



Figure 11.3.1 Atmospheric Dispersion

Table 11.3.1.1 Continuous Point Sources

A. Elevated Source, Elevated Receptor

(source height = $h(h_{eff})$; receptor height = z)

$$\chi(x,y,z) = \frac{\dot{Q}}{2\pi\sigma_y\sigma_z\bar{u}} \left[\exp\left\{-\frac{(h+z)^2}{2\sigma_z^2}\right\} + \exp\left\{-\frac{(h-z)^2}{2\sigma_z^2}\right\} \right] \left[\exp\left\{-\frac{y^2}{2\sigma_y^2}\right\} \right]$$

$\chi(x,y,z)$ = air concentration ($Bq\ m^{-3}$ or $Ci\ m^{-3}$) at downwind distance x , crosswind distance y , and height z ;

\dot{Q} = Activity release rate ($Bq\ sec^{-1}$ or $Ci\ sec^{-1}$)

σ_y = horizontal dispersion parameter (m)

σ_z = vertical dispersion parameter (m)

\bar{u} = mean inverse wind speed ($m\ sec^{-1}$)

$$\left(\frac{1}{\bar{u}}\right) = \frac{1}{N} \sum_{i=1}^N \frac{1}{u_i}$$

B. Elevated Source, Elevated Receptor, Centerline

(source height = $h(h_{eff})$; receptor height = z ; $y = 0$)

$$\chi(x,0,z) = \frac{\dot{Q}}{2\pi\sigma_y\sigma_z\bar{u}} \left[\exp\left\{-\frac{(h+z)^2}{2\sigma_z^2}\right\} + \exp\left\{-\frac{(h-z)^2}{2\sigma_z^2}\right\} \right]$$

C. Elevated Source, Ground-Level Receptor

(source height = $h(h_{eff})$; receptor height, $z = 0$)

$$\chi(x,y,0) = \frac{\dot{Q}}{\pi\sigma_y\sigma_z\bar{u}} \left[\exp\left\{-\frac{h^2}{2\sigma_z^2}\right\} \right] \left[\exp\left\{-\frac{y^2}{2\sigma_y^2}\right\} \right]$$

D. Elevated Source, Ground-Level Receptor, Centerline(source height = $h(h_{\text{eff}})$; receptor height, $z = 0$; $y = 0$)

$$\chi(x,0,0) = \frac{\dot{Q}}{\pi\sigma_y\sigma_z\bar{u}} \left[\exp\left\{-\frac{h^2}{2\sigma_z^2}\right\} \right]$$

Approximate Maximum Concentration:

$$\chi_{\text{max}} \sim \frac{2\dot{Q}}{\pi e \bar{u} h^2} \left(\frac{\sigma_z}{\sigma_y} \right)$$

where e is the base of natural logarithms ($e = 2.71 + \dots$). This maximum occurs when $\sigma_z = h/\sqrt{2}$. The distance that the maximum occurs can be read off the graphs for σ_z versus distance.

E. Ground-Level Source, Ground-Level Receptor(source height, $h = 0$; receptor height, $z = 0$)

$$\chi(x,y,0) = \frac{\dot{Q}}{\pi\sigma_y\sigma_z\bar{u}} \left[\exp\left\{-\frac{y^2}{2\sigma_y^2}\right\} \right]$$

F. Ground-Level Source, Ground-Level Receptor, Centerline(Release height, $h = 0$; receptor height, $z = 0$; $y = 0$)

$$\chi(x,0,0) = \frac{\dot{Q}}{\pi\sigma_y\sigma_z\bar{u}}$$

G. Crosswind Integrated Concentration

$$\begin{aligned} \chi_{\text{cwi}} &= \frac{\dot{Q}}{\pi\sigma_z\bar{u}} \left[\exp\left\{-\left(\frac{h^2}{2\sigma_z^2}\right)\right\} \right] \frac{1}{\sigma_y} \int_{-\infty}^{\infty} \exp\left\{-\left(\frac{y^2}{2\sigma_y^2}\right)\right\} dy \\ &= \left(\frac{2}{\pi}\right)^{1/2} \frac{\dot{Q}}{\sigma_z\bar{u}} \left[\exp\left\{-\left(\frac{h^2}{2\sigma_z^2}\right)\right\} \right] \end{aligned}$$

H. Sector-Averaged Long-Term Concentration

$$\begin{aligned} \chi_{\text{sector-averaged}} &= \frac{\dot{Q}}{\pi\sigma_z\bar{u}} \left[\exp\left\{-\left(\frac{h^2}{2\sigma_z^2}\right)\right\} \right] \frac{1}{\sigma_y} \int_{-\infty}^{\infty} \exp\left\{-\left(\frac{y^2}{2\sigma_y^2}\right)\right\} dy \\ &= \left(\frac{2}{\pi}\right)^{1/2} \frac{\dot{Q}}{\sigma_z\bar{u}} \left[\exp\left\{-\left(\frac{h^2}{2\sigma_z^2}\right)\right\} \right] \times \frac{0.01 f}{2\pi(x/n)} \end{aligned}$$

The sector-averaged equation uses the crosswind-integrated model but distributes the y -concentration evenly over a sector. The width of a sector is equal to the circumference ($= 2\pi x$) at distance x from the source divided by the number of sectors, n (typically $n = 16$ so that there are 16 $22\frac{1}{2}^\circ$ sectors in a full circle of 360°). The concentration in each sector is weighted by the fraction of the time that the wind blows into the sector of interest ($0.01 \times$ the percentage of the time, f , that wind is blowing into the sector of interest). Sector-averaging is an artifice for representing long-term meandering of the plume.