Noise Controls in Mining

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Noise Controls in Mining - Outline

- Introduction to Sound
  - Physics of Sound
- MSHA Noise Control Guidance
  - PIB No. P14-02
- Engineering Noise Controls
  - Acoustical Materials
    - Absorptive / Barriers / Vibration Controls

Introduction to Sound

Sound, like all energy, travels in waveform.

Basic Properties of Sound

Wavelength (λ)

Frequency (*f*)

Speed (c)

Amplitude

Introduction to Sound

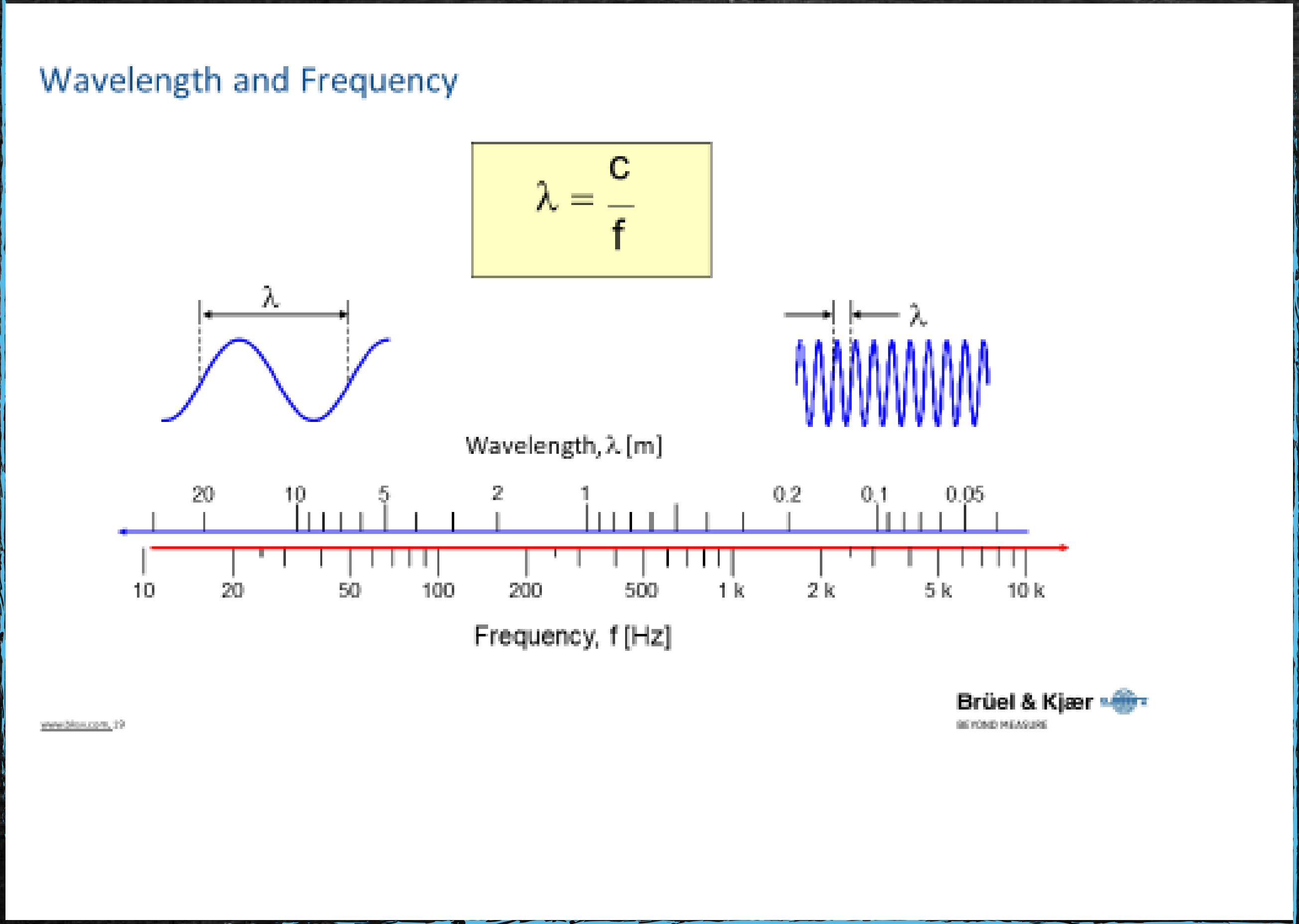


Photo From: Hottinger Brüel & Kjær

- Inverse relationship exists:

  $\lambda = c / f$

- Frequency ranges:

  20 – 20,000 Hz (Newborn)

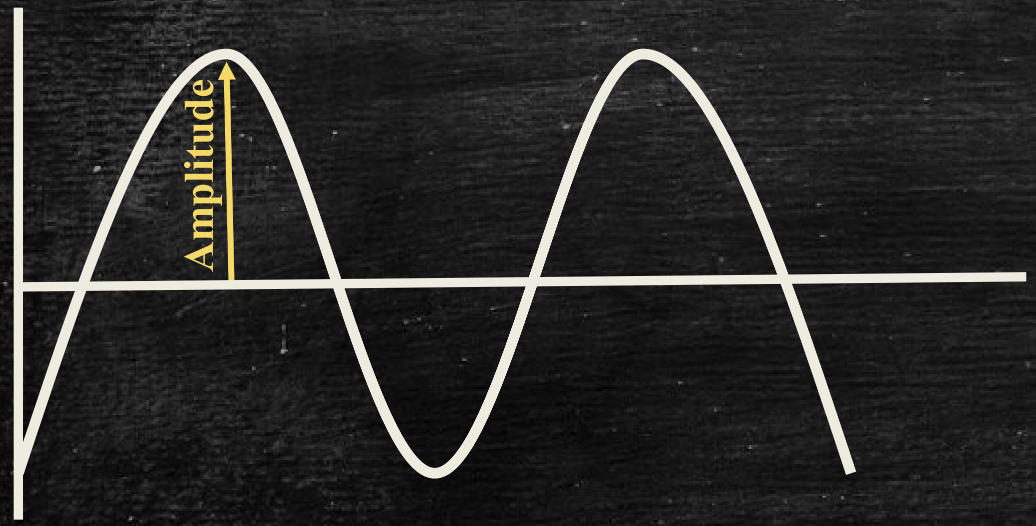
  250 – 4000 Hz (Speech)

- Wavelength

  Acoustical Material Selection

  Absorptive Material > 1/4 λ

Introduction to Sound



Maximum displacement of the wave from the "resting" medium.

Sound Pressure Level (L_p) - The air pressure that oscillates above and below atmospheric pressure at the instant a sound is generated.

Decibel (dB) – Logarithmic ratio of the measured pressure to a reference pressure.

$$Lp = 10*\log\left(\frac{p}{p_0}\right)^2 = 20*\log\left(\frac{p}{p_0}\right)$$

Reference Level (p_0) = measured in Pascals (Pa)
= 20 µPa = 20 x 10^{-6} Pa
= Threshold of Hearing

Introduction to Sound

- **dB vs. Pa**

Noise	dB	Pa	Factor
Threshold of Hearing	0	0.00002	Reference Level (20 µPa)
Whisper	20	0.0002	10x
Faint Speech	40	0.002	100x
Average Conversation	60	0.02	1,000x
Loud Speech	80	0.2	10,000x
Train Passing	100	2	100,000x
Threshold of Pain	120	20	1,000,000x
Jet Takeoff	140	200	10,000,000x

Introduction to Sound

Sound Pressure Level Addition:

$$L_{1+2} = 10 \log (10^{0.1L_1} + 10^{0.1L_2})$$

90 dB + 90 dB = 93 dB

3 dB Increase

Why is that Important?

MSHA Considers a Noise Control Significant if it Decreases 3 dB

MSHA REGULATIONS

- **30 CFR Part 62:** when a miner's noise exposure exceeds the permissible exposure level (PEL), all feasible engineering and administrative controls be utilized to reduce the miner's exposure to the PEL.
    - PEL = TWA_8 of 90 dBA (100% dose)
- **Program Information Bulletin PIB NO. P14-02 (03/07/14):** Provides guidance to operators on: technologically achievable, administratively achievable, and promising noise controls
    - A technologically or administratively achievable control or a combination of controls which achieves at least a 3 dBA reduction in a miner's noise exposure is considered significant, even if it fails to reduce the miner's exposure to the PEL.

Program Information Bulletin PIB NO. P14-02

16. Longwalls

MSHA considers the following engineering noise controls, or a combination of these controls, to be **technologically achievable** in reducing the noise exposure of miners working around the longwall mining system:

- **Automated shear;**
- **Automated jacks;**
- **Automated stage loader;**
- **Memory cut;**
- **Proper maintenance such as use of proper chain tensioning and flight spacing;**
- **Positioning of the miner to minimize exposure to noise such as keeping stageloader operator away from crusher, motors and gears, head drive, belt tail; head drum shear operator staying a minimum or 3 m (10 ft) outby the drum head; and**
- **Reduced run-time for face and stageloader conveyors when empty.**

MSHA considers the following engineering noise controls to be conditional:

- **Remote operation.**

Longwall Example:

- Tech/Admin Achievable
  - Automation
  - Positioning
- Conditional
  - Remote Operation
- Promising
  - Motor Enclosure

https://arlweb.msha.gov/REGS/COMPLIAN/PIB/PIB.HTM

PIB No. P14-02

From PIB P14-02:

While MSHA believes the listed controls are currently the most effective in reducing miner noise exposure, mine operators are not restricted in their selection of controls to those technologically and administratively achievable controls described in this document. They may use other administrative and engineering controls or combinations of controls to comply with MSHA's noise standard. We encourage the mining industry to share information regarding controls that have been implemented and found to be successful in reducing a miner's exposure to noise.

- Realize that noise controls need evaluated on a case-by-case basis
- Controls aren't one-size fits all

Noise Controls – Distance

SPL is Proportional to Distance:

- **For each doubling of distance from the source, the sound level will decrease by 6 dB IF in a Free-Field Environment (No Reverberations)**

$\Delta L = Lp_1 - Lp_2$

$\Delta L = 10 \log (R1/ R2)^2$

$\Delta L = 20 \log (R1/ R2)$

ΔL = difference in sound pressure level (dB)
Lp_1 = sound pressure level at location 1 (dB)
Lp_2 = sound pressure level at location 2 (dB)
R1 = distance from source to location 1 (ft)
R2 = distance from source to location 2 (ft)

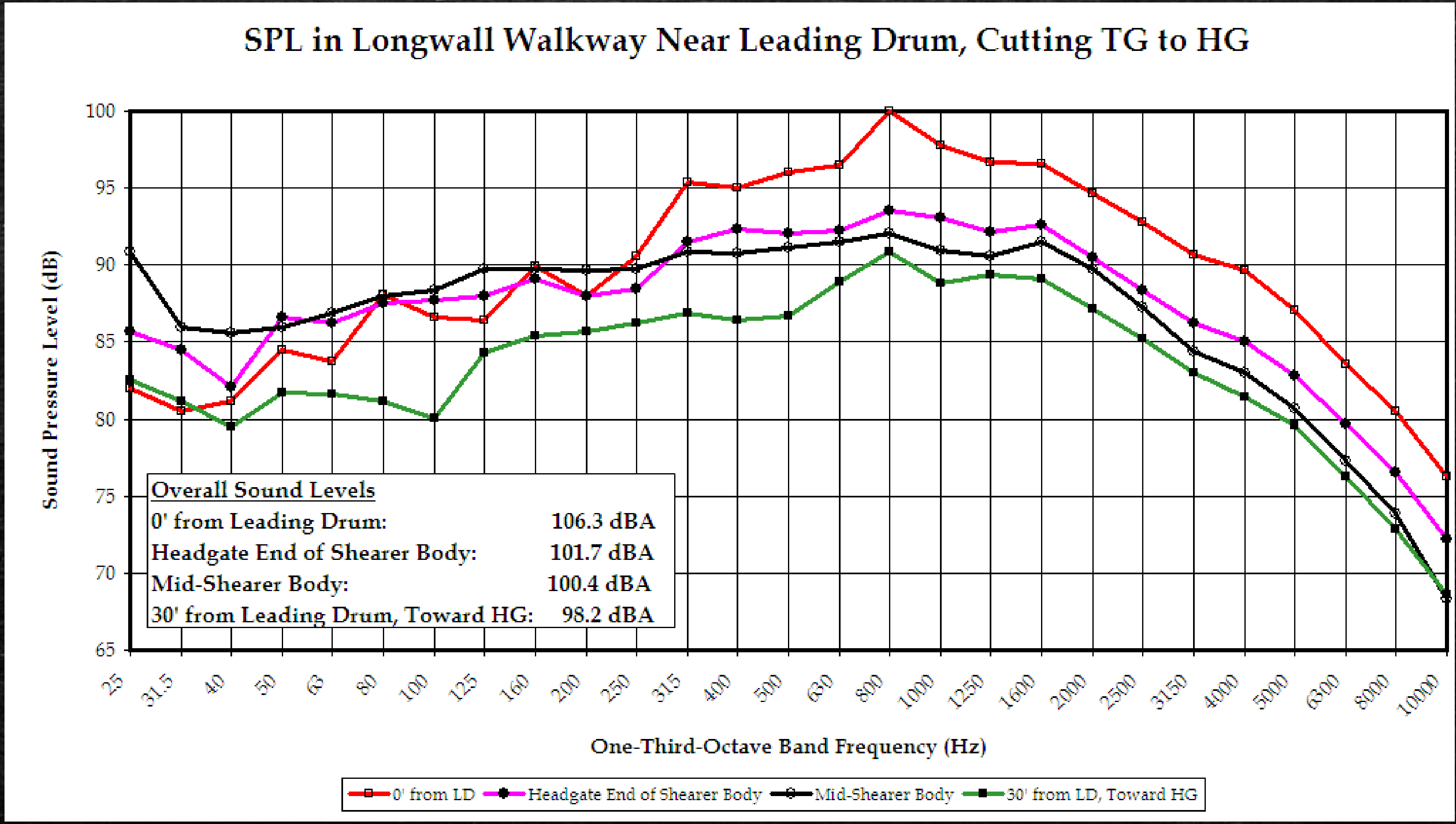
Example: CM Operator = 100 dB – 4' away from machine .
What is the SPL 8' away from the continuous miner?

$\Delta L = 20 \log (4 \text{ ft.} / 8 \text{ ft.}) = 6.0 \text{ dB}$

$Lp_2 = 100 \text{ dB} - 6 \text{ dB} = 94 \text{ dB}$

Move noise source to a distant location or vice versa

Example: Distancing from a Trona Shearer, 8.1 dBA Quieter 30' from Shearer



Noise Controls - Acoustical Materials

Any type of material that is designed to control sound

Absorptive

Barrier

Composite

Vibration

Absorptive Materials

Fiberglass

Neoprene Foam

Polyurethane Foam

- **Lightweight, porous, open cell materials used to absorb sound**
- **Acoustical materials absorb sound by converting acoustical energy into thermal energy.**

Apply Acoustical Material to Existing Enclosure

Example: Treated Cab

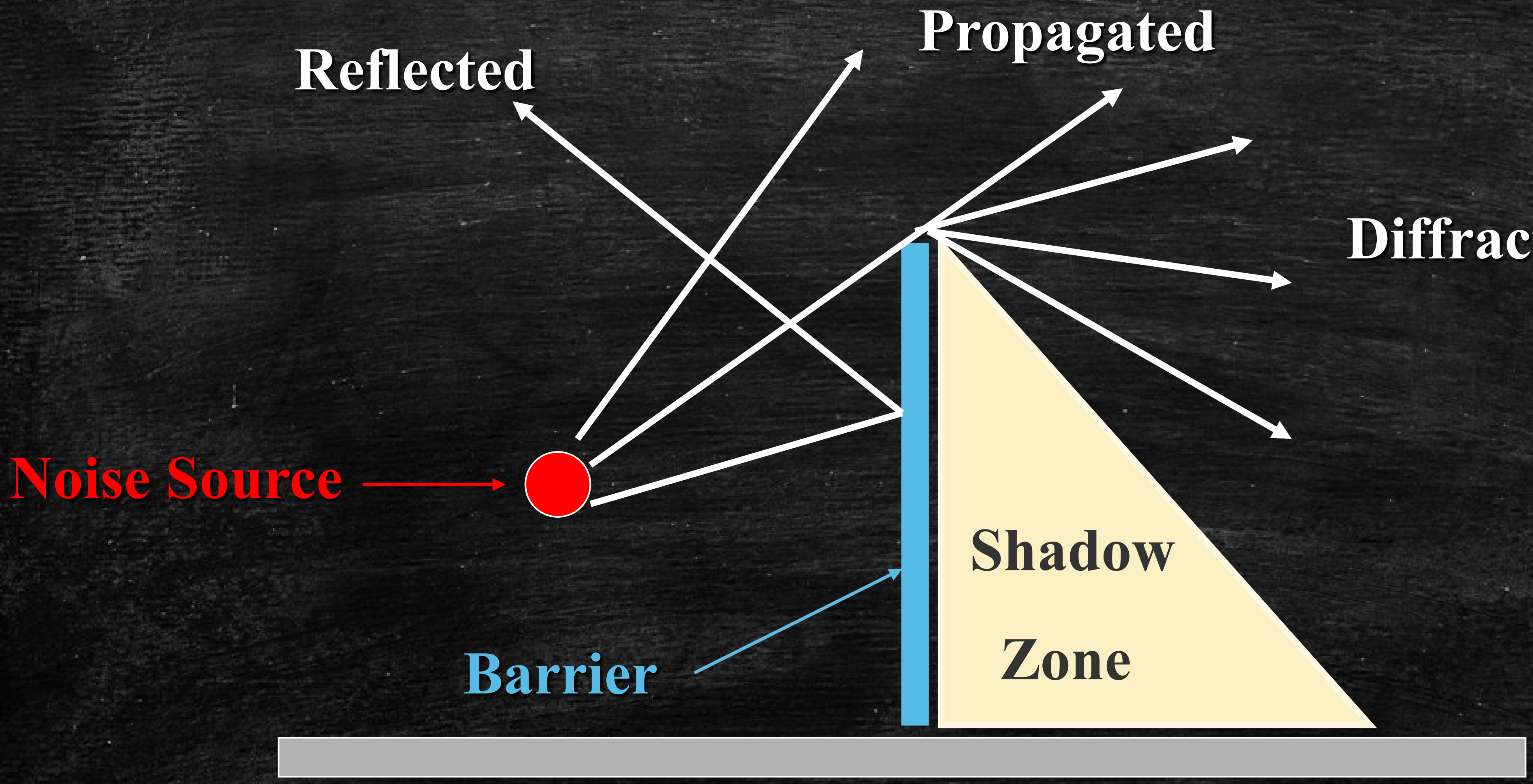
Untreated Interior

Treated Interior

Barrier Materials

- Dense, heavy materials used to block or prohibit sound from passing through. They can be flexible or rigid.
- Examples:
  - Plywood
  - Mass Loaded Vinyl
  - Vinyl Strip Curtain
  - Cement / Safety Glass / etc.
- Gaps
  - 1/3 Overlap

Barrier Concept



Install an acoustically effective barrier

Examples: Windshield and Portable Shield

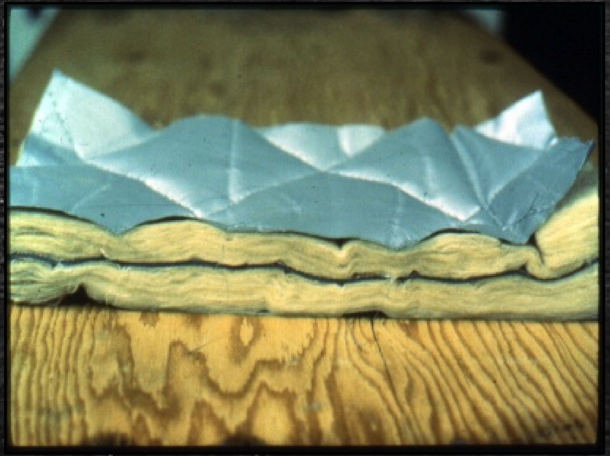
Pluton Bolter

Beside Windshield: 102.9 dBA
Behind Windshield: 92.2 dBA
Reduction: 10.7 dBA

Granite Quarry

At Drill Controls: 118.5 dBA
Beside Shield: 108.9 dBA
Behind Shield: 99.8 dBA

Composite Materials



Fiberglass-Vinyl-Fiberglass Composite Material

Foam-Vinyl Composite Material

- **Multi-layered materials used to both block and absorb sound.**

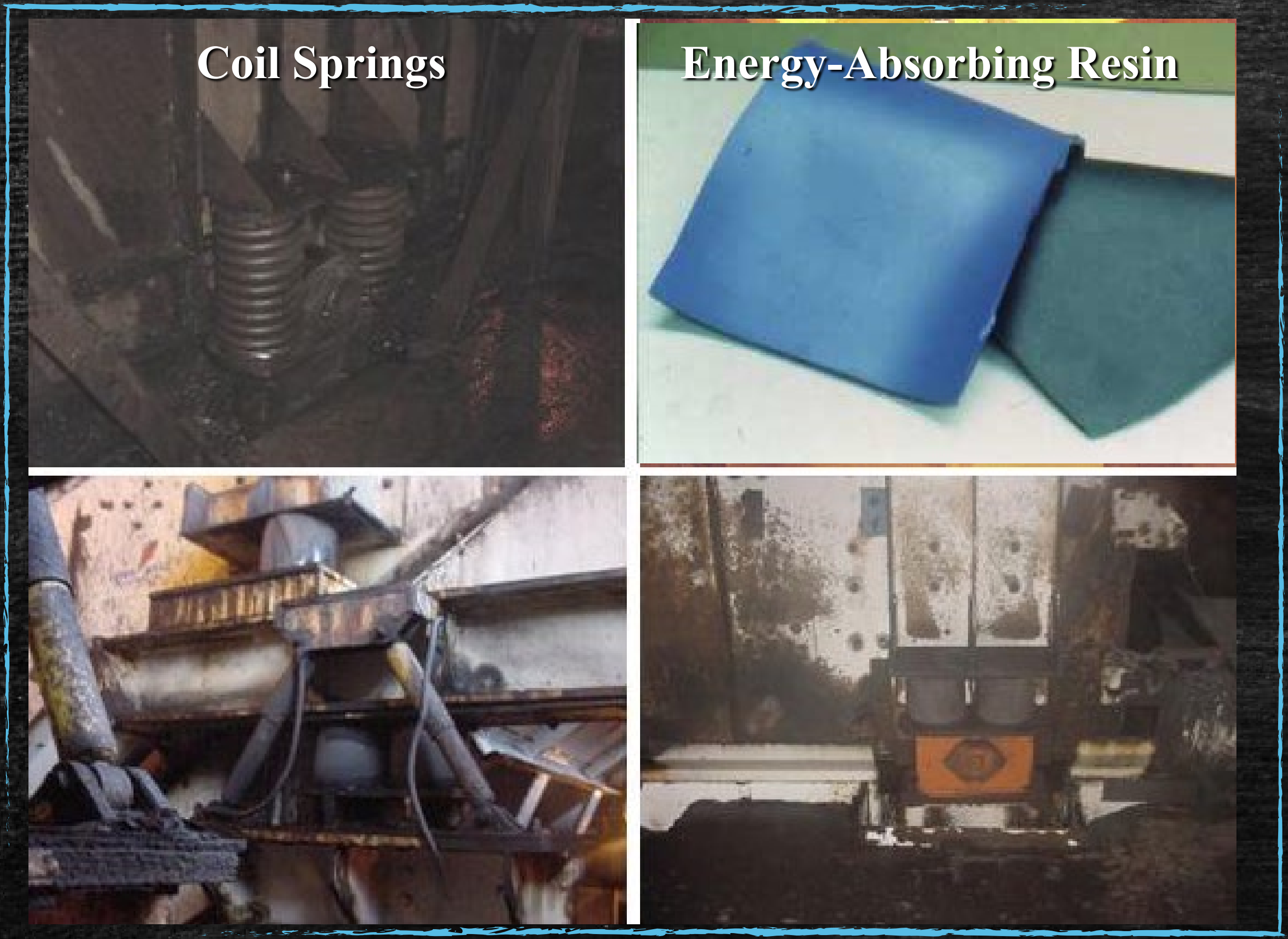
Covering source with damping material

Example: Thermal/Acoustic Blanket

Ball Mill

> 8dBA Reduction Between Adjacent Mills

Vibration Damping/Isolation



Shock Absobers

“Pillow Mounts”

- **Damping – Dense materials applied directly to a vibrating surface which absorb the energy before it becomes airborne noise**

- **Isolation – Materials or devices used to de-couple or isolate vibration sources from surrounding structures or objects.**

Material Flammability

- The degree to which acoustical material burns or propagates flame.

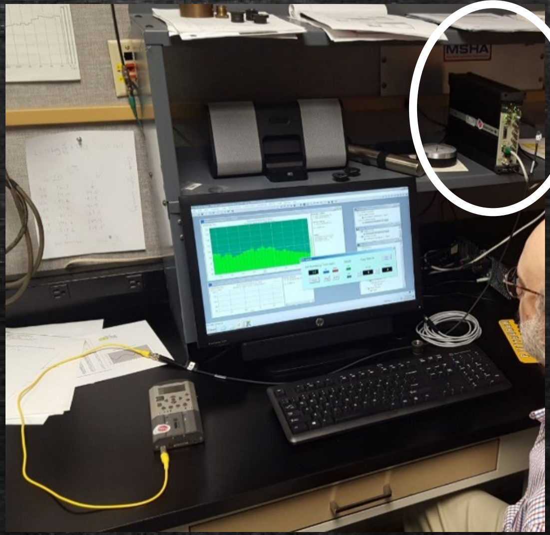
- Flame Spread Index:
  <25 Underground
  <50 Surface

- Fiberglass: 1 - 2
- Neoprene Foam: 3 - 6
- Polyurethane Foam*: 1500 - 2000
  *non-fire retardant type

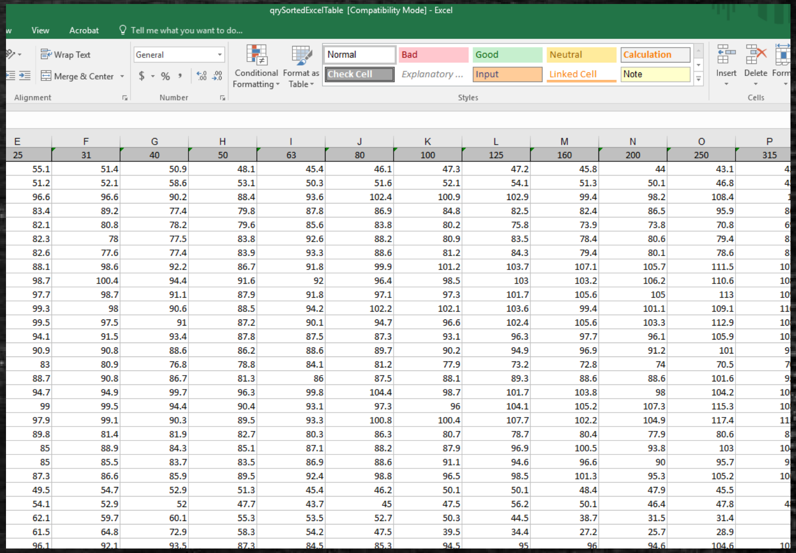
Acoustic Material Selection

1. Gather Data (Recording System)

2. Data Analysis (DAQ)



3. Interpret Results



E	F	G	H	I	J	K	L	M	N	O	P
25	31	40	50	63	80	100	125	160	200	250	315
55.1	51.4	50.9	48.1	45.4	46.1	47.3	47.2	45.8	44	43.1	
51.2	52.1	58.6	53.1	50.3	51.6	52.1	54.1	51.3	50.1	46.8	
96.6	96.6	90.2	88.4	93.6	102.4	100.9	102.9	99.4	98.2	108.4	
83.4	89.2	77.4	79.8	87.8	86.9	84.8	82.5	82.4	86.5	95.9	
82.1	80.8	78.2	79.6	85.6	83.8	80.2	75.8	73.9	73.8	70.8	
82.3	78	77.5	83.8	92.6	88.2	80.9	83.5	78.4	80.6	79.4	
82.6	77.6	77.4	83.9	93.3	88.6	81.2	84.3	79.4	80.1	78.6	
88.1	98.6	92.2	86.7	91.8	99.9	101.2	103.7	107.1	105.7	111.5	
98.7	100.4	94.4	91.6	92	96.4	98.5	103	103.2	106.2	110.6	
97.7	98.7	91.1	87.9	91.8	97.1	97.3	101.7	105.6	105	113	
99.3	98	90.6	88.5	94.2	102.2	102.1	103.6	99.4	101.1	109.1	
99.5	97.5	91	87.2	90.1	94.7	96.6	102.4	105.6	103.3	112.9	
94.1	91.5	93.4	87.8	87.5	87.3	93.1	96.3	97.7	96.1	105.9	
90.9	90.8	88.6	86.2	88.6	89.7	90.2	94.9	96.9	91.2	101	
83	80.9	76.8	78.8	84.1	81.2	77.9	73.2	72.8	74	70.5	
88.7	90.8	86.7	81.3	86	87.5	88.1	89.3	88.6	88.6	101.6	
94.7	94.9	99.7	96.3	99.8	104.4	98.7	101.7	103.8	98	104.2	
99	99.5	94.4	90.4	93.1	97.3	96	104.1	105.2	107.3	115.3	
97.9	99.1	90.3	89.5	93.3	100.8	100.4	107.7	102.2	104.9	117.4	
89.8	81.4	81.9	82.7	80.3	86.3	80.7	78.7	80.4	77.9	80.6	
85	88.9	84.3	85.1	87.1	88.2	87.9	96.9	100.5	93.8	103	
85	85.5	83.7	83.5	86.9	88.6	91.1	94.6	96.6	90	95.7	
87.3	86.6	85.9	89.5	92.4	98.8	96.5	98.5	101.3	95.3	105.2	
49.5	54.7	52.9	51.3	45.4	46.2	50.1	50.1	48.4	47.9	45.5	
54.1	52.9	52	47.7	43.7	45	47.5	56.2	50.1	46.4	47.8	
62.1	59.7	60.1	55.3	53.5	52.7	50.3	44.5	38.7	31.5	31.4	
61.5	64.8	72.9	58.3	54.2	47.5	39.5	34.4	27.2	25.7	28.9	
96.1	92.1	93.5	87.3	84.5	85.3	94.5	95	96	94.6	104.6	

Octave Band Analyzer

Acoustic Materials

Table 4.4 – Sound absorption coefficients by frequency*[4,5] (cont.)

Material	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz
Fiberglass boards and blankets:						
2.54 cm (1 in.) glass wool, 24 to 48 kg/m³ (1.5 to 3.0 lb/ft³)	0.08	0.25	0.65	0.85	0.80	0.75
5.1 cm (2 in.) glass wool, 24 to 48 kg/m³	0.17	0.55	0.80	0.90	0.85	0.80
2.54 cm glass wool, with 2.54 in. air space	0.15	0.55	0.80	0.90	0.85	0.80
5.1 cm glass-fiber panels, with plastic sheet wrapping, and perforated metal facing as installed	0.33	0.79	0.99	0.91	0.76	0.64
Glass:						
Large panes of heavy plate	0.18	0.06	0.04	0.03	0.02	0.02

Table 4.8 – Transmission loss, L_i, of common materials, dB* (cont)

Material	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz
Concrete:						
4 in. (102 mm) thick	29	35	37	43	44	50
Concrete block:						
6 in. (152 mm)	33	34	35	38	46	52
Glass:						
1/8-in. single plate-glass pane	18	21	26	31	33	22
1/4-in. single plate-glass pane with rubber gasket	25	28	30	34	24	35
9/32-in. laminated glass pane (i.e., viscoelasticlayer sandwiched between glass layers)	26	29	33	36	35	39

Tables From: AIHA Engineering Reference Manual, 3rd Edition

QUESTIONS?

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