10. AIR AND SOUND POLLUTION

PRIMARY POLLUTANTS

(i) Sulphur dioxide (especially $SO_2\uparrow$)
(ii) $CO\uparrow$
(iii) Nitrogen oxides NO and NO_2
(iv) Lead (Pb)
(v) Hydrocarbons
(vi) Allergic agents like pollens and spores
(vii) Radio active substances etc.

Certain less important primary pollutants are H_2S, H_2F and other fluorides, methyl and Ethyl mercaptans. etc.

SECONDARY POLLUTANTS

(i) H_2SO_4 (more toxic then $SO_2\uparrow$)
(ii) Ozone (O_3)
(iii) Formaldehydes
(iv) Peroxyacetyl-nitrate (PAN)etc.,

WIND SPEED

Wind speed is generally measured by Anemometer at a height say Z_0, knowing the wind speed say U_0, At a any height Z.

We can workout velocity U as

$$\boxed{U = U_0\left(\frac{Z}{Z_0}\right)^k}$$

where, k = const. $\approx \frac{1}{9}$ for large lapse rate

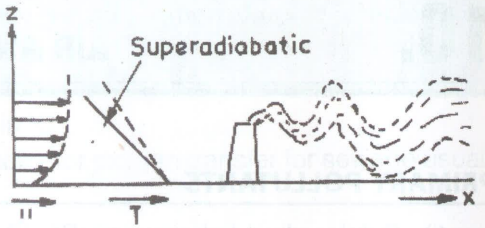
$= \frac{1}{3}$ for marked inversions

$\approx \frac{1}{7}$ (average normal value)

PLUME

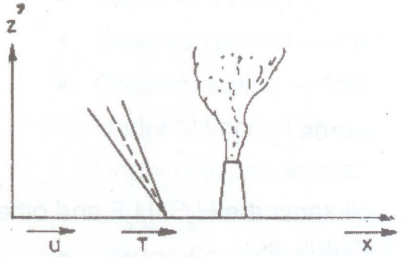
The emitted gases being known as a *plume* and their source of origin as *stack*.

(i) Looping plume



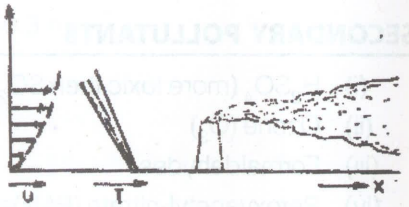
- Occurs in super adiabatic environment. Which produces highly unstable environment because of rapid mixing.
- Higher stacks are needed.

(ii) Neutral plume



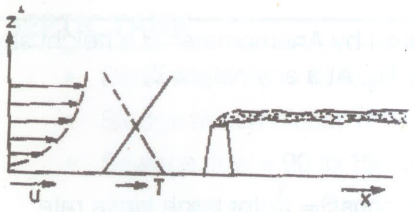
- Upward vertical rise
- when ELR = ALR

(iii) Coning plume



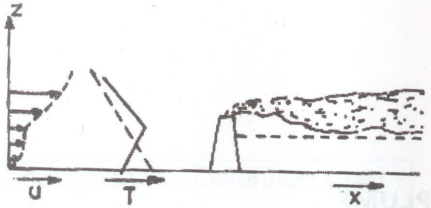
- When wind velocity > 32 km/hr & when clouds are present.
- Also occurs under sub-adiabatic condition. (ELR < ALR)
- Environment is slightly stable.

(iv) Fanning plume



- Under extreme inversion conditions
- Emission will spread only horizontally
- High rising stacks are needed.

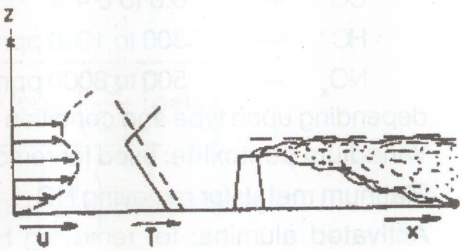
(v) Lofting plume 



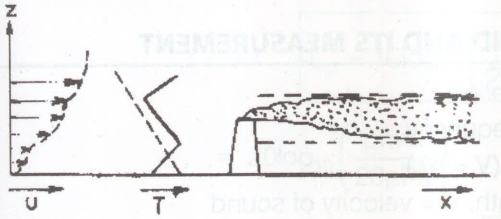
- when there exists a strong super adiabatic L.R. above surface inversion.
- Such plume has minimum downward mixing as its downward motion is prevented by inversion but upward mixing will be rapid and turbulent.

(vi) Fumigating plume 

- when inversion layer occurs at a short distance above the top of the stack and super adiabatic conditions prevail below the stack.
- Pollutants can not escape above the top of the stack because of inversion layer.



(vii) Trapping plume



- When inversion layer exists above the emission source as well as below the source. Naturally the emitted plume will neither go up nor down.

- **Various mechanical devices used for removal of particulate matters**

Name of device	Min. particle size (μm)	Efficiency of Removal
1. Gravitational settling chamber	> 50	< 50%
2. Centrifugal collectors including cyclone collectors or separators and dynamic precipitator	5-25	30-90%
3. Wet scrubbers of collectors including spray towers	> 10	< 80%
4. Cyclonic scrubbers	> 2.5	< 80%
5. Venturi scrubbers (Also used for gaseous pollutants)	> 0.5	< 99%
6. Electrostatic precipitator	> 1	95-99%
7. Fabric filters	< 1	> 99%

CONTROLLING AIR POLLUTION FROM AUTO MOBILES

Automobiles normally emit

CO	—	0.5 to 6.4%
HC	—	300 to 1000 ppm
NO_x	—	500 to 3000 ppm

depending upon type and condition of engine also.

Vanadium pentoxide: used for removing SO_2

Platinum metal: for removing NO_x

Activated alumina: for removing Hydrocarbons (impregnated with metallic compounds)

Pd^{++} & Cu^{++} for converting CO to CO_2

CHARACTERISTICS OF SOUND AND ITS MEASUREMENT

$$P = \frac{1}{f}$$

where, P = period
f = frequency
$c = f\lambda (V = n\lambda)$
λ = wave length, V = velocity of sound

n = frequency, $prms = \sqrt{p^2(t)} = \sqrt{\frac{1}{T}\int_0^T p^2(t)\,dt}$

p(t) = pressure at any time 't', prms = sound pressure

Sound pressure = Atmospheric pressure — barometric pressure.

POWER OF SOUND

The rate of doing work by a travelling sound wave in the direction of propagation of wave.

or

The energy transmitted by a sound wave in the direction of its propagation is thus defined as its power.

(i) Intensity of sound

'Sound power average' over the time per unit area normal to the direction of propagation of wave.

$$I = \frac{W}{a}$$

a = unit area ⊥ to the direction of wave motion.

$$I = \frac{p^2 rms}{\rho \times v}$$

P = density of medium
v = vel. in m/sec.

$$v = 20.05\sqrt{T}$$

T = temperature in K

(ii) Level of Noise

- Sound pressure which can be heard by human ≈ 20 μΠα.
- Loudest sound produced by rocket ≈ 200 Pa.
- Level (Measurement

$$L = \log_{10}\left(\frac{Q}{Q_0}\right) \text{bels}$$

$$= 10\text{Log}_{10}\left(\frac{Q}{Q_0}\right) \text{ decibel (dB)}$$

where, Q = measured quantity, Q_0 = Reference standard.
≈ 20 μΠα (if pressure)

$$L_p = 10\log_{10}\left(\frac{prms}{20\mu Pa}\right)^2$$

$$= 20\log_{10}\left(\frac{prms}{20\mu Pa}\right)$$

If Reference is power (≈ 10^{-12} watts) $L_w = 10\log_{10}\left(\frac{W}{10^{-12}}\right)$

If Reference Q_0 is sound Intensity (≈ 10^{-12} W/m^2)

$$L_I = 10\log_{10}\left(\frac{I}{10^{-12}}\right)$$

(iii) Averaging sound pressure levels

The average value of the various records at a place is given by

$$\bar{L}_p = 20\log\frac{1}{N}\sum_{n=1}^{N}(10)^{Ln/20}$$

$\bar{L}_p$ = average sound pressured level in dB(Re ≈ 20 μΠα)
N = No. of measurement reading
L_n = nth sound pressure level in dB (Re -20 μPa) say for e.g.. average of 4 measurement 40, 50, 62 and 72 dB (Re = 20 μPa)

$$\sum_{n=1}^{4}(10)^{Ln/20} = 10^{40/20} + 10^{50/20} + 10^{62/20} + 10^{72+20} = 5656.22$$

$$\bar{L}_p = 20\log_{10}\frac{1}{4}(5656.22) \qquad \bar{L}_p = 63\,dB$$

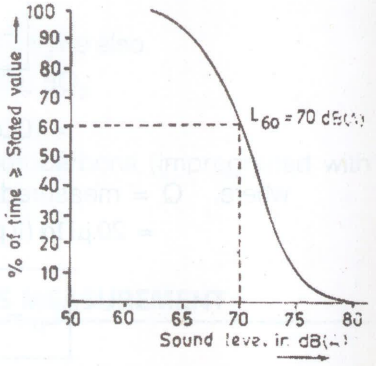
NOISE RATING SYSTEMS

A noise may consist of different types of sounds with different pressure levels. Operating for different time intervals, the frequency may also vary. Hence to find combined effect there are two concepts L_n and Leq concepts.

(i) The L_n Concept

The value of L_n will represent the sound pressure level that will exceed for N% of the gauging time. e.g. 70 dB value of L_{60} means that the sound level will exceed 70 dB for 60% of the measuring time.

Graph between L_n and N (N = ...%)



(ii) L_{eq} Concept

(Equivalent NOISE level)

Leq is that statistical value of sound pressure level that can be equated to any fluctuating noise level.

Thus, Leq is defined as the const. noise level which over a given time expands the same amount of energy as is expanded by the fluctuating levels over the same time, this value is expressed by the equation

$$L_{eq} = 10 \log \sum_{i=1}^{n} (10)^{Li/10} \times t_i$$

where, n = total no of sound samples
L_i = noise level of the i^{th} sample
t_i = time duration of i^{th} sample expressed as % total time.

L_{eq} value for fluctuating noise level of 95 minutes indicated earlier (i.e. the one with 80 dB lasting for 10 minutes, followed by 60 dB for 80 minutes followed by 100 dB for 5 min. can be worked out as below.

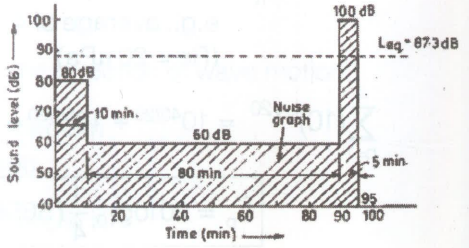
$$\sum_{1}^{3} (10)^{Li/10} \times t_i = \left[(10)^{80/10} \times \frac{10}{95} + (10)^{60/10} \times \frac{80}{95} + (10)^{100/10} \times \frac{5}{95} \right]$$

$$= 537.69 \times 10^6$$

$$L_{eq} = 10 \log_{10} (537.69 \times 10^6)$$

$$\boxed{L_{eq} = 87.3 \text{ dB}}$$

- The equivalent noise level (L_{eq}) constitutes an important parameter for evaluating the impact of fluctuating noise of all kinds.



- The duration in hours, over which L_{eq} is worked out for a given site is further mentioned in bracket, such as L_{eq} (8) which means that L_{eq} is based on 8 hr., measurement, when, however no such time is mentioned, then L_{eq} is always corresponds to one hr. measurement.

(iii) Noise levels of different sources

1. Air traffic = 90 – 110 dB
2. Rail traffic = 90 – 110 dB (about 30 m away)
3. Heavy Road traffic = 80 – 90 dB
4. Medium Road traffic = 70 – 80 dB
5. Light Road traffic = 60 – 70 dB

(iv) Noise reduction

$$\text{Noise reduction (dB)} = 10 \log_{10} \left(\frac{20H^2}{\lambda R} \right)$$

R = Distance between source and wall.
H = Height of barriers wall
λ = Wave length of sound
D = Distance between barrier and the receiving point.

CPCB STANDARDS OF NOISE LEVELS (D_B) ⇒ $D_{B(A)}$

Rural	Suburban	Residential (urban)	Urban (Residential & business)	City	Industrial
25-35	30-40	35-45	40-50	45-50	50-60

AMBIENT AIR QUALITY STANDARDS $D_{B(A)}$, $L_{EQ.}$

Area	Day time	Night time
Industrial area	75	70
Commercial area	65	55
Residential area	55	45
Silence zone	50	40

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