Today, we will:

- Finish our discussion about Fire and Explosion
- Do some example problems
- Begin discussion of Section 3.4 – Hearing and Noise
- Do some example problems

**Effect of P & T on Explosions:**

Note: LEL & UEL are at STP

LEL ↓ as T ↑ (easier to explode), UEL ↑ with T ↑

LEL ↓ as P ↑ (…)

Recall, mol fraction \( y_j = \frac{V_j}{V} \) does not change with T & P

If it won’t explode at STP, it may explode at higher T or P
Example
Given: Benzene vapors are mixed with air in a room. We are concerned about a potential explosion.
To do: Calculate the lean fuel-to-air mass ratio of benzene at its LEL
Solution:

From MSOS \( M = 78.1 \) 

LEL = 1.2 % \[ \text{by volume} \] @ STP

\( Y_j = 0.012 \) since \( Y_j = \frac{\text{Vol} \, \text{ben}}{\text{Vol} \, \text{air}} \)

\[ F/A = \frac{M_j}{M_t} = \frac{\frac{\text{mol ben}}{\text{mol air}}}{M_t} = Y_j \frac{M_j}{M_t} \sim M_{\text{air}} \]

\[ 0.012 \frac{\text{mol ben}}{\text{mol air}} \frac{78.1 \frac{\text{g ben}}{\text{mol ben}}}{28.97 \frac{\text{g air}}{\text{mol air}}} = 0.032 \frac{\text{g ben}}{\text{g air}} \]

Lean fuel limit = 3 % by mass \[ \text{[Compare to 1.2 % by volume]} \]

\[ \boxed{\text{PARTICLE EXPLOSIONS}} \]

- High concentration of dust particles or aerosols or powder in air can also explode
- LFL = lean flammability limit = concentration above which a spark or flame will cause an explosion
- **Autoignition temperature** → Dusty air can explode all by itself (no spark!) above this temperature

- **Particle size is also important here**
  - Large particles are less likely to explode than small particles

  **E.g.**
  - Concentration of coal $= \frac{1 \text{ kg}}{\text{m}^3}$

  **CASE A**
  - One 1-kg lump of coal $\rightarrow$ will not explode
  - Thousand or million of 10 mm particles
    - (Same mass of coal) $\rightarrow$ likely to explode

  **E.g.** Fig. 3.19
  - (Coal)
    - LFL
      - $= \frac{g}{m^3}$

  ![Graph of LFL vs. particle size](attachment:graph.png)

  - Smaller particles more likely to explode
  - Will not explode for $D_p$ larger than this

- Just like LELs, LFLs are typically $\gg$ PEL or TLV.
  - **E.g.** coal dust
    - TLV $= \frac{2 \text{ mg}}{m^3}$
    - LFL $= 90 \text{ to } 100 \frac{g}{m^3}$

  *See Eq. 3.3 in text*
Sec. 3.4 Hearing & Noise

Read → physiology of hearing

dissipation of the ear

Then, some fundamentals of noise

Physiology of the ear → see text + half on website

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Sound Levels

- Important because an air pollution control system (APCS) does not work if it is turned off!

- High sound levels cause hearing loss

- OSHA has sound level limits that must be met (or else get fines)

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3 parameters of importance are:

- Sound pressure \( P \) \( \text{[force/area]} \) \( \Rightarrow \) \( L_p = \text{sound pressure level} \) \( (dB) \)

- Intensity \( I \) \( \text{[power/area]} \) \( \Rightarrow \) \( L_I = \text{“intensity”} \) \( (W) \)

- Power \( W \) \( \text{[power]} \) \( \Rightarrow \) \( L_W = \text{sound power level} \) \( (dB) \)
\[ L_p = 20 \log_{10} \left( \frac{P}{P_0} \right) \]

\[ P_0 = 2 \times 10^{-5} \text{ N/m}^2 \]

= threshold of hearing @ 1000 Hz

(healthy person)

\[ I_0 = 1 \times 10^{-12} \text{ W/m}^2 \]

\[ W_0 = 10^{-12} \text{ W/Hz} \]

\[ L_I = 10 \log_{10} \left( \frac{I}{I_0} \right) \]

\[ L_W = 10 \log_{10} \left( \frac{W}{W_0} \right) \]

\[ L_W \text{ is independent of } r \text{ (distance from the source)} \]

\[ L_p \text{ and } L_I \text{ depend on } r. \]

\[ L_I = L_p = L_W + 10 \log_{10} Q - 11.0 - 20 \log \left( \frac{r}{r_0} \right) \]

\[ \text{dB} \]

where

\[ r = \text{radius (distance) from source} \]

\[ r_0 = 1 \text{ m} = \text{cm} \]

\[ Q = \text{directivity factor} \]

\[ Q = 1 \]

for a sound source in free air (no walls)

\[ \text{free space} \]

\[ \text{We use an anechoic chamber to simulate this} \]
If one reflecting wall, source is close to the wall:

$$10 \log_{10}(2) = 3 \text{ dB}$$

$L_P$ ↑ by 3 dB when we add a reflecting wall.

$Q = 4 \rightarrow 2$ walls

$$10 \log_{10}(4) = 6 \text{ dB}$$

$Q = 8 \rightarrow 3$ walls (a 3-0 corner)

$$10 \log_{10}(8) = 9 \text{ dB}$$

There are other values of $Q$, depending on geometry of walls and reflectivity of walls.

E.g. a single wall (floor) that is carpeted has a $Q$ between 1 and 2, perhaps 1.5 or so.