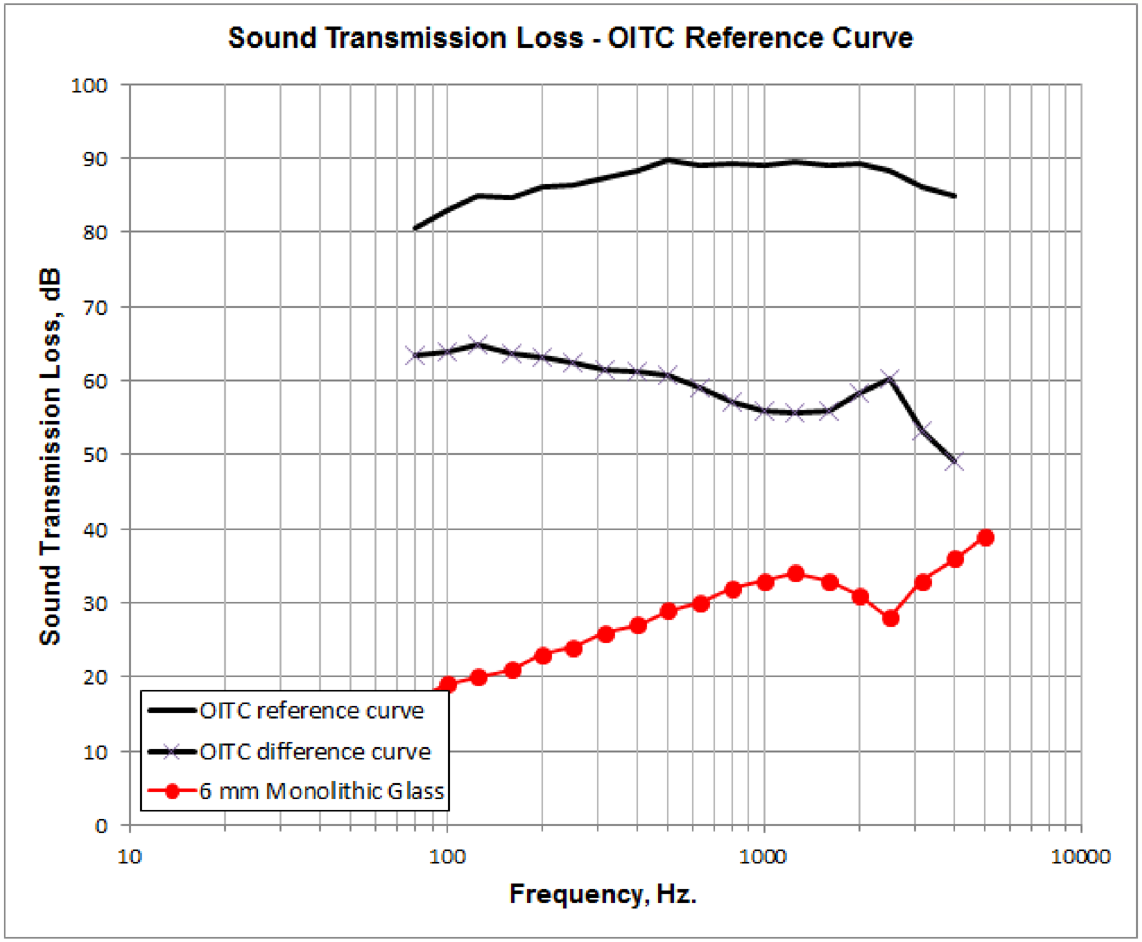
The deficiency at any frequency from 125 to 4,000 Hz shall not be greater than 8dB.

Single Number Ratings -OITC

OITC: Outdoor-Indoor Transmission Class rating system

- Intended to evaluate outdoor-to-indoor noise transfer from **vehicular, aircraft and railway traffic.**
- Appropriate for rank ordering exterior façade assemblies.
- Preferable over STC for exterior façade ranking because it includes lower frequencies (down to 80 Hz).
- Older TL data may not include the 80 and 100 Hz bands rendering it impossible to calculate the corresponding OITC value.

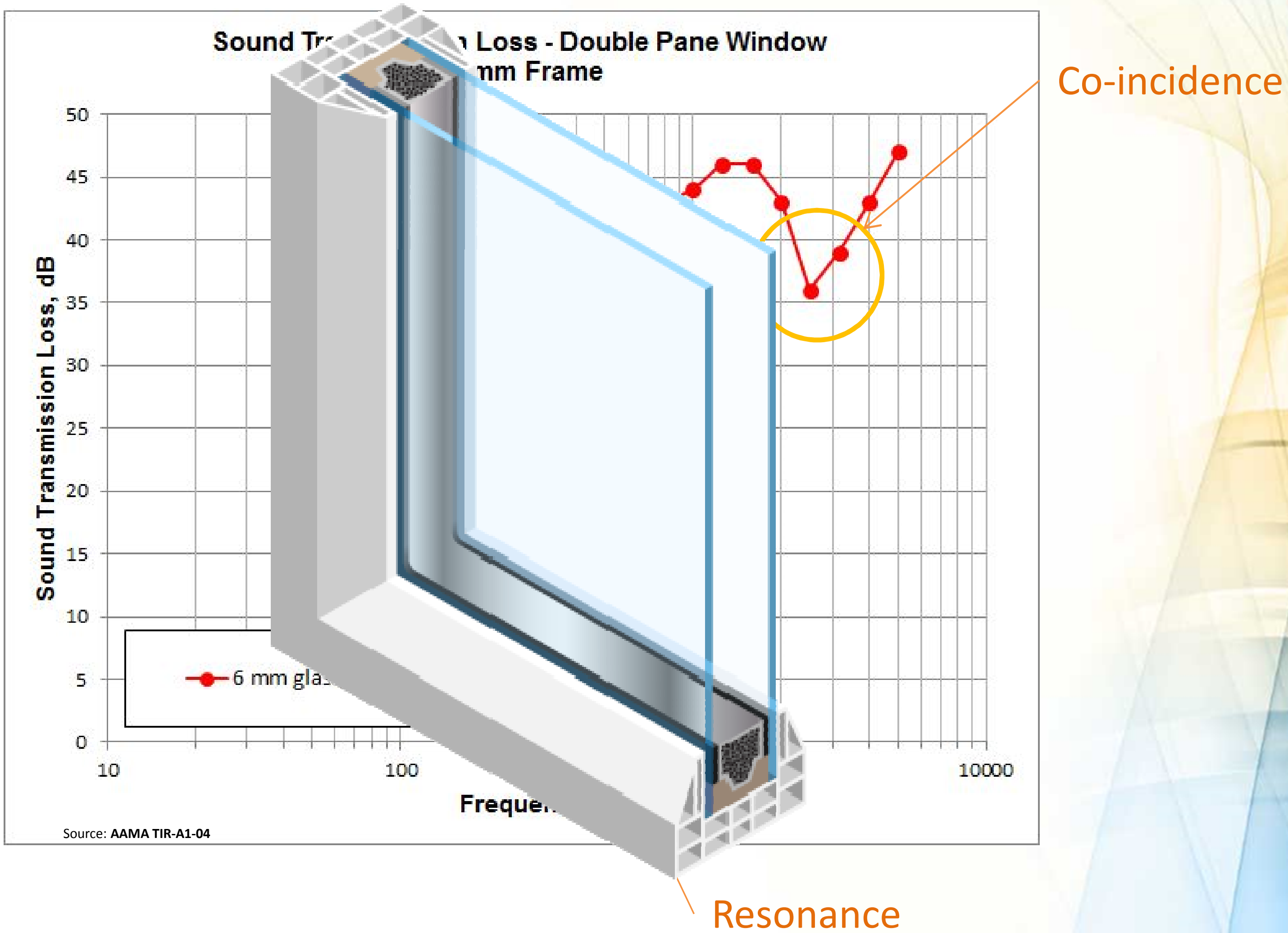
OITC Rating



The OITC rating the difference between:

- total outdoor energy (reference curve) and
- The total indoor energy (difference curve)

Sound Transmission in Double Panel Systems



Mass-Air-Mass Resonance

Increasing the airspace between glass lites generally improves sound isolation .

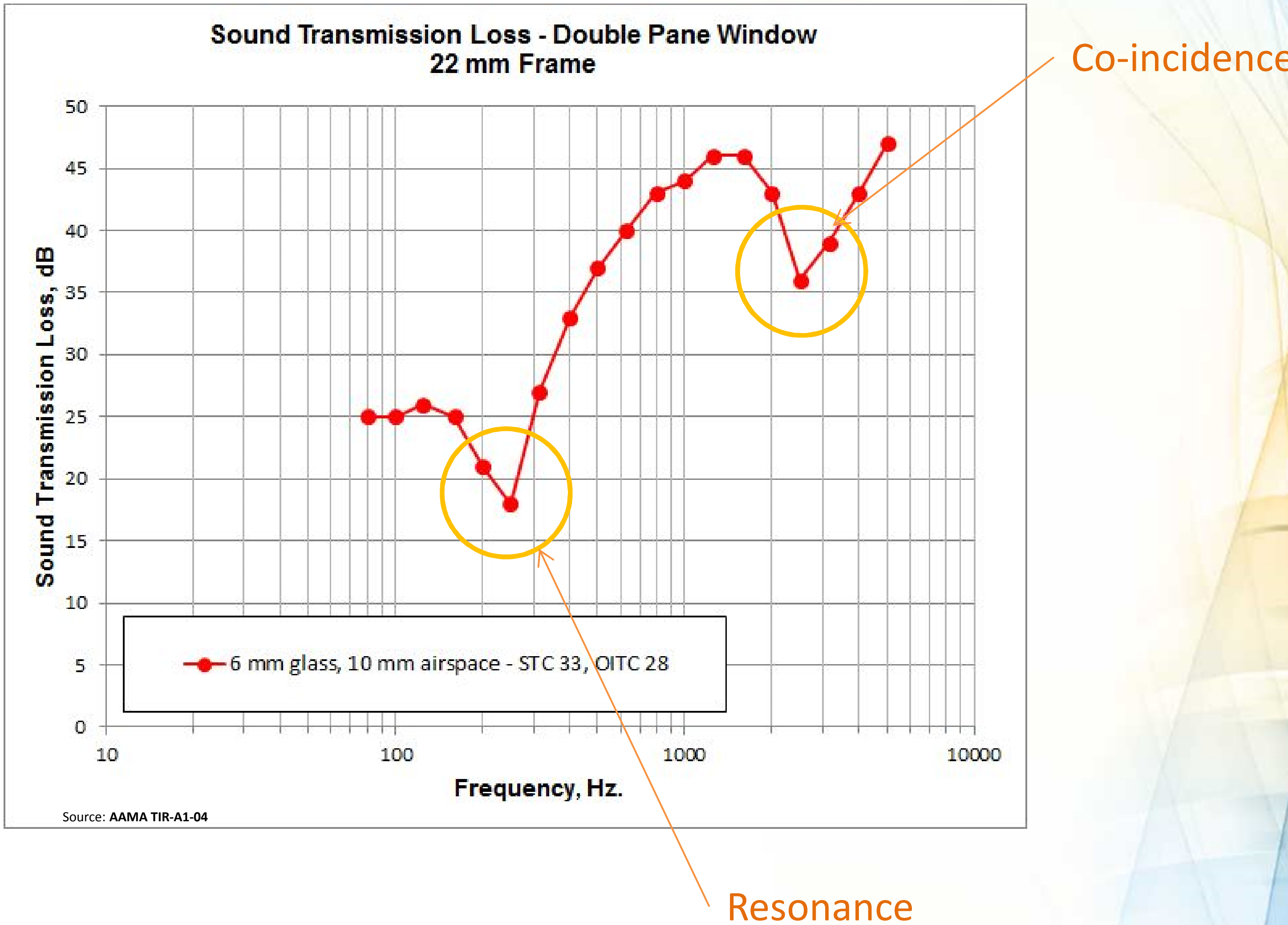
When the air space starts to act like a spring at a specific combination of glass thickness and airspace:

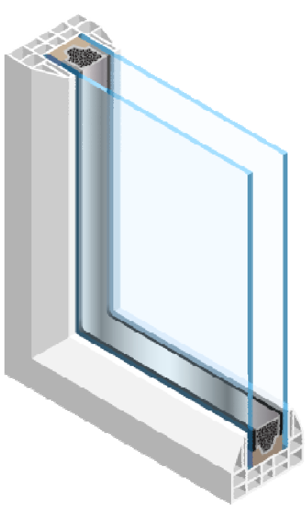
- Resonance results
- Sound passes through with little attenuation.
- TL will be low at this specific frequency.

Co-incidence Effect

When the natural frequency of the glass panel matches the frequency of the incident sound:

- Sound passes through with little attenuation.
- TL will be low at this specific frequency.


Sound Transmission Loss - Double Pane Window
22 mm Frame
Sound Transmission Loss, dB
0
5
10
15
20
25
30
35
40
45
50
10
100
1000
10000
Frequency, Hz.
6 mm glass, 10 mm airspace - STC 33, OITC 28
Source: AAMA TIR-A1-04
Co-incidence
Resonance



Glass Performance

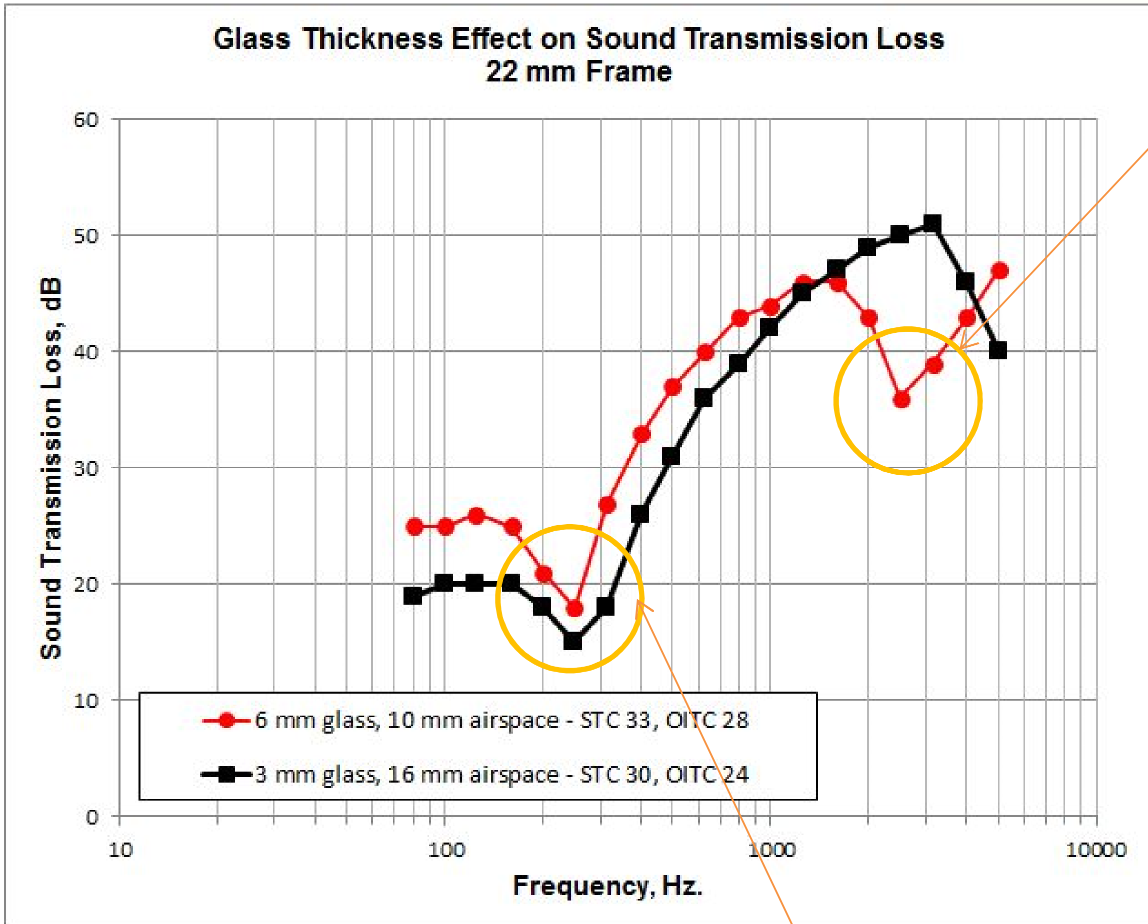
- Glass Thickness
- Air space
- Laminated vs Annealed glass
- Gas filling
- Edge Damping
- Glass Size

Glass Thickness - Mass Law

The STC of glass generally increases with thickness.

For a given frequency, the transmission loss can be increased by approximately 6 dB by doubling the mass per unit area.

Limited by the “Co-incidence Effect” and “Mass-Air-Mass Resonance”



Source: **AAMA TIR-A1-04**

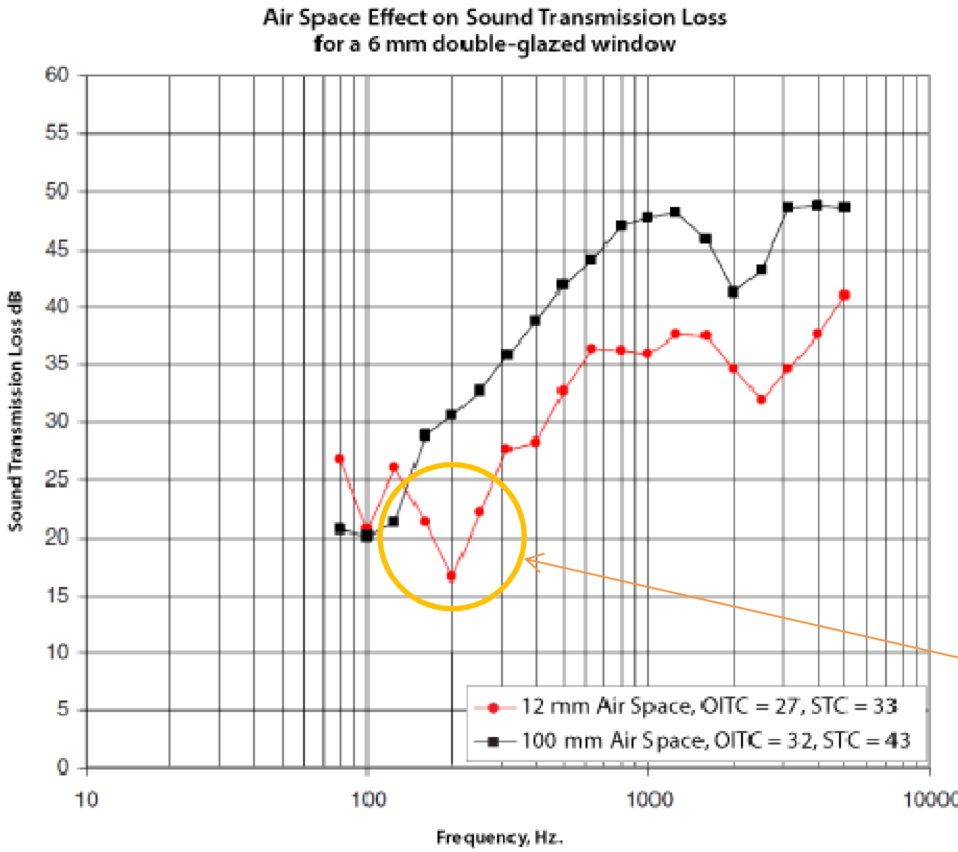
Co-incidence

Resonance

6 dB improvement outside of range of *Co-incidence* and *Resonance*

Air Space

Doubling the airspace provides 3 dB increase in TL



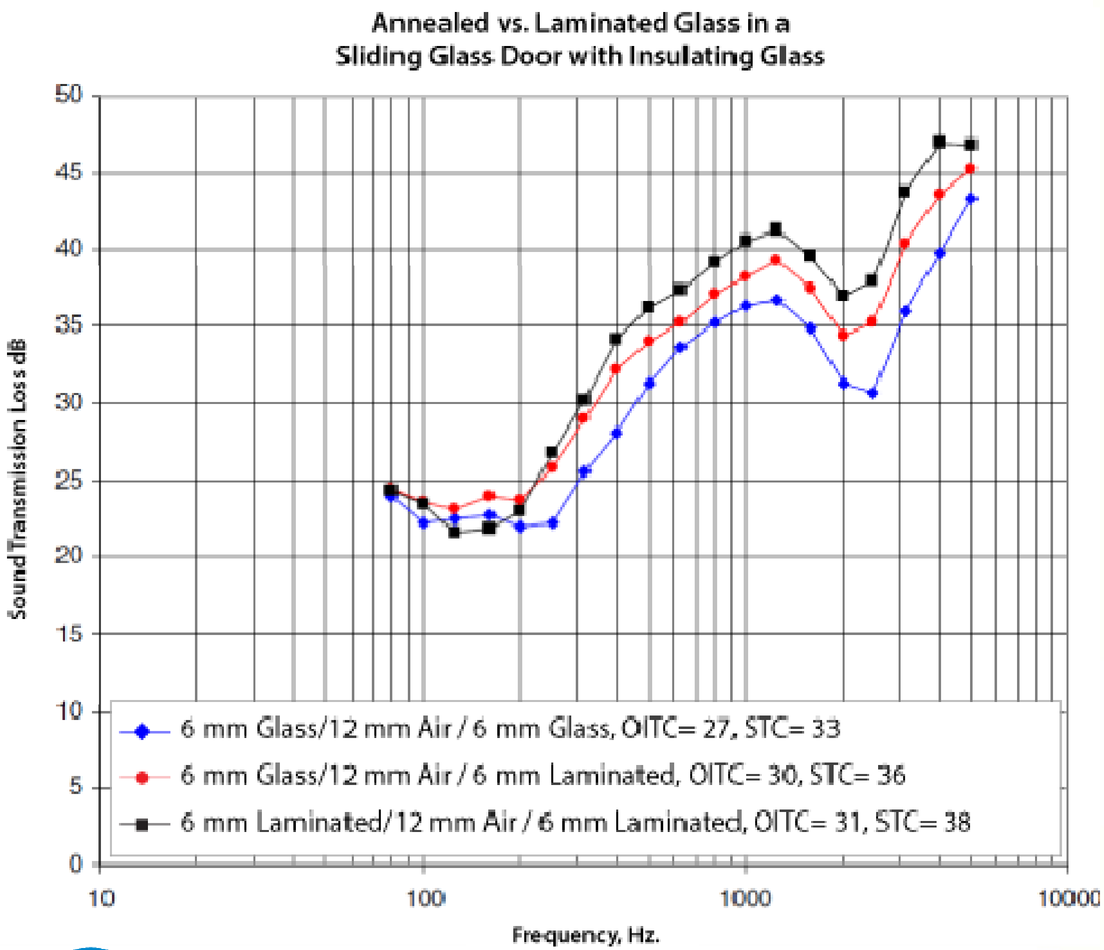
Works well for STC and for airspaces over 19 mm

Less correlated with the OITC rating

Resonance

Triple glazing performs **no better** than double glazing with the same total glass weight and the same overall section depth.

Laminated vs. Annealed Glass

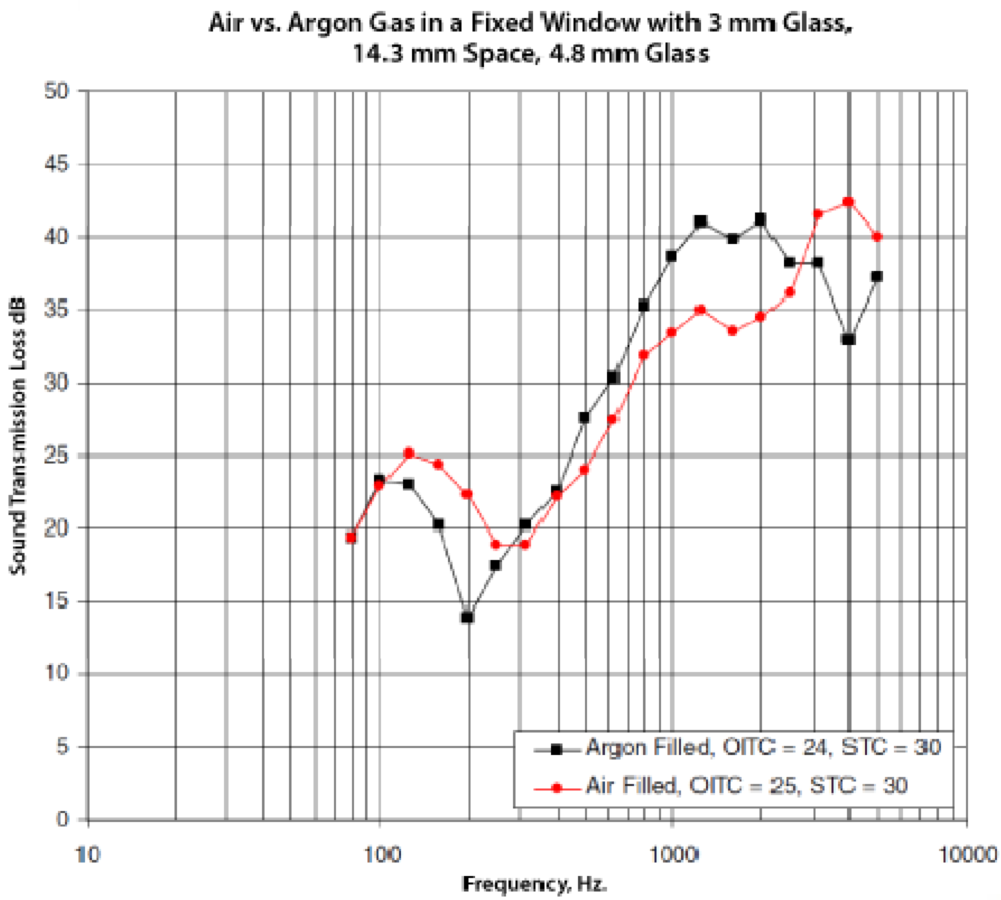


Laminated glass has constrained layer damping, which significantly improves the transmission loss

Increase temperature -> increase TL

Tempered safety glass is **not** acoustically equivalent to laminated glass.

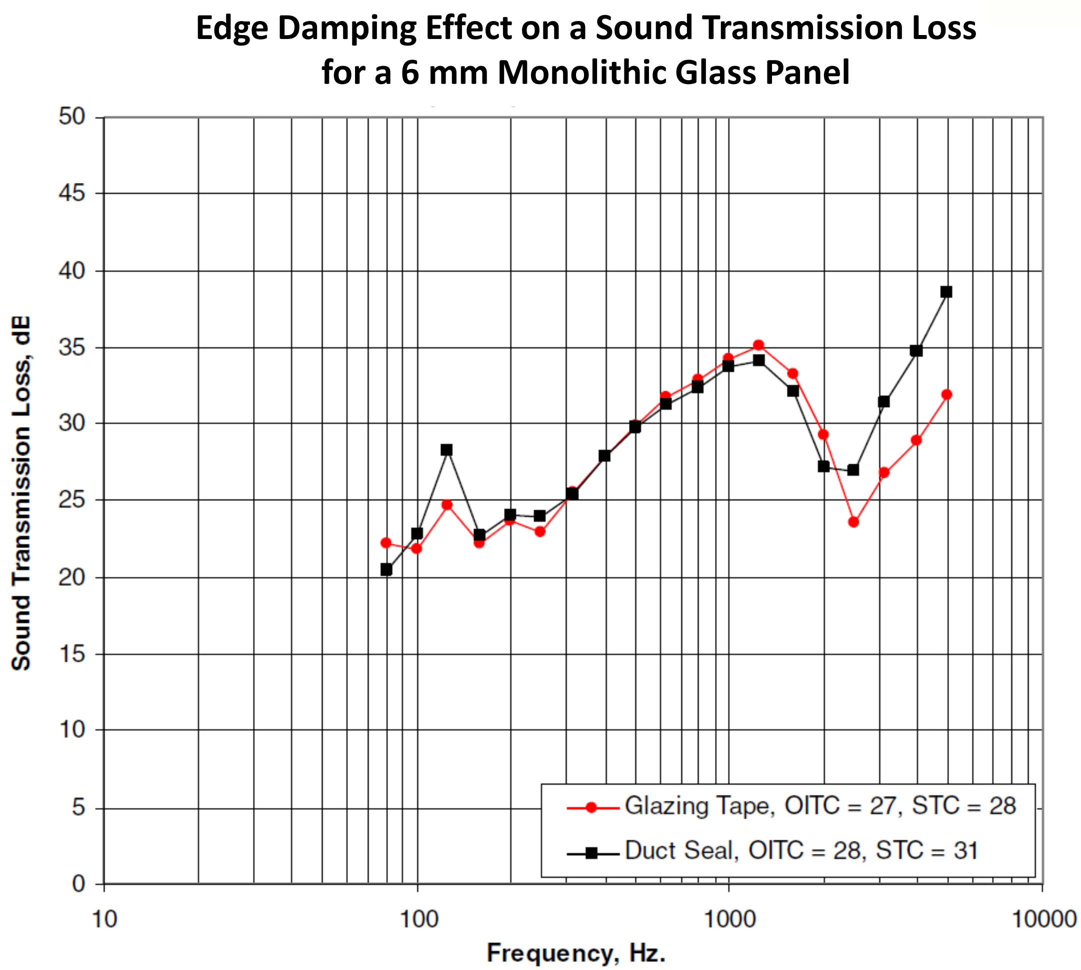
Gas Filling



Changes the shape of the TL curve

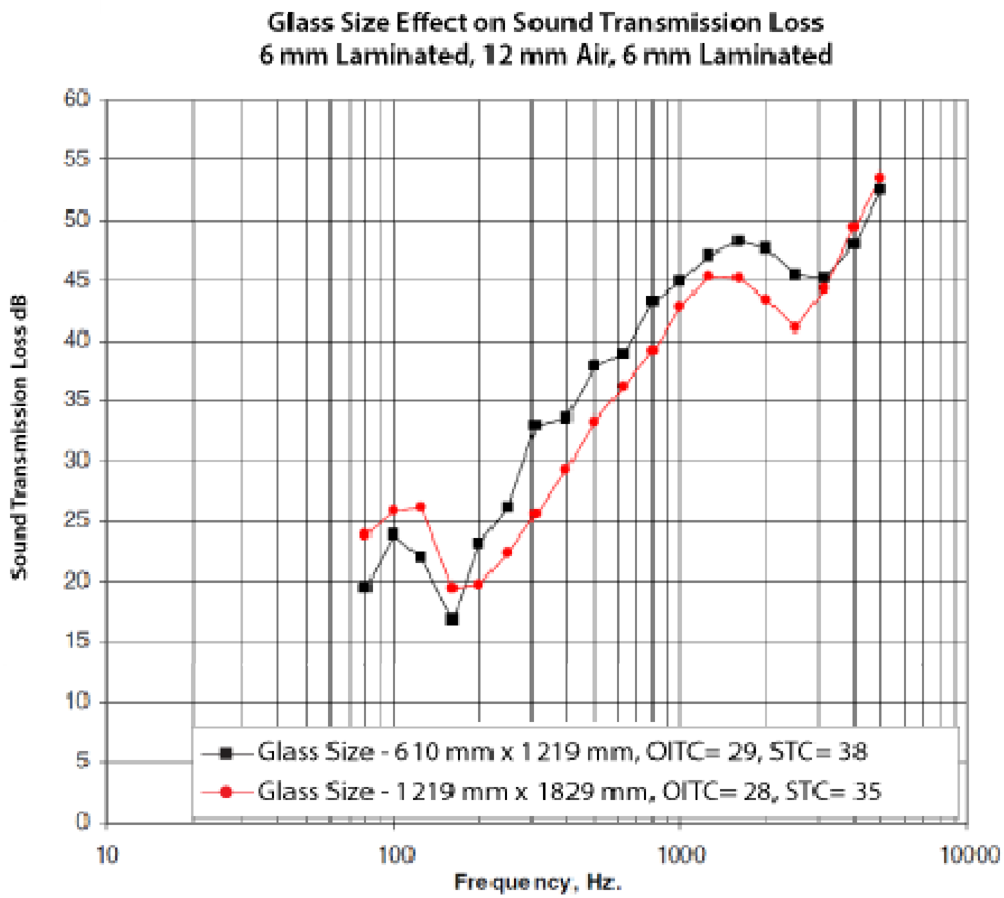
Gas filled glazing units perform acoustically better at some frequencies and worse at other frequencies when compared to air filled . **Look at frequencies of noise to be isolated when choosing gas vs. air**.

Edge Damping



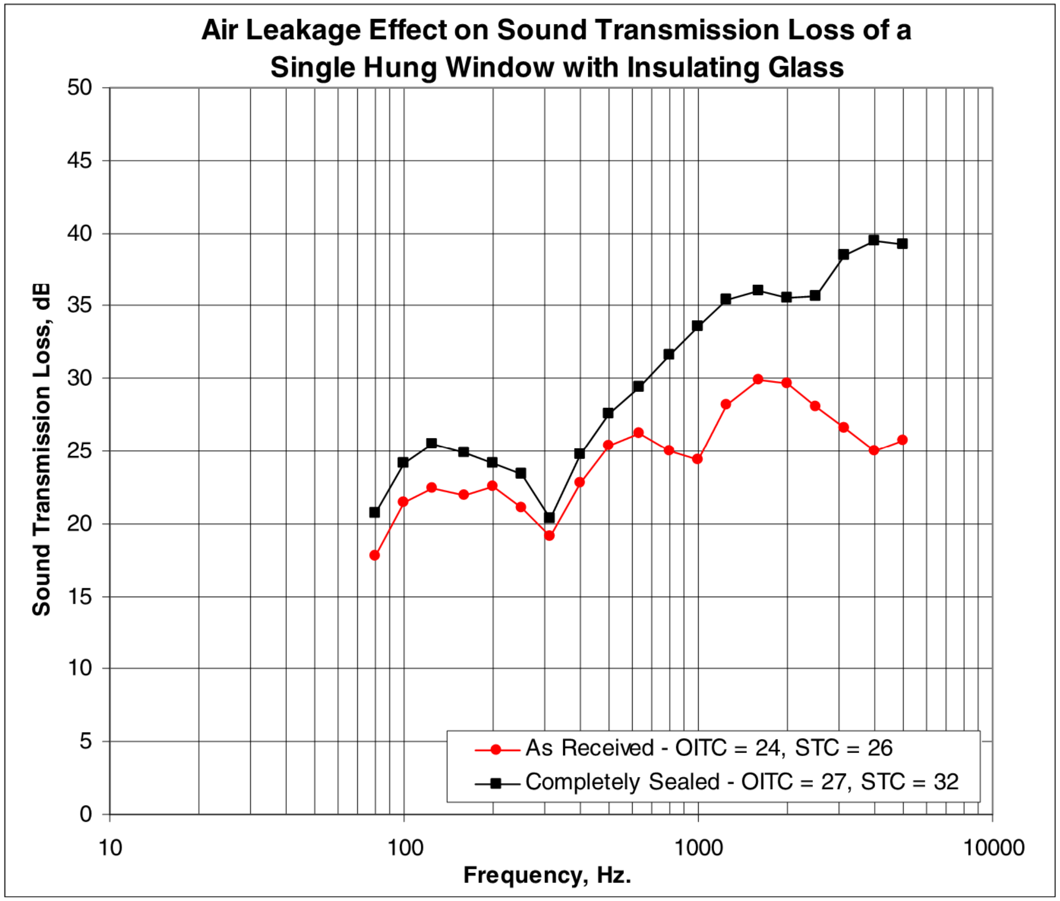
Damping improves TL at certain frequencies

Glass Size



More rigid, smaller panels provide higher TL values

Air Leakage



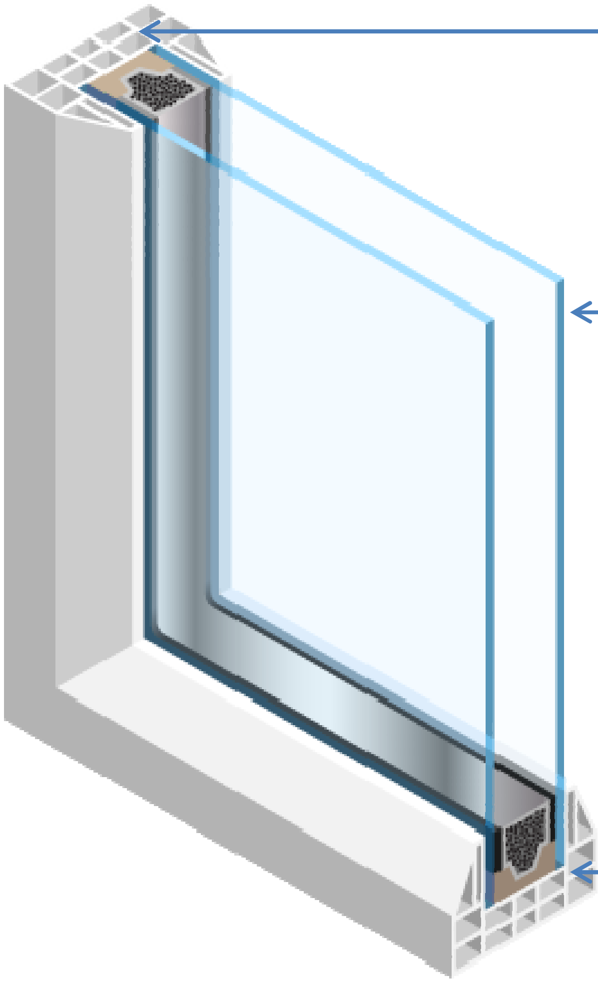
Most apparent at high frequencies

Good seals are needed

Maximising of Window TL

Increase damping	Laminated glass increases TL by approximately 5 dB.
Unbalanced Construction	TL is marginally improved compared to equivalent weight in a balanced construction.
Increase mass	6 dB improvement with doubling mass per unit area.
Increase airspace	3 dB improvement with doubling airspace.

Window Frame – Sound Transfer Paths



Frame

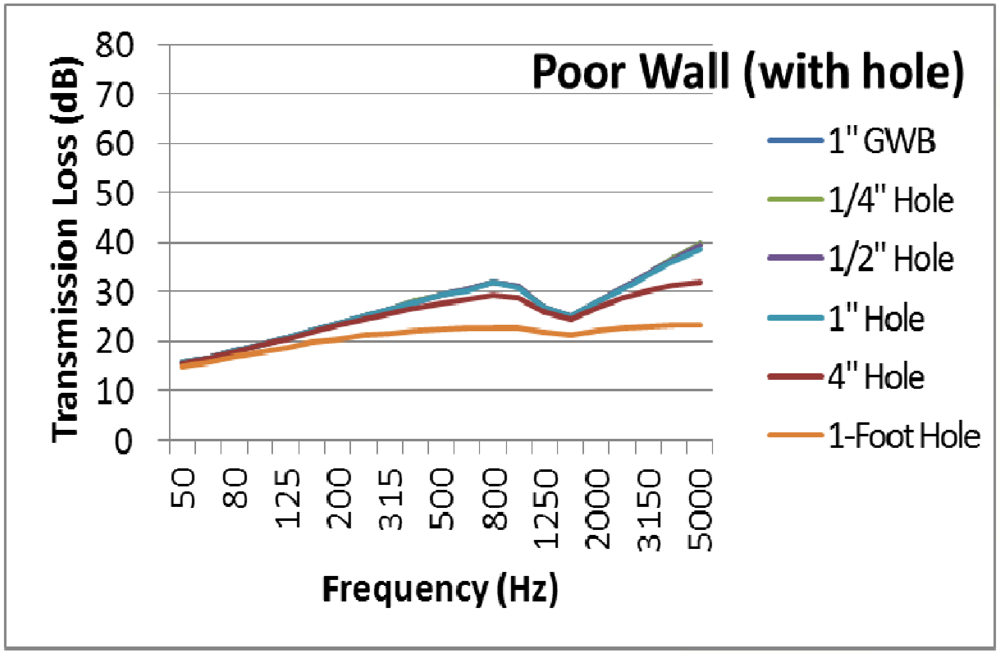
Glass

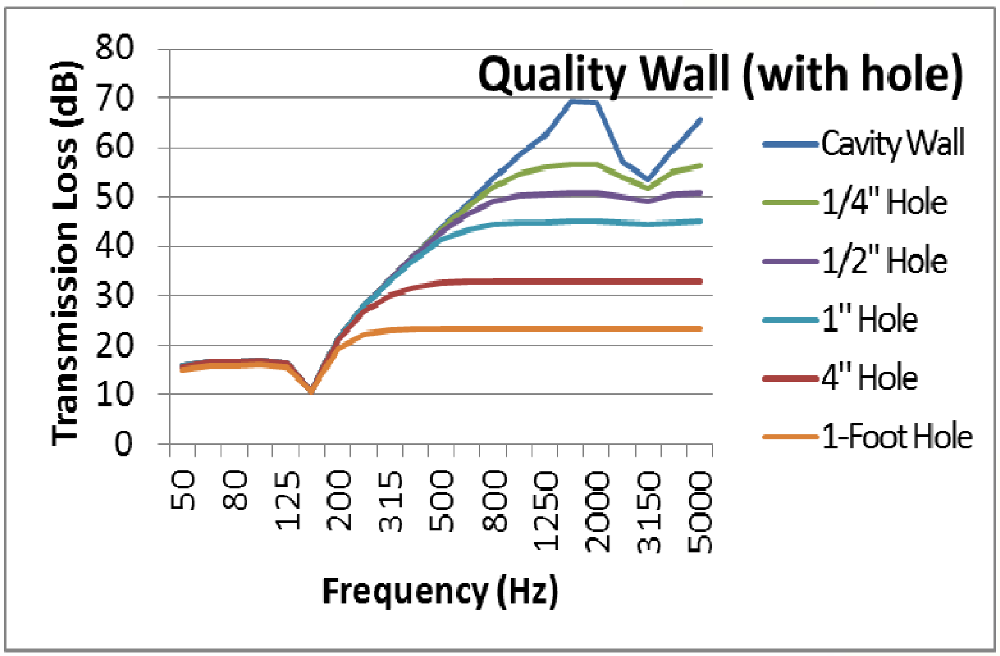
Any cracks or leaks:
- Gaskets
- Frame – glass junction

Lab ratings are under ideal test conditions

Maximising of TL – Window Frames

Increase mass	Increase mass of frames and perimeter infill
Fill frame cavity	Place sound absorptive materials or high mass materials in cavity
Improve air tightness	Careful consideration of perimeter construction


Poor Wall (with hole)
Transmission Loss (dB)
80
70
60
50
40
30
20
10
0
50
80
125
200
315
500
800
1250
2000
3150
5000
Frequency (Hz)
1" GWB
1/4" Hole
1/2" Hole
1" Hole
4" Hole
1-Foot Hole


Quality Wall (with hole)
Transmission Loss (dB)
80
70
60
50
40
30
20
10
0
50
80
125
200
315
500
800
1250
2000
3150
5000
Frequency (Hz)
Cavity Wall
1/4" Hole
1/2" Hole
1" Hole
4" Hole
1-Foot Hole

Air Tightness Specifications

A window classification of A3 (as found in the CSA standard CAN/CSA-A440-M90) or better should be considered as a minimum for windows.

Matching Window and Wall Performance

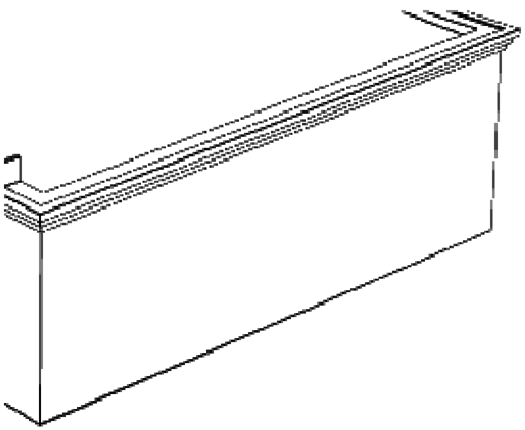
The composite transmission loss of an exterior facade is based on:

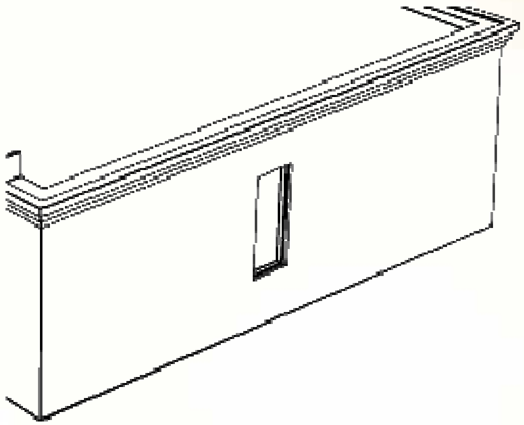
- The transmission loss of the individual elements (wall, doors and windows etc.)
- The surface area of these elements.

Matching Window and Wall Performance

Wall OITC = 41

Window OITC = 24

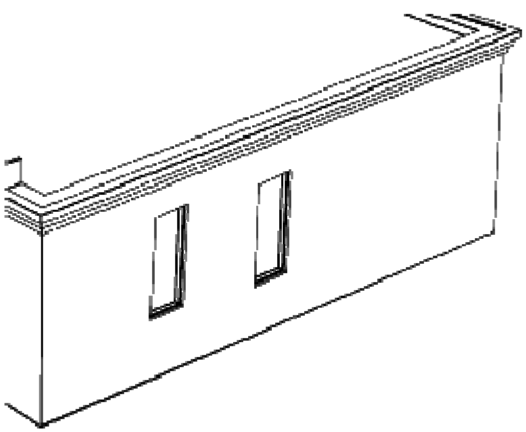


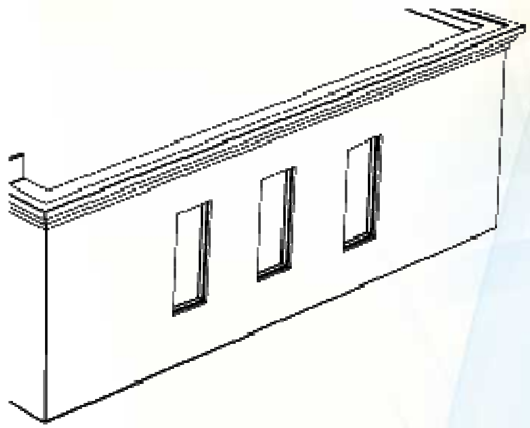


41 **36**

Composite OITC

34 **33**





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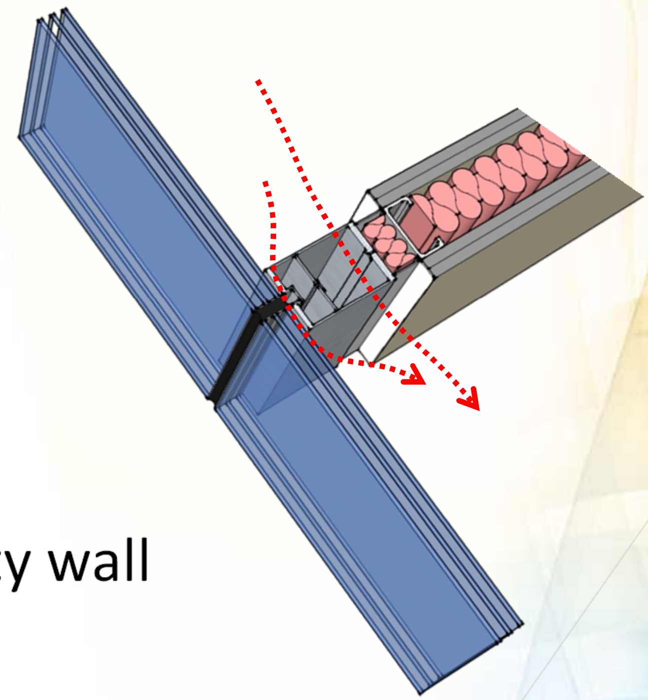
Party walls adjoint to windows

Sound flanking from the interface of window wall/party wall has two paths:

- through the window mullion assembly;
- through the gap between the window mullion and the party wall



Thank you for your time.

Any questions?

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