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

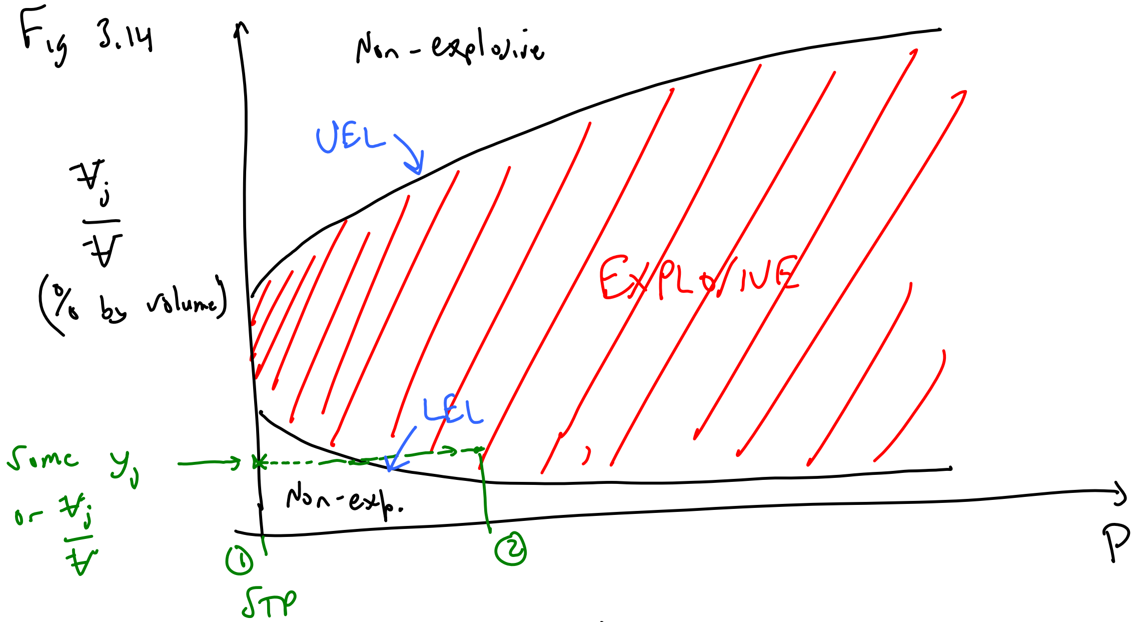
Effect of P & T on Explosions:

Note: LEL & UEL on MSDS are @ STP

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

LEL ↓ as P ↑ (") UEL ↑ as P ↑

Fig 3.14



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

* If it won't explode @ 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 MSDS → $M = 78.1$

$LEL = 1.2\%$ [by volume] @ STP

$y_j = 0.012$ since $y_j = \frac{\forall_j}{\forall}$

$$F/A = \frac{m_j}{m_t} = \frac{n_j}{n_t}\frac{M_j}{M_t} = y_j \frac{M_j}{M_t}$$

$\frac{n_j}{n_t} = y_j$, $M_t \approx M_{air}$

So,
$$F/A = \left(0.012 \frac{\text{mol ben}}{\text{mol air}}\right) \frac{78.1 \frac{\text{g ben}}{\text{mol ben}}}{28.97 \frac{\text{g air}}{\text{mol air}}} = 0.032 \frac{\text{g ben}}{\text{g air}}$$

Lean fuel limit ≃ 3% by mass

[Compare to 1.2% by volume]

Particle Explosiveness

- High concentrations of dust particles or aerosols or powders in air can also explode
- LFL = lean flammability limit ≡ concentration above which a spark or flame will cause an explosion

Units typ g/m^3

- Autoignition temperature → dusty air can explode all by itself (no spark!) above this temperature

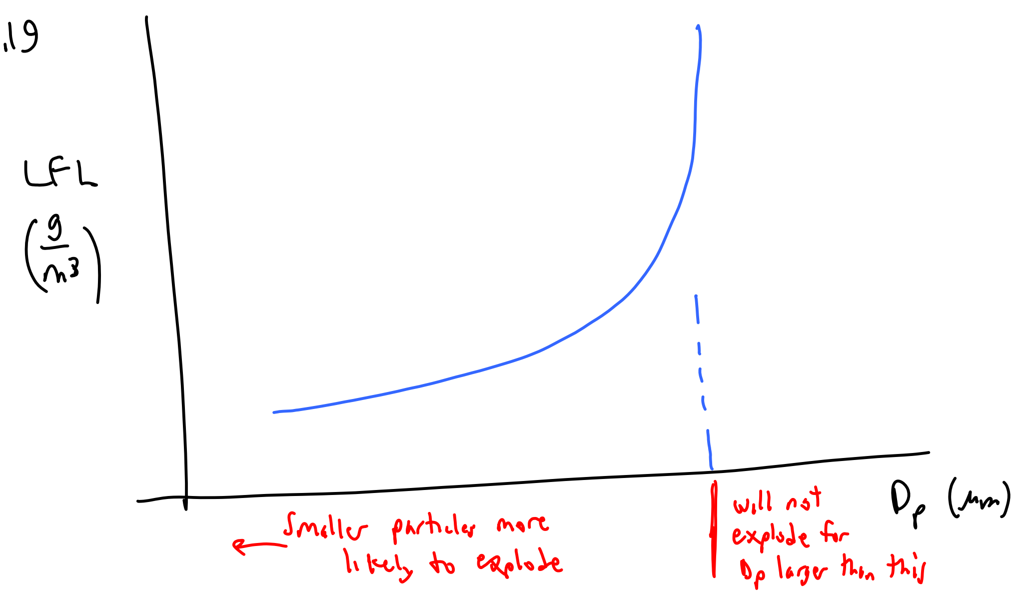
- Particle size is also important here

  ☆ large particles are less likely to explode than small particles

e.g. C = mass concentration of coal = $\frac{1\ kg}{m^3}$

CASE A
- one 1-kg lump of coal → will not explode
- thousands or millions of 10 μm particles (same mass of coal) → likely to explode

E.g. Fig. 3.19 (coal)



- Just like LELs, LFLs are typically >> PEL or TLV

  eg coal dust TLV = $2\ \frac{mg}{m^3}$, LFL = $90-100\ \frac{g}{m^3}$ } factor of 50,000!

See Eq. 3.3 in text

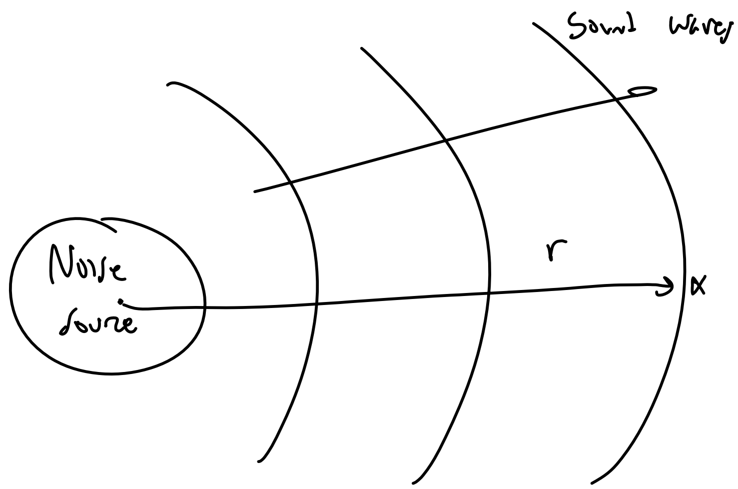
Sec. 3.4 Hearing & Noise

Read → physiology of hearing
diseases of the ear
Then, some fundamental eqs for noise

Physiology of the ear → see text + pdf on website

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)



3 parameters of importance are

- Sound pressure P {force/area} ⇒ L_p = sound pressure level (dB)
- " Intensity I {power/area} ⇒ L_I = " intensity " (dB)
- " power W {power} ⇒ L_W = sound power level (dB)

$$L_p = 20 \log_{10}(P/P_0)$$

$P_0 = 2 \times 10^{-5}\ N/m^2$

$\approx$ threshold of hearing @ 1000 Hz (healthy person)

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

$I_0 = 1 \times 10^{-12}\ \text{watt}/m^2$

$$L_W = 10 \log_{10} \frac{W}{W_0}$$

$W_0 = 10^{-12}$ watts

☆ L_W is independent of r (distance from the source)

But L_p & L_I depend on r.

Eq 3.27

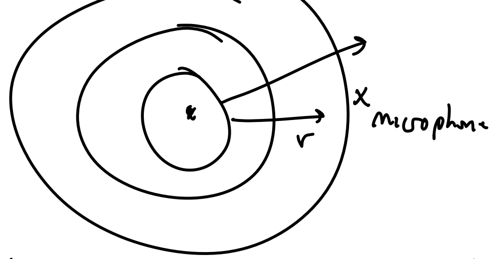
$$L_I = L_p = L_W + 10 \log_{10} Q - 11.0 - 20 \log\left(\frac{r}{r_0}\right)$$ in dB

where r = radius (distance) from source

$r_0 = 1\ m$ = const

Q = directivity factor

$Q \equiv 1$ for a sound source in free air (no walls) free space

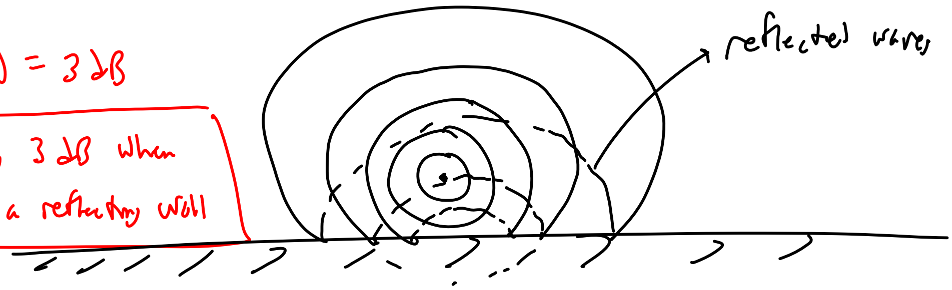


We use an anechoic chamber to simulate this

Q = 2 — if one reflecting wall & source is close to the wall

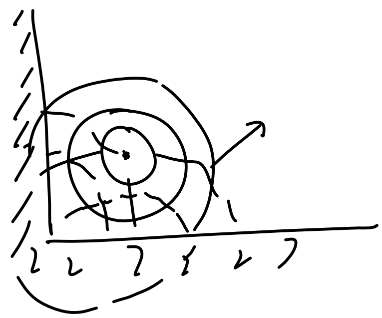
$10 \log_{10}(2) = 3$ dB

$L_p \uparrow$ by 3 dB when we add a reflecting wall



Q = 4 → 2 walls

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



Q = 8 → 3 walls (a 3-D corner)

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

There are other values of Q, depending on geometry of walls & reflectivity of walls

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