Appendix –1

Determination of mass flow rate of a pollutant gas for calculating heat emission rate (Q_h)

$$Q_h = \dot{m}.c.\Delta T \quad (1.1)$$

Q_h in eq. 1.1 represents emission rate. So mass expression in eq. (1.1) is mass flow rate since it's unit is $\frac{mass}{time}$

$$\dot{m} = \rho.\dot{V} \quad (1.2)$$

Therefore pollutant is a gas, from the ideal gas law:

$$\rho = \frac{P.M_A}{R.T} \quad (1.3)$$

Volumetric flow rate which is represented by $\dot{V}$ can be calculated by following expression:

$$\dot{V} = A.V_S \quad (1.4)$$

A : area of stack outlet

Vs : effluent gas velocity from the stack

Area for circular shapes can be calculated as follows :

$$A = \frac{\pi.D^2}{4} \quad (1.5)$$

D: inner diameter of stack outlet

Mass flow rate of pollutant gas can be estimated as in eq. (1.6)

$$\dot{m} = \frac{P.M_A}{R.T}.V_S\,\frac{\pi.D^2}{4} \quad (1.6)$$

Example 1: Calculate the mass flow rate for given values. Diameter of stack is 2 m, stack gas velocity and temperature are 6 m/s and 440 K, respectively. Flue gas has a molecular weight of 29 kg/kg.mole

$$\dot{m} = \frac{P.M_A}{R.T}.V_S\,\frac{\pi.D^2}{4}$$

$$\dot{m} = \frac{(1,0).(29)}{(0,082).(440)}.(6)\frac{(3,14).(2)^2}{4} = 15,14\frac{kg}{s}$$

Appendix –2

Determination of maximum ground-level concentration of a pollutant.

Example 2: Estimate the maximum ground level concentration of SO_2 for the given parameters. Emission rate of SO_2 is 160 g/s, effective stack height is 60 m, wind velocity at stack height is 6 m/s, atmospheric stability class is D.

Key to solve this kind of problem is that standard derivationo at z-axis must be determined as follows:

$$\sigma_Z = \frac{H}{\sqrt{2}} \quad (2.1)$$

Once, σ_Z is calculated, distance of this point from the source must be estimated from Figure 1.

$$\sigma_Z = \frac{H}{\sqrt{2}} = \frac{60}{\sqrt{2}} = 42{,}4m$$

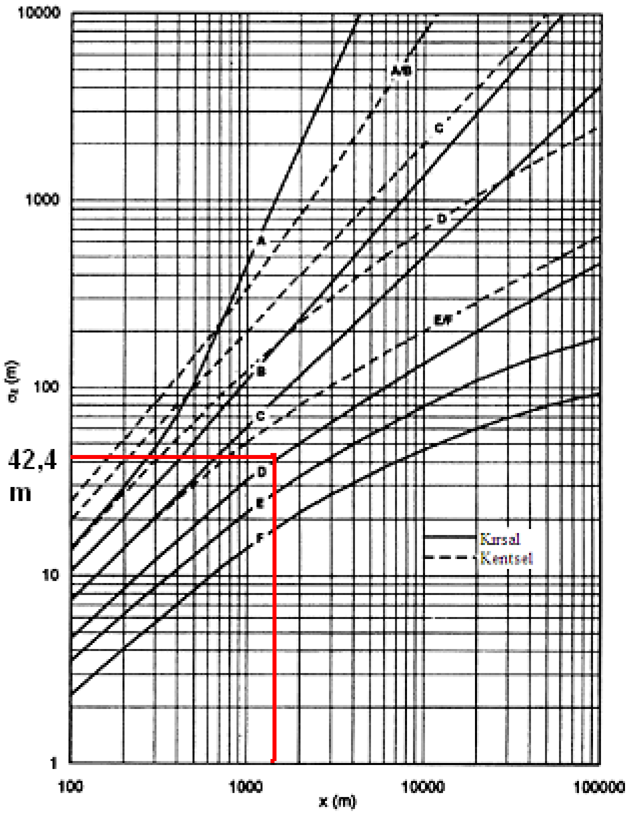

Figure 1. Standard derivation of z-axis

From Figure 1 distance from point source is approximately 1,55 km.

For this distance σ_Y must be estimated by using Figure 2.

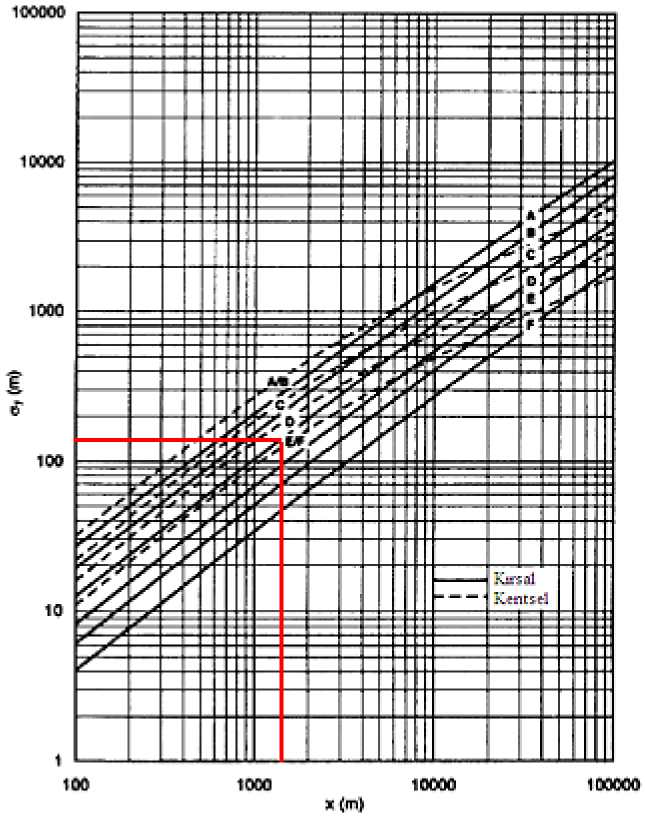

Figure 2. Standard derivation of y-axis

From Figure 2, σ_Y is approximately 140 m

What should be done from now on is to put the values in the Gauss-Dispersion formula or simplified Gauss-Dispersion formula for max. ground level concentration on the centerline and at the ground level.

$$C = \frac{Q}{2\pi . u . \sigma_y \sigma_z} \exp\left(\frac{-y^2}{2.\sigma_y{}^2}\right)\left[\exp\left(\frac{-(z-H)^2}{2.\sigma_z{}^2}\right) + \exp\left(\frac{-(z+H)^2}{2.\sigma_z{}^2}\right)\right] \quad (2.2)$$

$$C = \frac{160 g/s * 10^6 \mu g/g}{2(3{,}14).(6).(42{,}4)(140)} \exp\left(\frac{-0^2}{2.(140)^2}\right)\left[\exp\left(\frac{-(0-60)^2}{2.(42{,}4)^2}\right) + \exp\left(\frac{-(0+60)^2}{2.(42{,}4)^2}\right)\right] = 526 \frac{\mu g}{m^3}$$

another way is to use simplified equation as also stated in lecture notes:

$$C = \frac{0{,}1171.Q}{u.\sigma_y \sigma_z} \quad (2.3)$$

$$C = \frac{0{,}1171.Q}{u.\sigma_y \sigma_z} = \frac{0{,}1171.160.10^6}{6.(42{,}4).(140)} = 526 \frac{\mu g}{m^3}$$

Both, main GD formula and simplified GD formula are applicable.

Optional Section

Simplification of GD formula for maximum ground level concentration on the centerline.

It is obvious that maximum concentration of pollutant would be observed on the centerline, so y is equal to 0. eq. 2.2 can be written as in follows:

$$C = \frac{Q}{2\pi.u.\sigma_y \sigma_z} \left[\exp\left(\frac{-(z-H)^2}{2.\sigma_z^{\ 2}} \right) + \exp\left(\frac{-(z+H)^2}{2.\sigma_z^{\ 2}} \right) \right] (2.4)$$

at the ground level z = 0 . Adding values of 0 instead of z in eq. (2.4) , eq (2.5) can be acquired.

$$C = \frac{Q}{2\pi.u.\sigma_y \sigma_z} 2. \left[\exp\left(\frac{-H^2}{2.\sigma_z^{\ 2}} \right) \right] (2.5)$$

For max. concentration $\sigma_Z = \frac{H}{\sqrt{2}}$

$$C = \frac{Q}{\not{2}\pi.u.\sigma_y \sigma_z} \not{2}. \left[\exp\left(\frac{-H^2}{2.\left(\frac{H}{\sqrt{2}} \right)^2} \right) \right] \qquad (2.6)$$

$$C = \frac{Q}{(3{,}14).u.\sigma_y \sigma_z} e^{-1} \quad (2.7)$$

$$C = \frac{0{,}1171.Q}{u.\sigma_y \sigma_z}$$

This is eq. (2.3)