TOWER OBSERVATIONS OF ATMOSPHERIC DUST AT THE NATIONAL REACTOR TESTING STATION

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Consideration that the placing of air intakes for reactors at various elevations above the ground may be important to air cleaning design has resulted in tower observations of dustiness at the National Reactor Testing Station. The purpose of these observations is to determine for various meteorological conditions the variations of dustiness in the vertical.

It was assumed beforehand that the vertical gradient of dustiness would show characteristic differences for various wind velocities, and for temperature lapse (daytime) and temperature inversion (nighttime) conditions.

The 250-foot radio tower in the Central Facilities area was used to elevate high volume air samplers to various heights above the ground (Figure 1). The tower also accommodates continuous recording resistance thermometers at the 5, 100 and 250-foot levels, which are used to determine temperature lapse and temperature inversion conditions. Continuous wind speed records from an instrument exposed 20 feet above ground were used rather than records from the wind equipment on top of the tower. The high-volume samplers were attached to the tower at 5, 15, 30, 100, and 250 feet (Figure 2). Rate of flow through the samplers was checked at the beginning and ending of each sampling period.

Dust Concentrations

As might be expected, it is extremely difficult to separate the effect of winds from that of air stability, because the stronger winds and

temperature lapse conditions tend to occur simultaneously. Plots of dust concentration versus height for several conditions are shown in Figure 3. The following points are made:

1) Concentrations near the ground are much higher during periods of strong winds, but at 250 feet they are no higher than during periods of light or moderate winds.

2) There is little practical difference between concentrations during lapse conditions and inversion conditions as long as wind speeds are about the same.

3) The decrease of dustiness with height shows a distinct advantage in having air intakes located at the highest feasible elevations. This is especially true for the dustiest conditions.

Table I gives percentages of the 5-foot level dust concentrations found at levels above five feet. Note that there is only 42% as much dust at the 30-foot level during dustiest conditions and from 50%-69% as much during average conditions.

Particle Sizes

For particle sizing, dust was vacuumed off of the fluted filters on to molecular filters, and counting was accomplished by conventional methods using a Porton graticule in the ocular of the microscope. Median sizes ranged between three tenths and six tenths of a micron for all sampling periods, and all levels. As might be expected, the median size decreases with height, and increases with wind speed. There was a noticeably smaller

percentage of particles greater than 10 microns at higher levels. In the dustiest sample, the percentage of particles larger than 10 microns was five times less at 250 feet than at five feet.

Also of interest is the variation of the standard geometric deviation of particle sizes with height during various conditions. The same samplings shown in Figure 3 are plotted in Figure 4. The exact shape of the curves cannot be verified for so few samples; however, the following items are worthy of mention:

1) The two curves for lapse conditions show characteristic increases in standard geometric deviations (which means decreasing homogeneity of particle sizes) with height. Near the ground, however, the deviations are smaller for the cleaner sample.

2) The curves for "inversion" and for "lapse and inversion" show characteristic decreases of standard geometric deviations with height in the lower levels. These curves show larger standard geometric deviations near the ground than the two curves for lapse conditions.

3) The standard geometric deviations tend to be about the same at the 30-foot level during all meteorological conditions, ranging from five to six.

Larger Particles

Since the characteristics of the larger particles were not easily observed at the magnification of 1800X used for particle sizing, material

Table 1. Percent of 5-Foot Level Dust Concentrations Found at Various Levels

National Reactor Testing Station

Wind Condition	Total Exposure Hours	5-Ft. Level Concentration	15-Ft. Level	30-Ft. Level	100-Ft. Level
LAPSE					
Mostly Strong	10	0.416 mg/m^3	—%	42%	11%
Mostly Light	33	0.088	89	62	38
Mostly Light	41	0.085	89	63	39
LAPSE AND INVERSION					
Moderate, Day - Light, Night	24	0.091	90	64	—
Moderate, Day - Light, Night	24	0.075	85	69	49
Moderate, Day - Light, Night	24	0.072	76	50	21
Moderate, Day - Light, Night	72	0.069	—	55	35
Mostly Light, Day - Light, Night	24	0.068	83	57	11
Mostly Moderate, Day - Mostly Light, Night	72	0.053	—	—	38
INVERSION *					
Light	53	0.065	99	79	65
Light	55	0.051	84	79	56

Light Wind 0 - 11 mph, Moderate 12 - 23 mph, and Strong > 23 mph

* In the first inversion test, 19% of the preceeding lapse periods had moderate winds; but only 6% had moderate winds in the second test. Strong winds did not affect either test.

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was shaken from the fluted filters by rapping and examined at 100X. The following remarks apply to the examinations of the samples at low power and do not compare particles smaller than 45μ.

For all conditions, at the elevations sampled, particles in the size range from 45μ to 90μ predominated the microscopic field. At lower levels, inorganic material was predominant over organic material when smaller sizes are considered except during the windy, lapse period and during the typical inversion period. During these periods inorganic and organic material were more uniformly mixed.

At higher elevations there were fewer large inorganic particles (> 100μ), and in the typical inversion case there were practically none even at the lowest elevation.

Largest inorganic particles varied as follows:

TABLE II

	5'	100'	250'
Continuous (Lapse and Inversion)	300μ-550μ	260μ	75μ-175μ
Typical Lapse	640μ	225μ	--
Windy Lapse	890μ	360μ	100μ
Typical Inversion	200μ	75μ	--

Shape was perhaps a factor in determining the heights at which largest inorganic particles were found since some were flake-like..

Organic material appears to have less density and does not show significant size variations with height. The ratio of small to large particles remains nearly constant. Pollen varieties from 60μ to 450μ were evident at all levels.

Several houseflies were always present in each filter for 5 and 15 feet, but never at 30 feet and above. Smaller insects (300μ-2800μ) were present at all levels.

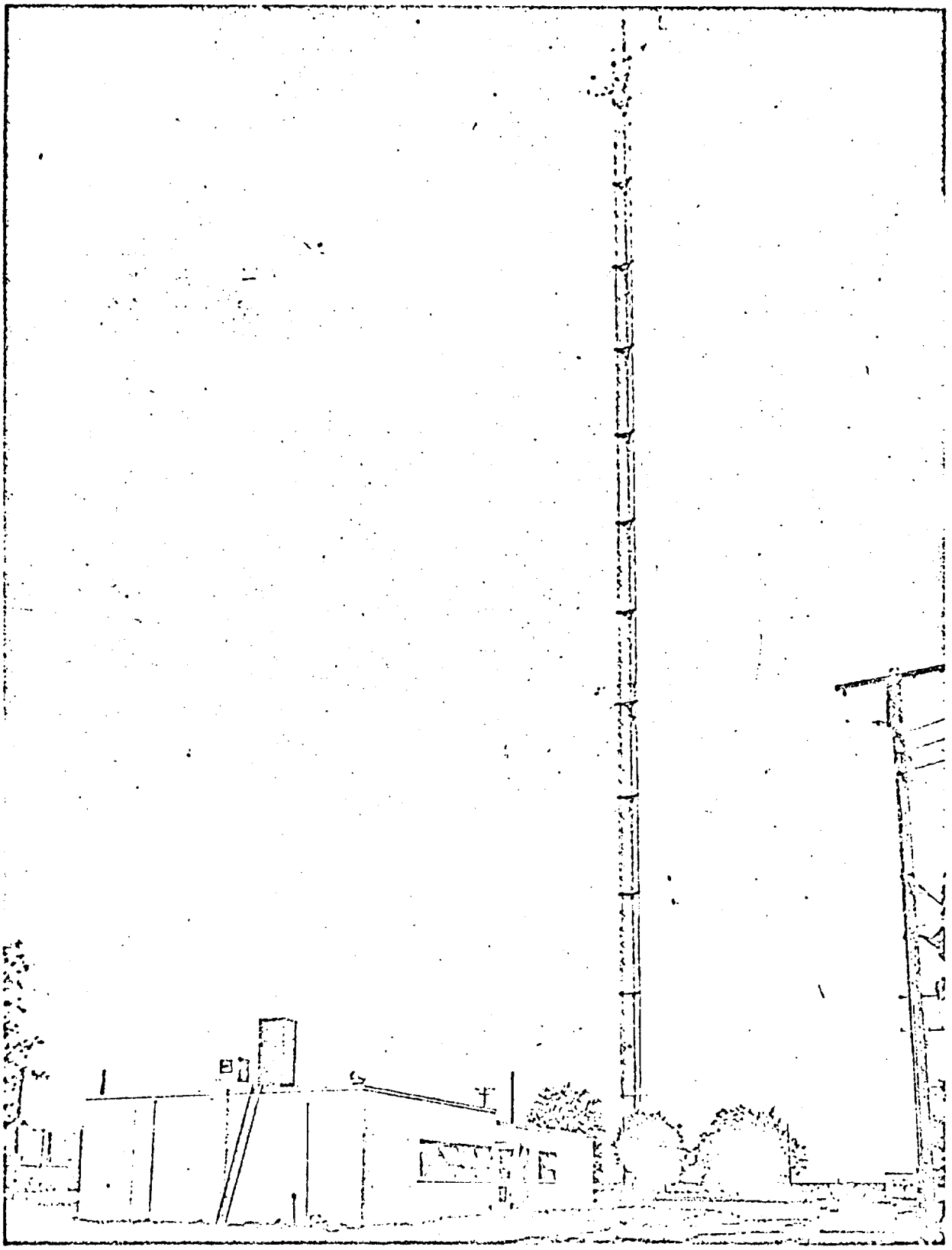


Figure 1

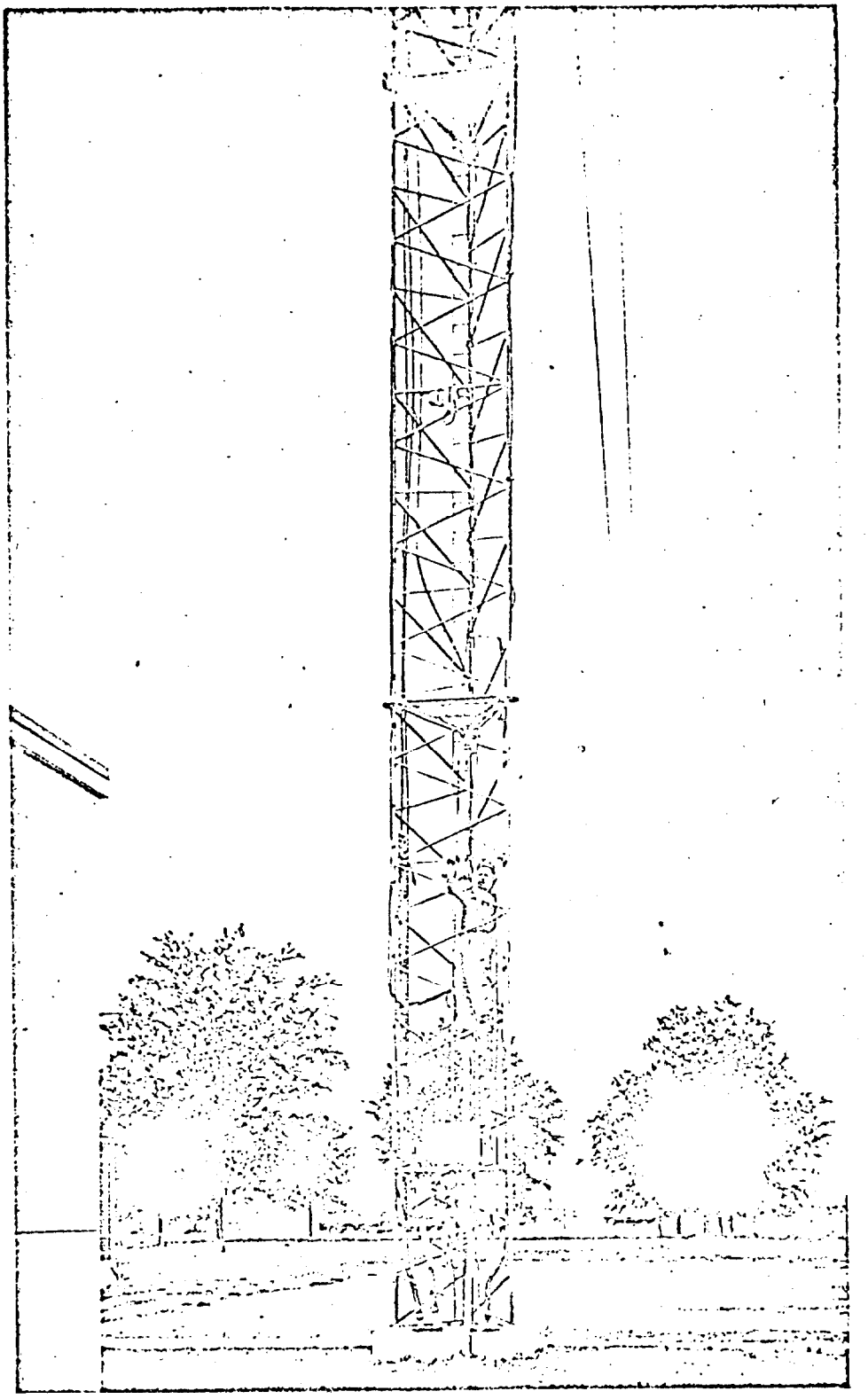


Figure 2

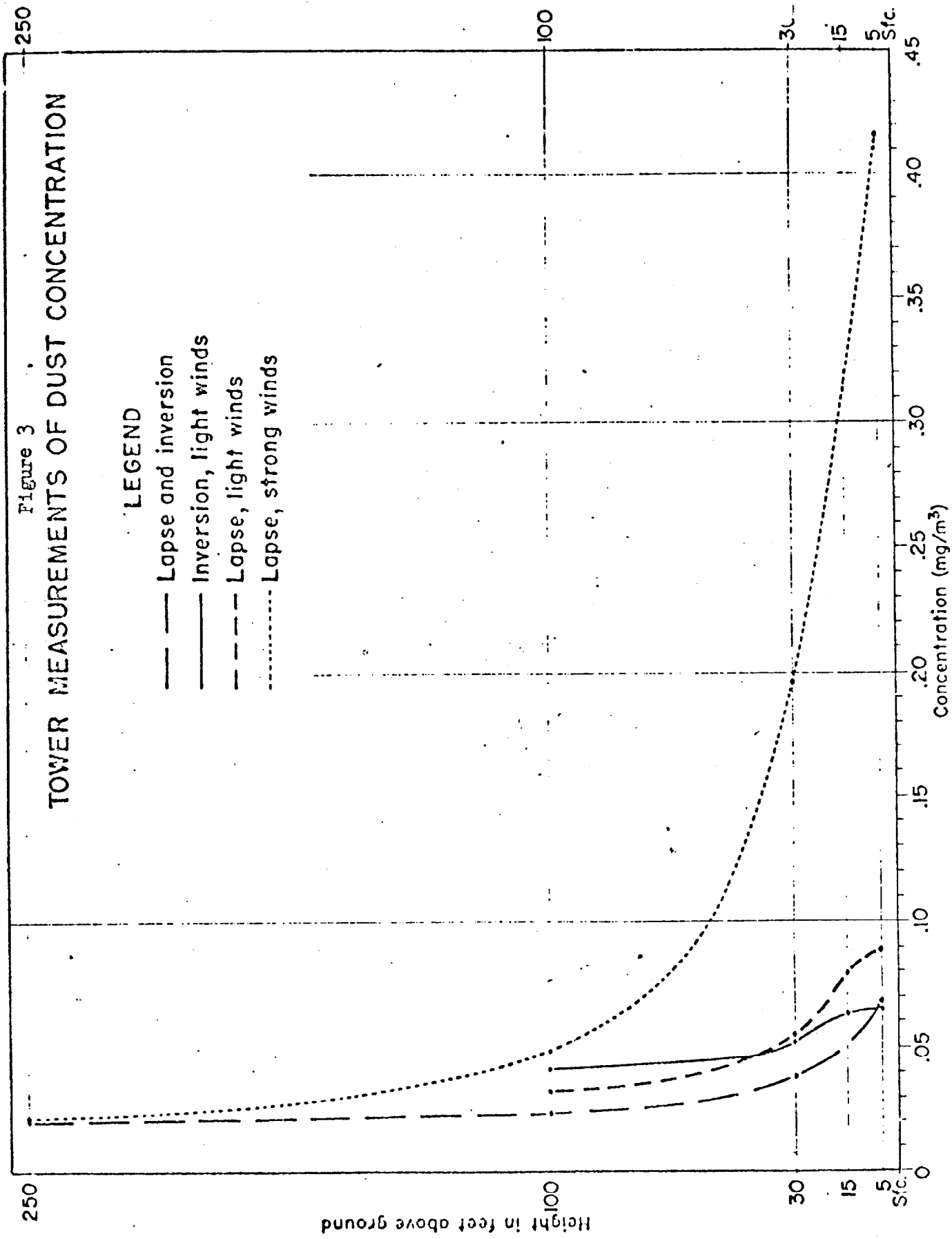


Figure 3
TOWER MEASUREMENTS OF DUST CONCENTRATION
LEGEND
Lapse and inversion
Inversion, light winds
Lapse, light winds
Lapse, strong winds
Height in feet above ground
250
100
30
15
5
Stc.
0
.05
.10
.15
.20
.25
.30
.35
.40
.45
Concentration (mg/m³)

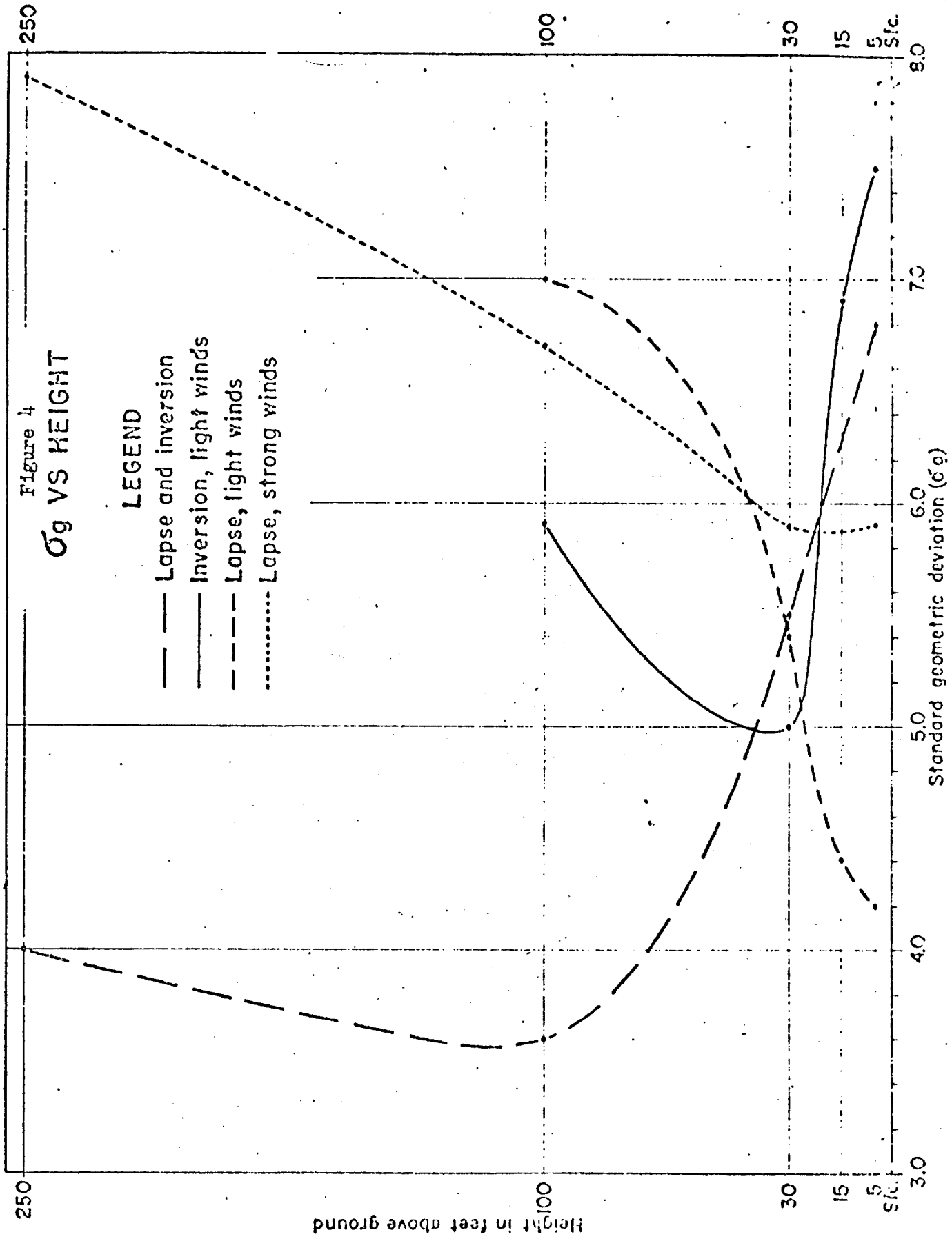


Figure 4
σg VS HEIGHT
LEGEND
Lapse and inversion
Inversion, light winds
Lapse, light winds
Lapse, strong winds
Height in feet above ground
250
100
30
15
5
Sfc.
3.0
4.0
5.0
6.0
7.0
8.0
Standard geometric deviation (σg)

ADDENDUM

Meteorological conditions during test periods considered in Figures 3 and 4. Wind given for 20 feet. Temperature gradient considered for 5 feet to 250 feet.

LAPSE AND INVERSION

On: 0805 MST, August 25, 1953 - Off: 0805 MST, August 28, 1953

Duration: 72 continuous hours

Wind Speed: Moderate during day and light at night

August 25. Hourly averages, calm to 8 miles per hour from beginning of test until almost noon then increasing to 12-19 miles per hour and dropping to 2-9 miles per hour after late afternoon. Peak gust 30 miles per hour at 1428 MST.

August 26. Hourly averages, 2-10 miles per hour until mid-morning, increasing to 12-19 miles per hour during afternoon and then decreasing to 5-8 miles per hour after early evening. Peak gust 33 miles per hour at 1136 MST.

August 27. Hourly averages, calm to 5 miles per hour until mid-morning, becoming 12-16 miles per hour during afternoon and then dropping to 2-8 miles per hour at night. Peak gust 29 miles per hour at 1447 MST.

August 28. Hourly averages, calm to 6 miles per hour until terminated at 0805 MST. Peak gust 9 miles per hour at 0100 MST.

Stability Condition:

August 25. 10 hours lapse, maximum 6.2°F. 6 hours inversion.

August 26. 12 hours lapse, maximum 6.9°F. 12 hours inversion.

August 27. 12 hours lapse, maximum 5.4°F. 12 hours inversion.

August 28. 2 hours lapse, maximum 2.0°F. 6 hours inversion.

Sky Condition: Mostly clear skies for entire period.

Weather: None

INVERSION, LIGHT WINDS

On:	1909 MST, August 10, 1953 - Off: 0815 MST, August 11, 1953
On:	1915 MST, August 11, 1953 - Off: 0815 MST, August 12, 1953
On:	1903 MST, August 12, 1953 - Off: 0843 MST, August 13, 1953
On:	1832 MST, August 13, 1953 - Off: 0750 MST, August 14, 1953
Duration:	53 hours 4 minutes
Wind Speed:	Light for entire period except for 2 hours moderate

August 10. Hourly averages, 5-9 miles per hour until midnight. Peak gust 15 miles per hour at 2100 MST.

August 11. Hourly averages, calm-4 miles per hour in morning, 3-8 miles per hour at night. Peak gust 14 miles per hour at 1900 MST.

August 12. Hourly averages, calm-5 miles per hour in morning, 7-10 miles per hour at night. Peak gust 16 miles per hour at 1900 MST.

August 13. Hourly averages, 1-8 miles per hour in morning, 7-17 miles per hour at night. Peak gust 28 miles per hour at 2130 MST.

August 14. Hourly averages, calm-4 miles per hour until termination. Peak gust 8 miles per hour at 0100 MST.

Stability Condition:

August 10. Inversion began 1917 MST.

August 11. Inversion ended 0636 MST, began 1914 MST.

August 12. Inversion ended 0710 MST, began 1859 MST.

August 13. Inversion ended 0708 MST, began 1819 MST.

August 14. Inversion ended 0647 MST.

Sky Condition: Mostly clear August 10, 11, and 12, partly cloudy 13 and 14.

Weather: None

LAPSE, LIGHT WINDS

On: 0810 MST, August 4, 1953 - Off: 1610 MST, August 4, 1953

On: 0757 MST, August 5, 1953 - Off: 1612 MST, August 5, 1953

On: 0755 MST, August 6, 1953 - Off: 1611 MST, August 6, 1953

On: 0745 MST, August 7, 1953 - Off: 1545 MST, August 7, 1953

Duration: 32 hours 31 minutes

Wind Speed: Mostly light with some moderate

August 4. Hourly averages, 13-17 miles per hour entire period. Peak gust 29 miles per hour at 1600 MST.

August 5. Hourly averages, 3-9 miles per hour entire period. Peak gust 15 miles per hour at 1600 MST.

August 6. Hourly averages, 4-10 miles per hour entire period. Peak gust 20 miles per hour at 1600 MST.

August 7. Hourly averages, 3-9 miles per hour except 12-15 miles per hour last two hours of period. Peak gust 28 at 1538 MST.

Stability Condition: August 4. Lapse began 0655 MST, ended 1921 MST, maximum 6.5°F.

August 5. Lapse began 0646 MST, ended 1930 MST, maximum 5.6°F.

August 6. Lapse began 0700 MST, ended 1808 MST, maximum 5.5°F.

August 7. Lapse began 0716 MST, ended 1845 MST, maximum 6.0°F.

Sky Condition: Mostly clear August 4, 5 and 7, partly cloudy on 6.

Weather: None

LAPSE, STRONG WINDS

On: 0843 MST, August 24, 1953 - Off: 1857 MST, August 24, 1953

Duration: 10 hours 14 minutes

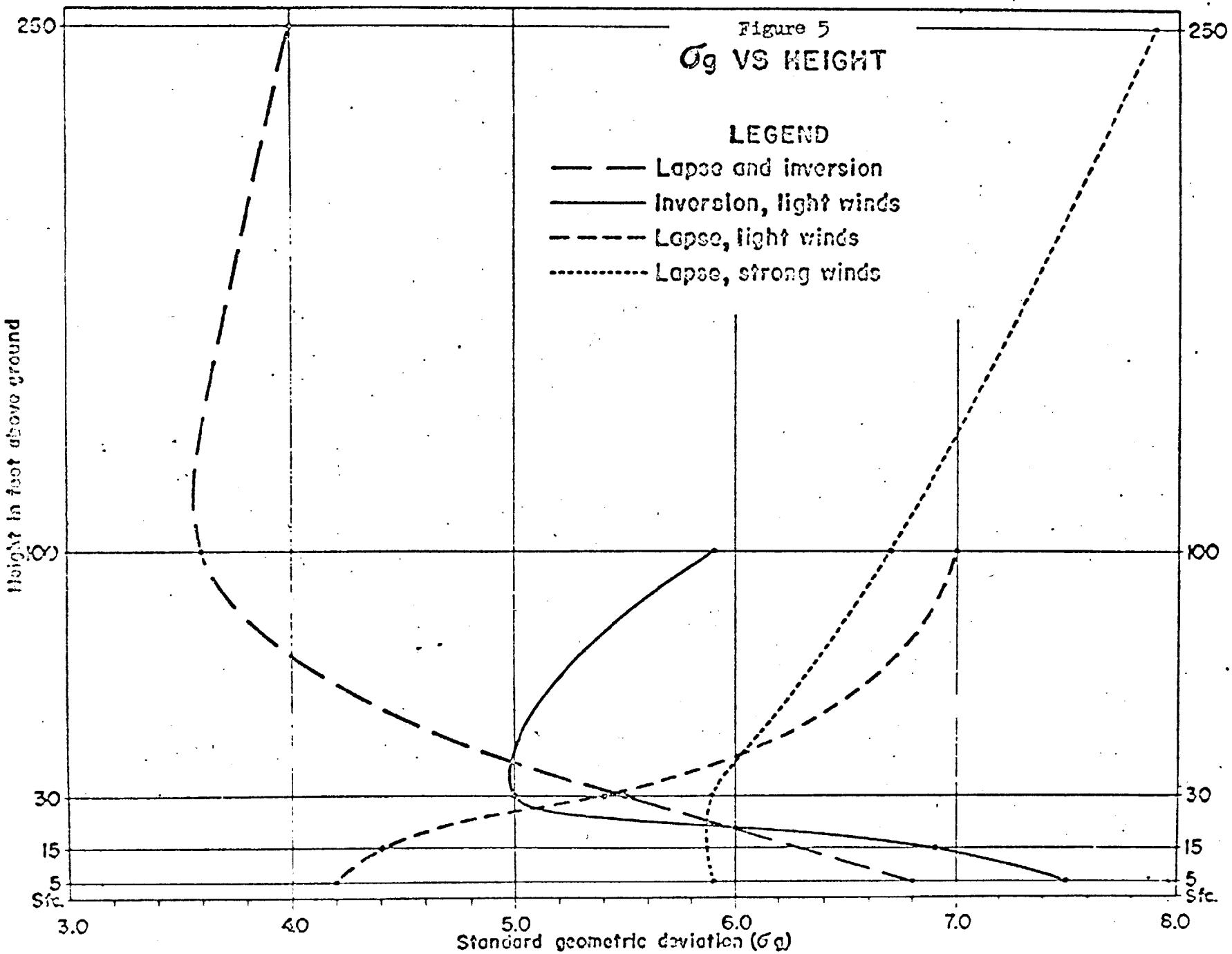
Wind Speed: Mostly strong with some moderate

August 24. Hourly averages 24-25 miles per hour most of time with 12-21 miles per hour at beginning and end of period. Peak gust 41 miles per hour at 1403 MST.

Stability Condition: August 24. Lapse began 0728 MST, ended 1900 MST, maximum 7.6°F.

Sky Condition: Scattered cloudiness

Weather: In addition to the general dustiness of the air, individual clouds of blowing dust from numerous sources of loose soil were visible in all directions. Dust clouds from nearby points of origin frequently blew across the sampling site.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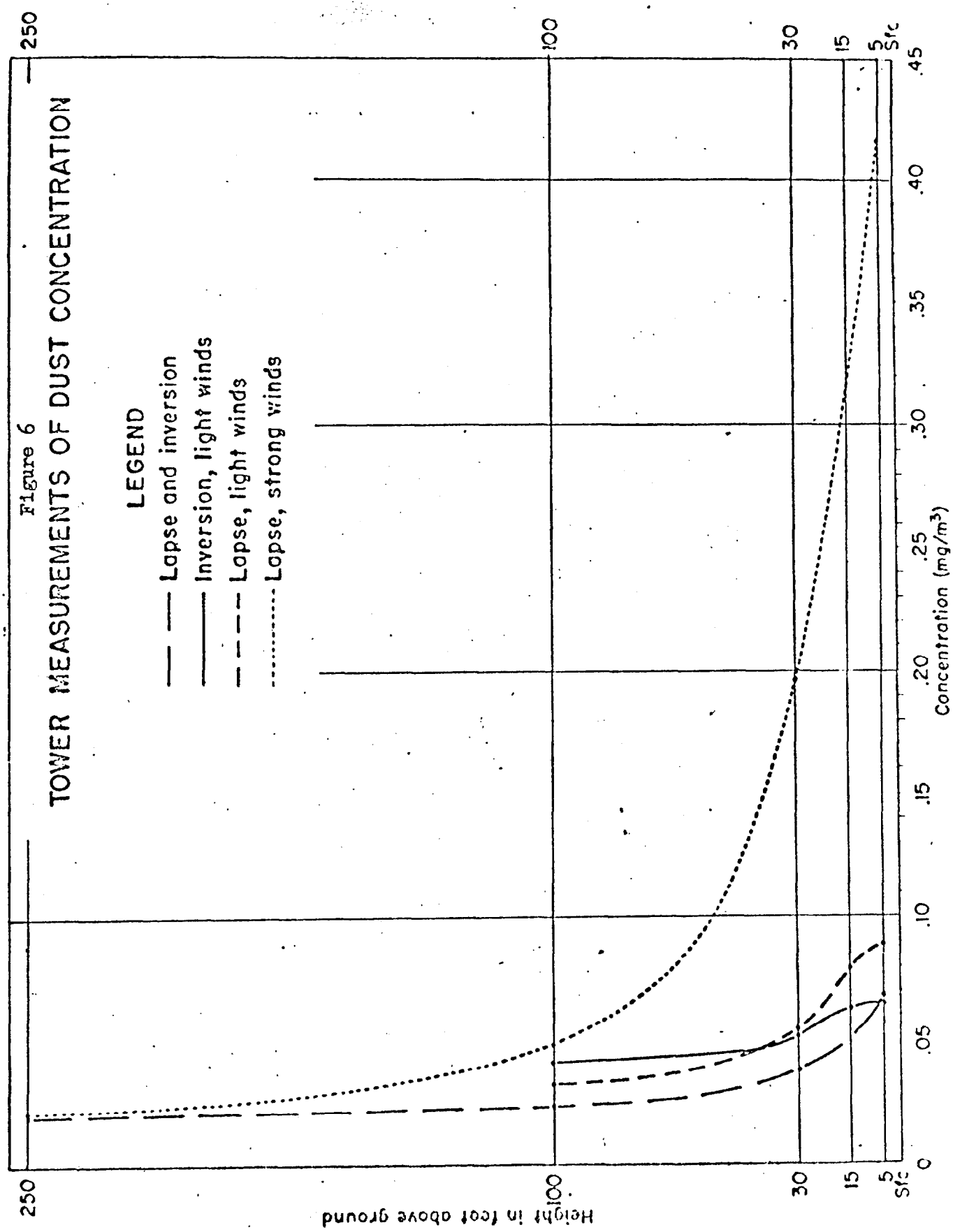
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.10
.15
.20
.25
.30
.35
.40
.45
Concentration (mg/m³)