

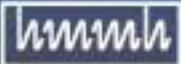


# Accounting for Frequency Spectra in Sound Insulation Testing

Presented to:  
**Airport Noise Abatement Committee**

September 13, 2010

**Ted Baldwin**  
**Harris Miller Miller & Hanson Inc.**



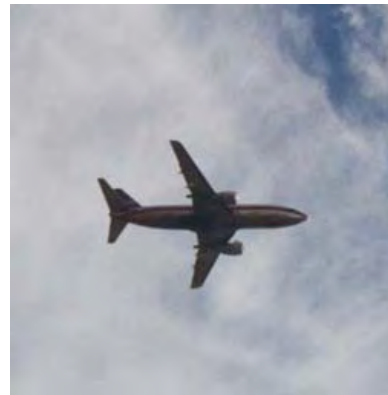
# Outline

- **Basic noise model**
  - Source-path-receiver
- **Acoustical testing process**
  - Pre-treatment testing
  - Post-treatment testing
  - Calculation of outdoor-indoor noise level reduction (OILR)
- **Noise source options**
  - Actual aircraft operations
  - Artificial noise source over loudspeaker
- **Case study using actual measurements**
- **Application to a worst-case aircraft spectrum**

# Basic Noise Model

- **Fundamentally noise can be broken into:**

- Source (two options)
  - Signal generator and loudspeaker
  - Aircraft operations



- Path
  - The building envelope



- Receiver
  - Interior dwelling space

# Testing Process

## ■ Pre-construction

- Measure the exterior source sound level
- Measure the interior sound level
- Determine outdoor-to-indoor noise level reduction (OILR)
  - Octave band by octave band
  - OILR in any octave band is independent of level
- Use worst-case aircraft spectrum (Boeing 727) to calculate Noise Level Reduction (NLR).

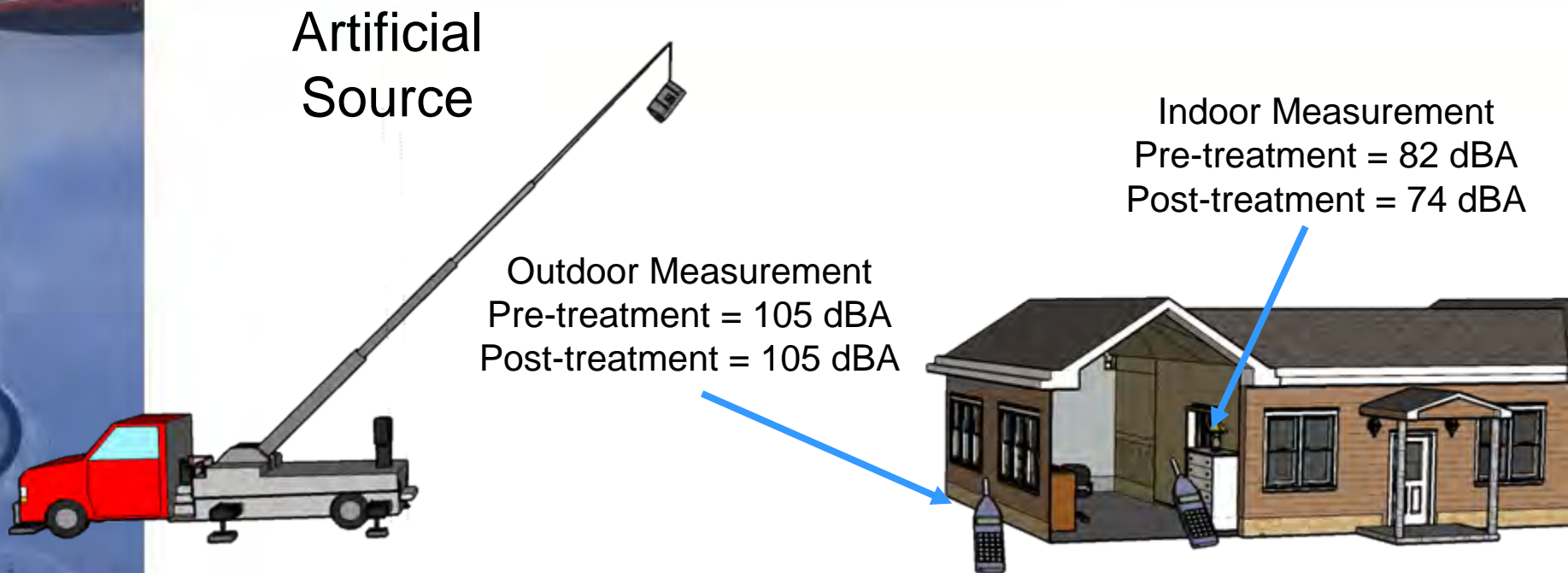
## ■ Post-construction

- Repeat pre-construction testing

## ■ Compare test results

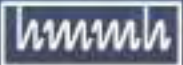
- Determine the overall NLR performance improvement from the acoustical treatment package

# Outdoor-Indoor NLR Example



NLR = outdoor measurement minus indoor measurement  
 Pre-treatment NLR = 23  
 Post-treatment NLR = 31

NLR *improvement* = post-treatment NLR minus pre-treatment NLR  
**31 – 23 = 8 dBA NLR improvement**



# Comparison of Noise Source Options

## *Actual Aircraft Operations*

### ■ Advantages

- Measurement of actual aircraft operations
- Assess type of operation; e.g., run-up, departure, arrival

### ■ Disadvantages

- Operations are unpredictable
- Measurements are not repeatable
- Background noise has a greater potential to interfere
- Does not provide reliable source across full spectrum
- Cannot isolate rooms or portions of the building
- Time consuming and costly
- Invasive – requires extended access to the home
- Cannot compare to other test data or manufacturer data

# Comparison of Noise Source Options

## *Artificial Source over Loudspeaker*

### ■ Advantages

- The source is controllable and predictable
- The test process is repeatable
- Can control for background noise
- Permits testing across entire frequency spectrum
- Provides for better isolation and testing of individual rooms or portions of the building envelope
- Permits comparison to other test data or manufacturer data
- Minimizes cost and testing time
- Less invasive – minimizes access required to home

### ■ Disadvantages

- Can be difficult for non-technical audience to understand

# Artificial Source Spectra

## ■ Test signal requirements

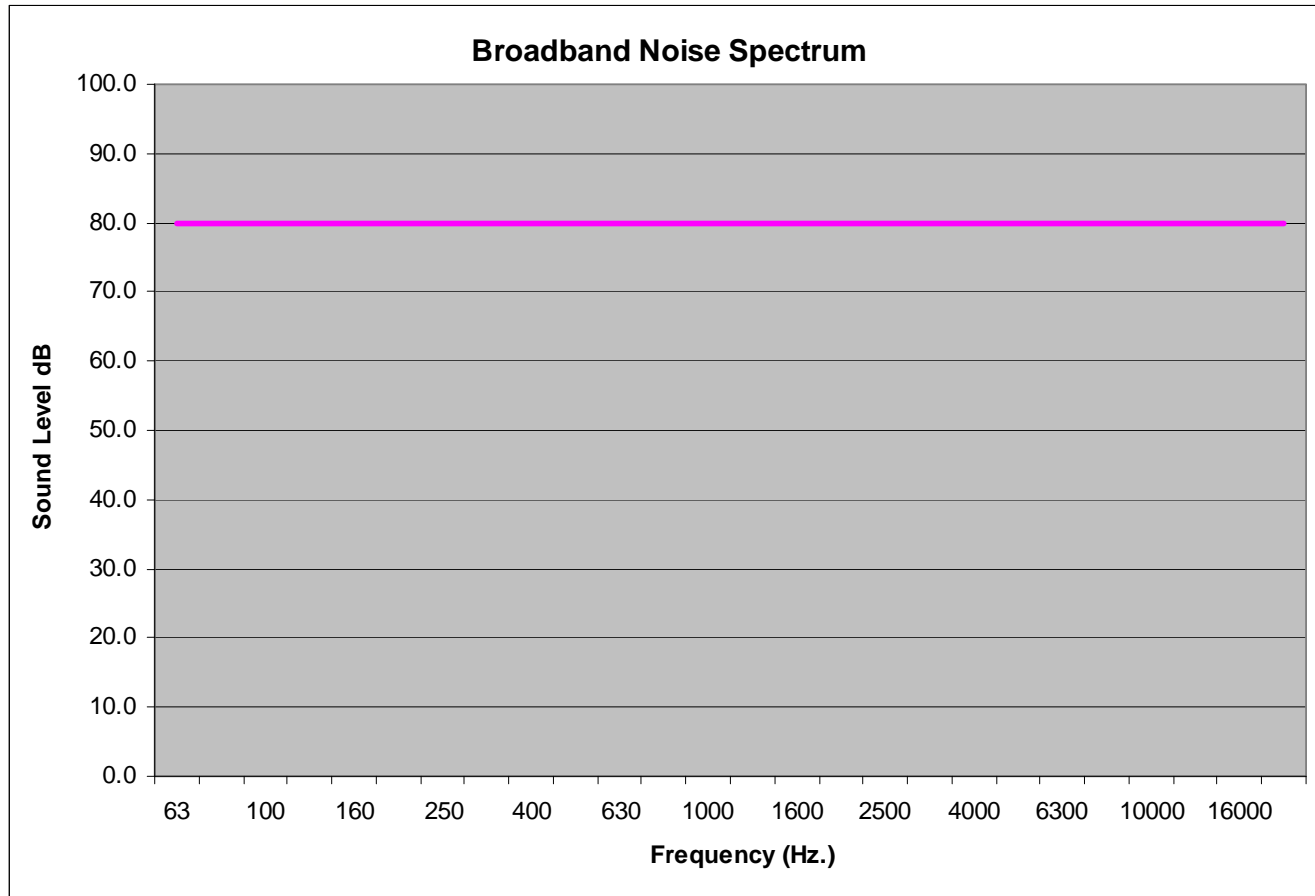
- Source *spectrum* must be “broadband” to test the building envelope across all frequency bands
- Source *level* must exceed background noise by 10 dB or more in each frequency band to ensure testing is not corrupted by uncontrolled variables
- Source must be repeatable

## ■ We use a “pink” source

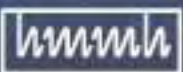


# Artificial Source Spectra – “Pink” Noise

- Random noise with equal energy per octave band

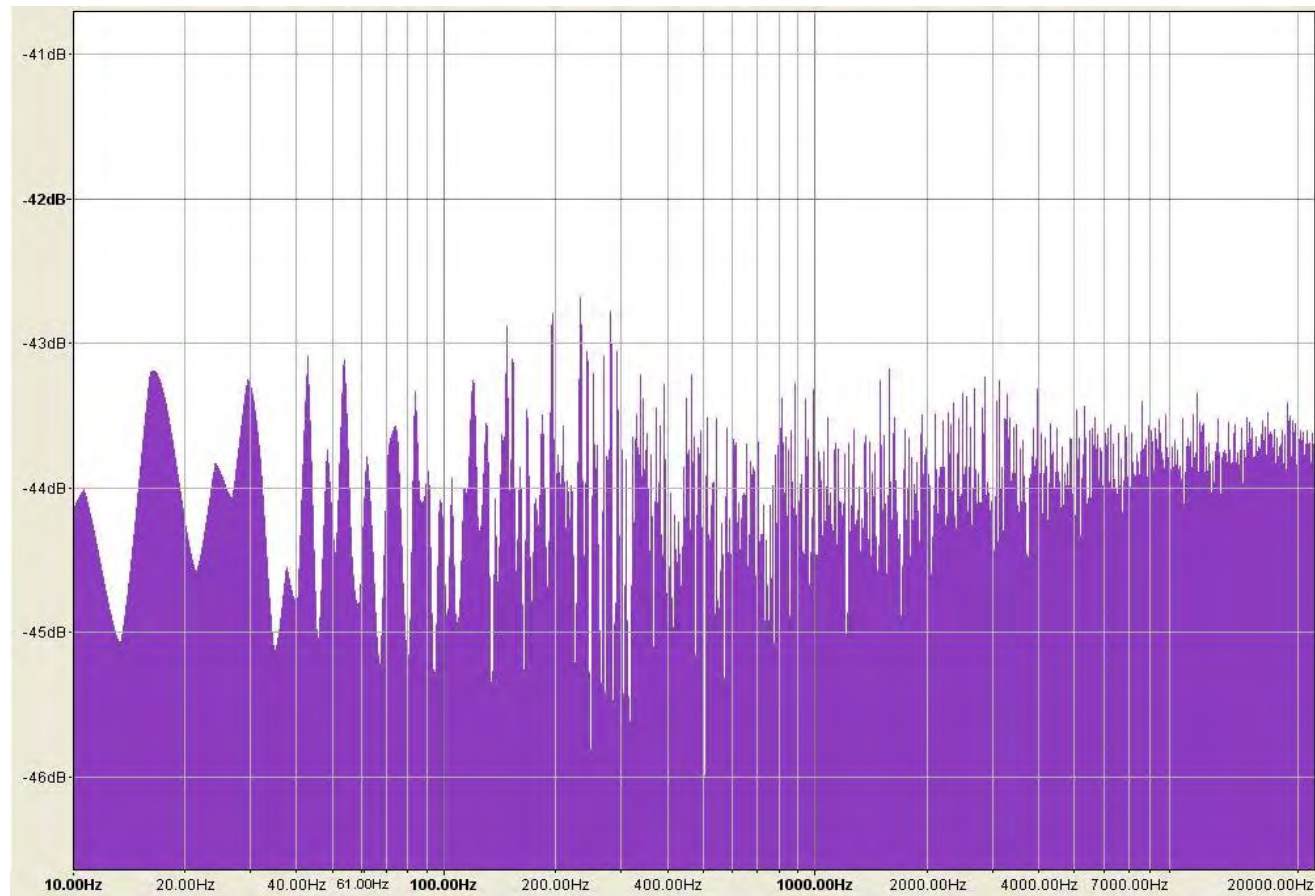


*Time-averaged spectrum output (1-3 seconds)*

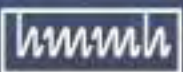


# Artificial Source Spectra – “Pink” Noise

- Random noise with equal energy per octave band

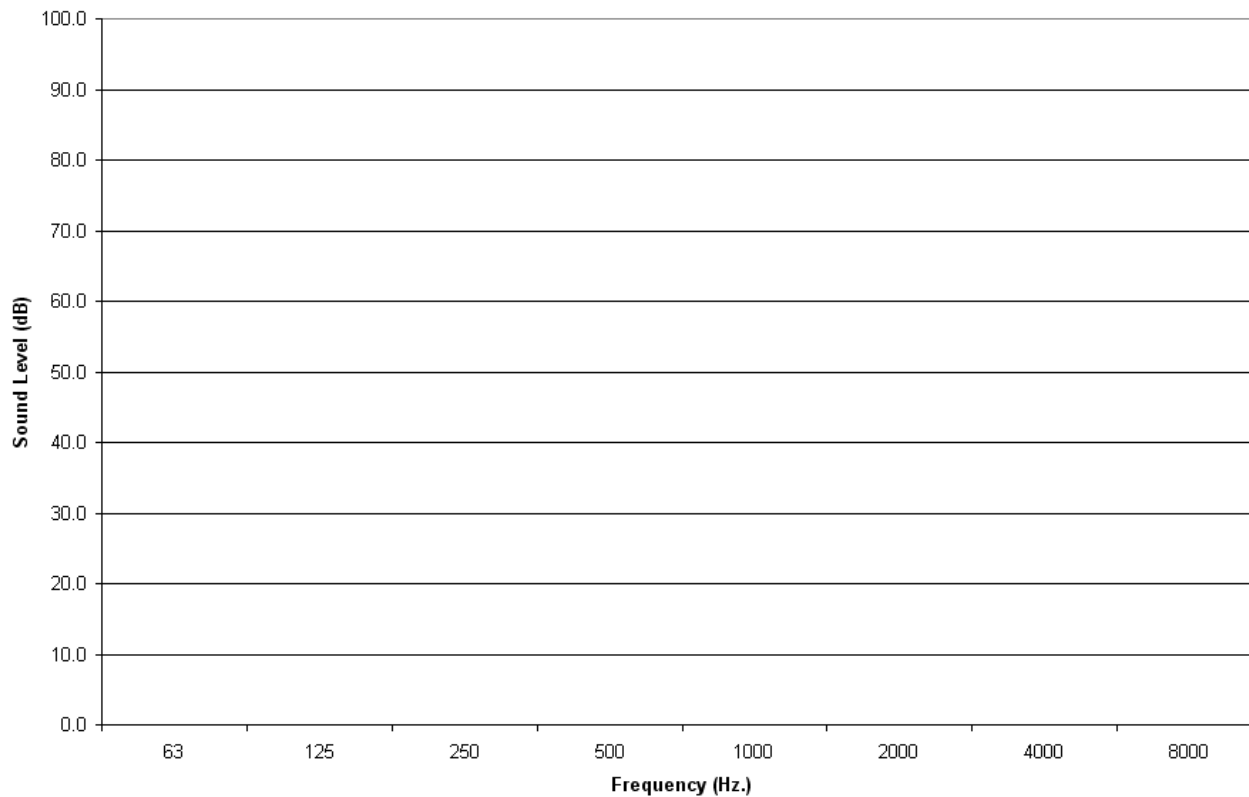


*Instantaneous* spectrum output (fraction of a second)



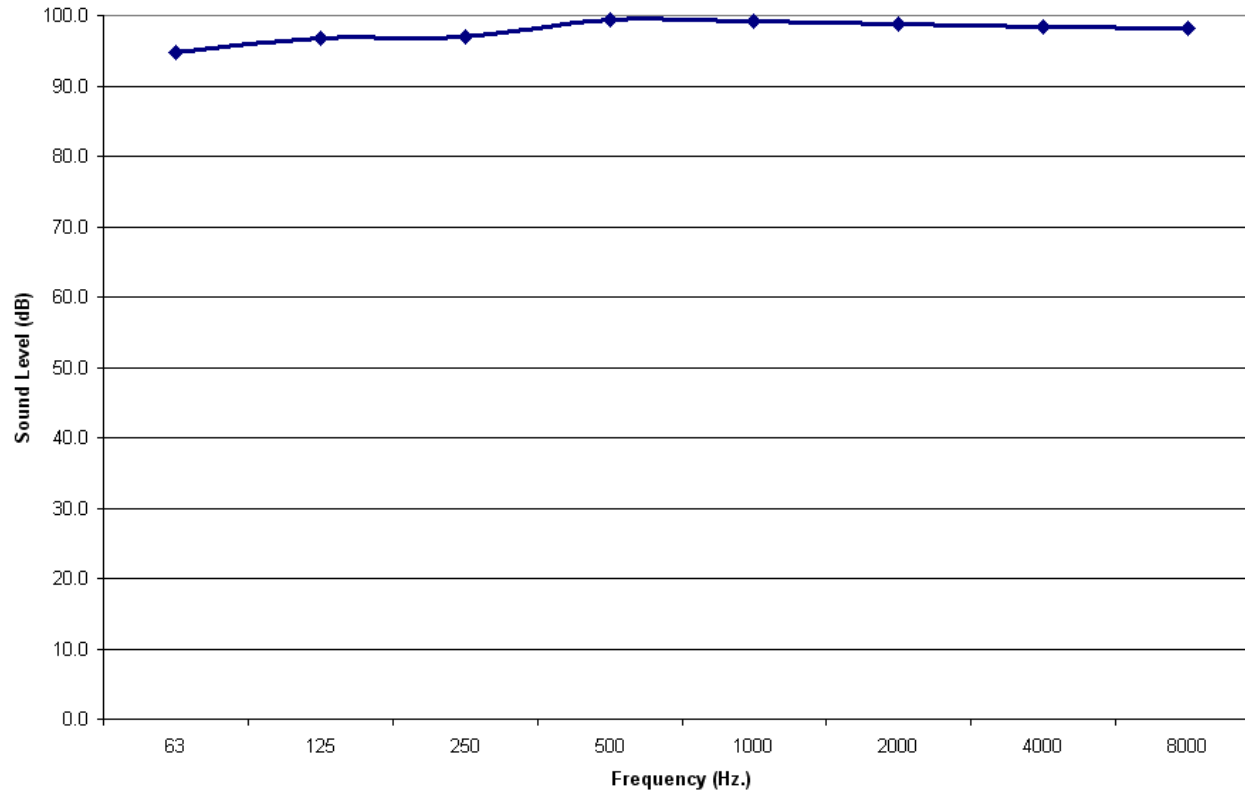
# Actual Case Study

## Acoustical testing results for broadband noise source



# Actual Case Study

## Acoustical testing results for broadband noise source

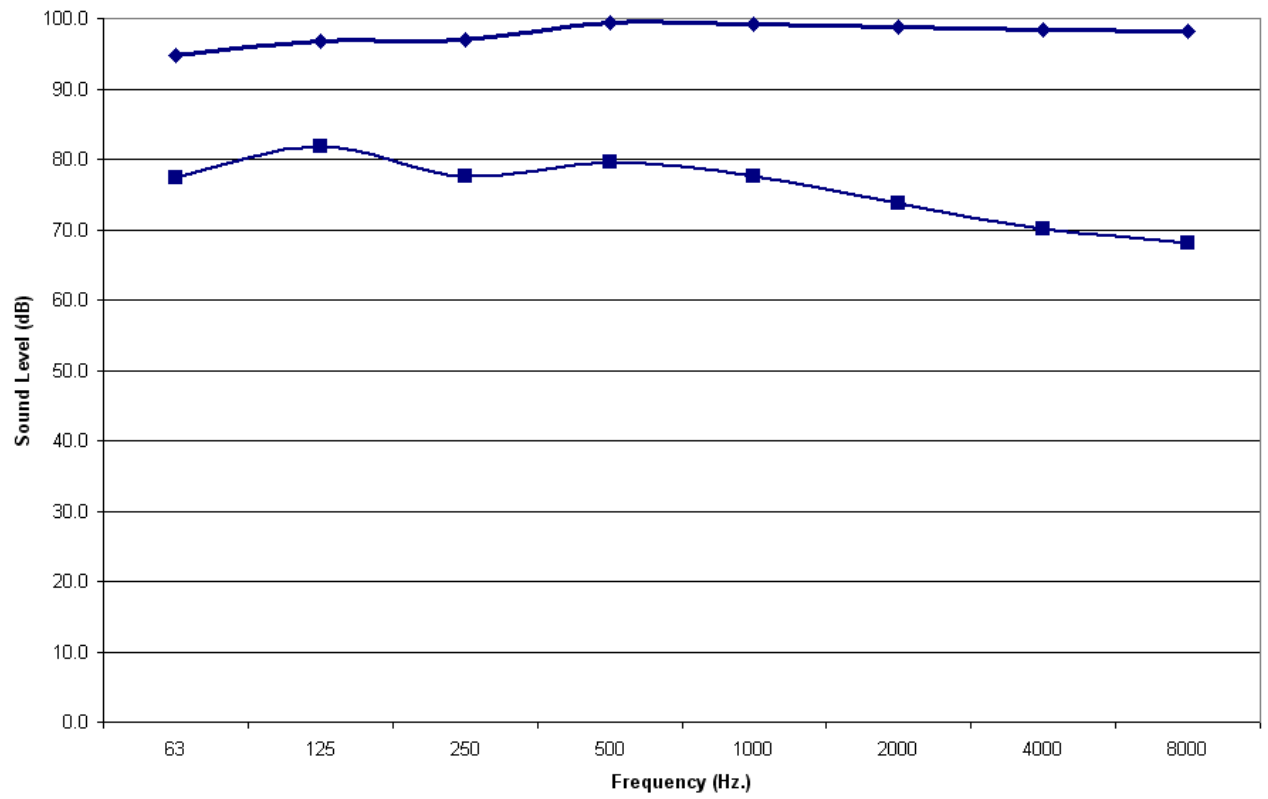


**Measured Exterior  
Level  
105 dBA**

# Actual Case Study

<http://www.hmmh.com/>

### Acoustical testing results for broadband noise source



**Measured Exterior Level  
105 dBA**

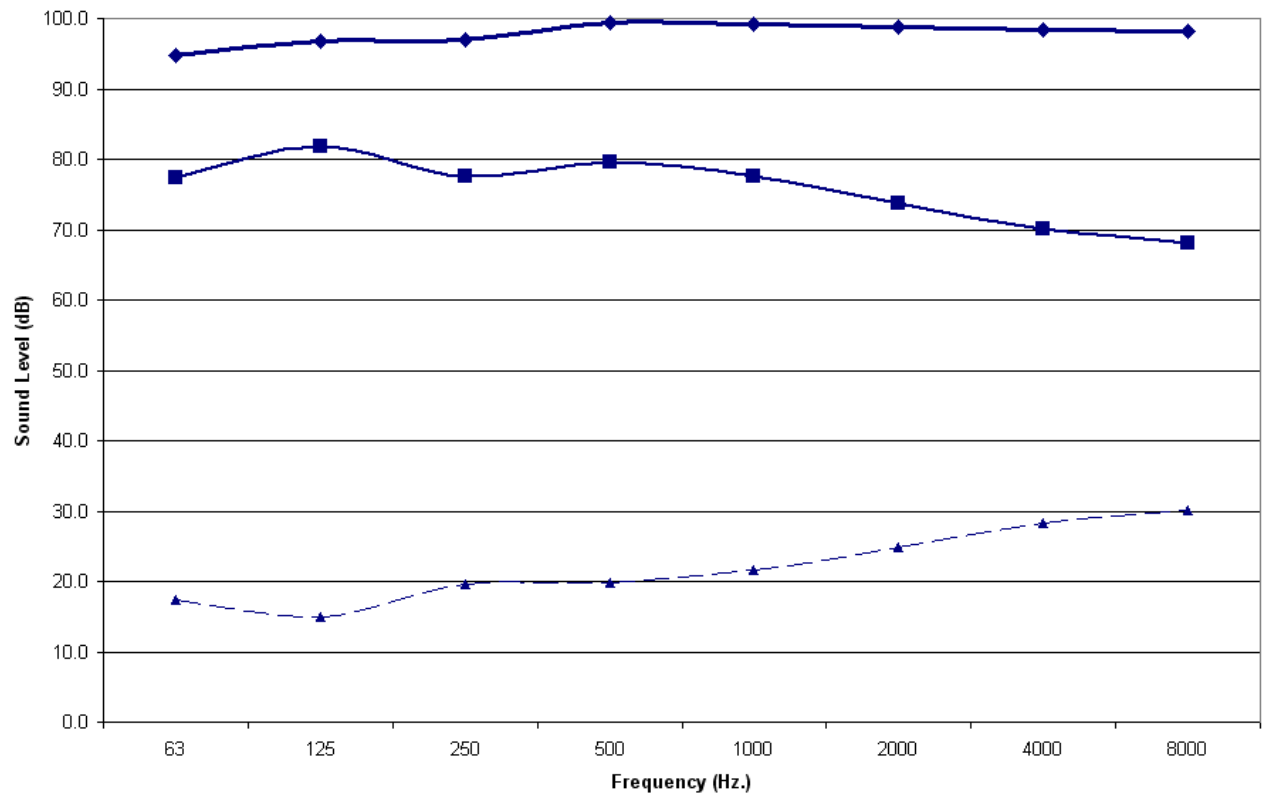
**Measured Interior Level  
82 dBA**



# Actual Case Study

<http://www.hmmh.com/>

### Acoustical testing results for broadband noise source



**Measured Exterior Level**  
**105 dBA**

**Measured Interior Level**  
**82 dBA**

**Measured Outdoor-Indoor Level Reduction**  
**23 dBA**

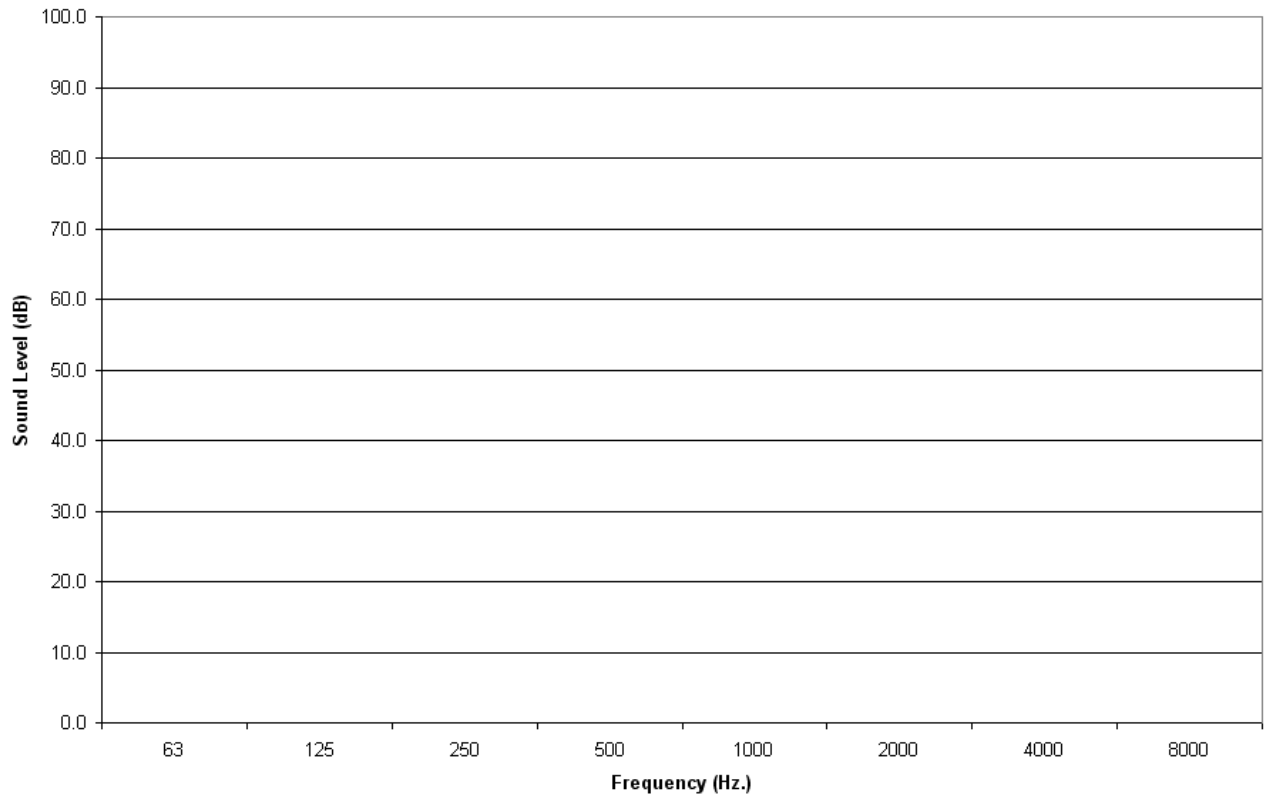


## Calculation for an Aircraft Spectrum

- Knowing the building's OILR in all octave bands permits us to determine how the building will perform for any aircraft spectrum
- OILR in any octave band is independent of source level
- We use the Boeing 727 to determine NLR
  - Based on empirical data, represents the “worst-case” spectrum for civil aircraft currently in operation
  - Applying the Boeing 727 spectrum to the calculated octave-band OILR permits us to determine the building's NLR performance for the worst-case aircraft type

# Application to Aircraft Spectrum

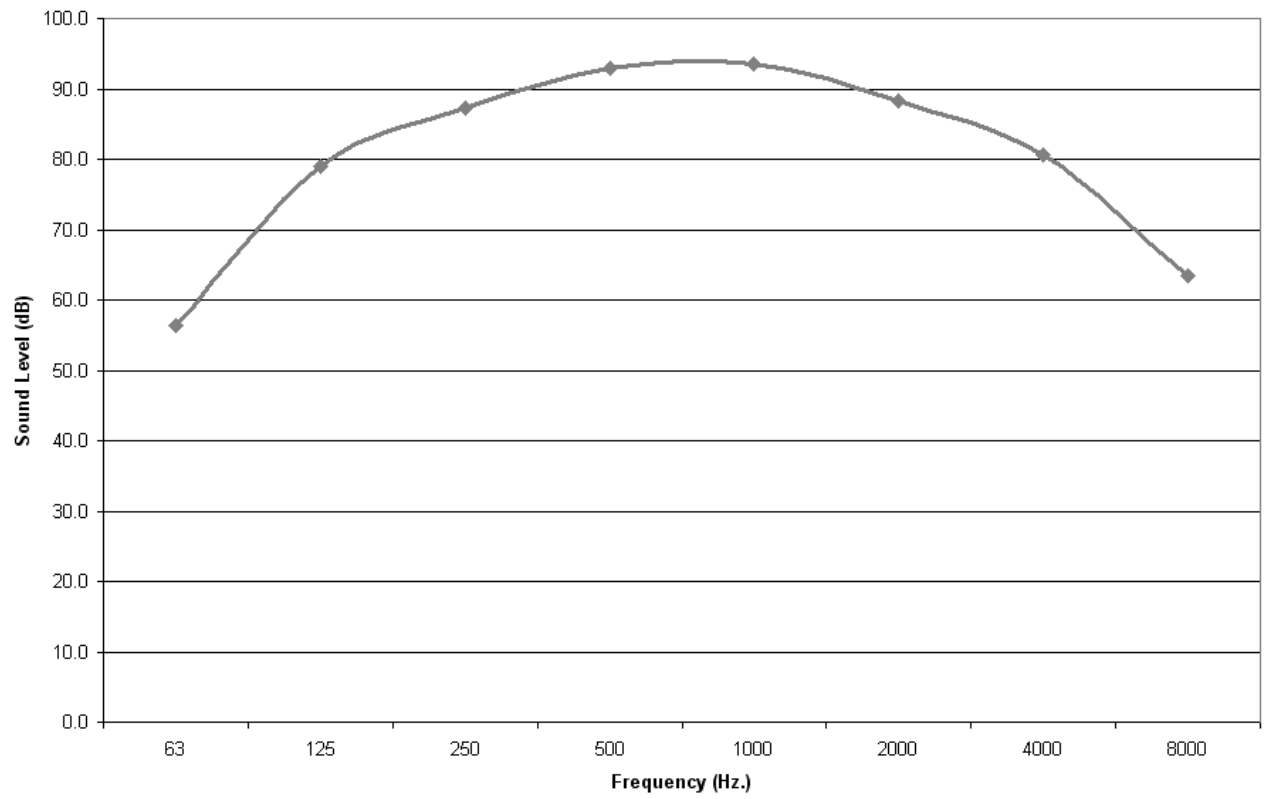
Apply aircraft spectrum to data



# Application to Aircraft Spectrum

<http://www.hmmh.com/>

Apply aircraft spectrum to data



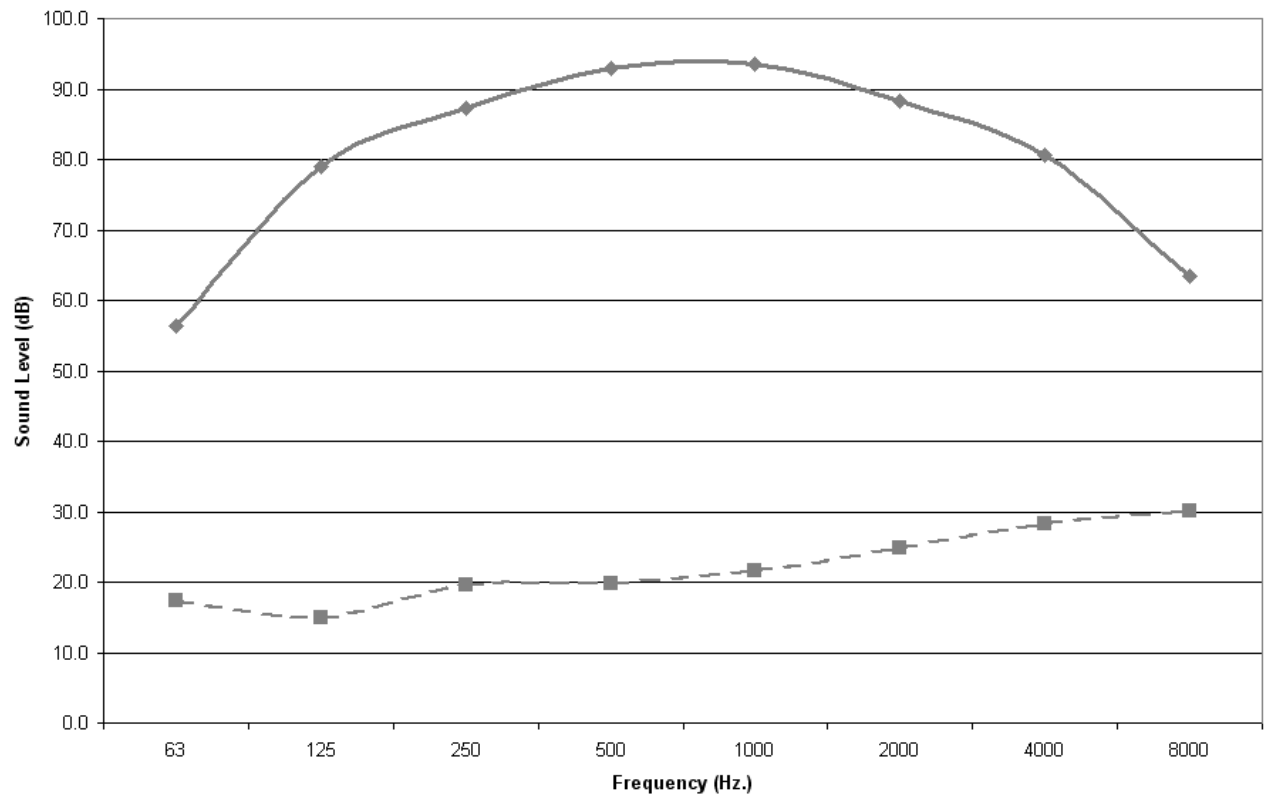
**Exterior Level  
Adjusted for  
Boeing 727  
Spectrum: 98 dBA**



# Application to Aircraft Spectrum

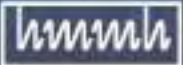
<http://www.hmmh.com/>

Apply aircraft spectrum to data



**Exterior Level  
Adjusted for  
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Spectrum: 98 dBA**

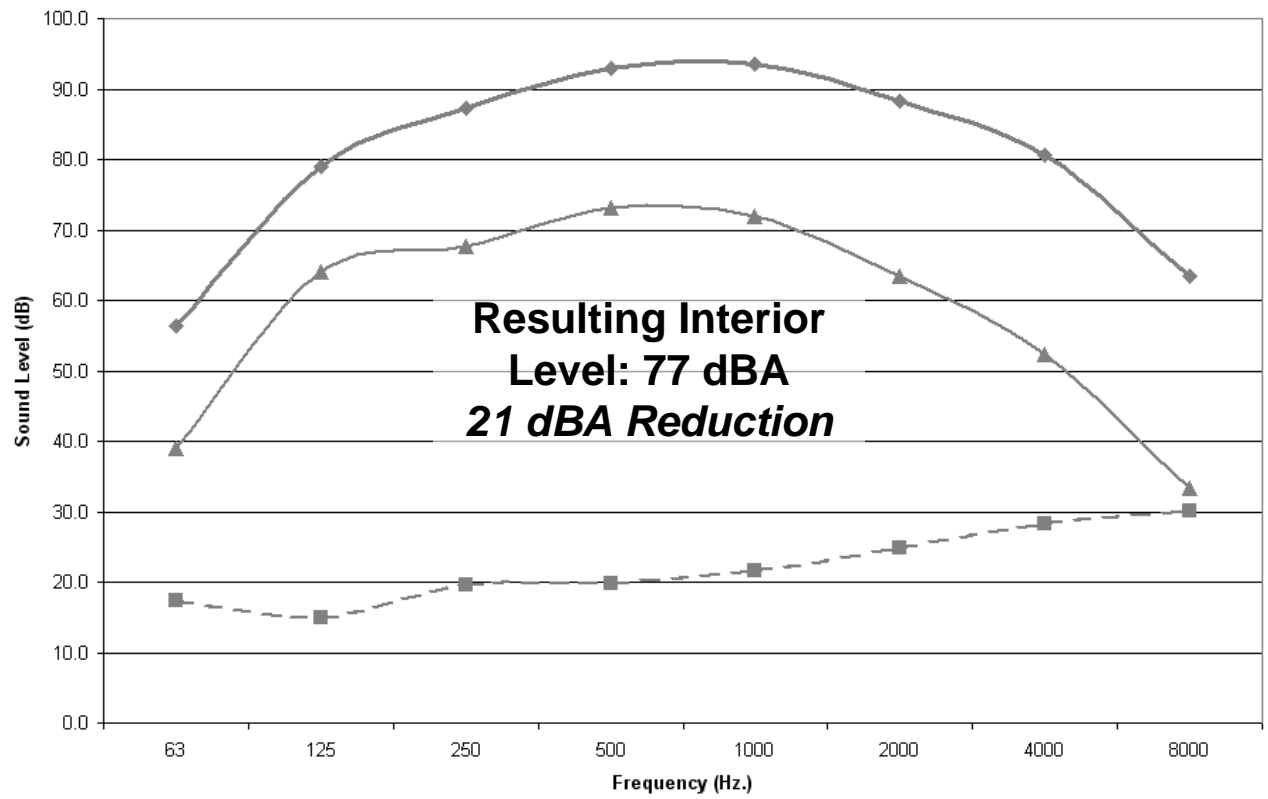
**Previously  
Measured  
Outdoor-Indoor  
Level Reduction**



# Application to Aircraft Spectrum

<http://www.hmmh.com/>

Apply aircraft spectrum to data



**Exterior Level  
Adjusted for  
Boeing 727  
Spectrum: 98 dBA**

**Resulting Interior  
Level: 77 dBA  
21 dBA Reduction**

**Previously  
Measured  
Outdoor-Indoor  
Level Reduction**



# Summary – Benefits of Test Approach

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- **The approach is repeatable.**
  - Pre- and post-construction
  - House-to-house
- **The source signal provides adequate excitation of the building partition or element under test.**
  - Permits testing of individual building elements
- **The process is less affected by background noise levels.**
- **The test process is less invasive, requires less time, and is more cost effective.**
- **The test results can be compared from house-to-house and to manufacturer's data.**

# Accounting for Frequency Spectra in Sound Insulation Testing

**Thank you for your attention.**  
*Any questions?*



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