2.5 WIND PROFILES AND STACK PLUME PATTERNS/PLUME RISE

- The moving air is called wind, such a movement caused by the unequal distribution of temperature and pressure on earth surface.
- A critical relationship exists between atmospheric stability and pollutant concentrations.
- Pollutants that cannot be transported or dispersed into the upper atmosphere quickly become trapped at ground level and pose a significant risk to human health and the environment.
- This relationship can be visualized in the behaviour of emission plumes from industrial smoke stacks.

Plume:

The dispersion of emitted gases from the source of their production is known as plume and the source is known as stack.

Plume rise:

It is defined as the distance of the hot plume from the stack into the atmosphere, due to the buoyancy and momentum.

Types of Plume rise:

Six types of air pollution plumes illustrate the relationship between atmospheric stability and pollutant emissions:

- Looping plumes
- Fanning plumes
- Coning plumes
- Lofting plumes
- Fumigating plumes

- Trapping plumes.

1. Looping plumes:

- Pollution that is released into an unstable atmosphere forms looping plumes.
- Rapid changes in temperature and pressure may result in plumes that appear billowing and puffy.
- While unstable conditions are usually favorable for pollutant dispersion, high concentrations of air pollution forced down by cooling air can be harmful if trapped at ground level.
- This can occur on sunny days with light to moderate winds, which combine with rising and sinking air to cause the stack gases to move up and down in a wavy pattern producing a looping plume (Godish, 1997).

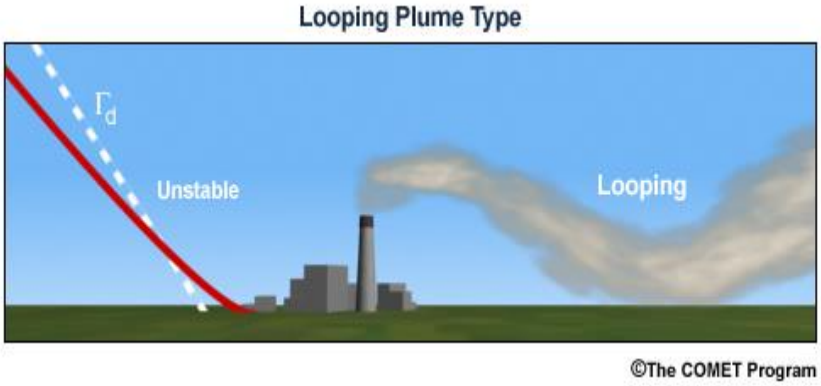

Figure 2.5.1 Looping plumes

[Source:http://stream1.cmatc.cn/pub/comet/EmergencyManagement/afwa_dis/comet/dispersion/afwa/txt/sect3.htm#classic]

2. Fanning plumes:

- A fanning plume occurs during stable conditions and is characterized by long, flat streams of pollutant emissions.
- Because atmospheric pressure is stable, there is neither a tendency for emissions to raise nor descend permitting (horizontal) wind velocity to transport and disperse the pollutant.

- Fanning plumes are usually seen during the early morning hours just before the sun begins to warm the atmosphere and winds are light (Godish, 1997).

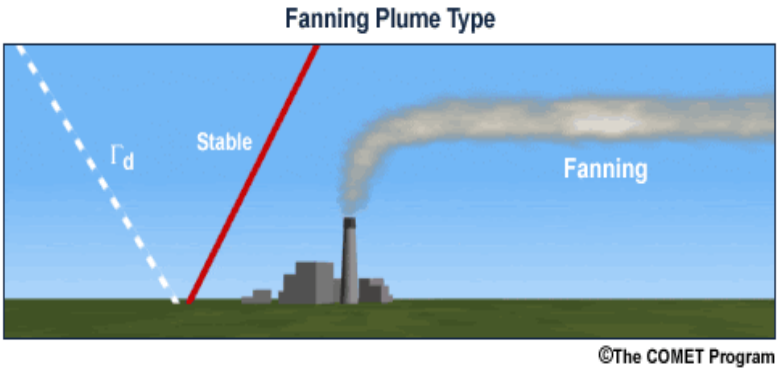

Figure2.5.2 Fanning Plume

[Source:http://stream1.cmatc.cn/pub/comet/EmergencyManagement/afwa_dis/comet/dispersion/afwa/media/graphics/classic1.gif]

3. Coning plumes:

- Neutral or slightly unstable conditions create a coning plume that is distinguished by large billows or puffs of pollutants.
- Coning plumes are typically formed on partly cloudy days when there is an alternate warming and cooling of the atmosphere.
- Warm gases released into cool, ambient air mix, expand, and rise into the upper atmosphere (Godish, 1977).

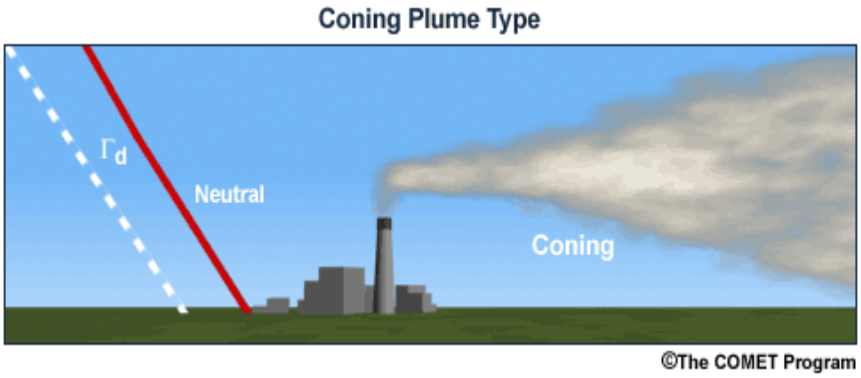

Figure 2.5.3 coning Plume

[Source:http://stream1.cmatc.cn/pub/comet/EmergencyManagement/afwa_dis/comet/dispersion/afwa/media/graphics/classic4.gif]

4. Lofting plumes:

- When the atmosphere is relatively stable, warm air remains above cool air and creates an inversion layer.
- Pollutants released below the inversion layer will remain trapped at ground level and, in the absence of any atmospheric instability, prevent the upward transport of the pollutant.
- When there is little or no vertical mixing, pollutants tend to form in high concentrations at ground level.
- When conditions are unstable or neutral above the inversion layer, stack gases above that level form a lofting plume that can effectively disperse the pollutant into the upper atmosphere (Godish, 1997).

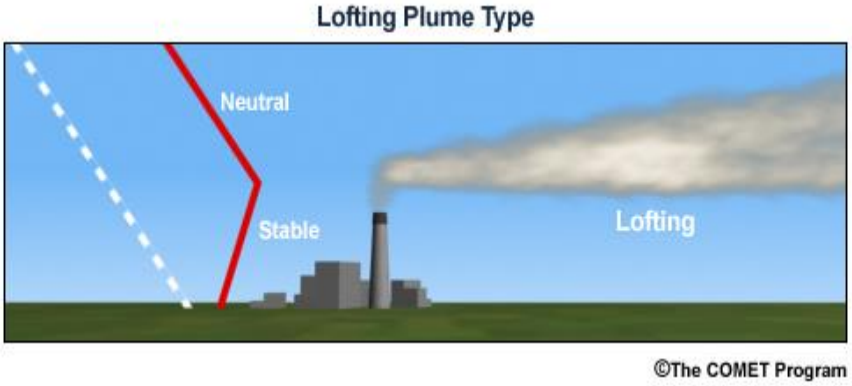

Figure 2.5.4 Lofting Plume

[Source:http://stream1.cmatc.cn/pub/comet/EmergencyManagement/afwa_dis/comet/dispersion/afwa/media/graphics/classic2.jpg]

5. Fumigating plumes:

- In the early morning, if the plume is released just below the inversion layer, a very serious air pollution episode could develop.
- When pollutants are released below the inversion layer, gaseous emissions quickly cool and descend to ground level.

- This condition is known as fumigation and results in a high concentration of pollution that can be damaging to both humans and the environment alike.

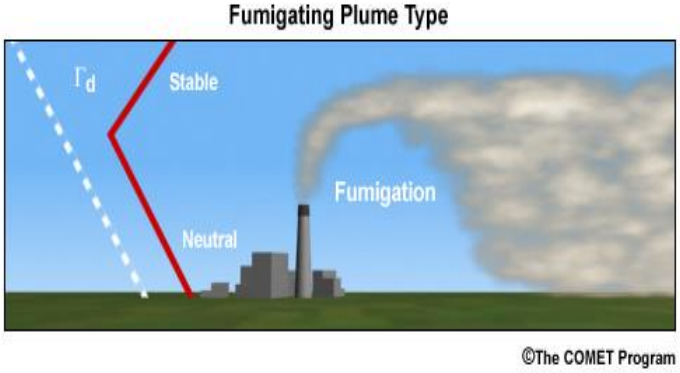

Figure 2.5.5 Fumigating Plume

[Source:http://stream1.cmatc.cn/pub/comet/EmergencyManagement/afwa_dis/comet/dispersion/afwa/media/graphics/classic2.jpg]

6. Trapping plumes:

- Lapse rates and atmospheric stability weak lapse rate below, Inversion aloft(Trapping)
- Radiation inversion at ground level, subsidence inversion at higher altitude (evening-night)

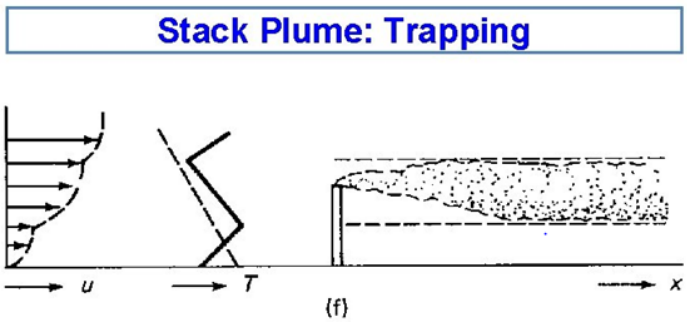

Figure 2.5.6 Trapping Plume

[Source:http://stream1.cmatc.cn/pub/comet/EmergencyManagement/afwa_dis/comet/dispersion/afwa/media/graphics/classic2.jpg]