

11.2.6 INDUSTRIAL PAVED ROADS

11.2.6.1 General

Various field studies have indicated that dust emissions from industrial paved roads are a major component of atmospheric particulate matter in the vicinity of industrial operations. Industrial traffic dust has been found to consist primarily of mineral matter, mostly tracked or deposited onto the roadway by vehicle traffic itself, when vehicles enter from an unpaved area or travel on the shoulder of the road, or when material is spilled onto the paved surface from open truck bodies.

11.2.6.2 Emissions And Correction Parameters¹⁻²

The quantity of dust emissions from a given segment of paved road varies linearly with the volume of traffic. In addition, field investigations have shown that emissions depend on correction parameters (road surface silt content, surface dust loading and average vehicle weight) of a particular road and associated vehicle traffic.

Dust emissions from industrial paved roads have been found to vary in direct proportion to the fraction of silt (particles equal to or less than 75 microns in diameter) in the road surface material. The silt fraction is determined by measuring the proportion of loose dry surface dust that passes a 200 mesh screen, using the ASTM-C-136 method. In addition, it has also been found that emissions vary in direct proportion to the surface dust loading. The road surface dust loading is that loose material which can be collected by broom sweeping and vacuuming of the traveled portion of the paved road. Table 11.2.6-1 summarizes measured silt and loading values for industrial paved roads.

11.2.6.3 Predictive Emission Factor Equations

The quantity of total suspended particulate emissions generated by vehicle traffic on dry industrial paved roads, per vehicle kilometer traveled (VKT) or vehicle mile traveled (VMT), may be estimated with a rating of B or D (see below), using the following empirical expression²:

$$E = 0.022 I \left(\frac{4}{n} \right) \left(\frac{s}{10} \right) \left(\frac{L}{280} \right) \left(\frac{W}{2.7} \right)^{0.7} \quad (\text{kg/VKT}) \quad (1)$$
$$E = 0.077 I \left(\frac{4}{n} \right) \left(\frac{s}{10} \right) \left(\frac{L}{1000} \right) \left(\frac{W}{3} \right)^{0.7} \quad (\text{lb/VMT})$$

where: E = emission factor
I = industrial augmentation factor (dimensionless) (see below)
n = number of traffic lanes
s = surface material silt content (%)
L = surface dust loading, kg/km (lb/mile) (see below)
W = average vehicle weight, Mg (ton)

TABLE 11.2.6-1. TYPICAL SILT CONTENT AND LOADING VALUES FOR
PAVED ROADS AT INDUSTRIAL FACILITIES^a

Industry	No. of sites	No. of samples	Silt (wgt. %)		No. of travel lanes	Total loading x 10 ⁻³			Silt loading (g/m ²)	
			Range	Mean		Range	Mean	Units ^b	Range	Mean
Copper smelting	1	3	15.4 - 21.7	19.0	2	12.9 - 19.5 45.8 - 69.2	15.9 55.4	kg/km lb/mi	188 - 400	292
Iron and steel production	6	20	1.1 - 35.7	12.5	2	0.006 - 4.77 0.020 - 16.9	0.495 1.75	kg/km lb/mi	0.09 - 79	12
Asphalt batching	1	3	2.6 - 4.6	3.3	1	12.1 - 18.0 43.0 - 64.0	14.9 52.8	kg/km lb/mi	76 - 193	120
Concrete batching	1	3	5.2 - 6.0	5.5	2	1.4 - 1.8 5.0 - 6.4	1.7 5.9	kg/km lb/mi	11 - 12	12
Sand and gravel processing	1	3	6.4 - 7.9	7.1	1	2.8 - 5.5 9.9 - 19.4	3.8 13.3	kg/km lb/mi	53 - 95	70

^a References 1-5.^b Multiply entries by 1,000 to obtain stated units.

11.2.7 INDUSTRIAL WIND EROSION

11.2.7.1 General¹⁻³

Dust emissions may be generated by wind erosion of open aggregate storage piles and exposed areas within an industrial facility. These sources typically are characterized by nonhomogeneous surfaces impregnated with nonerodible elements (particles larger than approximately 1 centimeter (cm) in diameter). Field testing of coal piles and other exposed materials using a portable wind tunnel has shown that (a) threshold wind speeds exceed 5 meters per second (11 miles per hour) at 15 centimeters above the surface or 10 meters per second (22 miles per hour) at 7 meters above the surface, and (b) particulate emission rates tend to decay rapidly (half life of a few minutes) during an erosion event. In other words, these aggregate material surfaces are characterized by finite availability of erodible material (mass/area) referred to as the erosion potential. Any natural crusting of the surface binds the erodible material, thereby reducing the erosion potential.

11.2.7.2 Emissions And Correction Parameters

If typical values for threshold wind speed at 15 centimeters are corrected to typical wind sensor height (7-10 meters), the resulting values exceed the upper extremes of hourly mean wind speeds observed in most areas of the country. In other words, mean atmospheric wind speeds are not sufficient to sustain wind erosion from flat surfaces of the type tested. However, wind gusts may quickly deplete a substantial portion of the erosion potential. Because erosion potential has been found to increase rapidly with increasing wind speed, estimated emissions should be related to the gusts of highest magnitude.

The routinely measured meteorological variable which best reflects the magnitude of wind gusts is the fastest mile. This quantity represents the wind speed corresponding to the whole mile of wind movement which has passed by the 1 mile contact anemometer in the least amount of time. Daily measurements of the fastest mile are presented in the monthly Local Climatological Data (LCD) summaries. The duration of the fastest mile, typically about 2 minutes (for a fastest mile of 30 miles per hour), matches well with the half life of the erosion process, which ranges between 1 and 4 minutes. It should be noted, however, that peak winds can significantly exceed the daily fastest mile.

The wind speed profile in the surface boundary layer is found to follow a logarithmic distribution:

$$u(z) = \frac{u^*}{0.4} \ln \frac{z}{z_0} \quad (z > z_0) \quad (1)$$

where u = wind speed, centimeters per second
 u^* = friction velocity, centimeters per second
 z = height above test surface, cm
 z_0 = roughness height, cm
0.4 = von Karman's constant, dimensionless

The friction velocity (u^*) is a measure of wind shear stress on the erodible surface, as determined from the slope of the logarithmic velocity profile. The roughness height (z_0) is a measure of the roughness of the exposed surface as determined from the y intercept of the velocity profile, i. e., the height at which the wind speed is zero. These parameters are illustrated in Figure 11.2.7-1 for a roughness height of 0.1 centimeters.

Emissions generated by wind erosion are also dependent on the frequency of disturbance of the erodible surface because each time that a surface is disturbed, its erosion potential is restored. A disturbance is defined as an action which results in the exposure of fresh surface material. On a storage pile, this would occur whenever aggregate material is either added to or removed from the old surface. A disturbance of an exposed area may also result from the turning of surface material to a depth exceeding the size of the largest pieces of material present.

11.2.7.3 Predictive Emission Factor Equation⁴

The emission factor for wind generated particulate emissions from mixtures of erodible and nonerodible surface material subject to disturbance may be expressed in units of grams per square meter per year as follows:

$$\text{Emission factor} = k \sum_{i=1}^N P_i \quad (2)$$

where k = particle size multiplier
 N = number of disturbances per year
 P_i = erosion potential corresponding to the observed (or probable) fastest mile of wind for the i th period between disturbances, g/m^2

The particle size multiplier (k) for Equation 2 varies with aerodynamic particle size, as follows:

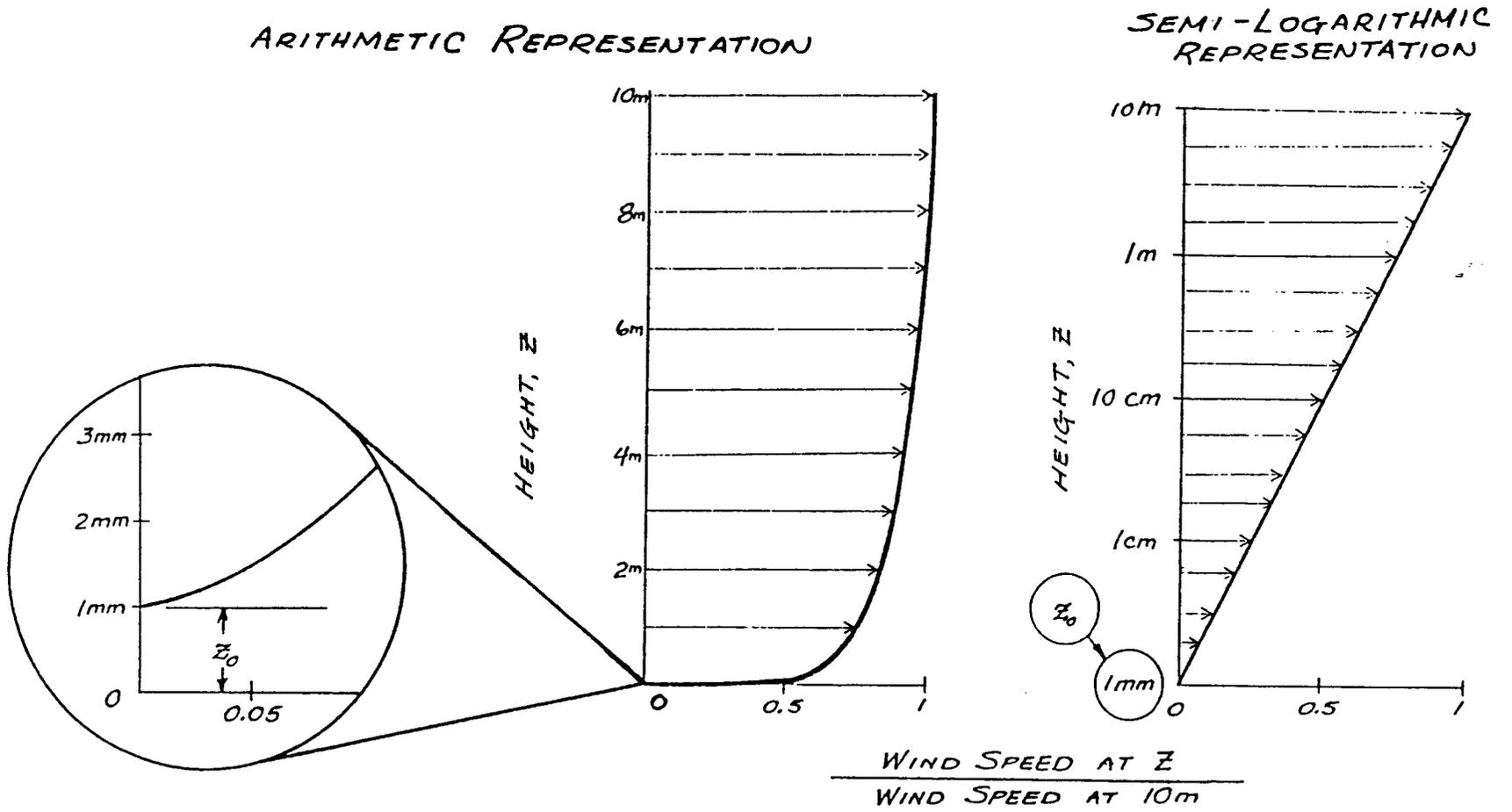
AERODYNAMIC PARTICLE SIZE MULTIPLIERS FOR EQUATION 2

$30 \mu m$	$<15 \mu m$	$<10 \mu m$	$<2.5 \mu m$
1.0	0.6	0.5	0.2

This distribution of particle size within the under 30 micron fraction is comparable to the distributions reported for other fugitive dust sources where wind speed is a factor. This is illustrated, for example, in the distributions for batch and continuous drop operations encompassing a number of test aggregate materials (see Section 11.2.3).

In calculating emission factors, each area of an erodible surface that is subject to a different frequency of disturbance should be treated separately. For a surface disturbed daily, $N = 365$ per year, and for a surface disturbance once every 6 months, $N = 2$ per year.

Figure 11.2.7-1. Illustration of logarithmic velocity profile.



The erosion potential function for a dry, exposed surface is:

$$P = 58 (u^* - u_t^*)^2 + 25 (u^* - u_t^*) \quad (3)$$

$$P = 0 \text{ for } u^* \leq u_t^*$$

where u^* = friction velocity (m/s)

u_t^* = threshold friction velocity (m/s)

Because of the nonlinear form of the erosion potential function, each erosion event must be treated separately.

Equations 2 and 3 apply only to dry, exposed materials with limited erosion potential. The resulting calculation is valid only for a time period as long or longer than the period between disturbances. Calculated emissions represent intermittent events and should not be input directly into dispersion models that assume steady state emission rates.

For uncrusted surfaces, the threshold friction velocity is best estimated from the dry aggregate structure of the soil. A simple hand sieving test of surface soil can be used to determine the mode of the surface aggregate size distribution by inspection of relative sieve catch amounts, following the procedure described below in Table 11.2.7.-1. Alternatively, the threshold friction velocity for erosion can be determined from the mode of the aggregate size distribution, as described by Gillette.⁵⁻⁶

Threshold friction velocities for several surface types have been determined by field measurements with a portable wind tunnel. These values are presented in Table 11.2.7-2.

TABLE 11.2.7-1. FIELD PROCEDURE FOR DETERMINATION OF THRESHOLD FRICTION VELOCITY

Tyler sieve no.	Opening (mm)	Midpoint (mm)	u_t^* (cm/sec)
5	4	3	100
9	2	1.5	72
16	1	0.75	58
32	0.5	0.375	43
60	0.25		

FIELD PROCEDURE FOR DETERMINATION OF THRESHOLD FRICTION VELOCITY
(from a 1952 laboratory procedure published by W. S. Chepil):

1. Prepare a nest of sieves with the following openings: 4 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm. Place a collector pan below the bottom (0.25 mm) sieve.
2. Collect a sample representing the surface layer of loose particles (approximately 1 cm in depth, for an encrusted surface), removing any rocks larger than about 1 cm in average physical diameter. The area to be sampled should be not less than 30 cm.
3. Pour the sample into the top sieve (4 mm opening), and place a lid on the top.
4. Move the covered sieve/pan unit by hand, using a broad circular arm motion in the horizontal plane. Complete 20 circular movements at a speed just necessary to achieve some relative horizontal motion between the sieve and the particles.
5. Inspect the relative quantities of catch within each sieve, and determine where the mode in the aggregate size distribution lies, i. e., between the opening size of the sieve with the largest catch and the opening size of the next largest sieve.
6. Determine the threshold friction velocity from Figure 1.

The fastest mile of wind for the periods between disturbances may be obtained from the monthly LCD summaries for the nearest reporting weather station that is representative of the site in question.⁷ These summaries report actual fastest mile values for each day of a given month. Because the erosion potential is a highly nonlinear function of the fastest mile, mean values of the fastest mile are inappropriate. The anemometer heights of reporting weather stations are found in Reference 8, and should be corrected to a 10 meter reference height using Equation 1.

To convert the fastest mile of wind (u_{10}^+) from a reference anemometer height of 10 meters to the equivalent friction velocity (u^*), the logarithmic wind speed profile may be used to yield the following equation:

$$u^* = 0.053 u_{10}^+ \quad (4)$$

where u^* = friction velocity (meters per second)

u_{10}^+ = fastest mile of reference anemometer for period
between disturbances (meters per second)

This assumes a typical roughness height of 0.5 cm for open terrain. Equation 4 is restricted to large relatively flat piles or exposed areas with little penetration into the surface wind layer.

TABLE 11.2.7-2. THRESHOLD FRICTION VELOCITIES

Material	Threshold friction velocity (m/s)	Roughness height (cm)	Threshold wind velocity at 10 m (m/s)	
			$z_o = \text{Act}$	$z_o = 0.5 \text{ cm}$
Overburden ^a	1.02	0.3	21	19
Scoria (roadbed material) ^a	1.33	0.3	27	25
Ground coal ^a (surrounding coal pile)	0.55	0.01	16	10
Uncrusted coal pile ^a	1.12	0.3	23	21
Scraper tracks on coal pile ^{a, b}	0.62	0.06	15	12
Fine coal dust on concrete pad ^c	0.54	0.2	11	10

^aWestern surface coal mine. Reference 2.

^bLightly crusted.

^cEastern power plant. Reference 3.

If the pile significantly penetrates the surface wind layer (i. e., with a height-to-base ratio exceeding 0.2), it is necessary to divide the pile area into subareas representing different degrees of exposure to wind. The results of physical modeling show that the frontal face of an elevated pile is exposed to wind speeds of the same order as the approach wind speed at the top of the pile.

For two representative pile shapes (conical and oval with flattop, 37 degree side slope), the ratios of surface wind speed (u_s) to approach wind speed (u_r) have been derived from wind tunnel studies.⁹ The results are shown in Figure 11.2.7-2 corresponding to an actual pile height of 11 meters, a reference (upwind) anemometer height of 10 meters, and a pile surface roughness height (z_o) of 0.5 centimeters. The measured surface winds correspond to a height of 25 centimeters above the surface. The area fraction within each contour pair is specified in Table 11.2.7-3.

The profiles of u_s/u_r in Figure 11.2.7-2 can be used to estimate the surface friction velocity distribution around similarly shaped piles, using the following procedure:

1. Correct the fastest mile value (u^+) for the period of interest from the anemometer height (z) to a reference height of 10 m (u_{10}^+) using a variation of Equation 1:

$$u_{10}^+ = u^+ \frac{\ln(10/0.005)}{\ln(z/0.005)} \quad (5)$$

where a typical roughness height of 0.5 cm (0.005 meters) has been assumed. If a site specific roughness height is available, it should be used.

2. Use the appropriate part of Figure 11.2.7-2 based on the pile shape and orientation to the fastest mile of wind, to obtain the corresponding surface wind speed distribution (u_s^+):

$$u_s^+ = \frac{(u_s)}{u_r} u_{10}^+ \quad (6)$$

3. For any subarea of the pile surface having a narrow range of surface wind speed, use a variation of Equation 1 to calculate the equivalent friction velocity (u^*):

$$u^* = \frac{0.4 u_s^+}{\frac{25}{\ln 0.5}} = 0.10 u_s^+$$

From this point on, the procedure is identical to that used for a flat pile, as described above.

Implementation of the above procedure is carried out in the following steps:

1. Determine threshold friction velocity for erodible material of interest (see Table 11.2.7-2 or determine from mode of aggregate size distribution).
2. Divide the exposed surface area into subareas of constant frequency of disturbance (N).
3. Tabulate fastest mile values (u^+) for each frequency of disturbance and correct them to 10 m (u_{10}^+) using Equation 5.
4. Convert fastest mile values (u_{10}) to equivalent friction velocities (u^*), taking into account (a) the uniform wind exposure of nonelevated surfaces, using Equation 4, or (b) the nonuniform wind exposure of elevated surfaces (piles), using Equations 6 and 7.
5. For elevated surfaces (piles), subdivide areas of constant N into subareas of constant u^* (i. e., within the isopleth values of u_s/u_r in Figure 11.2.7-2 and Table 11.2.7-3) and determine the size of each subarea.
6. Treating each subarea (of constant N and u^*) as a separate source, calculate the erosion potential (P_i) for each period between disturbances using Equation 3 and the emission factor using Equation 2.
7. Multiply the resulting emission factor for each subarea by the size of the subarea, and add the emission contributions of all subareas. Note that the highest 24-hr emissions would be expected to occur on the windiest day of the year. Maximum emissions are calculated assuming a single event with the highest fastest mile value for the annual period.

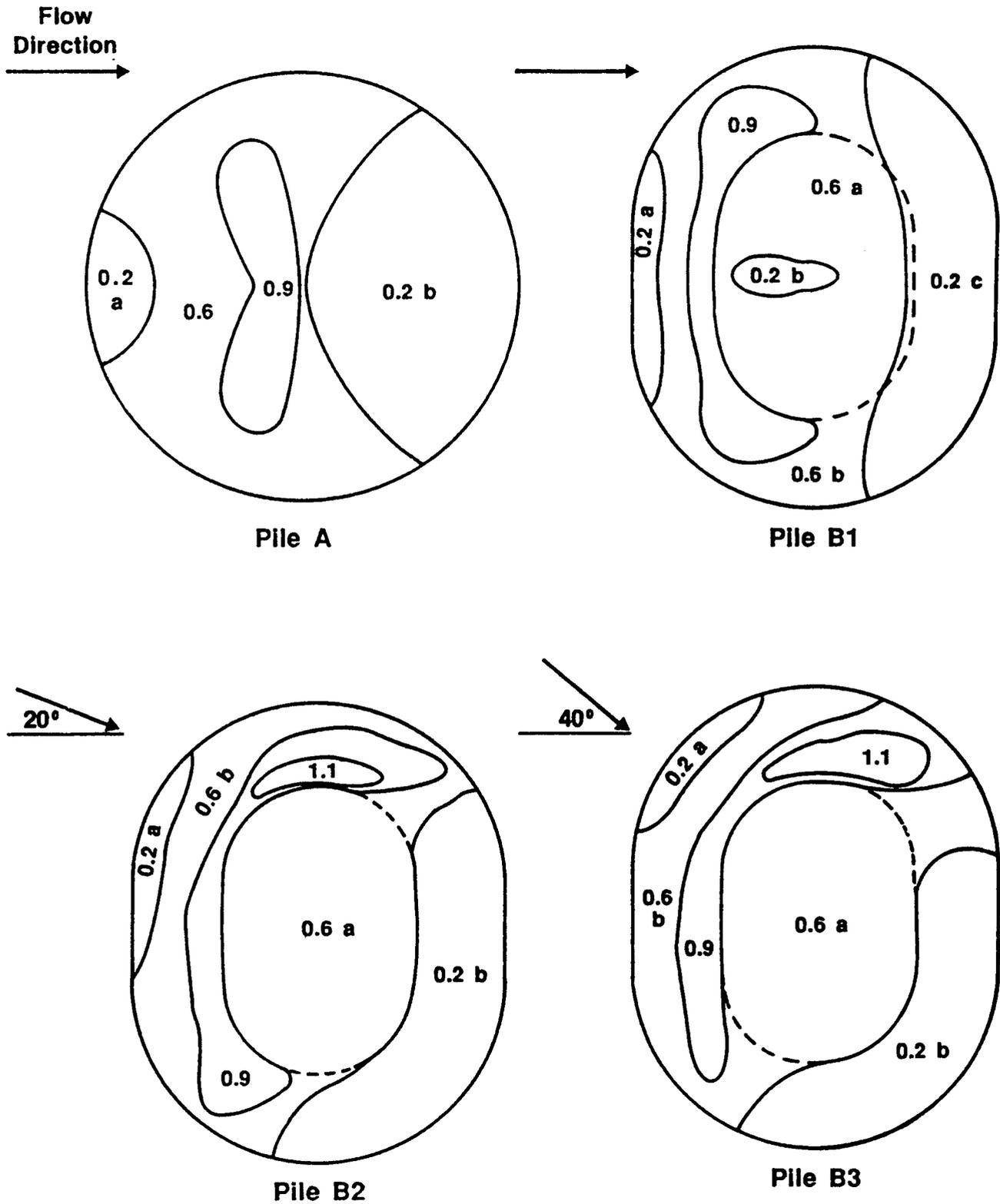


Figure 11.2.7-2. Contours of normalized surface wind speeds, u_s/u_r .

TABLE 11.2.7-3. SUBAREA DISTRIBUTION FOR REGIMES OF u_s/u_r

Pile Subarea	Percent of pile surface area			
	Pile A	Pile B1	Pile B2	Pile B3
0.2a	5	5	3	3
0.2b	35	2	28	25
0.2c	-	29	-	-
0.6a	48	26	29	28
0.6b	-	24	22	26
0.9	12	14	15	14
1.1	-	-	3	4

The recommended emission factor equation presented above assumes that all of the erosion potential corresponding to the fastest mile of wind is lost during the period between disturbances. Because the fastest mile event typically lasts only about 2 minutes, which corresponds roughly to the halflife for the decay of actual erosion potential, it could be argued that the emission factor overestimates particulate emissions. However, there are other aspects of the wind erosion process which offset this apparent conservatism:

1. The fastest mile event contains peak winds which substantially exceed the mean value for the event.
2. Whenever the fastest mile event occurs, there are usually a number of periods of slightly lower mean wind speed which contain peak gusts of the same order as the fastest mile wind speed.

Of greater concern is the likelihood of overprediction of wind erosion emissions in the case of surfaces disturbed infrequently in comparison to the rate of crust formation.

11.2.7.4 Example 1: Calculation for wind erosion emissions from conically shaped coal pile

A coal burning facility maintains a conically shaped surge pile 11 meters in height and 29.2 meters in base diameter, containing about 2000 megagrams of coal, with a bulk density of 800 kg/m^3 (50 lb/ft^3). The total exposed surface area of the pile is calculated as follows:

$$\begin{aligned}
 S &= \pi r (r^2 + h^2) \\
 &= 3.14(14.6) (14.6)^2 + (11.0)^2 \\
 &= 838 \text{ m}^2
 \end{aligned}$$

Coal is added to the pile by means of a fixed stacker and reclaimed by front-end loaders operating at the base of the pile on the downwind side. In addition, every 3 days 250 megagrams (12.5 percent of the stored capacity of coal) is added back to the pile by a topping off operation, thereby restoring

the full capacity of the pile. It is assumed that (a) the reclaiming operation disturbs only a limited portion of the surface area where the daily activity is occurring, such that the remainder of the pile surface remains intact, and (b) the topping off operation creates a fresh surface on the entire pile while restoring its original shape in the area depleted by daily reclaiming activity.

Because of the high frequency of disturbance of the pile, a large number of calculations must be made to determine each contribution to the total annual wind erosion emissions. This illustration will use a single month as an example.

Step 1: In the absence of field data for estimating the threshold friction velocity, a value of 1.12 meters per second is obtained from Table 11.2.7-2.

Step 2: Except for a small area near the base of the pile (see Figure 11.2.7-3), the entire pile surface is disturbed every 3 days, corresponding to a value of $N = 120$ per year. It will be shown that the contribution of the area where daily activity occurs is negligible so that it does not need to be treated separately in the calculations.

Step 3: The calculation procedure involves determination of the fastest mile for each period of disturbance. Figure 11.2.7-4 shows a representative set of values (for a 1-month period) that are assumed to be applicable to the geographic area of the pile location. The values have been separated into 3-day periods, and the highest value in each period is indicated. In this example, the anemometer height is 7 meters, so that a height correction to 10 meters is needed for the fastest mile values. From Equation 5,

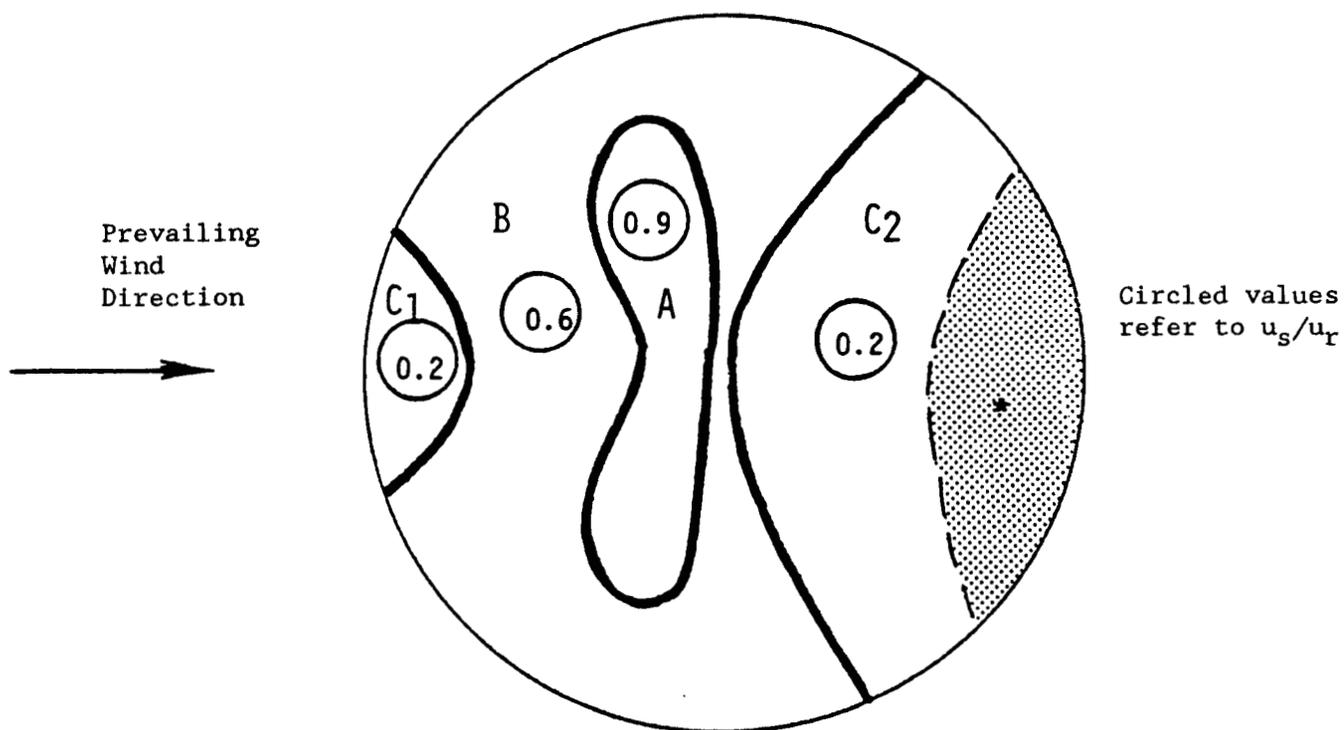
$$u_{10}^+ = u_7^+ \left(\frac{\ln(10/0.005)}{\ln(7/0.005)} \right)$$

$$u_{10}^+ = 1.05 u_7^+$$

Step 4: The next step is to convert the fastest mile value for each 3 day period into the equivalent friction velocities for each surface wind regime (i. e., u_s/u_r ratio) of the pile, using Equations 6 and 7. Figure 11.2.7-3 shows the surface wind speed pattern (expressed as a fraction of the approach wind speed at a height of 10 meters). The surface areas lying within each wind speed regime are tabulated below the figure.

The calculated friction velocities are presented in Table 11.2.7-4. As indicated, only three of the periods contain a friction velocity which exceeds the threshold value of 1.12 meters per second for an uncrusted coal pile. These three values all occur within the $u_s/u_r = 0.9$ regime of the pile surface.

Step 5: This step is not necessary because there is only one frequency of disturbance used in the calculations. It is clear that the small area of daily disturbance (which lies entirely within the $u_s/u_r = 0.2$ regime) is never subject to wind speeds exceeding the threshold value.



* A portion of C₂ is disturbed daily by reclaiming activities.

Area ID	$\frac{u_s}{u_r}$	Pile Surface	
		%	Area (m ²)
A	0.9	12	101
B	0.6	48	402
C ₁ + C ₂	0.2	40	<u>335</u>
		Total	838

Figure 11.2.7-3. Example 1: Pile surface areas within each wind speed regime.

TABLE 11.2.7-4. EXAMPLE 1: CALCULATION OF FRICTION VELOCITIES

3-day period	u_7^+		u_{10}^+		$u^* = 0.1 u_s^+$ (m/s)		
	(mph)	(m/s)	(mph)	(m/s)	$u_s/u_T: 0.2$	0.6	0.9
1	14	6.3	15	6.6	0.13	0.40	0.59
2	29	13.0	31	13.7	0.27	0.82	1.23
3	30	13.4	32	14.1	0.28	0.84	1.27
4	31	13.9	33	14.6	0.29	0.88	1.31
5	22	9.8	23	10.3	0.21	0.62	0.93
6	21	9.4	22	9.9	0.20	0.59	0.89
7	16	7.2	17	7.6	0.15	0.46	0.68
8	25	11.2	26	11.8	0.24	0.71	1.06
9	17	7.6	18	8.0	0.16	0.48	0.72
10	13	5.8	14	6.1	0.12	0.37	0.55

Steps 6 and 7: The final set of calculations (shown in Table 11.2.7-5) involves the tabulation and summation of emissions for each disturbance period and for the affected subarea. The erosion potential (P) is calculated from Equation 3.

TABLE 11.2.7-5. EXAMPLE 1: CALCULATION OF PM₁₀ EMISSIONS^a

3-day period	u^* (m/s)	$u^* - u_t^*$ (m/s)	P (g/m ²)	ID	Pile	
					Surface Area (m ²)	kPA (g)
2	1.23	0.11	3.45	A	101	170
3	1.27	0.15	5.06	A	101	260
4	1.31	0.19	6.84	A	101	350
Total:						780

^awhere $u_t^* = 1.12$ meters per second for uncrusted coal and $k = 0.5$ for PM₁₀.

For example, the calculation for the second 3 day period is:

$$\begin{aligned}
 P &= 58(u^* - u_t^*)^2 + 25(u^* - u_t^*) \\
 P_2 &= 58(1.23 - 1.12)^2 + 25(1.23 - 1.12) \\
 &= 0.70 + 2.75 = 3.45 \text{ g/m}^2
 \end{aligned}$$

The PM₁₀ emissions generated by each event are found as the product of the PM₁₀ multiplier ($k = 0.5$), the erosion potential (P), and the affected area of the pile (A).

Local Climatological Data

MONTHLY SUMMARY



WIND					DATE
RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE		
			SPEED M.P.H.	DIRECTION	
13	14	15	16	17	22
30	5.3	6.9	9	36	1
01	10.5	10.6	14	01	2
10	2.4	6.0	10	02	3
13	11.0	11.4	16	13	4
12	11.3	11.9	15	11	5
20	11.1	19.0	23	30	6
29	19.6	19.8	30	30	7
29	10.9	11.2	17	30	8
22	3.0	8.1	15	13	9
14	14.6	15.1	23	12	10
29	22.3	23.3	31	29	11
17	7.9	13.5	23	17	12
21	7.7	15.5	18	18	13
10	4.5	9.6	22	13	14
10	6.7	8.8	13	11	15
01	13.7	13.8	22	36	16
33	11.2	11.5	15	34	17
27	4.3	5.8	12	31	18
32	9.3	10.2	14	35	19
24	7.5	7.8	16	24	20
22	10.3	10.6	16	20	21
32	17.1	17.3	25	32	22
29	2.4	8.5	14	13	23
07	5.9	8.8	15	02	24
34	11.3	11.7	17	32	25
31	12.1	12.2	16	32	26
30	8.3	8.5	16	26	27
30	8.2	8.3	13	32	28
33	5.0	6.6	10	32	29
34	3.1	5.2	9	31	30
29	4.9	5.5	8	25	31
FOR THE MONTH:					
30	3.3	11.1	31	29	
					DATE: 11

Figure 11.2.7-4. Example daily fastest miles of wind for periods of interest.

As shown in Table 11.2.7-5, the results of these calculations indicate a monthly PM₁₀ emission total of 780 grams.

11.2.7.5 Example 2: Calculation for wind erosion from flat area covered with coal dust

A flat circular area of 29.2 meters in diameter is covered with coal dust left over from the total reclaiming of a conical coal pile described in the example above. The total exposed surface area is calculated as follows:

$$S = \frac{\pi}{4} d^2 = 0.785 (29.2)^2 = 670 \text{ m}^2$$

This area will remain exposed for a period of 1 month when a new pile will be formed.

Step 1: In the absence of field data for estimating the threshold friction velocity, a value of 0.54 m/s is obtained from Table 11.2.7-2.

Step 2: The entire surface area is exposed for a period of 1 month after removal of a pile and $N = 1/\text{yr}$.

Step 3: From Figure 11.2.7-4, the highest value of fastest mile for the 30-day period (31 mph) occurs on the 11th day of the period. In this example, the reference anemometer height is 7 m, so that a height correction is needed for the fastest mile value. From Step 3 of the previous example, $u_{10}^+ = 1.05 u_7^+$, so that $u_{10}^+ = 33 \text{ mph}$.

Step 4: Equation 4 is used to convert the fastest mile value of 33 mph (14.6 mps) to an equivalent friction velocity of 0.77 mps. This value exceeds the threshold friction velocity from Step 1 so that erosion does occur.

Step 5: This step is not necessary, because there is only one frequency of disturbance for the entire source area.

Steps 6 and 7: The PM₁₀ emissions generated by the erosion event are calculated as the product of the PM₁₀ multiplier ($k = 0.5$), the erosion potential (P) and the source area (A). The erosion potential is calculated from Equation 3 as follows:

$$\begin{aligned} P &= 58(u^* - u_t^*)^2 + 25(u^* - u_t^*) \\ P &= 58(0.77 - 0.54)^2 + 25(0.77 - 0.54) \\ &= 3.07 + 5.75 \\ &= 8.82 \text{ g/m}^2 \end{aligned}$$

Thus the PM₁₀ emissions for the 1 month period are found to be:

$$\begin{aligned} E &= (0.5)(8.82 \text{ g/m}^2)(670 \text{ m}^2) \\ &= 3.0 \text{ kg} \end{aligned}$$

References for Section 11.2.7

1. C. Cowherd Jr., "A New Approach To Estimating Wind Generated Emissions From Coal Storage Piles", Presented at the APCA Specialty Conference on Fugitive Dust Issues in the Coal Use Cycle, Pittsburgh, PA, April 1983.
2. K. Axtell and C. Cowherd, Jr., Improved Emission Factors For Fugitive Dust From Surface Coal Mining Sources, EPA-600/7-84-048, U. S. Environmental Protection Agency, Cincinnati, OH, March 1984.
3. G. E. Muleski, "Coal Yard Wind Erosion Measurement", Midwest Research Institute, Kansas City, MO, March 1985.
4. Update Of Fugitive Dust Emissions Factors In AP-42 Section 11.2 - Wind Erosion, MRI No. 8985-K, Midwest Research Institute, Kansas City, MO, 1988.
5. W. S. Chepil, "Improved Rotary Sieve For Measuring State And Stability Of Dry Soil Structure", Soil Science Society Of America Proceedings, 16:113-117, 1952.
6. D. A. Gillette, et al., "Threshold Velocities For Input Of Soil Particles Into The Air By Desert Soils", Journal Of Geophysical Research, 85(C10):5621-5630.
7. Local Climatological Data, National Climatic Center, Asheville, NC.
8. M. J. Changery, National Wind Data Index Final Report, HCO/T1041-01 UC-60, National Climatic Center, Asheville, NC, December 1978.
9. B. J. B. Stunder and S. P. S. Arya, "Windbreak Effectiveness For Storage Pile Fugitive Dust Control: A Wind Tunnel Study", Journal Of The Air Pollution Control Association, 38:135-143, 1988.