The Ninth Experiment

Choosing the behavior of instantaneous pollutant dispersal according to atmospheric stability

The Objective of the experiment:

Using Pasquill's table to determine the quality of atmospheric stability and to choose the ideal behavior for the dispersal of ejected clouds from the chimneys to the surrounding atmosphere.

The Theoretical Part:

You must have traveled outside your city. Of course, you must have seen polluted clouds emanating from point sources such as chimneys in electric power plants, oil refineries, factories or workshops, which are often located outside cities. We notice the spread of these clouds with different spreading patterns from time to time. . This diffusion behavior certainly depends on the stability of the surrounding air.

The stability of the atmosphere is the resistance or enhancement of vertical movement, and is determined by the difference in temperature with altitude, the change in wind speed, the intensity of solar radiation and the amount of clouds. In general, atmospheric stability is classified in three cases: stable when the air sample is returned to its original position after its ascent or descent, unstable where the sample moves upward as a result of the buoyant force acting on it vertically, and neutral where the sample does not tend to go up or down. Instabilities generally appear on sunny days and intensify at noon. As for the conditions of stable weather, it seems clear after midnight, while the conditions of sunrise and sunset, or when the sky is overcast with clouds or strong winds, the cases of equalization abound [1]. Stability is usually classified into six categories:

F	E	D	C	B	A	*Item Code*
very stable	*moderately stable*	*neutral*	*a little unstable*	*medium unstable*	*very unstable*	*Stability type*

There are many and familiar ways to determine these types, the simplest and most famous of which is the Pasequill-Turner-Pasequill method, as it requires data on wind speed, solar radiation during the day, and the quantities of clouds at night

approved by the meteorological departments. When monitoring this data and based on the Pasquale-Toner table (4-1) below, the type of stability is determined:

Table (4-1): shows the modified Pasquale-Toner ratings for atmospheric stability [16]

Wind speed (m/s)	Daytime incoming Solar radiation (w/m^2)				Within 1h before Sunset or after Sunrise	Night cloud amount (Oktas)		
	Strong >600	Moderate (300- 600)	Slight (<300)	overcast		0-3	4-7	8
≤ 2	A	A-B	B	C	D	F-G	F	D
2.0-3.0	A-B	B	C	C	D	E	E	D
3.0-5.0	B	B-C	C	C	D	D	D	D
5.0-6.0	C	C-D	D	D	D	D	D	D
> 6.0	C	D	D	D	D	D	D	D

The many changes that occur in the forms of clouds emerging from the chimneys come from the diversity of cases of turbulence, air circulation, wind movement, temperature decline, wind movement, and the decline of vertical temperatures, in other words, the weather stability determines the forms of these clouds, and I have been counted in five standard forms [9] and [4].The following describes the conditions accompanying these forms:

1. **Looping plume :** It occurs in very unstable atmospheres, i.e. Class A or B, where the cloud moves in an irregular wave shape that dissipates and disappears relatively quickly in the form of small pieces as it moves away from the chimney, as shown in Figure (4-1a) and occurs during the day when conditions of clear sky or few clouds and solar radiation Strong, calm winds, gradient rate adiabatic or above adiabatic.
2. **Coning plumes**: It occurs in stable, weak or neutral conditions (classes F or D), as there is little vertical mixing and arises on cloudy or sunny days and sometimes occurs in the late morning. When the atmosphere is stable, the vertical mixing and the horizontal mixing are approximately equal, so the cloud spreads vertically and horizontally by approximately the same amount, which gives a conical appearance to the cloud. Figure (4-1c).

3. **Fanning plumes:** It occurs in very stable atmospheres (classes E and F) or when there is severe surface inversion. Under these conditions, the vertical spread is absent or very weak, and this condition occurs at the time of the late night, accompanied by light winds and clear skies, Figure (1d-4).

4. **Lofting plumes:** If the overturning layer is below the level of the chimney nozzle, the lower mixing will stop while the cloud will continue to spread sideways and upward and the pollutants cannot go down because they are restricted to overturning. This condition often occurs during the night when the inversion is superficial (Fig. 4-1e).

5. **Fumigation plumes:** These clouds occur when the overturning layer is located above the chimney mouth, the vertical movement will be trapped by the overturning layer and thus the pollutants will spread downwards, Figure (4-1f).

TheMaterials and Tools used

1. Wind speed measuring device at .10 m
2. Solar radiation measuring unit w/m^2.
3. Air temperature measuring device to be inside a wooden box with good ventilation.

The Method of Work

1. Turn on the wind meter and make sure it is working properly.
2. When the device is stable and after a short period of time, record the reading of the device, let it be U1.
3. Turn on the solar radiation meter and record your reading as R1 after making sure it is working well.
4. Record the reading of the temperature device at the first altitudes T1 and the second T2.
5. Repeat steps 2, 3, and 4 after ten minutes have passed, as U2, R2, T12, T22.
6. Take the averages for each anaerobic component.
7. From the data of wind speed and solar radiation, the class of atmospheric stability was determined according to the Pasquale-Toner table (1-4).

8. Calculate the true vertical gradient of temperature γ, which is equal to

$$\gamma = \frac{\overline{T_2} - \overline{T_1}}{\Delta Z}$$

Air Element	First observation	Second observation	Reading rate	γ	Atmospheric Stability Class	The Number and quality of the expected pollutant spread
U (m/s)						
R (w/m^2)						
T_1 (°C)						
T_2 (°C)						

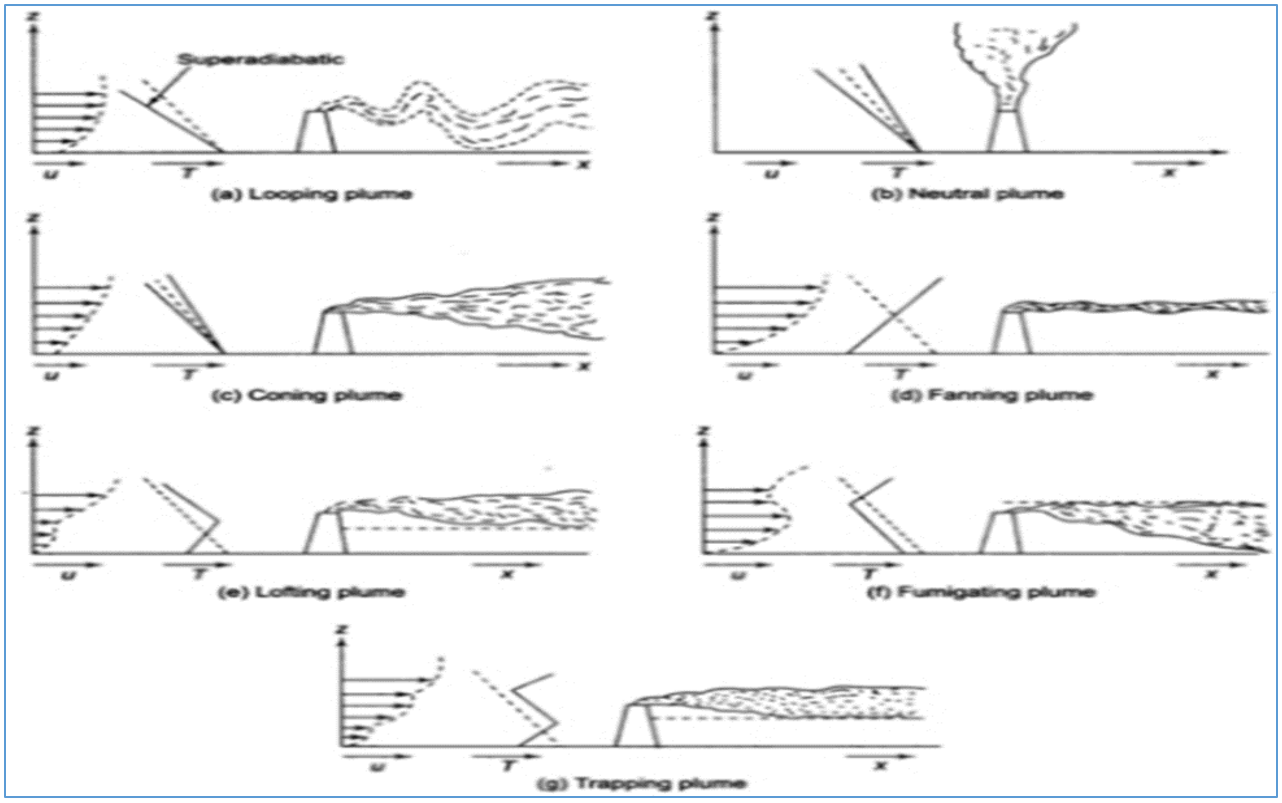

Figure (4-1): Patterns of smoke clouds according to atmospheric stability

9. Based on step 8 and the previous step, a prediction of the dispersal behavior of pollutants in the outside air surrounding you for the location of any of the above ideal forms of pollutant diffusion corresponds.

Discussion

Q1/ According to your result, the expected behavior of the polluted cloud spread, what is its impact on residential areas?

Q2/ In your opinion, can this experience be reversed, that is, if we see the spread of the cloud emerging from a chimney crater in the air, it is possible to predict the type of atmospheric stability?

Q3/ Explain the role of vertical mixing in your results?

Q4/ What does temperature change with altitude mean if the change is positive or negative and what kind of change in your results in this experiment?