Noise Control

EOH 466A
Fall 2008

Priority of Control

• Familiar order
  – Engineering Control
  – Administrative Control
  – Personal Protection.
Priority of Control

• Engineering control prevents exposure more safely, but can be expensive. Cost of engineering control is the primary reason that the OSHA PEL has not been reduced.
• In most situations, engineering controls are technically feasible.
• Solving problems can be difficult (you need experts.)

Noise Control Management

• Background
  – Noise exposure is a common problem
    • history of poor planning
    • management attitudes
      – unique industry (exempt)
      – 'don't fix it if it ain't broken'
      – complacency
      – other priorities
    • noise control plans need to take these attitudes into consideration
Noise Control Management

• Identify sources of noise and their relative importance.
  – sources of noise

Vibrating Surfaces

Vibrations from a shaver are transmitted to the large glass plate, and the noise is loud.

Vibrations are no longer transmitted to the plate, and the noise decreases.
Mechanical Impacts

- A flat strip of metal can be bent with a hammer.
- Or quietly with pliers.

Turbulent Gas Flow

- Less turbulence at smooth walls.
- Strip flanges cause more turbulence.

Noise Control
Air Jets

Gears and Machine Operation
Noise Control Management

• Consider the cost of reducing noise
• List and evaluate possible noise control procedures at the source, path and receiver.
• Source: modify, redesign or relocate

Noise Control Management

• Path: enclosure, absorption, barrier
• Receiver: enclosure, absorption, relocate
• Identify relative contribution from direct and reflected sound
  – Direct sound travels in a straight path
  – Reflected sound bounces off walls
Noise Control Techniques

- Distinguish between absorption and isolation of noise
- Absorption reduces sound inside a room
- Isolation reduces sound outside a room
Noise Control Techniques

• Identify and evaluate significance of flanking paths
  – Sound can travel through structure or air space around a wall

• Identify and evaluate the significance of structure-borne noise
  – Structures can greatly amplify the noise: act as a speaker.
Engineering Control

- Control at the source.
- Specify new equipment purchases should not produce excessive noise.
- It is becoming more common for low-noise specification to be used.
- Review of product literature
Engineering Control

- Calculate expected noise levels based on data (vendor other data). Based on characteristics of destination
- Identify noise sources
  - noises may have characteristic frequency, and type of sound
  - octave band analysis can be helpful (sometimes very detailed)
  - turn equipment on/off to help identify the noisiest machines.

Engineering Control

- Use quiet operations:
  - axial fans generate more hi frequency noise
  - electric motors: designed to operate < 80. unidirectional fan will have lower noise levels.
  - operate at 'design' rate; efficient = quiet
  - proper maintenance
  - avoid resonance
  - proper air flow
Engineering Control of Noise

• Control noise in the path
• Once noise is generated by the source, it will spread in all directions, subject to diffraction, bending, absorption and reflection.

Noise Control Terms

• Absorption: sound energy is converted to heat in a medium. Air absorbs sound. High-frequency sound is better absorbed than low frequency sound (wavelength small relative to pores). Curtains, carpets and acoustic tiling also absorb sound that hits surfaces.
Noise Control Terms

- **Reflection**: sound energy can bounce off surfaces, particularly surfaces that are large compared to the wavelength of the sound, just like light bounces off a mirror. An echo is a reflected sound. Echo is less intense, since reflected sound has to travel further than the original sound.
Noise Control Terms

- **Reverberation**: multiple reflections of a sound. This occurs where there are several hard surfaces that can reflect a sound wave. The sound waves may reinforce one another, increasing the intensity of the sound. Can add 15 dB to noise levels.
Noise Control Terms

- **Diffraction**: bending of sound waves around a barrier. Sound waves move beyond line of sight, passing a barrier.
  - Limits use of sound walls.
  - Noise through an open door is heard throughout a room.
Noise Control Terms

- **Refraction**: sound waves bend as they travel through air of differing density. (Travel distance)
  - Affects how sound waves travel as they move through space (the environment).
  - [http://www.kettering.edu/~drussell/Demos/refract/refract.html](http://www.kettering.edu/~drussell/Demos/refract/refract.html)

- **Diffusion**: spreading of the sound wave with distance.
  - Behavior of sound after reflecting off a surface or through an opening.
Noise Control Terms

• **Sound Transmission Loss** is the difference in noise level striking the surface and that passing through the surface. Calculated in laboratory conditions by ASTM method.
• Tau ($\tau$) is transmission coefficient. $\tau = 0$, perfect barrier. $\tau = 1$ no transmission loss.
• $TL = 10 \log \left(\frac{1}{\tau}\right)$
• TL usually up to 70 dB for good barrier. 1 % open area = 25 dB reduction in TL

Noise Control Terms

• **Sound Absorption**
• Compare energy incident to energy reflected
  - $\alpha = \frac{E_{\text{incident}} - E_{\text{reflected}}}{E_{\text{incident}}}$
  - frequency dependent
• Actually measured by ASTM standard in an anechoic chamber
• **Noise Reduction Coefficient (NRC)**
  - Average $\alpha$ at 250, 500, 1000, 2000 Hz
  - Round to nearest 0.05
Noise Control Terms

- Absorption coefficient for a room.
- Find $\alpha$ for each surface in room.
- Find surface area for each surface in a room.
- Include people and objects in the room.

$$\alpha = \frac{\sum S_i \alpha_i}{\sum S_i}$$

Engineering Control

- Use distance to reduce noise exposure: The energy in the sound will be reduced by the square of distance (in proportion to the surface area of the sphere.)
- So, if the distance from a point source is doubled, the sound level will be reduced by 6 dB.
- $\text{SPL}_2 = \text{SPL}_1 - 15 \log \left( \frac{d_2}{d_1} \right)$
  (for sounds on ground level)
Engineering Control

- Use a noise barrier to reduce noise. Noise barriers are designed to prevent noise transmission, with most of the noise reflected back.
- Highway noise is often controlled by the use of sound walls. Go to this url for discussion:
  http://www.fhwa.dot.gov/environment/htnoise.htm
Engineering Control

• Use transmission loss.
•Noise reduction between rooms will depend on transmission loss of walls and doors and room constant of receiving room.

Engineering Control

• Use a sound absorber to reduce reflected noise. A sound absorber will allow noise to pass through, but will absorb reflected noise.
• Increasing sound absorption (room constant) will reduce noise in the reverberant field.
Engineering Control

- Suppliers of sound control material usually provide absorbance information for their products, for specific frequencies.
- Rule of thumb, ceilings < 16 ' spectrum mid to high range, 4 - 6 dBA reduction possible.

Engineering Control

- Another method would be to calculate the room constant (absorbance times area) before treatment, and then with sound absorption treatment.
- \[ NR = 10 \log \left( \frac{\text{Sabins after}}{\text{Sabins before}} \right) \] (in the reverberant field)
- A chart is available to allow an estimate of the noise reduction from increasing room constant.
Engineering Control

• Use acoustical lining: line ducts, pipes, or other passageways on the inside surface, so sounds will not be transmitted along them. This is most effective for frequency 1000 Hz and above. Effect of this treatment can be predicted.

Engineering Control

• Use mufflers, silencers: for example, on internal combustion engines, with high-pressure, high-velocity gasses, etc. Can be dramatic (car muffler)
Engineering Control

• Use enclosures to contain the noise: transmission barriers that enclose the noise source. For example, portable compressors can be enclosed so they are not very noisy.

• Or, isolate the worker from the noise.

Isolate the Worker
Engineering Control

• Vibration isolation usually involves low frequency noise (< 100 Hz). Resonance with building structure. Avoid resonance.

Engineering Control

• Use noise cancellation technology
• If a noise has a regular pattern, and does not have many excursions, it may be possible to use sound waves to cancel the undesirable sound waves.
• Noise cancellation technology is different than applying masking noise - where white noise is introduced to an environment to 'cover up' an annoying noise.