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Phillips 66 Company

BEFORE THE HEARING BOARD OF THE

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

In the Matter of PHILLIPS 66 COMPANY, [Facility I.D. No. 171109] Petitioner, vs. SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT, Respondent.	**Case No. 4900-115** DECLARATION OF LISA FAICHNEY FOR PHILLIPS 66 COMPANY TO THE HEARING BOARD Date: December 6, 2022 Time: Consent Calendar

US-DOCS\135515878.11

Petitioner Phillips 66 Company ("Petitioner" or "Phillips 66") hereby submits this Declaration of Lisa Faichney, Environmental Specialist for Phillips 66, to the Hearing Board:

1. My name is Lisa Faichney. I am an Environmental Specialist at Phillips 66 and assist with environmental services and permitting issues. I am familiar with the Petition for a short variance that was filed in this matter. I am also familiar with the equipment that is the subject of this variance request.

2. Petitioner owns and operates a refinery located at 1520 East Sepulveda, Carson, California 90745 ("Facility" or "Carson Plant"). The Facility is a major refiner of crude oil for gasoline, diesel fuel, jet fuel, and other petroleum-derived products. The Facility is permitted under Title V and RECLAIM Permit No. 171109 as a SOx and NOx RECLAIM facility

3. The subject equipment consists of the Coke Barn at the Carson Plant. Petroleum Coke ("Coke") is a necessary and useful byproduct of the oil refining process. The Coke is continuously produced by the Coker Unit throughout the refining process. The Coke needs to be stored on site in an enclosed structure, such as the Coke Barn, before being transported offsite for shipment. Without the ability to store Coke, Facility operations would be significantly impacted.

4. Copies of the relevant sections of the Facility Permit, issued on February 24, 2022, are attached to the Petition for Short Variance ("Petition") as Exhibit 1.

5. District Rule 1158(d)(2) requires the Petitioner to maintain all Coke piles in enclosed storage. At the Carson Plant, the Coke Barn is used to store the Coke produced by the Coker Unit. The Coke Barn is also the center for the trucking of Coke from the Carson Plant. As such, the Coke Barn is both critical and essential to Facility operations.

6. On February 2, 2022, Petitioner discovered that Beam #9 in the Coke Barn needs to be replaced. On July 1, 2022, Beam #14 was found to be sheared. The Coke Barn's A-frame was not fully stabilized and beams were recommended for replacement. Upon review and consultation, Petitioner determined that two (2) reinforcement beams need to be installed. Furthermore, a portion of siding from all four (4) sections need to be removed to allow the Coke Barn to settle into position and shift the load onto the new reinforcement beams. During the replacement of the beams, the conveyer tube saddle support will also be replaced.

7. True and correct copies of photographs of the Coke Barn that illustrate the repairs are attached to the Petition as Exhibit 2.

8. Petitioner is currently in compliance with applicable District rules and regulations for storage of Coke at the Carson Plant. However, a variance is needed to open panels on the Coke Barn to replace the two beams and the conveyer tube saddle support. The work will help to preserve the life of the Coke Barn and prevent a potential structural collapse.

9. Petitioner has acted prudently and reasonably in this matter. The Coke Barn repair work was identified in advance with a detailed analysis, including use of a drone to generate video footage of inaccessible areas. Petitioner hired an expert consultant to assist with the planning and execution of the work. Petitioner has properly evaluated the need for repairs to the Coke Barn. Because a small portion of the Coke Barn will be open, a short variance is needed for the work.

10. Petitioner requires relief from District Rules 203(b), 2004(f)(1) and 3002(c)(1) [for Section D, Permit Condition Nos. S13.1 and E136.1 and for Section E, Administrative Condition No. 2] in this matter. Condition S13.1 requires that the Facility comply with Rule 1158. Condition E136.1 requires that Coke be stored in an enclosure. Administrative Condition No. 2 requires the operator to maintain all equipment in such a manner that ensures proper operation of the equipment. In addition, Petitioner requires relief from District Rule 1158(d)(2). This rule requires the operator to "maintain all piles in enclosed storage." The repair work will require the removal of numerous roof panels on the Coke Barn. Petitioner cannot maintain compliance with all District rules and permit conditions until the repairs are finished.

11. It is beyond Petitioner's reasonable control to comply with the District Rules and permit conditions during the repairs. The initial inspection of the 140' barn roof was conducted with drones and exposed two (2) horizontal beams that require replacement. In addition, the conveyer tube saddle support will need to be replaced as a part of preventative maintenance. The work cannot be performed within the 14 days allowed under the Rule 1158(k)(10).

12. The project requires twenty-four (24) 3' x 20' panel cut-outs to safely install two (2) reinforcement beams. In addition, there will be ten (10) 3' x 20' panels cut out to perform

preventative maintenance on the conveyor tube saddle support. The majority of the work will be overhead, which requires cranes and workers in man baskets to perform repairs. This phase of the project will be completed one section of the Coke Barn or bay at a time.

13. A copy of the Procedure and Record for Repairs or Alterations to Refinery Equipment for the Coke Barn, issued 9/2/2022, is attached to the Petition as Exhibit 3.

14. To safely execute the work and minimize the amount of time the Coke Barn is open to atmosphere, Phillips 66 requests a 28-day short variance. The short variance will allow for the safe completion of demolition activities, the installation of two (2) new beams, and conveyer tube saddle support replacement. The I-beam #14 will be replaced first; then upon completion of Beam #14, Petitioner will begin work on Beam #9. For the saddle replacement, a section of the conveyer tube saddle support will be replaced and that requires the siding of the Coke Barn to be removed. This work will be completed in parallel with the beam work.

15. Petitioner considered performing the repair work under District Rule 1158(k)(10). This "safe harbor" exemption allows for storage of Coke without a complete enclosure for "facilities performing routine maintenance/repair of replacing component parts on/in enclosed storage structures, such as roofing and siding material." Under Rule 1158(k)(10)(C), the safe harbor exemption requires that the period for repair work be completed in 14 days. However, Petitioner estimates that the repair work will take about 28 days to complete. As such, the Facility does not qualify for the safe harbor exemption.

16. Petitioner considered removing all the Coke from the Coke Barn as an alternative to obtaining a variance. It would be nearly impossible to remove all the Coke without creating significant particulate emissions from Coke movement and cleanup. Petitioner has concluded that removal of the Coke in lieu of obtaining a variance was not practicable. Moreover, failure to grant a variance could result in the Coker having to be shut down if the Coke Barn became structurally unfit or collapsed because it could not be repaired. Without the ability to store Coke in the Coke Barn, the Coker would be required to shut down to cease the generation of Coke at the Carson Plant. This would result in the shutdown and restart of other refinery units at the

Carson and Wilmington Plants. A restart of these refinery units would result in greater emissions.

17. Petitioner has maintained the subject equipment in good operating condition. The Coke Barn has been subject to routine inspection, maintenance and repairs. In 2001, structural maintenance on the main steel framing was performed on the Coke Barn. In 2003, the roof was opened and the internal structural members for the shuttle conveyor were repaired under a short variance (Case No. 4900-58). In 2017, a piping and vessel inspection was performed. Petitioner determined that a replacement of several internal structural steel supports was needed. In 2019, the roof was opened and I-beams were replaced during the 14-day window allowed under District Rule 1158(k)(10)(C). An additional I-beam was removed and replaced under a short variance (4900-105) in 2019. Operators perform daily rounds, check the coke storage equipment and perform preventative maintenance, and check for compliance with Rule 1158.

18. Petitioner estimates excess emissions of 0.39 pounds per day of particulate matter (PM) during the variance period. *See* Revised Emissions Calculations for Coke Barn Operations, prepared by EA Inc. and dated May 15, 2019 ("Report"). Using U.S. EPA AP-42 emissions factors for wind erosion of pile surfaces and ground areas around piles, PM was estimated at 0.39 pounds per day for partially controlled coke piles. *See* calculation for wind erosion at page 9-11.

19. A copy of Petitioner's Report with the calculation of estimated excess emissions is attached to the Declaration as <u>Attachment 1</u>.

20. Petitioner will reduce or mitigate any excess emissions during the variance period to the maximum extent feasible. Petitioner will have water available to control any accidental fugitive dust emissions from the Coke Barn side and roof openings. Petitioner will also ensure no materials be actively moved or disturbed in the structure during the variance period. Petitioner will maintain the surface area of components being replaced to not exceed 2% of the total structure surface area. Further, Petitioner will ensure that no visible emissions occur during the repair period. Petitioner will also ensure that any water spray system or air pollution control equipment associated be used to prevent visible emissions during the repair period.

21. Petitioner will monitor for emissions during the variance period at the Carson Plant. The data will be made available to the District upon request.

22. Petitioner has considered curtailment of operations in lieu of a variance in this matter. However, there is no option that would avoid the need for a variance. Petitioner has identified structural issues. If the variance were denied, the Coke Barn may experience a sudden failure. If this should occur, then there would be no place for the Coke generated by the Carson Plant to be stored and shipped in compliance with District rules. There is no reasonable alternative that would avoid the need for a variance in this matter. Repairs are needed.

23. If the variance were denied and the Coke Barn could not be repaired, Petitioner would not be able to produce and store petroleum coke in compliance with applicable District rules and regulations. The Coker is a critical operating unit for the Carson Plant. When it operates, the Coker produces petroleum coke that must be stored in the Coke Barn prior to shipment and sales. If the Coke Barn is down or unavailable, then the Coker cannot operate because there would be no place to store and ship the coke in compliance with District rules.

24. If the Coke Barn suddenly collapsed, Petitioner would immediately be out of compliance with Rule 1158. The Coker would need to be immediately shut down to stop the movement of coke and the time of the outage would be indefinite. A denial of the request for variance could result in economic losses in excess of $500,000 per day in lost production. These losses would result in the practical closing of a lawful business without a corresponding benefit in reducing air contaminants.

25. If the variance is denied, Petitioner may be forced to shut down and restart Refinery units. Emissions would result from the shutdown and restart of Refinery units that could be avoided with the variance. In comparison, Petitioner estimates excess emissions of 0.39 pounds per day of PM from the Coke Barn while repairs are performed pursuant to the path forward requested in this variance petition. As such, the granting of the short variance allowing for the repairs to the Coke Barn with the Carson Plant in service would benefit the environment.

26. To achieve final compliance, Petitioner requests a 28-day short variance to safely execute the work and minimize any impacts. Petitioner requests a short variance from District

Rules 203(b), 2004(f)(1), and 3002(c)(1) [for Section D, Permit Condition Nos. S13.1 and E136.1 and for Section E, Administrative Condition No. 2] and 1158(d)(2) to repair the Coke Barn. Petitioner requests that the short variance start on January 12, 2023 and end on February 9, 2023, to complete the repairs and achieve final compliance.

27. Operation under the order is not expected to result in a violation of Health and Safety Code Section 41700.

FOR PHILLIPS 66 COMPANY:

Dated: November 28, 2022

By: ______________________________
Lisa Faichney
Environmental Specialist Phillips 66 Company

ATTACHMENT 1

ENVIRONMENTAL AUDIT, INC.®
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714/632-8521 FAX: 714/632-6754
www.EnvAudit.com

40th ANNIVERSARY
mbaverman@envaudit.com
mchoi@envaudit.com

sent via email

MEMORANDUM

Project No. 3137

DATE: May 15, 2019

TO: Shelly Micucci
Phillips 66

FROM: Marcia Baverman

RE: Revised Emissions Calculations for Coke Barn Operations

Environmental Audit, Inc. (EAI) was requested to calculate emissions from coke barn operations at the Phillips 66 Carson Refinery in preparation for maintenance activities of the barn. This memo presents the results of the calculations and subsequent review by Phillips 66.

EAI reviewed data presented in the South Coast Air Quality Management District (SCAQMD) staff report prepared for the Proposed Amended Rule 1158 (PAR 1158) that was adopted June 11, 1999 and amended in July 11, 2008. Emission calculations presented in PAR 1158 were based on sections of the U.S. Environmental Protection Agency (U.S. EPA) AP-42 emission factors. EAI reviewed U.S. EPA AP-42 for updates to the emission factors used in PAR 1158. The pile wind erosion factor used in PAR 1158 was based on Section 11.2.3-3, equation 3, May 1983. This has been updated and is now presented in Section 13.2.5. Attachment A shows the components of coke handling emission estimate calculations and the respective emissions associated with each activity. The pertinent sections of PAR 1158 and U.S. EPA AP-42 are presented in Appendix B for reference.

There are four components to coke handling activities: 1) loading of aggregate onto storage piles including conveyor transfer points, 2) equipment traffic in storage area, 3) wind erosion of pile surfaces and ground areas around piles, and 4) loadout of aggregate for shipment. Item 4 relates to truck loading activities, which are not pertinent to coke barn maintenance activities. Emissions from truck loading would not be affected and remain unchanged and, therefore, were not calculated.

PETITIONER: CASE NO. 4900-106
Exhibit No. 1 Consisting of 79 pages
Identification 5/21/19 Evidence ______

The assumptions used for the calculations are consistent with those used in PAR 1158 with the exception of the maximum wind speed for pile erosion calculations. The maximum wind speed used in PAR 1158 was 12 miles per hour. EAI used the 99th percentile maximum wind speed from the SCAQMD meteorology data from the Long Beach monitoring station for modeling purposes, which approximately 17 miles per hour. This change was made to calculate a more conservative emission estimate of uncontrolled emissions, should maintenance activities warrant calculation of emissions with less control. The emissions were calculated using three scenarios and presented in Attachment A. The scenarios are as listed below:

1. Uncontrolled – No control measures used.

   The uncontrolled coke PM10 emissions from loading of storage piles are estimated to be 0.64 pounds per day, which includes two transfer points. One transfer point is from conveyor to conveyor and one transfer point from conveyor to storage pile. It is expected that only one conveyor set (15 and 16 or 17 and 18) operate at a time. The uncontrolled coke PM10 emissions from equipment in the storage area are estimated to be 0.06 pounds per day. The uncontrolled coke PM10 emissions from wind erosion are estimated to be 5.62 pounds per day. The total daily PM10 emissions are estimated to be 6.32 pounds per day.

   The uncontrolled coke PM2.5 emissions from loading of storage piles are estimated to be 0.10 pounds per day, which includes two transfer points. One transfer point is from conveyor to conveyor and one transfer point from conveyor to storage pile. It is expected that only one conveyor set (15 and 16 or 17 and 18) operate at a time. The uncontrolled coke PM2.5 emissions from equipment in the storage area are estimated to be less than 0.01 pounds per day. The uncontrolled coke PM2.5 emissions from wind erosion are estimated to be 0.04 pounds per day. The total daily PM2.5 emissions are estimated to be 0.95 pounds per day.

2. Controlled – Control measures consistent with Rule 1158.

   The controlled coke PM10 emissions from loading of storage piles are estimated to be 0.03 pounds per day, which includes two transfer points. One transfer point is from conveyor to conveyor and one transfer point from conveyor to storage pile. It is expected that only one conveyor set (15 and 16 or 17 and 18) operate at a time. The controlled coke PM10 emissions from equipment in the storage area are estimated to be less than 0.01 pounds per day. The controlled coke PM10 emissions from wind erosion are estimated to be 0.28 pounds per day. The total daily PM10 emissions are estimated to be 0.32 pounds per day.

   The controlled coke PM2.5 emissions from loading of storage piles are estimated to be less than 0.01 pounds per day, which includes two transfer points. One transfer point is from conveyor to conveyor and one transfer point from conveyor to storage pile. It is expected that only one conveyor set (15 and 16 or 17 and 18) operate at a time. The controlled coke PM2.5 emissions from equipment in the storage area are estimated to be less than 0.01 pounds per day. The controlled coke PM2.5 emissions from wind erosion are estimated to be 0.04 pounds per day. The total daily PM2.5 emissions are estimated to be 0.05 pounds per day.

3. Partially Controlled – Control measures consistent with Rule 1158, with 98 percent capture efficiency due to 2 percent exposure during maintenance.

   The partially controlled coke PM10 emissions from loading of storage piles are estimated to be 0.04 pounds per day, which includes two transfer points. One transfer point is from conveyor to conveyor and one transfer point from conveyor to storage pile. It is expected that only one conveyor set (15 and 16 or 17 and 18) operate at a time. The partially controlled coke PM10 emissions from equipment in the storage area are estimated to be less than 0.01 pounds per day. The partially controlled coke PM10 emissions from wind erosion are estimated to be 0.39 pounds per day. The total daily PM10 emissions are estimated to be 0.44 pounds per day.

   The partially controlled coke PM2.5 emissions from loading of storage piles are estimated to be 0.01 pounds per day, which includes two transfer points. One transfer point is from conveyor to conveyor and one transfer point from conveyor to storage pile. It is expected that only one conveyor set (15 and 16 or 17 and 18) operate at a time. The partially controlled coke PM2.5 emissions from equipment in the storage area are estimated to be less than 0.01 pounds per day. The partially controlled coke PM2.5 emissions from wind erosion are estimated to be 0.06 pounds per day. The total daily PM2.5 emissions are estimated to be 0.07 pounds per day.

Approximately 90 percent of the estimated emissions are from wind erosion of storage piles. Therefore, loss of enclosure would be most influenced by wind erosion of storage piles. Emissions from wind erosion of storage piles are dependent on wind speed, and particle size. Therefore, if control efficiency decreases, wind speed could be monitored and installation of a temporary enclosure could be employed to compensate for high wind speed.

If you have questions or comments, please contact me at (714) 632-8521 ext. 237.

MRB:mc

Attachments

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ATTACHMENT A

EMISSION ESTIMATES

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Phillips 66 Coke Barn
PM10 Emission Estimate Calculations

1. Loading of Aggregate onto Storage Piles

$EF_1(lb/ton) = k_1*(0.0032)*(U/5)^{1.3}/(M/2)^{1.4}$

where, EF_1 = Emission Factor, Storage Piles
k_1 = Particle Size Multiplier (dimensionless)
U = Mean Wind Speed, (miles/hr)
M = Material Moisture Content (%)

Source: U.S. EPA AP-42, 13.2.4 Eq. (1)

Variables:

k_1 = 0.35 Aerodynamic Particle Size Multiplier for PM10, Source: AP-42, k factor table, page 13.2.4-4.
U = 5.77 mph, Source: SCAQMD Long Beach Met Data 2012-2016.
M = 12 %, Source: SCAQMD PAR 1158, Appendix E, page E-7.

Operating Data: 2903 maximum tons/day
2650 average tons/day

Number of Transfer Points = 2 Normal activities would load lump or fines, not both simultaneously, and involve conveyor 17 to conveyor 18 to pile, or conveyor 15 to conveyor 16 to pile.

$$EF_1 = 0.35 * 0.0032 * \left(\frac{5.8}{5}\right)^{1.3} / \left(\frac{12}{2}\right)^{1.4}$$

EF_1 = 1.10E-04 lbs/ton

Unontrolled Emissions

E_1 = 6.38E-01 lbs/day, maximum
E_1 = 5.82E-01 lbs/day, average

Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.

$E_{1c} = EF_1*(1\text{-Control Efficiency})*\text{Activity}$
E_{1c} = 1.10E-04 * 0.05 * Activity
E_{1c} = 5.49E-06 lb/ton
E_{1c} = 0.03 lbs/day, maximum
E_{1c} = 0.03 lbs/day, average

Partially Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.
Enclosure Capture Efficiency = 98 %, Assumes 2% opening during maintenance.

$E_{1P} = EF_1*(1\text{-Capture Efficiency}*\text{Control Efficiency})$
E_{1P} = 1.10E-04 * 0.069
E_{1P} = 7.58E-06 lb/ton
E_{1P} = 0.04 lbs/day, maximum
E_{1P} = 0.04 lbs/day, average

2. Equipment Traffic in Storage Area

EF_2 (lb/VMT) = k_2*$(sL)^{0.91}$*$(W)^{1.02}$

where, EF_2 = Emission Factor, Bulldozer
k_2 = Particle Size Multiplier (lb/VMT)
sL = Road Surface Silt Loading (g/m2)
W = Mean Vehicle Weight (tons)

Source: U.S. EPA AP-42, 13.2.1.3 Eq. (1)

Variables:

k_2 = 0.0022 Aerodynamic Particle Size Multiplier for PM10, Source: AP-42,Table 13.2.1-1, page 13.2.1-4.
sL= 0.015 g/m2, Source: AP-42, Table 13.2.1-2, page 13.2.1-8 for limited access.
W = 20 tons, Source: ConocoPhillips

EF_2 (lb/VMT) = k_2*$(sL)^{0.91}$*$(W)^{1.02}$

$EF_2 = 0.0022 * 0.015^{0.91} * 20^{1.02}$

EF_2 = 0.00102 lb/VMT

Operating Data: 6.8 mph, maximum speed for dozer full throttle, forward, open area
3.4 mph, estimated average speed, dozer moving back and forth to move pile to plow conveyor
8 hrs/day, hours of operation

VMT (max miles/day) = 54 mi/day, max
VMT (average mile/day) = 27 mi/day, average

Uncontrolled Emissions

E_2= **0.06 lbs/day, maximum**
0.03 lbs/day, average

Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.

E_{2c} = EF_2*(1-Control Efficiency)

E_{2c} = 0.03 * 0.05 * VMT

E_{2c} = **0.003 lbs/day, maximum**

E_{2c} = 0.001 lbs/day, average

Partially Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.
Enclosure Capture Efficiency = 98 %, Assumes 2% opening during maintenance.

E_{2P} = EF_2*(1-Control Efficiency*Capture Efficiency)

E_{2P} = 0.00102 * 0.069

E_{2P} = **0.004 lbs/day, maximum**

E_{2P} = 0.002 lbs/day, average

3. Wind Erosion of Pile Surfaces and Ground Areas Around Piles

$E_3 = k \Sigma P_i$

where, E_3 = Emission Factor g/day, Wind Erosion

k_2 = Particle Size Multiplier, 0.5 for PM10

Σ = Sum from 1 to N, N = number of disturbances per year

P_i = Erosion potential corresponding to the observed (or probable) fastest mile of wind for the ith period between disturbances (g/m^2)

Source: U.S. EPA AP-42, 13.2.5 Eq. (2)

Using the procedure outlined in U.S. EPA AP-42, Section 13.2.5, on page 13.2.5-5.

Step 1: Determine Threshold Friction Velocity (u_t) for erodible material from Table 13.2.5-2

u_t = 0.55 m/s

Step 2: Divide the exposed surface area into subareas of constant frequency of disturbance (N)

The coke barn contains 4 conical piles that are disturbed daily.

N = 365

Step 3: Tabulate fastest mile values (u^+) for each frequency of disturbance and correct them to 10 m (u^+_{10}) using Eq. 5

Review of the SCAQMD met modeling data for the Long Beach station shows the 99th percentile wind speed to be 17 miles/hr or 7.6 m/s. Data is already at 10 m. Therefore, no adjustment is made.

$u^+ = u^+_{10}$ = 17.0 miles/hr

Step 4: Convert fastest mile values (u+10) to equivalent friction (u*), taking into account the nonuniform wind exposure of elevated surfaces (piles) using Eq. 6 and Eq.7

From Table 13.2.5-4, using u^+_{10} = 16.8 miles/hr,

u* for (u_s/u_r=0.2) = 0.15 m/s

u* for (u_s/u_r=0.6) = 0.46 m/s

u* for (u_s/u_r=0.9) = 0.68 m/s

Step 5: For elevated surfaces (piles), subdivide areas of constant N into subareas of constant u* and determine the size of each subarea

From Table 13.2.5.3, for a conical pile (Pile A)

Pile Subarea	%	Area (m^2)
0.2a	5	502.5442
0.2b	35	3517.81
0.6a	48	4824.424
0.9	12	1206.106

The coke barn has 4 piles, each with a maximum diameter of 150 ft and maximum height of 87 ft.

$A = \pi * r * (r^2 + h^2)^{0.5}$

A = 27064 ft^2 per pile

A = 108258 ft^2

Step 6: For each subarea of constant N and u*, calculate the erosion potential (P_i) using Eq 3.

$P = 58 * (u^* - u_t^*)^2 + 24 * (u^* - u_t^*)$ and $P = 0$ for $u^* \leq u_t^*$

For 15 miles/hr, $u^* < u_t^*$ for pile subareas 0.2a and 0.6a. Therefore, only one P_i is calculated.

$P_{0.9} = 58(0.68 - 0.55)^2 + 25(0.68 - 0.55)$

$P_{0.9}$ = 4.2302 g/m^2

Step 7: Multiply the resulting emission factor for each subarea by the size of the subarea, and the sum for all subareas.

Since $P_{0.2}$ and $P_{0.6} = 0$, $P = P_{0.9} \cdot A_{0.9}$.

P = 4.2302 * 1206.1

P = 5102.1 g/day

Phillips 66 Coke Barn
PM10 Emission Estimate Calculations

Uncontrolled Emissions

$E_3 = k * \Sigma P_i$

E_3 = 5.62 lb/day

Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.

$E_{3c} = E_3 \cdot (1-.95)$

E_{3c} = 0.28 lb/day

Partially Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.
Enclosure Capture Efficiency = 98 %, Assumes 2% opening during maintenance.

$E_{3P} = E_3 \cdot (1-.95*.98)$

E_{3P} = 0.39 lb/day

4. Summary of Emissions

UNCONTROLLED EMISSIONS FROM THE COKE BARN

$E = E_1 + E_2 + E_3$

$E = 0.64 + 0.06 + 5.62$

$E = 6.32$ lbs/day

TOTAL CONTROLLED EMISSIONS FROM THE COKE BARN

$E_c = E_{1c} + E_{2c} + E_{3c}$

$E_c = 0.03 + 0.003 + 0.28$

$E_c = 0.32$ lbs/day

PARTIALLY CONTROLLED EMISSIONS FROM THE COKE BARN

$E_P = E_{1P} + E_{2P} + E_{3P}$

$E_P = 0.04 + 0.004 + 0.39$

$E_P = 0.44$ lbs/day

References: U.S. EPA AP-42 Sections 13.2.4 (1/95) U.S. EPA AP-42 Section 13.2.5 (1/95)

Phillips 66 Coke Barn
PM2.5 Emission Estimate Calculations

1. Loading of Aggregate onto Storage Piles

EF_1(lb/ton) = k_1*(0.0032) *$(U/5)^{1.3}/(M/2)^{1.4}$

where, EF_1 = Emission Factor, Storage Piles
k_1 = Particle Size Multiplier (dimensionless)
U = Mean Wind Speed, (miles/hr)
M = Material Moisture Content (%)

Source: U.S. EPA AP-42, 13.2.4 Eq. (1)

Variables:

k_1 = 0.053 Aerodynamic Particle Size Multiplier for PM2.5, Source: AP-42, k factor table, page 13.2.4-4.
U = 5.77 mph, Source: SCAQMD Long Beach Met Data 2012-2016.
M = 12 %, Source: SCAQMD PAR 1158, Appendix E, page E-7.

Operating Data: 2903 maximum tons/day
2650 average tons/day

Number of Transfer Points = 2 Normal activities would load lump or fines, not both simultaneously, and involve conveyor 17 to conveyor 18 to pile, or conveyor 15 to conveyor 16 to pile.

$$EF_1 = 0.053 * 0.0032 * \left(\frac{5.8}{5}\right)^{1.3} / \left(\frac{12}{2}\right)^{1.4}$$

EF_1 = 1.66E-05 lbs/ton

Unontrolled Emissions

E_1 = 9.66E-02 lbs/day, maximum
E_1 = 8.81E-02 lbs/day, average

Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.

E_{1c} = EF_1*(1-Control Efficiency)*Activity
E_{1c} = 1.66E-05 * 0.05 * Activity
E_{1c} = 8.31E-07 lb/ton
E_{1c} = 0.005 lbs/day, maximum
E_{1c} = 0.004 lbs/day, average

Partially Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.
Enclosure Capture Efficiency = 98 %, Assumes 2% opening during maintenance.

E_{1P} = EF_1*(1-Capture Efficiency*Control Efficiency)
E_{1P} = 1.66E-05 * 0.069
E_{1P} = 1.15E-06 lb/ton
E_{1P} = 0.01 lbs/day, maximum
E_{1P} = 0.01 lbs/day, average

2. Equipment Traffic in Storage Area

EF_2 (lb/VMT) = k_2*$(sL)^{0.91}$*$(W)^{1.02}$

where, EF_2 = Emission Factor, Bulldozer
k_2 = Particle Size Multiplier (lb/VMT)
sL = Road Surface Silt Loading (g/m2)
W = Mean Vehicle Weight (tons)

Source: U.S. EPA AP-42, 13.2.1.3 Eq. (1)

Variables:

k_2 = 0.00054 Aerodynamic Particle Size Multiplier for PM2.5, Source: AP-42,Table 13.2.1-1, page 13.2.1-4.
sL= 0.015 g/m2, Source: AP-42, Table 13.2.1-2, page 13.2.1-8 for limited access.
W = 20 tons, Source: ConocoPhillips

EF_2 (lb/VMT) = k_2*$(sL)^{0.91}$*$(W)^{1.02}$

EF_2 = 0.00054 * $0.015^{0.91}$ * $20^{1.02}$
EF_2 = 0.00025 lb/VMT

Operating Data:
6.8 mph, maximum speed for dozer full throttle, forward, open area
3.4 mph, estimated average speed, dozer moving back and forth to move pile to plow conveyor
8 hrs/day, hours of operation

VMT (max miles/day) = 54 mi/day, max
VMT (average mile/day) = 27 mi/day, average

Uncontrolled Emissions

E_2 = 0.014 lbs/day, maximum
0.007 lbs/day, average

Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.

E_{2c} = EF_2*(1-Control Efficiency)
E_{2c} = 0.01 * 0.05 * VMT
E_{2c} = 0.001 lbs/day, maximum
E_{2c} = 0.0003 lbs/day, average

Partially Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.
Enclosure Capture Efficiency = 98 %, Assumes 2% opening during maintenance.

E_{2P} = EF_2*(1-Control Efficiency*Capture Efficiency)
E_{2P} = 0.00025 * 0.069
E_{2P} = 0.001 lbs/day, maximum
E_{2P} = 0.0005 lbs/day, average

3. Wind Erosion of Pile Surfaces and Ground Areas Around Piles

$E_3 = k \Sigma P_i$

where, E_3 = Emission Factor g/day, Wind Erosion

k_2 = Particle Size Multiplier, 0.075 for PM2.5

Σ = Sum from 1 to N, N = number of disturbances per year

P_i = Erosion potential corresponding to the observed (or probable) fastest mile of wind for the ith period between disturbances (g/m^2)

Source: U.S. EPA AP-42, 13.2.5 Eq. (2)

Using the procedure outlined in U.S. EPA AP-42, Section 13.2.5, on page 13.2.5-5.

Step 1: Determine Threshold Friction Velocity (u_t) for erodible material from Table 13.2.5-2

u_t = 0.55 m/s

Step 2: Divide the exposed surface area into subareas of constant frequency of disturbance (N)

The coke barn contains 4 conical piles that are disturbed daily.

N = 365

Step 3: Tabulate fastest mile values (u^+) for each frequency of disturbance and correct them to 10 m (u^+_{10}) using Eq. 5

Review of the SCAQMD met modeling data for the Long Beach station shows the 99th percentile wind speed to be 17 miles/hr or 7.6 m/s. Data is already at 10 m. Therefore, no adjustment is made.

$u^+ = u^+_{10}$ = 17.0 miles/hr

Step 4: Convert fastest mile values (u+10) to equivalent friction (u*), taking into account the nonuniform wind exposure of elevated surfaces (piles) using Eq. 6 and Eq.7

From Table 13.2.5-4, using u^+_{10} = 16.8 miles/hr,

u^* for (u_s/u_r=0.2) = 0.15 m/s

u^* for (u_s/u_r=0.6) = 0.46 m/s

u^* for (u_s/u_r=0.9) = 0.68 m/s

Step 5: For elevated surfaces (piles), subdivide areas of constant N into subareas of constant u* and determine the size of each subarea

From Table 13.2.5.3, for a conical pile (Pile A)

Pile Subarea	%	Area (m^2)
0.2a	5	502.5442
0.2b	35	3517.81
0.6a	48	4824.424
0.9	12	1206.106

The coke barn has 4 piles, each with a maximum diameter of 150 ft and maximum height of 87 ft.

$A = \pi * r * (r^2 + h^2)^{0.5}$

A = 27064 ft^2 per pile

A = 108258 ft^2

Step 6: For each subarea of constant N and u*, calculate the erosion potential (P_i) using Eq 3.

$P = 58 * (u^* - u_t^*)^2 + 24 * (u^* - u_t^*)$ and $P = 0$ for $u^* \leq u_t^*$

For 15 miles/hr, $u^* < u_t^*$ for pile subareas 0.2a and 0.6a. Therefore, only one P_i is calculated.

$P_{0.9}$ = $58(0.68 - 0.55)^2 + 25(0.68 - 0.55)$

$P_{0.9}$ = 4.2302 g/m^2

Step 7: Multiply the resulting emission factor for each subarea by the size of the subarea, and the sum for all subareas.

Since $P_{0.2}$ and $P_{0.6} = 0$, $P = P_{0.9} \cdot A_{0.9}$.

P = 4.2302 * 1206.1

P = 5102.1 g/day

Phillips 66 Coke Barn
PM2.5 Emission Estimate Calculations

Uncontrolled Emissions

$E_3 = k * \Sigma P_I$

E_3 = 0.84 lb/day

Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.

$E_{3c} = E_3 \cdot (1-.95)$

E_{3c} = 0.04 lb/day

Partially Controlled Emissions

Enclosure Control Efficiency = 95 %, Source SCAQMD PAR 1158, Appendix C, page C-2.
Enclosure Capture Efficiency = 98 %, Assumes 2% opening during maintenance.

$E_{3P} = E_3 \cdot (1-.95*.98)$

E_{3P} = 0.06 lb/day

4. Summary of Emissions

UNCONTROLLED EMISSIONS FROM THE COKE BARN

$E = E_1 + E_2 + E_3$

$E = 0.10 + 0.014 + 0.84$

$E = 0.95$ lbs/day

TOTAL CONTROLLED EMISSIONS FROM THE COKE BARN

$E_c = E_{1c} + E_{2c} + E_{3c}$

$E_c = 0.005 + 0.001 + 0.04$

$E_c = 0.05$ lbs/day

PARTIALLY CONTROLLED EMISSIONS FROM THE COKE BARN

$E_P = E_{1P} + E_{2P} + E_{3P}$

$E_P = 0.01 + 0.001 + 0.06$

$E_P = 0.07$ lbs/day

References: U.S. EPA AP-42 Sections 13.2.4 (1/95) U.S. EPA AP-42 Section 13.2.5 (1/95)

ATTACHMENT B

PERTINENT SECTIONS OF PAR 1158 AND U.S. EPA AP-42

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APPENDIX E

EMISSION BASELINE AND REDUCTIONS CALCULATION METHODOLOGIES

The material transfer/continuous/batch drop variables include the load in/out factor, number of transfers to/from a pile and the throughput. The load in/out factor includes the PM <10 micron/<30 micron factor, average wind speed (mph), percent moisture and unit conversion factors. The average annual wind speed used was six miles per hour based on local monitoring data. The average percent coke and coal moisture, the number of transfers (continuous/batch drop transfer to the pile and continuous/batch transfer from the pile), the throughput and other facility specific details are in the following Table E-1.

TABLE E-1
PILE MATERIAL TRANSFER INPUT DETAIL

Facility	Moisture Coke/Sulfur %	Moisture Coal %	Primary Thruput Coke/Sulfur tpy	Secondary Thruput Coal/Coke tpy	No. of Transfers Coke/Sulfur	No. of Transfers Coal/Coke
Company 1	4	4	2500000	4400000	3	3
Company 2	4		500000		3	
Company 3	4		181000		3	
Company 4	8	4	2000000	200000	3	0
Company 5	4		950000		3	
Company 6	4	4	2000000	1500000	3	3
Company 7	4	4	750000	750000	3	3
Company 8	4	4	26000	59000	2	2
Company 9	2.5		200000		3	
Company 10	8		900000		3	
Company 11	8		850000		3	
Company 12	8		1131500		3	
Company 13	8		547500		3	
Company 14	0.5	4	450000	630000	3	3
Company 15	2.5		370000		3	
Company 16	4		9820		2	
Company 17	4		9820		2	
Company 18	4		100000		3	

The pile erosion variables include percent silt, number of days a year with at least 0.01 inches of precipitation, percent of time that the wind speed exceeds twelve miles per hour, the PM10/PM30 factor and the acreage of land that the pile occupies. Based on field inspections and various studies, the silt content used for coke was 6 %. Local monitoring data indicates that the average number of days exceeding 0.01 inches a year is 34, and the percentage of time the wind speed exceeds twelve miles per hour is 8%. The PM10/PM ratio is 0.5. The acreage of land that a pile occupies varies depending on the facility, as detailed in Table E-2.

An additional emission source associated with pile activity is attributed to water trucks travelling over silt laden roads and adjacent piles. Water truck pile activity associated with Company 1 was derived using the "vehicle travel on paved road" equation (AP-42. 13.2.1-3, 10/97). The input factors were; silt loading at 2.10 g/m^2; vehicle weight at 16.5 tons; and annual distance traveled at 4,817 miles. Vehicle weight was calculated assuming a half-full four ton (3,000 gallon) water truck. The annual vehicle miles were calculated from information provided by Company 1. Water truck pile activity associated with Companies 3 and 7 used the vehicle travel on unpaved road equation (AP-42 13.2.2-3, 9/98). The input factors were; silt content at 12%, vehicle weight at 16.5 tons; and annual distance travelled at 4,560 and 4,585 miles, respectively. Vehicle weight was calculated assuming a half-full four ton (3,000 gallon) water truck. Annual vehicle miles were calculated from information provided by Company 3 and extrapolated to Company 7 based on acreage.

TABLE E-2
PILE EROSION INPUT DETAIL

Facility	Primary Coke/Sulfur Acreage	Secondary Coal/Coke Acreage
Company 1	0.7625	10
Company 2	0.91	
Company 3	4.575	
Company 4	0	2
Company 5	0	
Company 6	0.7625	0
Company 7	0	4.6
Company 8	0	1
Company 9	2.2875	
Company 10	0	
Company 11	0	
Company 12	0	
Company 13	0	
Company 14	0	0
Company 15	0	
Company 16	0.1	
Company 17	0.1	
Company 18	6.1	

The endloader/tractor variables include percent silt, endloader/tractor speed, endloader/tractor weight, average number of days with at least 0.01 inches of precipitation and average endloader/tractor miles traveled a year. Due to the crushing of material from the weight of the endloader/tractor, percent silt for coke and coal used was 12% and 5%, respectively. Estimated average four wheeled endloader/tractor speed for coke and caol was 4.3 mph and 12 mph, respectively; endloader/tractor weight is 18 tons (125 ton and 38 ton tractors are used at Company 1, and a 104.3 ton tractor is used at Company 8) based on field inspections; and annual vehicle mileage was proportioned to the amount stored at each facility, as detailed in Table E-3, based on the know milage at Compny 1. Watering truck activity was also included.

TABLE E-3
PILE ENDLOADER INPUT DETAIL

Facility	Primary Coke/Sulfur Annual miles	Secondary Coal/Coke Annual miles
Company 1	27,352	8,085
Company 2	5,470	
Company 3	1,980	
Company 4	21,881	0
Company 5	0	
Company 6	21,881	2,756
Company 7	8,205	8,205
Company 8	0	186
Company 9	2,188	
Company 10	9,847	
Company 11	9,300	
Company 12	12,379	
Company 13	5,990	
Company 14	0	0
Company 15	4,048	
Company 16	107	
Company 17	107	
Company 18	1,094	

Conveyor emissions set-up:

Conveyor emissions were calculated based on the AP-42 material transfer/continuous/batch drop equation. Facilities were assumed to operate 365 days a year. The following equation was used to conveyor emissions.

$$\text{Conveyor Emission Rate, tpy} = \left(\frac{(\text{LF} \times \text{Trans} \times \text{Thru})}{2000 \frac{\text{lbs}}{\text{ton}}} \right) \times \text{Eff}$$

Where :

$$\text{LF} = \text{Load in/out Factor}, \frac{\text{lb}}{\text{metric ton}}$$

$$= k_L \times 0.0032 \times \left(1.1 \frac{\text{ton}}{\text{metric ton}} \right) \times \left(\frac{\text{WS}}{5} \right)^{1.3} \times \left(\frac{\text{M}}{2} \right)^{-1.4}$$

Trans = Number of Transfers

Thru = Annual Facility Throughput

Eff = Efficiency of Fugitive Dust Controls

Water Spray System = 80% (AP - 42, 8.19.1 - 2, 9/85)

Enclosure and Waterspray = 95% (assumed)

Variables :

k_L = Particle Size Multiplier = 0.35 (PM10) & 0.74 (PM30)

WS = Mean Wind Speed, mph

M = Material Moisture Content, % .

The material transfer/continuous/batch drop variables include the load in/out factor, number of conveyor transfers and the throughput. The load in/out factor includes the PM <10 micron/<30 micron factor, average wind speed, percent moisture and unit conversion factors. The average annual wind speed used was six miles per hour based on local monitoring data. The average percent coke and coal moisture used was six percent at storage and shiploading facilities, and twelve percent at refinery facilities based on field inspections except a Company 1, where detailed moisture content of shipped materials were kept and provided to the SCAQMD. At Company 1, the percent moisture for conveyed coke and coal was 8.9 and 8.6, respectively. The number of continuous/batch transfers depends on the number of conveyors at each facility. Throughput also depends on the individual facility, as indicated in Table E-4.

TABLE E-4
CONVEYOR MATERIAL TRANSFER INPUT DETAIL

Facility	Primary Coke/Sulfur Moisture %	Secondary Coal/Coke Moisture %	Primary Coke/Sulfur No. Transfer	Secondary Coal/Coke No. Transfer	Primary Coke/Sulfur Thruput tpy	Secondary Coal/Coke Thruput tpy
Company 1	8.9	8.6	20	20	2500000	4400000
Company 2	6		4		500000	
Company 3	6		0		181000	
Company 4	12		5		2000000	
Company 5	6		10		950000	
Company 6	6	6	5	5	2000000	1500000
Company 7	12		4		1500000	
Company 8	6		2		85000	
Company 9	12		0		200000	
Company 10	12		6		900000	
Company 11	12		5		850000	
Company 12	12		5		1131500	
Company 13	12		3		547500	
Company 14	0.5	6	10	4	450000	630000
Company 15	12		0		370000	
Company 18	6		0		100000	

Truck/railcar unloading, loading emissions set-up:

Truck/railcar unloading, loading emissions were calculated based on the AP-42 material transfer/continuous/batch drop equation. Facilities were assumed to operate 365 days a year. The following equation was used to estimate loading and unloading emissions associated with pile activities.

$$\text{Truck Load/Unload Emission Rate, tpy} = \left(\frac{(\text{LF} \times \text{Truck} \times \text{Thru} \times \text{Days})}{2000 \frac{\text{lbs}}{\text{ton}}} \right) \times \text{Eff}$$

Where :

$$\text{LF} = \text{Load in/out Factor}, \frac{\text{lb}}{\text{metric ton}}$$

$$= k_L \times 0.0032 \times \left(1.1 \frac{\text{ton}}{\text{metric ton}}\right) \times \left(\frac{\text{WS}}{5}\right)^{1.3} \times \left(\frac{\text{M}}{2}\right)^{-1.4}$$

Truck = Number of Trucks Per Day

Thru = Annual Facility Throughput, metric ton

Days = Days Per Year Facility Operates = 365

Eff = Efficiency of Fugitive Dust Controls

Water Spray System = 80% (AP - 42, 8.19.1 - 2, 9/85)

Enclosure and Waterspray = 95% (assumed)

Variables :

k_L = Particle Size Multiplier = 0.35 (PM10) & 0.74 (PM30)

WS = Mean Wind Speed, mph

M = Material Moisture Content, %

The truck unloading/railcar unloading activities take place at the storage and shipping facilities; the truck/railcar loading activities take place at the refinery facilities. Variables include the load in/out factor, number of number of trucks per day and the throughput per truck. The load in/out factor includes the PM <10 micron/<30 micron factor, average wind speed, percent moisture and unit conversion factors. The average annual wind speed used was six miles per hour based on local monitoring data. The average percent coke and coal moisture used was six percent at storage and shiploading facilities, and twelve percent at refinery facilities based on field inspections. The number of trucks per day is a function of the throughput, with each truck load carrying 25 metric tons (9 metric tons for small end-user facilities). The facility specific details are as follows in Table E-5.

TABLE E-5
TRUCK & RAILCAR LOADING & UNLOADING INPUT DETAIL

Facility	Primary Coke/Sulfur Moisture %	Secondary Coal/Coke Moisture %	Rail Moisture %,	Primary Coke/Sulfur No. Trucks/ day	Secondary Coal/Coke No. Trucks/ day	No. Rails/ day	Thruput ton	Thruput ton
Company 1	6	N/A	6	274	N/A	120	N/A	100
Company 2	6			55				
Company 3	6			40				
Company 4	12			219				
Company 5	6			104				
Company 6	6	N/A	6	219	N/A	41	N/A	100
Company 7	9			164				
Company 8	4	4		3		2	100	
Company 9	2.5			22				
Company 10	12			99				
Company 11	12			93				
Company 12	12			110				
Company 13	12			60				
Company 14	0.5	6	0.5	49	69	2	25	90
Company 15	2.5			41				
Company 16	4			3				
Company 17	4			3				
Company 18	6			22				

Wind erosion during coke truck transport:

Emissions from wind erosion during transport off the open top truck were calculated based on the AP-42 industrial wind erosion equations. The emissions associated with this activity are tagged to the facility delivering the material (refinery facility) and not to the facility receiving the material (storage, shiploading facility). The following equation was used to estimate transport emissions.

INTRODUCTION

Appendix E summarizes the methodology for calculating the emissions baseline and reductions.

METHODOLOGIES

Reference: EPA's AP-42

1. Chapter 11, Section 11.2.3.3, equation 3, 5/83, Pile erosion.
2. Chapter 13, Section, 13.2.1.3, equation 1, 10/97, Track out.
3. Chapter 13, Section 13.2.2.2, equation 1, 1/95, Endloader/tractor activity.
4. Chapter 13, Section 13.2.4.3, equation 1, 1/95, Material transfer, continuous/batch drop.
5. Chapter 13, Sections 13.2.5, equations 1-5, 1/95, Industrial wind erosion.

Storage and handling emissions set-up:

Storage and handling emissions were calculated based on AP-42's material transfer/continuous/batch drop, pile erosion and endloader/tractor activity equations. All facilities were assumed to operate 365 days a year. The following equation was used to estimate storage and handling emissions associated with pile activities.

$$\text{Transport Emission Rate, tpy} = (\text{EP} \times \text{SA} \times \text{Freq} \times \text{Vehicle} \times \text{MF} \times \text{PM10}) \times \text{Eff}$$

Where:

EP = Erosion Potential

$$= 58 \times (U^* - Ut)^2 + 25 \times (U^* - Ut)$$

SA = Surface Area

Freq = Disturbance Frequency

Vehicle = Number of Vehicles

MF = Moisture Factor

$$= \left(\frac{M}{2}\right)^{-1.4}$$

PM10 = PM10 Ratio

Eff = Efficiency of Fugitive Dust Controls = 95% (assumed)

Slot Tops = 85%

Fiberglass and Sliding Hard Tops = 96.5%

Variables:

U^* = Friction Velocity

$$= \frac{0.4 \times WS}{\ln(\text{height/roughness height})}$$

Ut = Threshold Velocity (Environ Study)

WS = Mean Wind Speed, mph

M = Material Moisture Content, %

The associated variables include: erosion potential, exposed surface area; disturbance frequency; number of vehicles; a moisture factor and PM_{10}/PM ratio (0.5); and a default roughness height of 0.3 centimeters. Erosion potential is calculated using the friction velocity and threshold friction velocity. Friction velocity is calculated based on the height above the surface of the material to the top of the trailer, and the fastest mile of wind in miles per hour. The height above the exposed surface is estimated at one foot and the threshold friction velocity is the minimum wind velocity impacting the open top and causing a surface disturbance. The threshold friction velocity of coke is estimated at 1.61 miles per hour based on the Environ Study. A moisture factor was included to impart control efficiency. The disturbance frequency is assumed to be once per trip. Field measurements indicate surface areas of 258 square feet for open top sets, 129 sq. feet for aluminum slot top sets, and 18 sq. feet for fiberglass top sets, and the number of trucks varies, depending on the facility, as indicated in Table E-6.

TABLE E-6
MATERIAL LOSS DURING TRANSPORT INPUT DETAILS

Facility	Moisture %	Wind speed mph	Threshold velocity mph	Surface area, sq. Ft.	Disturb-ances	No. Trucks per year
Company 1	6	60	1.61	129	0	0
Company 2	6	60	1.61	258	0	0
Company 3	6	60	1.61	258	1	7240
Company 4	12	60	1.61	258	1	80000
Company 5	6	60	1.61	258	0	0
Company 6	6	60	1.61	258	0	0
Company 7	9	45	1.61	258	1	60000
Company 8	3	60	1.61	258	0	0
Company 9	6	60	2.98	258	1	8000
Company 10	12	60	1.61	258	1	36000
Company 11	12	60	1.61	258	1	34000
Company 12	12	60	1.61	129	1	40000
Company 13	12	60	1.61	129	1	21900
Company 14	0.5	45	1.61	18	1	15400
Company 15	6	60	2.98	258	1	14800
Company 16	3	60	1.61	129	0	0
Company 17	3	60	1.61	129	0	0
Company 18	6	60	1.61	258	1	4000

Truck/Vehicle Travel On Paved Roads: Track-out emissions:

A predictive emission equation (AP42 13.2.1, 10/97) for paved roads was applied to calculate a track-out emission rate. Two track-out areas were identified; the first is paved surfaces within the facility where primarily in-plant vehicle traffic exists; and the second is the paved road outside the facility exit where coke trucks and cars co-exist on public thru-ways. In-plant vehicle traffic is assumed to be coke trucks only, and for outside traffic, local vehicle traffic counts were obtained from city and county agencies. The following equation was used to estimate trackout emissions.

$$\text{Transport Emission Rate, tpy} = (k \times s \times WF \times \text{Vehicle} \times VMT) \times Eff$$

Where:

$$k = \text{Particle Size Multiplier}$$
$$= 0.016 \frac{lb}{VMT} (PM10)$$
$$= 0.082 \frac{lb}{VMT} (PM30)$$
$$s = \text{Silt Factor} = \left(\frac{\text{Baseline SL}}{2}\right)^{0.65}$$
$$WF = \text{Vehicle Factor} = \left(\frac{W}{3}\right)^{1.5}$$

$$\text{Vehicle} = \text{Number of Vehicles per day}$$
$$VMT = \text{Vehicle Miles Traveled}, \frac{\text{miles}}{\text{day}}$$
$$Eff = \text{Efficiency of Fugitive Dust Controls} = \text{Controlled SL}$$

(Prevention and Streetcleaning)

Variables:

$$SL = \text{Silt Loading Value}, \frac{g}{m^2}$$
$$W = \text{Mean Vehicle Weight, tons}$$

Variables include the particle size PM_{10}/PM_{30} multiplier (pounds per vehicle mile traveled), silt loading factor (grains per square foot), average vehicle weight factor (tons), number of vehicles and annual miles per vehicle.

Silt loading values were obtained from a review of the sources, AP-42 (1/95), MRI (1996) and Environ (1997) and a study performed SCAQMD by Environmental Audit in 1999, that sampled silt at PAR 1158 affected facilities. To determine the baseline silt loading value for paved surfaces within the facility, a value of 2.10 g/m^2 was selected from the following sources:

Report	Category	Silt Loading g/m^2
Environ	Dockside	3.28
AP-42	Low ADT, worst case	3
AP-42	Industrial Roads mean values	7/4-292
MRI	Low ADT, noticeable trackout	2.04

To determine the rule limit (controlled) for paved surfaces within the facility, a value of 0.25 g/m² was selected from the following sources:

Report	Category	Silt Loading g/m²
Environ	Pier G Ave	0.45
AP-42	Low ADT, normal	0.4
MRI	Low ADT, South Coast	0.05-0.184

To determine the baseline silt loading value for paved roads outside the facility, a value of 0.45 g/m² was selected from the following sources:

Report	Category	Silt Loading g/m²
Environ	Pier G Ave.	0.45
AP-42	Public Roads High ADT, worst case	0.4

Finally, to determine the silt loading value for the controlled (rule limit) emissions for roads outside the facility, a value of 0.05 g/m² was selected from the following sources.

Report	Category	Silt Loading g/m²
Environ	710 Ramp	0.15
MRI	High ADT, South Coast	0.011-0.046
AP-42	Public roads, normal high ADT	0.1

Average vehicle weight for coke carrying trucks within the facility assumed half the time fully loaded and half the time fully unloaded. Since a fully loaded truck cannot weigh more than 40 tons (36 metric tons) total weight, and assuming 25 metric ton loads, the average weight is estimated at 24 metric tons. The average vehicle weight used for all vehicles traveling outside a facility was 14 metric tons (Environ study). The facility specific input data for inside and outside trackout are presented in the following two tables E-7 and E-8.

TABLE E-7
INSIDE TRACKOUT INPUT DETAILS

Facility	Uncontrolled Silt Loading g/m²	Controlled Silt Loading g/m²	Weight mt	Distance, miles	No. Trucks per day
Company 1	2.10	0.25	24	0.25	274
Company 2	2.10	0.25	24	0.25	55
Company 3	N/A	0.25	24	0.25	20
Company 4	2.10	0.25	24	0.25	219
Company 5	2.10	0.25	24	0.25	104
Company 6	2.10	0.25	24	0.25	219
Company 7	2.10	0.25	24	0.25	164
Company 8	2.10	0.45	24	0.25	3
Company 9	2.10	0.25	24	0.25	22
Company 10	2.10	0.25	24	0.25	99
Company 11	2.10	0.25	24	0.25	93
Company 12	2.10	0.25	24	0.25	110
Company 13	2.10	0.25	24	0.25	60
Company 14	2.10	0.25	24	0.25	118
Company 15	2.10	0.25	24	0.25	41
Company 16	2.10	0.45	15	0.25	3
Company 17	2.10	0.45	15	0.25	3
Company 18	2.10	0.25	24	0.25	11

TABLE E-8
OUTSIDE TRACKOUT DETAILS

Facility	Uncontrolled Silt Loading g/m²	Controlled Silt Loading g/m²	Weight mt	Distance miles	No. Vehicles per year
Company 1	0.45	0.05	13	0.25	1551250
Company 2	0.45	0.05	13	0.25	2460465
Company 3	0.45	0.05	13	0.25	1551250
Company 4	0.45	0.05	3.1	0.25	16972500
Company 5	0.45	0.05	13	0.25	1222750
Company 6	0.45	0.05	13	0.25	2460465
Company 7	0.45	0.05	3.1	0.25	4927500
Company 9	0.45	0.05	4.398	0.25	12045000
Company 10	0.45	0.05	3.1	0.25	4380000
Company 11	0.45	0.05	4.398	0.25	16972500
Company 12	0.45	0.05	2.55	0.25	16972500
Company 13	0.45	0.05	3.1	0.25	12045000
Company 14	0.45	0.05	3.1	0.25	12045000
Company 15	0.45	0.05	3.1	0.25	12045000
Company 18	0.45	0.05	13	0.25	1551250

APPENDIX I

EMISSION BASELINE AND REDUCTIONS CALCULATION SPREADSHEETS

SUMMARY TABLES

BASIN-WIDE BASELINE AND PROPOSED PM10 EMISSIONS FROM COKE, COAL & PRILLED SULFUR

	EMISSION, TPY BASELINE	EMISSION, TPY AFTER CONTROL	EMISSION, TPY REDUCTION
COKE STORAGE/HANDLING	44.79	0.94	43.85
COAL STORAGE/HANDLING	7.33	6.82	0.50
PRILLED SULFUR STORAGE/HANDLING	2.60	2.60	0.00
COKE CONVEYOR	4.52	0.36	4.16
COAL CONVEYOR	1.37	0.12	1.25
PRILLED SULFUR CONVEYOR	0.00	0.00	0.00
COKE TRUCK UNLOAD & LOAD	0.56	0.35	0.21
COKE RAILCAR LOAD	0.00	0.00	0.00
COAL RAILCAR UNLOAD	0.03	0.03	0.00
PRILLED SULFUR TRUCK UNLOAD & LOAD	0.33	0.33	0.00
COKE TRACK OUT (INSIDE FACILITY)	43.74	6.65	37.09
COKE TRACK OUT (OUTSIDE FACILITY)	146.95	35.23	111.72
PRILLED SULFUR TRACK OUT (INSIDE)	1.07	0.27	0.80
PRILLED SULFUR TRACK OUT (OUTSIDE)	25.81	6.19	19.62
COKE TRUCK TRANSPORT	53.31	7.93	45.38
PRILLED SULFUR TRUCK TRANSPORT	1.99	1.99	0.00
TOTAL	334	70	265

PM10 BASELINE EMISSIONS PER FACILITY

FACILITY	EMISSION, TPY BASELINE	EMISSION, TPY AFTER CONTROL	EMISSION, TPY REDUCTION
COMPANY 7	41.05	2.19	38.85
COMPANY 6	36.05	6.23	30.82
COMPANY 4	35.02	4.88	30.14
COMPANY 11	31.85	6.17	25.69
COMPANY 1	31.64	10.72	20.92
COMPANY 3	23.09	2.83	20.26
COMPANY 2	21.29	4.31	16.98
COMPANY 9	19.87	7.26	12.61
COMPANY 14	16.69	7.44	9.25
COMPANY 12	14.68	4.99	9.69
COMPANY 18	14.17	2.72	11.45
COMPANY 13	13.10	2.67	10.44
COMPANY 10	12.76	1.57	11.19
COMPANY 15	11.93	4.11	7.82
COMPANY 5	10.21	2.48	7.73
COMPANIES 8, 16 & 17	1.00	0.24	0.77
TOTAL	334	70	265

PM10 BASELINE EMISSIONS PER MATERIAL

	STORAGE	CONVEYING	UNLOAD & LOAD	TRACK OUT	TRANSPORT	*TOTAL*
COKE	44.79	4.52	0.56	190.68	53.31	293.86
COAL	7.33	1.37	0.03	SEE COKE	0.00	8.73
PRILLED SULFUR	2.60	0.00	0.33	26.89	1.99	31.80
TOTAL	54.72	5.89	0.92	217.57	55.29	334

PM10 AFTER CONTROL EMISSIONS PER MATERIAL

	STORAGE	CONVEYING	UNLOAD & LOAD	TRACK OUT	TRANSPORT	*TOTAL*
COKE	0.94	0.36	0.35	41.88	7.93	51.46
COAL	6.82	0.12	0.03	SEE COKE	0.00	6.98
PRILLED SULFUR	2.60	0.00	0.33	6.46	1.99	11.37
TOTAL	10.36	0.48	0.71	48.33	9.92	70

PM10 EMISSION REDUCTIONS PER MATERIAL

	STORAGE	CONVEYING	UNLOAD & LOAD	TRACK OUT	TRANSPORT	*TOTAL.*
COKE	43.85	4.16	0.21	148.81	45.38	242.41
COAL	0.50	1.25	0.00	SEE COKE	0.00	1.75
PRILLED SULFUR	0.00	0.00	0.00	20.43	0.00	20.43
TOTAL	44.36	5.40	0.21	169.24	45.38	265

THROUGHPUT AND OPEN STORAGE DATA FROM FACILITIES IN EMISSIONS ESTIMATES

	COKE		COAL		SULFUR	
	THRUPUT	OPEN STORAGE	THRUPUT	OPEN STORAGE	THRUPUT	OPEN STORAGE
FACILITY	TPY	TONS	TPY	TONS	TPY	TONS
COMPANY 6	2,000,000	50,000	1,500,000	0	35,000	0
COMPANY 1	2,500,000	50,000	4,400,000	655,737	0	0
COMPANY 7	1,500,000	60,328	0	0	0	0
COMPANY 4	2,000,000	0	0	0	125,000	0
COMPANY 2	500,000	59,672	0	0	0	0
COMPANY 12	1,131,500	0	0	0	128,000	0
COMPANY 5	950,000	0	0	0	200,000	0
COMPANY 10	900,000	0	0	0	160,000	0
COMPANY 11	850,000	0	0	0	0	0
COMPANY 13	547,500	0	0	0	0	0
COMPANY 14	450,000	0	0	0	0	0
COMPANY 3	181,000	300,000	0	0	0	0
COMPANY 18	100,000	400,000	0	0	0	0
COMPANY 9	0	0	0	0	200,000	150,000
COMPANY 15	0	0	0	0	370,000	0
COMPANIES 8, 16 & 17	45600	19640	59000	25000	0	0
TOTAL	13,655,600	939,639	5,959,000	680,737	1,218,000	150,000

THROUGHPUT AND ENCLOSED STORAGE DATA FROM FACILITIES IN EMISSIONS ESTIMATES

	COKE		COAL		SULFUR	
	THRUPUT	ENCLOSED	THRUPUT	ENCLOSED	THRUPUT	ENCLOSED
FACILITY	TPY	TONS	TPY	TONS	TPY	TONS
COMPANY 6	2,000,000	0	1,500,000	100,000	35,000	0
COMPANY 1	2,500,000	100,000	4,400,000	0	0	0
COMPANY 7	1,500,000	130,000	0	0	0	0
COMPANY 4	2,000,000	100,000	0	0	125,000	0
COMPANY 2	500,000	200,000	0	0	0	0
COMPANY 12	1,131,500	5,000	0	0	128,000	0
COMPANY 5	950,000	64,000	0	0	200,000	0
COMPANY 10	900,000	70,000	0	0	160,000	0
COMPANY 11	850,000	65,000	0	0	0	0
COMPANY 13	547,500	2,000	0	0	0	0
COMPANY 14	450,000	80,000	0	0	0	0
COMPANY 3	181,000	0	0	0	0	0
COMPANY 18	100,000	0	0	0	0	0
COMPANY 9	0	0	0	0	200,000	0
COMPANY 15	0	0	0	0	370,000	50,000
COMPANIES 8, 16 & 17	45600	2000	59000	0	0	0
TOTAL	13,655,600	818,000	5,959,000	100,000	1,218,000	50,000

BASIN-WIDE BASELINE AND PROPOSED TSP EMISSIONS FROM COKE, COAL & PRILLED SULFUR

	EMISSION, TPY BASELINE	EMISSION, TPY AFTER CONTROL	EMISSION, TPY REDUCTION
COKE STORAGE/HANDLING	111.23	2.05	109.18
COAL STORAGE/HANDLING	15.54	14.51	1.03
PRILLED SULFUR STORAGE/HANDLING	10.90	10.90	0.00
COKE CONVEYOR	9.56	0.77	8.79
COAL CONVEYOR	2.89	0.26	2.63
PRILLED SULFUR CONVEYOR	0.00	0.00	0.00
COKE TRUCK UNLOAD & LOAD	1.19	0.74	0.45
COKE RAILCAR LOAD	0.01	0.00	0.01
COAL RAILCAR UNLOAD	0.07	0.07	0.00
PRILLED SULFUR TRUCK UNLOAD & LOAD	0.69	0.69	0.00
COKE TRACK OUT (INSIDE FACILITY)	191.18	34.06	157.11
COKE TRACK OUT (OUTSIDE FACILITY)	753.10	180.55	572.55
PRILLED SULFUR TRACK OUT (INSIDE)	5.51	1.38	4.12
PRILLED SULFUR TRACK OUT (OUTSIDE)	132.29	31.72	100.58
COKE TRUCK TRANSPORT	106.61	15.86	90.75
PRILLED SULFUR TRUCK TRANSPORT	3.98	3.98	0.00
TOTAL	1345	298	1047

TSP BASELINE EMISSIONS PER FACILITY

FACILITY	EMISSION, TPY BASELINE	EMISSION, TPY AFTER CONTROL	EMISSION, TPY REDUCTION
COMPANY 11	140.15	30.71	109.44
COMPANY 6	139.28	26.04	113.24
COMPANY 7	129.51	9.55	119.96
COMPANY 4	124.17	22.85	101.32
COMPANY 1	115.42	33.96	81.46
COMPANY 2	98.79	21.97	76.82
COMPANY 9	91.88	27.25	64.63
COMPANY 3	89.53	13.88	75.64
COMPANY 14	69.75	23.69	46.07
COMPANY 12	66.85	19.02	47.83
COMPANY 18	62.22	13.54	48.68
COMPANY 15	61.49	21.42	40.08
COMPANY 13	59.44	13.33	46.10
COMPANY 5	52.10	12.61	39.49
COMPANY 10	41.76	7.09	34.67
COMPANIES 8, 16 & 17	2.39	0.61	1.78
TOTAL	1345	298	1047

TSP BASELINE EMISSIONS PER MATERIAL

	STORAGE	CONVEYING	UNLOAD & LOAD	TRACK OUT	TRANSPORT	*TOTAL*
COKE	111.23	9.56	1.19	844.27	106.61	1172.87
COAL	15.54	2.89	0.07	SEE COKE	0.00	18.50
PRILLED SULFUR	10.90	0.00	0.69	137.80	3.98	153.37
TOTAL	137.67	12.45	1.95	1082.07	110.59	1345

TSP AFTER CONTROL EMISSIONS PER MATERIAL

	STORAGE	CONVEYING	UNLOAD & LOAD	TRACK OUT	TRANSPORT	*TOTAL*
COKE	2.05	0.77	0.74	214.61	15.86	234.03
COAL	14.51	0.26	0.07	SEE COKE	0.00	14.83
PRILLED SULFUR	10.90	0.00	0.69	33.10	3.98	48.67
TOTAL	27.46	1.02	1.51	247.71	19.84	298

TSP EMISSION REDUCTIONS PER MATERIAL

	STORAGE	CONVEYING	UNLOAD & LOAD	TRACK OUT	TRANSPORT	*TOTAL*
COKE	109.18	8.79	0.45	729.66	90.75	938.83
COAL	1.03	2.63	0.00	SEE COKE	0.00	3.67
PRILLED SULFUR	0.00	0.00	0.00	104.70	0.00	104.70
TOTAL	110.21	11.42	0.45	834.36	90.75	1047

BASIN-WIDE BASELINE AND PROPOSED PM10 EMISSIONS FROM COKE, COAL & PRILLED SULFUR

	EMISSION, TPY BASELINE	EMISSION, TPY AFTER CONTROL	EMISSION, TPY REDUCTION
REFINERY	117.87	22.20	95.67
HARBOR	160.23	37.45	122.78
TRANSPORT	55.29	9.92	45.38
ENDUSERS	1.00	0.24	0.77
TOTAL	334	70	265

BASIN-WIDE BASELINE AND PROPOSED TSP EMISSIONS FROM COKE, COAL & PRILLED SULFUR

	EMISSION, TPY BASELINE	EMISSION, TPY AFTER CONTROL	EMISSION, TPY REDUCTION
REFINERY	537.08	110.81	426.26
HARBOR	694.69	166.28	528.41
TRANSPORT	110.59	19.84	90.75
ENDUSERS	2.39	0.61	1.78
TOTAL	1345	298	1047

METHODOLOGY

ISION ASSUMPTIONS

FACILITY	% SILT		RAINY DAYS > 0.01 INCH	% WIND > 12 MPH	% WIND > 12 MPH	ACRE	ACRE	OPERATING DAYS	PM10/PM FACTOR	WATER EFFICIENCY	ENCLOSURE EFFICIENCY	B/H EFFICIENCY	BASELINE TPY COKE	BASELINE TPY COAL	BASELINE TPY SULFUR	CONTROLLED TPY COKE	CONTROLLED TPY COAL	CONTROLLED TPY SULFUR
COMPANY 1	6	6	34	8	8	0.7625	10	365	0.5/1	80	95		0.0711	0.9322		0.00355	0.93225	
COMPANY 3	6		34	8		4.575		365	0.5/1	80	95		0.4265			0.02133		
COMPANY 5	6		34	8		0		365	0.5/1	80	95		0			0		
COMPANY 18	6		34	8		6.1		365	0.5/1	80	95		0.5687			0.02843		
COMPANY 6	6	6	34	8	8	0.7625	0	365	0.5/1	80	95	99	0.0711	0		0.00355	0	
COMPANY 10	6		34	8		0		365	0.5/1	80	95		0			0		
COMPANY 4	6		34	8	8	0	2	365	0.5/1	80	95		0.1664			0.00932		
COMPANY 11	6		34	8		0		365	0.5/1	80	95		0			0		
COMPANY 12	6		34	8		0		365	0.5/1	80	95		0			0		
COMPANY 13	6		34	8		0		365	0.5/1	80	95		0			0		
COMPANY 14	6		34	8	8	0	0	365	0.5/1	80	95	99	0			0		
COMPANY 7	6		34	8	8	0	4.6	365	0.5/1	80	95		0.4288			0.02144		
COMPANY 2	6		34	8		0.91		365	0.5/1	80	95		0.0648			0.00424		
COMPANY 15	6		34	8		0		365	0.5/1	80	95				0			0
COMPANY 9	6		34	8		2.2875		365	0.5/1	80	95				1.066257			1.06626
COMPANY 16	6		34	8		0.1		365	0.5/1	80	95		0.0466			0.00233		
COMPANY 17	6		34	8		0.1		365	0.5/1	80	95		0.0466			0.00233		
COMPANY 8	6		34	8	8	0	1	365	0.5/1	80	95		0	0.4661		0	0.09322	
												(SUB TOTAL)	*1.93*	*1.40*	*1.07*	*0.10*	*1.03*	*1.07*
												TOTAL	34.71	7.33	2.60	0.94	6.82	2.60

PILE MATERIAL TRANSFER ASSUMPTIONS

FACILITY	MOISTURE %	MOISTURE %	WIND MPH	WIND MPH	THRUPUT TPY	THRUPUT TPY	TRANSFER NO.	TRANSFER NO.	PM10/PM FACTOR		BASELINE TPY COKE	BASELINE TPY COAL	BASELINE TPY SULFUR		CONTROLLED TPY COKE	CONTROLLED TPY COAL	CONTROLLED TPY SULFUR
COMPANY 1	4	4	6	6	2500000	4400000	3	3	0.35/0.74		0.813593	3.9052449			0.02219	3.90524	
COMPANY 3	4		6		161000		3		0.35/0.74		0.160648				0.00161		
COMPANY 5	4		6		950000		3		0.35/0.74		0.042159				0.00843		
COMPANY 18	4		6		100000		3		0.35/0.74		0.088756				0.00089		
COMPANY 6	4	4	6	6	2000000	1600000	3	3	0.35/0.74		1.775111	0.0665667			0.01775	0.06657	
COMPANY 10	8		6		900000		3		0.35/0.74		0.015134				0.00303		
COMPANY 4	8	4	6	6	2000000	200000	3	0	0.35/0.74		0.033632				0.00673		
COMPANY 11	8		6		850000		3		0.35/0.74		0.014294				0.00286		
COMPANY 12	8		6		1131500		3		0.35/0.74		0.019027				0.00381		
COMPANY 13	8		6		547500		3		0.35/0.74		0.009207				0.00184		
COMPANY 14	0.5	4	6	6	450000	630000	3	3	0.35/0.74		0.031628				0.00926		
COMPANY 7	4	4	6	6	750000	750000	3	3	0.35/0.74		0.69895				0.01331		
COMPANY 2	4		6		500000		3		0.35/0.74		0.443778				0.00444		
COMPANY 15	2.5		6		370000		3		0.35/0.74				0.0317				0.0317
COMPANY 9	2.5		6		200000		3		0.35/0.74				0.3428				0.3428
COMPANY 16	4		6		8820		2		0.35/0.74		0.005811				0.00029		
COMPANY 17	4		6		8820		2		0.35/0.74		0.005811				0.00029		
COMPANY 8	4	4	6	6	26000	53000	2	2	0.35/0.74		0.000769	0.0349105			0.00077	0.00698	
										(SUB TOTAL)	*4.16*	*4.01*	*0.37*		*0.10*	*3.98*	*0.37*
										TOTAL	34.71	7.33	2.60	0	0.94	6.82	2.60

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PILE ENDLOADER ASSUMPTIONS

METHODOLOGY

FACILITY	SILT %	SILT %	VEHICLE SPEED MPH		VEHICLE WEIGHT TON	VEHICLE WEIGHT TON	RAIN >0.01 INCH DAYS	ANNUAL MILES	ANNUAL MILES	NO. WHEELS	PM10/PM FACTOR	BASELINE TPY COKE	BASELINE TPY COAL	BASELINE TPY SULFUR	CONTROLLED TPY COKE	CONTROLLED TPY COAL	CONTROLLED TPY SULFUR
COMPANY 1	12	6	4.3	1.2	36	128	34	27352	8068	4	0.36/0.8	8.18712	1.7662		0.223285	1.768	
COMPANY 3	12		4.3		18		34	1980		4	0.36/0.8	0.95803			0.00958		
COMPANY 5	12		4.3		18		34	0		4	0.36/0.8	0			0		
COMPANY 18	12		4.3		18		34	1094		4	0.36/0.8	0.52933			0.005293		
COMPANY 6	12	6	4.3		18	18	34	21881	2758	4	0.36/0.8	10.5872	0.02778		0.105872	0.028	
COMPANY 10	12		4.3		18		34	9847		4	0.36/0.8	0.23822			0.047645		
COMPANY 4	12	12	4.3		18	18	34	21881	0	4	0.36/0.8	0.52936			0.105872		
COMPANY 11	12		4.3		18		34	9300		4	0.36/0.8	0.22499			0.044998		
COMPANY 12	12		4.3		18		34	12378		4	0.36/0.8	0.29948			0.059896		
COMPANY 13	12		4.3		18		34	5990		4	0.36/0.8	0.14491			0.028983		
COMPANY 14	12	12	4.3		18	18	34	0	0	4	0.36/0.8	0			0		
COMPANY 7	12	12	4.3		18	18	34	8205	8205	4	0.36/0.8	4.16851			0.0794		
COMPANY 2	12		4.3		18		34	5470		4	0.36/0.8	2.64667			0.026467		
COMPANY 15	12		4.3		18		34	4048		4	0.36/0.8			0.0979			0.09793
COMPANY 9	12		4.3		18		34	2188		4	0.36/0.8			1.0567			1.05867
COMPANY 16	12		4.3		18		34	107		4	0.36/0.8	0.05177			0.002589		
COMPANY 17	12		4.3		18		34	107		4	0.36/0.8	0.05177			0.002589		
COMPANY 8	12	6	4.3		18	104.3	34	0	188	4	0.36/0.8	0	0.12827		0	0.028	
											(SUB TOTAL)	*28.62*	*1.02*	*1.16*	*0.74*	*1.82*	*1.16*
											TOTAL	34.71	7.33	2.60	0.94	8.82	2.60

CONVEYOR MATERIAL TRANSFER ASSUMPTIONS

FACILITY	WIND MPH	WIND MPH	MOISTURE %	MOISTURE %	TRANSFER NO.	TRANSFER NO.	THRUPUT TPY	THRUPUT TPY	PM10/PM FACTOR	BASELINE TPY COKE	BASELINE TPY COAL	BASELINE TPY SULFUR	CONTROLLED TPY COKE	CONTROLLED TPY COAL	CONTROLLED TPY SULFUR
COMPANY 1	6	6	6.9	6.6	20	20	2500000	4400000	0.35/0.74	0.049282	0.0891646		0.04828	0.06916	
COMPANY 3	6		6		0		181000		0.35/0.74	0			0		
COMPANY 5	6		6		10		950000		0.35/0.74	0.015932			0.01693		
COMPANY 18	6		6		0		100000		0.35/0.74	0			0		
COMPANY 6	6	6	6	6	5	5	2000000	1600000	0.35/0.74	1.677052	1.2577691		0.01677	0.01258	
COMPANY 10	6		12		6		900000		0.35/0.74	0.017168			0.00343		
COMPANY 4	6		12		8		2000000		0.35/0.74	0.635484			0.00635		
COMPANY 11	6		12		5		650000		0.35/0.74	0.270081			0.0027		
COMPANY 12	6		12		6		1131600		0.35/0.74	0.359525			0.0036		
COMPANY 13	6		12		3		547600		0.35/0.74	0.104376			0.00104		
COMPANY 14	6	6	0.5	6	10	4	450000	630000	0.35/0.74	0.567308			0.24891		
COMPANY 7	6		12		4		1600000		0.35/0.74	0.38129			0.00381		
COMMPANY 2	6		6		4		500000		0.35/0.74	0.33541			0.00335		
COMPANY 15	6		12		0		370000		0.35/0.74			0			0
COMPANY 9	6		12		0		200000		0.35/0.74			0			0
COMPANY 8	6		6		2		85000		0.35/0.74	0.008719	0.0197986		0.00872	0.0198	
									TOTAL	4.82	1.37	0.00	0.36	0.12	0.00

AILCAR LOADING/UNLOADING ASSUMPTIONS

FACILITY	WIND MPH	WIND MPH	WIND MPH RAIL	MOISTUR %	MOISTUR %	MOISTURE % RAIL	TRUCKS PER DA	TRUCKS PER DAY	RAILS PER DAY	THRUP TON	THRUPUT TON	THRUPUT TON	OPERATING DAYS	PM10/PM FACTOR	WATER EFFICIENCY	ENCLOSURE EFFICIENCY	BASELINE TPY COKE	BASELINE TPY COAL	BASELINE TPY SULFUR	CONTROLLED TPY COKE	CONTROLLED TPY COAL	CONTROLLED TPY SULFUR
COMPANY 1	6	N/A	6	6	N/A	6	274	N/A	120	25	N/A	100	365	0.35/0.74	80	95	0.020965	0.007		0.00419	0.01	
COMPANY 3	6			4			40			25			365	0.35/0.74	80	95	0.061212			0.03091		
COMPANY 5	6			6			104			25			365	0.35/0.74	80	95	0.007958			0.00159		
COMPANY 18	6			5			22			25			366	0.35/0.74	60	95	0.033667			0.017		
COMPANY 6	6	N/A	6	6	N/A	6	219	N/A	41	25	N/A	100	365	0.35/0.74	80	95	0.016767	0.003		0.00335	0	
COMPANY 10	6			12			99			25			365	0.35/0.74	80	95	0.00287			0.00287		
COMPANY 4	6			12			219			25			365	0.35/0.74	80	95	0.126394			0.00635		
COMPANY 11	6			12			93			24			365	0.35/0.74	80	95	0.002696			0.0027		
COMPANY 12	6			12			110			25			366	0.35/0.74	80	95	0.003169			0.00319		
COMPANY 13	6			12			60			25			365	0.35/0.74	80	95	0.000348			0.00035		
COMPANY 14	0	6	6	0.5	6	0.8	49	69	2	25	26	90	365	0.35/0.74	80	95	0.130414			0.1228		
COMPANY 7	6			9			164			25			365	0.35/0.74	60	95	0.142264			0.14229		
COMPANY 2	6			6			65			25			365	0.35/0.74	80	95	0.004208			0.00084		
COMPANY 15	6			2.5			41			25			365	0.35/0.74	80	95			0.21373			0.21373
COMPANY 9	6			2.5			22			25			365	0.35/0.74	80	95			0.11468			0.11468
COMPANY 16	6			4			3			9			365	0.35/0.74	60	95	0.002916			0.00292		
COMPANY 17	6			4			3			8			365	0.35/0.74	60	95	0.002916			0.00292		
COMPANY 8	6	5		4	4		3		2	25	100		365	0.35/0.74	60	95	0.008099	0.022		0.0081	0.02	
																TOTAL	0.57	0.03	0.33	0.38	0.03	0.33

TRANSPORT ASSUMPTIONS

FACILITY	MOISTURE %	WIND SPEED MPH	HEIGHT FEET	ROUGHNESS CM	THRESHOLD VELOCITY MPH	SURFACE AREA SQ. FT.	DISTURBANCE FREQUENCY	NO. TRUCKS PER YEAR	PM10/PM FACTOR	CONTROL EFF	BASELINE TPY COKE	BASELINE TPY COAL	BASELINE TPY SULFUR	CONTROLLED TPY COKE	CONTROLLED TPY COAL	CONTROLLED TPY SULFUR
COMPANY 1	6	60	1	0.3	1.61	129	0	0	0.5/1	50	0	0		0	0	
COMPANY 3	6	60	1	0.3	1.61	258	1	7240	0.5/1	96.5	3.8807			0.13582		
COMPANY 5	6	60	1	0.3	1.61	258	0	0	0.5/1	96.5	0			0		
COMPANY 18	6	60	1	0.3	1.61	258	1	4000	0.5/1	96.6	2.144			0.07504		
COMPANY 6	6	60	1	0.3	1.61	256	0	0	0.5/1	96.5	0	0		0	0	
COMPANY 10	12	60	1	0.3	1.61	259	1	35000	0.5/1	96.6	7.3118			0.25591		
COMPANY 4	12	60	1	0.3	1.61	258	1	80000	0.5/1	96.5	16.249			0.5687		
COMPANY 11	12	60	1	0.3	1.61	258	1	34000	0.5/1	96.5	6.9056			0.2417		
COMPANY 12	12	60	1	0.3	1.51	129	1	40000	0.5/1	50	2.0311			2.03107		
COMPANY 13	12	60	1	0.3	1.61	129	1	21900	0.5/1	96.6	2.224			0.07784		
COMPANY 14	0.6	45	1	0.3	1.51	18	1	15400	0.5/1	50	4.2538			4.25375		
COMPANY 7	9	48	1	0.3	1.61	258	1	60000	0.5/1	96.6	8.3061			0.29071		
COMPANY 2	6	60	1	0.3	1.61	258	0	0	0.5/1	96.5	0			0		
COMPANY 15	6	60	3	0.3	2.98	258	1	14800	0.5/1	0			1.291			1.29
COMPANY 9	6	60	3	0.3	2.98	258	1	8000	0.5/1	0			0.698			0.7
COMPANY 16	3	60	1	0.3	1.61	129	0	0	0.5/1	0	0			0		
COMPANY 17	3	60	1	0.3	1.61	129	0	0	0.5/1	0	0			0		
COMPANY 8	3	60	1	0.3	1.61	258	0	0	0.5/1	0	0			0		
										TOTAL	83.31	0.00	1.99	7.93	0.00	1.99

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METHODOLOGY

TRACKOUT INSIDE ASSUMPTIONS

FACILITY	SILT LOADING G/M^2	SILT LOADING G/M^2	WEIGHT MT	SILT %	MOISTURE %	DISTANCE MILES/TRUCK	NO. TRUCKS PER DAY	OPERATING DAYS	PM10/PM FACTOR	BASELINE TPY		CONTROLLED TPY	
COMPANY 1	2.1	0.25	24	N/A	N/A	0.25	274	365	0.016/0.082	4.6718		1.1714	
COMPANY 3	N/A	0.25	24	12	4	0.25	20	365	0.016/0.082	2.2189		0.0855	
COMPANY 5	2.1	0.25	24	N/A	N/A	0.25	104	365	0.016/0.082	1.7732		0.4446	
COMPANY 18	2.1	0.25	24	N/A	N/A	0.25	11	365	0.016/0.082	0.1876		0.047	
COMPANY 6	2.1	0.25	24	N/A	N/A	0.25	219	365	0.016/0.082	3.734		0.9363	
COMPANY 10	2.1	0.25	24	N/A	N/A	0.25	99	365	0.016/0.082	1.688		0.4232	
COMPANY 4	2.1	0.25	24	N/A	N/A	0.25	219	365	0.016/0.082	3.734		0.9363	
COMPANY 11	2.1	0.25	24	N/A	N/A	0.25	93	365	0.016/0.082	1.5857		0.3976	
COMPANY 12	2.1	0.25	24	N/A	N/A	0.25	110	365	0.016/0.082	1.8755		0.4703	
COMPANY 13	2.1	0.25	24	N/A	N/A	0.25	60	365	0.016/0.082	1.023		0.2565	
COMPANY 14	2.1	0.25	24	N/A	N/A	0.25	118	365	0.016/0.082	2.0119		0.5045	
COMPANY 7	N/A	0.25	24	12	4	0.25	164	365	0.016/0.082	10.196		0.7011	
COMPANY 2	2.1	0.25	24	N/A	N/A	0.25	55	365	0.016/0.082	0.9378		0.2351	
COMPANY 15	2.1	0.25	24	N/A	N/A	0.25	41	365	0.016/0.082		0.66906		0.1763
COMPANY 9	2.1	0.25	24	N/A	N/A	0.25	22	365	0.016/0.082		0.37511		0.0941
COMPANY 16	2.1	0.45	15	N/A	N/A	0.25	3	365	0.016/0.082	0.0253		0.0093	
COMPANY 17	2.1	0.45	15	N/A	N/A	0.25	3	365	0.016/0.082	0.0253		0.0093	
COMPANY 8	2.1	0.45	24	N/A	N/A	0.25	3	365	0.016/0.082	0.0512		0.0185	
									TOTAL	43.74	1.07	6.65	0.27

TRACKOUT OUTSIDE ASSUMPTIONS

FACILITY	SILT LOADING G/M^2	SILT LOADING G/M^2	WEIGHT MT	DISTANCE MILES/TRUCK	NO. VEHICLES YEAR	PM10/PM FACTOR LB/VMT	BASELINE TPY		CONTROLLED TPY	
COMPANY 1	0.45	0.05	13	0.25	1551250	0.016/0.082	10.61382		2.6445	
COMPANY 3	0.45	0.05	13	0.25	1551250	0.016/0.082	10.61362		2.5448	
COMPANY 5	0.45	0.05	13	0.25	1223760	0.016/0.082	8.366031		2.0057	
COMPANY 18	0.45	0.05	13	0.25	1551250	0.016/0.082	10.61362		2.6445	
COMPANY 6	0.45	0.05	13	0.25	2460465	0.016/0.082	16.83445		4.0359	
COMPANY 10	0.45	0.05	3.1	0.25	4380000	0.016/0.082	3.481662		0.0366	
COMPANY 4	0.45	0.05	3.1	0.25	16972500	0.016/0.082	13.52244		3.2419	
COMPANY 11	0.45	0.05	4.398	0.25	16972500	0.016/0.082	22.85046		5.4782	
COMPANY 12	0.45	0.05	2.55	0.25	16972500	0.016/0.082	10.08841		2.4186	
COMPANY 13	0.45	0.05	3.1	0.25	12045000	0.016/0.082	9.596571		2.3007	
COMPANY 14	0.45	0.05	3.1	0.25	12045000	0.016/0.082	9.596571		2.3007	
COMPANY 7	0.45	0.05	3.1	0.25	4927500	0.016/0.082	3.92587		0.9412	
COMPANY 2	0.45	0.05	13	0.25	2460465	0.016/0.082	16.83445		4.0359	
COMPANY 15	0.45	0.05	3.1	0.25	12045000	0.016/0.082		9.596571		2.3007
COMPANY 9	0.45	0.05	4.398	0.25	12045000	0.016/0.082		16.21547		3.8876
						TOTAL	146.95	25.81	35.23	6.19

WATER TRUCK ASSUMPTIONS

FACILITY	SILT %	SILT LOADING g/sq. meter	WEIGHT TONS	MOISTURE %	DISTANCE VMT		BASELINE TPY	CONTROLLED TPY
COMPANY 1	N/A	2.1	16.5	N/A	4517		0.51307838	0
COMPANY 3	12		16.5	4	4560		4.7724517	0
COMPANY 7	12		16.5	4	4585		4.79864662	0
						TOTAL	10.08	0.00

13.2.4 Aggregate Handling And Storage Piles

13.2.4.1 General

Inherent in operations that use minerals in aggregate form is the maintenance of outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage.

Dust emissions occur at several points in the storage cycle, such as material loading onto the pile, disturbances by strong wind currents, and loadout from the pile. The movement of trucks and loading equipment in the storage pile area is also a substantial source of dust.

13.2.4.2 Emissions And Correction Parameters

The quantity of dust emissions from aggregate storage operations varies with the volume of aggregate passing through the storage cycle. Emissions also depend on 3 parameters of the condition of a particular storage pile: age of the pile, moisture content, and proportion of aggregate fines.

When freshly processed aggregate is loaded onto a storage pile, the potential for dust emissions is at a maximum. Fines are easily disaggregated and released to the atmosphere upon exposure to air currents, either from aggregate transfer itself or from high winds. As the aggregate pile weathers, however, potential for dust emissions is greatly reduced. Moisture causes aggregation and cementation of fines to the surfaces of larger particles. Any significant rainfall soaks the interior of the pile, and then the drying process is very slow.

Silt (particles equal to or less than 75 micrometers [µm] in diameter) content is determined by measuring the portion of dry aggregate material that passes through a 200-mesh screen, using ASTM-C-136 method.[1] Table 13.2.4-1 summarizes measured silt and moisture values for industrial aggregate materials.

Table 13.2.4-1. TYPICAL SILT AND MOISTURE CONTENTS OF MATERIALS AT VARIOUS INDUSTRIES[a]

Industry	No. Of Facilities	Material	Silt Content (%)			Moisture Content (%)		
			No. Of Samples	Range	Mean	No. Of Samples	Range	Mean
Iron and steel production	9	Pellet ore	13	1.3 - 13	4.3	11	0.64 - 4.0	2.2
		Lump ore	9	2.8 - 19	9.5	6	1.6 - 8.0	5.4
		Coal	12	2.0 - 7.7	4.6	11	2.8 - 11	4.8
		Slag	3	3.0 - 7.3	5.3	3	0.25 - 2.0	0.92
		Flue dust	3	2.7 - 23	13	1	—	7
		Coke breeze	2	4.4 - 5.4	4.9	2	6.4 - 9.2	7.8
		Blended ore	1	—	15	1	—	6.6
		Sinter	1	—	0.7	0	—	—
		Limestone	3	0.4 - 2.3	1.0	2	ND	0.2
Stone quarrying and processing	2	Crushed limestone	2	1.3 - 1.9	1.6	2	0.3 - 1.1	0.7
		Various limestone products	8	0.8 - 14	3.9	8	0.46 - 5.0	2.1
Taconite mining and processing	1	Pellets	9	2.2 - 5.4	3.4	7	0.05 - 2.0	0.9
		Tailings	2	ND	11	1	—	0.4
Western surface coal mining	4	Coal	15	3.4 - 16	6.2	7	2.8 - 20	6.9
		Overburden	15	3.8 - 15	7.5	0	—	—
		Exposed ground	3	5.1 - 21	15	3	0.8 - 6.4	3.4
Coal-fired power plant	1	Coal (as received)	60	0.6 - 4.8	2.2	59	2.7 - 7.4	4.5
Municipal solid waste landfills	4	Sand	1	—	2.6	1	—	7.4
		Slag	2	3.0 - 4.7	3.8	2	2.3 - 4.9	3.6
		Cover	5	5.0 - 16	9.0	5	8.9 - 16	12
		Clay/dirt mix	1	—	9.2	1	—	14
		Clay	2	4.5 - 7.4	6.0	2	8.9 - 11	10
		Fly ash	4	78 - 81	80	4	26 - 29	27
		Misc. fill materials	1	—	12	1	—	11

[a] References 1-10. ND = no data.

13.2.4.3 Predictive Emission Factor Equations

Total dust emissions from aggregate storage piles result from several distinct source activities within the storage cycle:

1. Loading of aggregate onto storage piles (batch or continuous drop operations).
2. Equipment traffic in storage area.
3. Wind erosion of pile surfaces and ground areas around piles.
4. Loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

Either adding aggregate material to a storage pile or removing it usually involves dropping the material onto a receiving surface. Truck dumping on the pile or loading out from the pile to a truck with a front-end loader are examples of batch drop operations. Adding material to the pile by a conveyor stacker is an example of a continuous drop operation.

The quantity of particulate emissions generated by either type of drop operation, per kilogram (kg) (ton) of material transferred, may be estimated, with a rating of A, using the following empirical expression:[11]

$$E = k(0.0016)\ \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\ \text{(kg/megagram [Mg])}$$

$$E = k(0.0032)\ \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\ \text{(pound [lb]/ton)} \qquad (1)$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 μm	< 15 μm	< 10 μm	< 5 μm	< 2.5 μm
0.74	0.48	0.35	0.20	0.053[a]

[a] Multiplier for < 2.5 μm taken from Reference 14.

The equation retains the assigned quality rating if applied within the ranges of source conditions that were tested in developing the equation, as follows. Note that silt content is included, even though silt content does not appear as a correction parameter in the equation. While it is reasonable to expect that silt content and emission factors are interrelated, no significant correlation between the 2 was found during the derivation of the equation, probably because most tests with high silt contents were conducted under lower winds, and vice versa. It is recommended that estimates from the equation be reduced 1 quality rating level if the silt content used in a particular application falls outside the range given:

Ranges Of Source Conditions For Equation 1			
Silt Content (%)	Moisture Content (%)	Wind Speed	
		m/s	mph
0.44 - 19	0.25 - 4.8	0.6 - 6.7	1.3 - 15

To retain the quality rating of the equation when it is applied to a specific facility, reliable correction parameters must be determined for specific sources of interest. The field and laboratory procedures for aggregate sampling are given in Reference 3. In the event that site-specific values for correction parameters cannot be obtained, the appropriate mean from Table 13.2.4-1 may be used, but the quality rating of the equation is reduced by 1 letter.

For emissions from equipment traffic (trucks, front-end loaders, dozers, etc.) traveling between or on piles, it is recommended that the equations for vehicle traffic on unpaved surfaces be used (see Section 13.2.2). For vehicle travel between storage piles, the silt value(s) for the areas among the piles (which may differ from the silt values for the stored materials) should be used.

Worst-case emissions from storage pile areas occur under dry, windy conditions. Worst-case emissions from materials-handling operations may be calculated by substituting into the equation appropriate values for aggregate material moisture content and for anticipated wind speeds during the worst case averaging period, usually 24 hours. The treatment of dry conditions for Section 13.2.2, vehicle traffic, "Unpaved Roads", follows the methodology described in that section centering on parameter p. A separate set of nonclimatic correction parameters and source extent values corresponding to higher than normal storage pile activity also may be justified for the worst-case averaging period.

13.2.4.4 Controls[12-13]

Watering and the use of chemical wetting agents are the principal means for control of aggregate storage pile emissions. Enclosure or covering of inactive piles to reduce wind erosion can also reduce emissions. Watering is useful mainly to reduce emissions from vehicle traffic in the storage pile area. Watering of the storage piles themselves typically has only a very temporary slight effect on total emissions. A much more effective technique is to apply chemical agents (such as surfactants) that permit more extensive wetting. Continuous chemical treating of material loaded onto piles, coupled with watering or treatment of roadways, can reduce total particulate emissions from aggregate storage operations by up to 90 percent.[12]

References For Section 13.2.4

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13.2.1 Paved Roads

13.2.1.1 General

Particulate emissions occur whenever vehicles travel over a paved surface such as a road or parking lot. Particulate emissions from paved roads are due to direct emissions from vehicles in the form of exhaust, brake wear and tire wear emissions and resuspension of loose material on the road surface. In general terms, resuspended particulate emissions from paved roads originate from, and result in the depletion of, the loose material present on the surface (i.e., the surface loading). In turn, that surface loading is continuously replenished by other sources. At industrial sites, surface loading is replenished by spillage of material and trackout from unpaved roads and staging areas. Figure 13.2.1-1 illustrates several transfer processes occurring on public streets.

Various field studies have found that public streets and highways, as well as roadways at industrial facilities, can be major sources of the atmospheric particulate matter within an area.[1-9] Of particular interest in many parts of the United States are the increased levels of emissions from public paved roads when the equilibrium between deposition and removal processes is upset. This situation can occur for various reasons, including application of granular materials for snow and ice control, mud/dirt carryout from construction activities in the area, and deposition from wind and/or water erosion of surrounding unstabilized areas. In the absence of continuous addition of fresh material (through localized track out or application of antiskid material), paved road surface loading should reach an equilibrium value in which the amount of material resuspended matches the amount replenished. The equilibrium surface loading value depends upon numerous factors. It is believed that the most important factors are: mean speed of vehicles traveling the road; the average daily traffic (ADT); the number of lanes and ADT per lane; the fraction of heavy vehicles (buses and trucks); and the presence/absence of curbs, storm sewers and parking lanes.[10]

The particulate emission factors presented in a previous version of this section of AP-42, dated October 2002, implicitly included the emissions from vehicles in the form of exhaust, brake wear, and tire wear as well as resuspended road surface material. EPA included these sources in the emission factor equation for paved roads since the field testing data used to develop the equation included both the direct emissions from vehicles and emissions from resuspension of road dust.

This version of the paved road emission factor equation only estimates particulate emissions from resuspended road surface material[28]. The particulate emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOVES[29] model. This approach eliminates the possibility of double counting emissions. Double counting results when employing the previous version of the emission factor equation in this section and MOVES to estimate particulate emissions from vehicle traffic on paved roads. It also incorporates the decrease in exhaust emissions that has occurred since the paved road emission factor equation was developed. Earlier versions of the paved road emission factor equation includes estimates of emissions from exhaust, brake wear, and tire wear based on emission rates for vehicles in the 1980 calendar year fleet. The amount of PM released from vehicle exhaust has decreased since 1980 due to lower new vehicle emission standards and changes in fuel characteristics.

13.2.1.2 Emissions And Correction Parameters

Dust emissions from paved roads have been found to vary with what is termed the "silt loading" present on the road surface. In addition, the average weight and speed of vehicles traveling the road influence road dust emissions. The term silt loading (sL) refers to the mass of silt-size material (equal to or less than 75 micrometers [μm] in physical diameter) per unit area of the travel surface. The total road surface dust loading consists of loose material that can be collected by broom sweeping and vacuuming of the traveled portion of the paved road. The silt fraction is determined by measuring the proportion of the loose dry surface dust that passes through a 200-mesh screen, using the ASTM-C-136 method. Silt loading is the product of the silt fraction and the total loading, and is abbreviated "sL". Additional details on the sampling and analysis of such material are provided in AP-42 Appendices C.1 and C.2.

The surface sL provides a reasonable means of characterizing seasonal variability in a paved road emission inventory. In many areas of the country, road surface loadings [11-21] are heaviest during the late winter and early spring months when the residual loading from snow/ice controls is greatest. As noted earlier, once replenishment of fresh material is eliminated, the road surface loading can be expected to reach an equilibrium value, which is substantially lower than the late winter/early spring values.

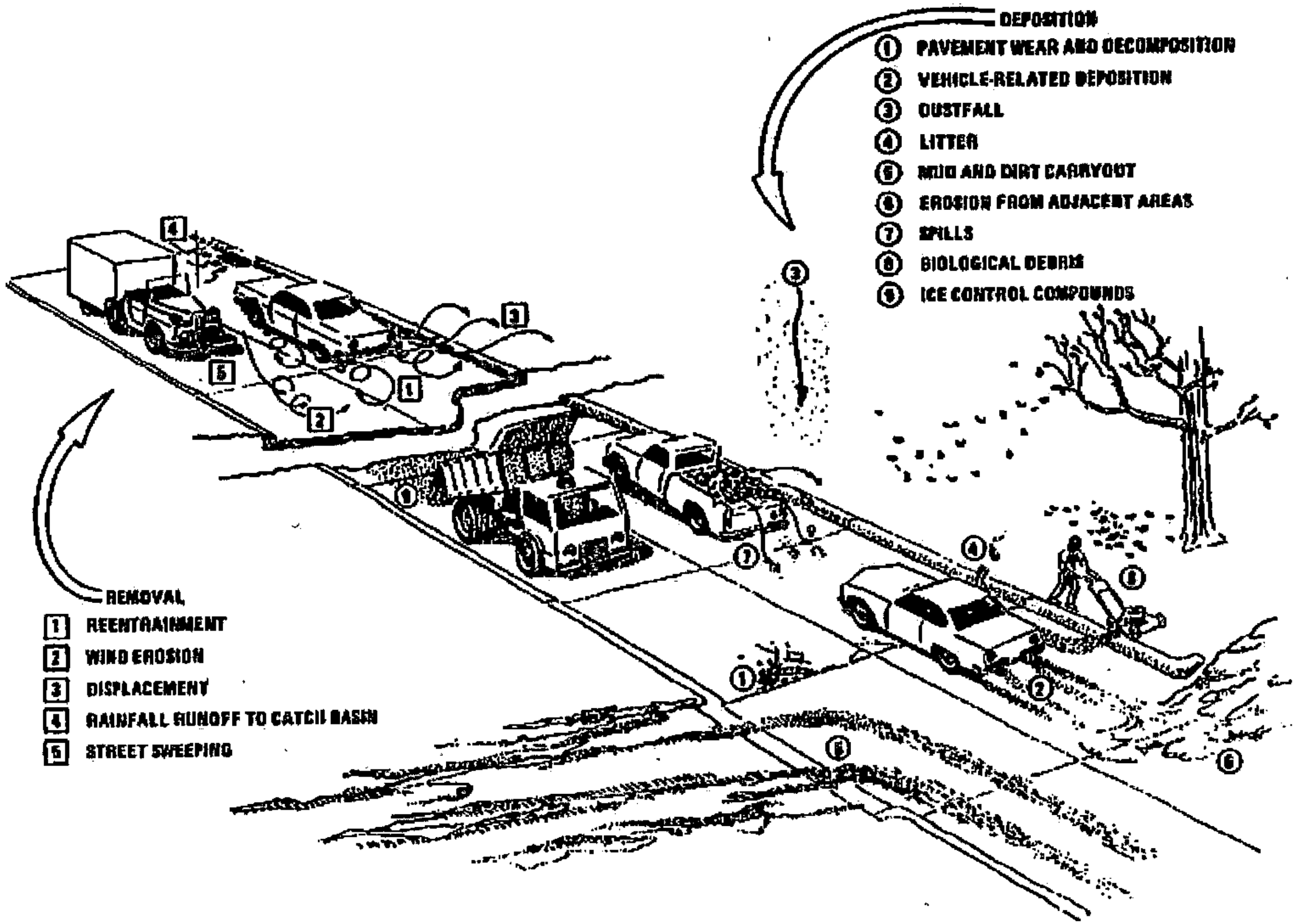

Figure 13.2.1-1. Deposition and removal processes.

13.2.1.3 Predictive Emission Factor Equations[10,29]

The quantity of particulate emissions from resuspension of loose material on the road surface due to vehicle travel on a dry paved road may be estimated using the following empirical expression:

$$E = k\,(sL)^{0.91} \times (W)^{1.02} \qquad (1)$$

where:
- E = particulate emission factor (having units matching the units of k),
- k = particle size multiplier for particle size range and units of interest (see below),
- sL = road surface silt loading (grams per square meter) (g/m^2), and
- W = average weight (tons) of the vehicles traveling the road.

It is important to note that Equation 1 calls for the average weight of all vehicles traveling the road. For example, if 99 percent of traffic on the road are 2 ton cars/trucks while the remaining 1 percent consists of 20 ton trucks, then the mean weight "W" is 2.2 tons. More specifically, Equation 1 is *not* intended to be used to calculate a separate emission factor for each vehicle weight class. Instead, only one emission factor should be calculated to represent the "fleet" average weight of all vehicles traveling the road.

The particle size multiplier (k) above varies with aerodynamic size range as shown in Table 13.2.1-1. To determine particulate emissions for a specific particle size range, use the appropriate value of k shown in Table 13.2.1-1.

To obtain the total emissions factor, the emissions factors for the exhaust, brake wear and tire wear obtained from either EPA's MOBILE6.2 [27] or most recent MOVES [29] software model should be added to the emissions factor calculated from the empirical equation.

Table 13.2.1-1. PARTICLE SIZE MULTIPLIERS FOR PAVED ROAD EQUATION

Size range[a]	Particle Size Multiplier k[b]		
	g/VKT	g/VMT	lb/VMT
PM-2.5[c]	0.15	0.25	0.00054
PM-10	0.62	1.00	0.0022
PM-15	0.77	1.23	0.0027
PM-30[d]	3.23	5.24	0.011

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.

[b] Units shown are grams per vehicle kilometer traveled (g/VKT), grams per vehicle mile traveled (g/VMT), and pounds per vehicle mile traveled (lb/VMT). The multiplier k includes unit conversions to produce emission factors in the units shown for the indicated size range from the mixed units required in Equation 1.

[c] The k-factors for $PM_{2.5}$ were based on the average $PM_{2.5}$:PM_{10} ratio of test runs in Reference 30.

[d] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

Equation 1 is based on a regression analysis of 83 tests for PM-10.[3, 5-6, 8, 27-29, 31-36] Sources tested include public paved roads, as well as controlled and uncontrolled industrial paved roads. The majority of tests involved freely flowing vehicles traveling at constant speed on relatively level roads. However, 22 tests of slow moving or "stop-and-go" traffic or vehicles under load were available for inclusion in the data base.[32-36] Engine exhaust, tire wear and break wear were subtracted from the emissions measured in the test programs prior to stepwise regression to determine Equation 1.[37, 39] The equations retain the quality rating of A (D for PM-2.5), if applied within the range of source conditions that were tested in developing the equation as follows:

Silt loading:	0.03 - 400 g/m^2 0.04 - 570 grains/square foot (ft^2)
Mean vehicle weight:	1.8 - 38 megagrams (Mg) 2.0 - 42 tons
Mean vehicle speed:	1 - 88 kilometers per hour (kph) 1 - 55 miles per hour (mph)

The upper and lower 95% confidence levels of equation 1 for PM_{10} is best described with equations using an exponents of 1.14 and 0.677 for silt loading and an exponents of 1.19 and 0.85 for weight. Users are cautioned that application of equation 1 outside of the range of variables and operating conditions specified above, e.g., application to roadways or road networks with speeds above 55 mph and average vehicle weights of 42 tons, will result in emission estimates with a higher level of uncertainty. In these situations, users are encouraged to consider an assessment of the impacts of the influence of extrapolation to the overall emissions and alternative methods that are equally or more plausible in light of local emissions data and/or ambient concentration or compositional data.

To retain the quality rating for the emission factor equation when it is applied to a specific paved road, it is necessary that reliable correction parameter values for the specific road in question be determined. With the exception of limited access roadways, which are difficult to sample, the collection and use of site-specific silt loading (sL) data for public paved road emission inventories are strongly recommended. The field and laboratory procedures for determining surface material silt content and surface dust loading are summarized in Appendices C.1 and C.2. In the event that site-specific values cannot be obtained, an appropriate value for a paved public road may be selected from the values in Table 13.2.1-2, but the quality rating of the equation should be reduced by 2 levels.

Equation 1 may be extrapolated to average uncontrolled conditions (but including natural mitigation) under the simplifying assumption that annual (or other long-term) average emissions are inversely proportional to the frequency of measurable (> 0.254 mm [0.01 inch]) precipitation by application of a precipitation correction term. The precipitation correction term can be applied on a daily or an hourly basis [26, 38].

For the daily basis, Equation 1 becomes:

$$E_{ext} = [\, k\, (sL)^{0.91} \times (W)^{1.02}\,]\, (1 - P/4N) \qquad (2)$$

where k, sL, W, and S are as defined in Equation 1 and

E_{ext} = annual or other long-term average emission factor in the same units as k,

P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period, and

N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly).

Note that the assumption leading to Equation 2 is based on analogy with the approach used to develop long-term average unpaved road emission factors in Section 13.2.2. However, Equation 2 above incorporates an additional factor of "4" in the denominator to account for the fact that paved roads dry more quickly than unpaved roads and that the precipitation may not occur over the complete 24-hour day.

For the hourly basis, equation 1 becomes:

$$E_{ext} = [\, k\, (sL)^{0.91} \times (W)^{1.02}\,]\,(1 - 1.2P/N) \qquad (3)$$

where k, sL, W, and S are as defined in Equation 1 and

E_{ext} = annual or other long-term average emission factor in the same units as k,

P = number of hours with at least 0.254 mm (0.01 in) of precipitation during the averaging period, and

N = number of hours in the averaging period (e.g., 8760 for annual, 2124 for season 720 for monthly)

Note: In the hourly moisture correction term (1-1.2P/N) for equation 3, the 1.2 multiplier is applied to account for the residual mitigative effect of moisture. For most applications, this equation will produce satisfactory results. Users should select a time interval to include sufficient "dry" hours such that a reasonable emissions averaging period is evaluated. For the special case where this equation is used to calculate emissions on an hour by hour basis, such as would be done in some emissions modeling situations, the moisture correction term should be modified so that the moisture correction "credit" is applied to the first hours following cessation of precipitation. In this special case, it is suggested that this 20% "credit" be applied on a basis of one hour credit for each hour of precipitation up to a maximum of 12 hours.

Note that the assumption leading to Equation 3 is based on analogy with the approach used to develop long-term average unpaved road emission factors in Section 13.2.2.

Figure 13.2.1-2 presents the geographical distribution of "wet" days on an annual basis for the United States. Maps showing this information on a monthly basis are available in the *Climatic Atlas of the United States*[23]. Alternative sources include other Department of Commerce publications (such as local climatological data summaries). The National Climatic Data Center (NCDC) offers several products that provide hourly precipitation data. In particular, NCDC offers *Solar and Meteorological Surface Observation Network 1961-1990* (SAMSON) CD-ROM, which contains 30 years worth of hourly meteorological data for first-order National Weather Service locations. Whatever meteorological data are used, the source of that data and the averaging period should be clearly specified.

It is emphasized that the simple assumption underlying Equations 2 and 3 has not been verified in any rigorous manner. For that reason, the quality ratings for Equations 2 and 3 should be downgraded one letter from the rating that would be applied to Equation 1.

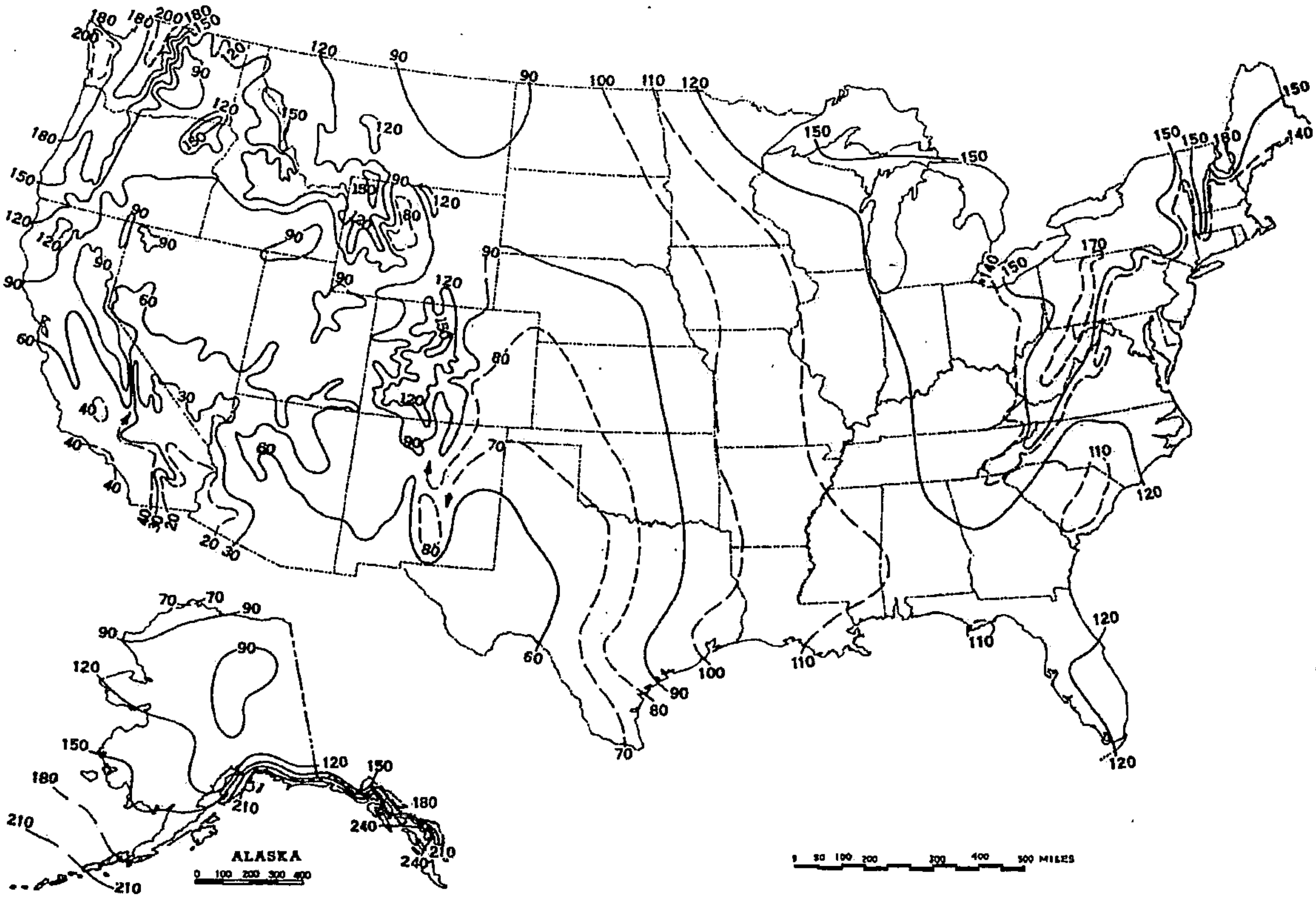

Figure 13.2.1-2. Mean number of days with 0.01 inch or more of precipitation in the United States.

Table 13.2.1-2 presents recommended default silt loadings for normal baseline conditions and for wintertime baseline conditions in areas that experience frozen precipitation with periodic application of antiskid material[24]. The winter baseline is represented as a multiple of the non-winter baseline, depending on the ADT value for the road in question. As shown, a multiplier of 4 is applied for low volume roads (< 500 ADT) to obtain a wintertime baseline silt loading of 4 X 0.6 = 2.4 g/m^2.

Table 13.2.1-2. Ubiquitous Silt Loading Default Values with Hot Spot Contributions from Anti-Skid Abrasives (g/m^2)

ADT Category	< 500	500-5,000	5,000-10,000	> 10,000
Ubiquitous Baseline g/m^2	0.6	0.2	0.06	0.03 0.015 limited access
Ubiquitous Winter Baseline Multiplier during months with frozen precipitation	X4	X3	X2	X1
Initial peak additive contribution from application of antiskid abrasive (g/m^2)	2	2	2	2
Days to return to baseline conditions (assume linear decay)	7	3	1	0.5

It is suggested that an additional (but temporary) silt loading contribution of 2 g/m^2 occurs with each application of antiskid abrasive for snow/ice control. This was determined based on a typical application rate of 500 lb per lane mile and an initial silt content of 1 % silt content. Ordinary rock salt and other chemical deicers add little to the silt loading, because most of the chemical dissolves during the snow/ice melting process.

To adjust the baseline silt loadings for mud/dirt trackout, the number of trackout points is required. It is recommended that in calculating PM_{10} emissions, six additional miles of road be added for each active trackout point from an active construction site, to the paved road mileage of the specified category within the county. In calculating $PM_{2.5}$ emissions, it is recommended that three additional miles of road be added for each trackout point from an active construction site.

It is suggested the number of trackout points for activities other than road and building construction areas be related to land use. For example, in rural farming areas, each mile of paved road would have a specified number of trackout points at intersections with unpaved roads. This value could be estimated from the unpaved road density (mi/sq. mi.).

The use of a default value from Table 13.2.1-2 should be expected to yield only an order-of-magnitude estimate of the emission factor. Public paved road silt loadings are dependent upon: traffic characteristics (speed, ADT, and fraction of heavy vehicles); road characteristics (curbs, number of lanes, parking lanes); local land use (agriculture, new residential construction) and regional/seasonal factors (snow/ice controls, wind blown dust). As a result, the collection and use of site-specific silt loading data is highly recommended. In the event that default silt loading values are used, the quality ratings for the equation should be downgraded 2 levels.

Limited access roadways pose severe logistical difficulties in terms of surface sampling, and few silt loading data are available for such roads. Nevertheless, the available data do not suggest great variation in silt loading for limited access roadways from one part of the country to another. For annual conditions, a default value of 0.015 g/m^2 is recommended for limited access roadways.[9,22] Even fewer of the available data correspond to worst-case situations, and elevated loadings are observed to be quickly depleted because of high traffic speeds and high ADT rates. A default value of 0.2 g/m^2 is recommended for short periods of time following application of snow/ice controls to limited access roads.[22]

The limited data on silt loading values for industrial roads have shown as much variability as public roads. Because of the variations of traffic conditions and the use of preventive mitigative controls, the data probably do not reflect the full extent of the potential variation in silt loading on industrial roads. However, the collection of site specific silt loading data from industrial roads is easier and safer than for public roads. Therefore, the collection and use of site-specific silt loading data is preferred and is highly recommended. In the event that site-specific values cannot be obtained, an appropriate value for an industrial road may be selected from the mean values given in Table 13.2.1-3, but the quality rating of the equation should be reduced by 2 levels.

The predictive accuracy of Equation 1 requires thorough on-site characterization of road silt loading. Road surface sampling is time-consuming and potentially hazardous because of the need to block traffic lanes. In addition, large number of samples is required to represent spatial and temporal variations across roadway networks. Mobile monitoring is a new alternative silt loading or road dust emission characterization method for either paved or unpaved roads. It utilizes a test vehicle that generates and monitors its own dust plume concentration (mass basis) at a fixed sampling probe location. A calibration factor is needed for each mobile monitoring configuration (test vehicle and sampling system), to convert the relative dust emission intensity to an equivalent silt loading or emission factor. Typically, portable continuous particle concentration monitors do not comply with Federal Reference Method (FRM) standards. Therefore, a controlled study must be performed to correlate the portable monitor response to the road silt loading or size specific particle concentration measured with an approved FRM sampling system. In the calibration tests, multiple test conditions should be performed to provide an average correlation with known precision and to accommodate variations in road silt loading, vehicle speed, road dust characteristics and other road conditions that may influence mobile monitoring measurements or emissions characteristics. Because the paved road dust emissions are also dependent on the average vehicle weight for the road segment, it is important that the weight of the test vehicle correspond closely to the average vehicle weight for the road segment or be adjusted using the average vehicle weight relationship in Equation 1. In summary, it is believed that the Mobile Monitoring Method will provide improved capabilities to provide reliable temporally and spatially resolved silt loading or emissions factors with increased coverage, improved safety, reduced traffic interference and decreased cost.[40,41,42]

Table 13.2.1-3 (Metric And English Units). TYPICAL SILT CONTENT AND LOADING VALUES FOR PAVED ROADS AT INDUSTRIAL FACILITIES [a]

Industry	No. of Sites	No. Of Samples	Silt Content (%)		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	9	48	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	9.7
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
Municipal solid waste landfill	2	7		-	2	-			1.1-32.0	7.4
Quarry	1	6		-	2	-			2.4-14	8.2
Corn wet mills	3	15		-	2	-			0.05 – 2.9	1.1

[a] References 1-2,5-6,11-13. Values represent samples collected from *industrial* roads. Public road silt loading values are presented in Table-13.2.1-2. Dashes indicate information not available.[b] Multiply entries by 1000 to obtain stated units; kilograms per kilometer (kg/km) and pounds per mile (lb/mi).

13.2.1.4 Controls[6,25]

Because of the importance of the silt loading, control techniques for paved roads attempt either to prevent material from being deposited onto the surface (preventive controls) or to remove from the travel lanes any material that has been deposited (mitigative controls). Covering of loads in trucks, and the paving of access areas to unpaved lots or construction sites, are examples of preventive measures. Examples of mitigative controls include vacuum sweeping, water flushing, and broom sweeping and flushing. Actual control efficiencies for any - of these techniques can be highly variable. Locally measured silt loadings before and after the application of controls is the preferred method to evaluate controls. It is particularly important to note that street sweeping of gutters and curb areas may actually increase the silt loading on the traveled portion of the road. Redistribution of loose material onto the travel lanes will actually produce a short-term increase in the emissions.

In general, preventive controls are usually more cost effective than mitigative controls. The cost-effectiveness of mitigative controls falls off dramatically as the size of an area to be treated increases. The cost-effectiveness of mitigative measures is also unfavorable if only a short period of time is required for the road to return to equilibrium silt loading condition. That is to say, the number and length of public roads within most areas of interest preclude any widespread and routine use of mitigative controls. On the other hand, because of the more limited scope of roads at an industrial site, mitigative measures may be used quite successfully (especially in situations where truck spillage occurs). Note, however, that public agencies could make effective use of mitigative controls to remove sand/salt from roads after the winter ends.

Because available controls will affect the silt loading, controlled emission factors may be obtained by substituting controlled silt loading values into the equation. (Emission factors from controlled industrial roads were used in the development of the equation.) The collection of surface loading samples from treated, as well as baseline (untreated), roads provides a means to track effectiveness of the controls over time. The use of Mobile Monitoring Methodologies provide an improved means to track progress in controlling silt loading values.

13.2.1.5 Changes since Fifth Edition

The following changes were made since the publication of the Fifth Edition of AP-42:

October 2002

1) The particle size multiplier for $PM_{2.5}$ was revised to 25% of PM_{10}. The approximately 55% reduction was a result of emission testing using FRM monitors. The monitoring was specifically intended to evaluate the PM-2.5 component of the emissions.

2) Default silt loading values were included in Table 13.2.1-2 replacing the Tables and Figures containing silt loading statistical information.

3) Editorial changes within the text were made indicating the possible causes of variations in the silt loading between roads within and among different locations. The uncertainty of using the default silt loading value was discussed.

4) Section 13.2.1.1 was revised to clarify the role of dust loading in resuspension. Additional minor text changes were made.

5) Equations 2 and 3, Figure 13.2.1-2, and text were added to incorporate natural mitigation into annual or other long-term average emission factors.

December 2003

1) The emission factor equation was adjusted to remove the component of particulate emissions- from exhaust, brake wear, and tire wear. A parameter C representing these emissions was included in the predictive equation. The parameter C varied with aerodynamic size range of the particulate matter. Table 13.2.1-2 was added to present the new coefficients.

2) The default silt loading values in Table 13.2.1-3 were revised to incorporate the results from a recent analysis of silt loading data.

November 2006

1) The $PM_{2.5}$ particle size multiplier was revised to 15% of PM_{10} as the result of wind tunnel studies of a variety of dust emitting surface materials.

2) References were rearranged and renumbered.

January 2011

1) The empirical predictive equation was revised. The revision is based upon stepwise regression of 83 profile emissions tests and an adjustment of individual test data for the exhaust; break wear and tire wear emissions prior to regression of the data.

2) The C term is removed from the empirical predictive equation and Table 13.2.1-2 with the C term values is removed since the exhaust; break wear and tire wear emissions were no longer part of the regressed data.

3) The $PM_{2.5}$ particle size multiplier was revised to 25% of PM_{10} since the PM_{10} test data used to develop the equation did not meet the necessary PM_{10} concentrations for a ratio of 15%.

4) The lower speed of the vehicle speed range supported by the empirical predictive equation was revised to 1 mph.

5) Information was added on an improved methodology to develop spatially and temporally resolved silt loadings or emissions factors by Mobile Monitoring Methodologies.

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13.2.5 Industrial Wind Erosion

13.2.5.1 General[1-3]

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 (m/s) (11 miles per hour [mph]) at 15 cm above the surface or 10 m/s (22 mph) at 7 m 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.

13.2.5.2 Emissions And Correction Parameters

If typical values for threshold wind speed at 15 cm are corrected to typical wind sensor height (7 - 10 m), 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 that 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 that 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 mph), 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:

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

where:

u = wind speed, cm/s
u^* = friction velocity, cm/s
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 13.2.5-1 for a roughness height of 0.1 cm.

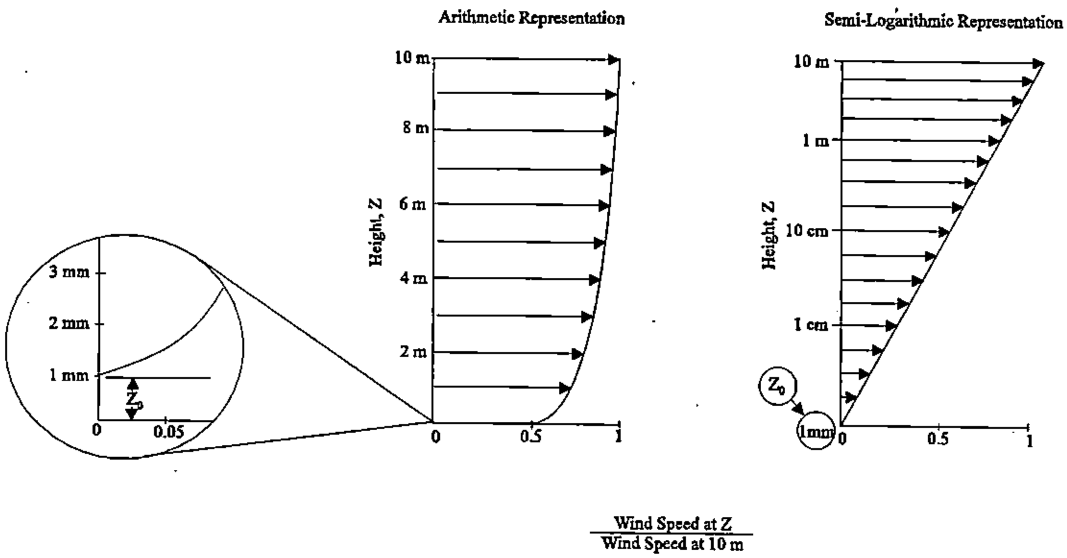


Figure 13.2.5-1. Illustration of logarithmic velocity profile.

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 that 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.

13.2.5.3 Predictive Emission Factor Equation[4]

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 (g/m^2) per year as follows:

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

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 ith 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 µm	<15 µm	<10 µm	<2.5 µm
1.0	0.6	0.5	0.075[a]

[a] Multiplier for < 2.5 um taken from Reference 11.

This distribution of particle size within the under 30 micrometer (µm) 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 13.2.4).

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.

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

$$P = 58\,(u^* - u_t^*)^2 + 25\,(u^* - u_t^*)$$
$$P = 0 \text{ for } u^* \le u_t^* \qquad (3)$$

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.

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, and 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 by 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 Table 13.2.5-1.

The results of the sieving can be interpreted using Table 13.2.5-1. Alternatively, the threshold friction velocity for erosion can be determined from the mode of the aggregate size distribution using the graphical relationship described by Gillette.[5-6] If the surface material contains nonerodible elements that are too large to include in the sieving (i. e., greater than about 1 cm in diameter), the effect of the elements must be taken into account by increasing the threshold friction velocity.[10]

Table 13.2.5-1 (Metric Units). FIELD PROCEDURE FOR DETERMINATION OF THRESHOLD FRICTION VELOCITY

Tyler Sieve No.	Opening (mm)	Midpoint (mm)	u_t^* (cm/s)
5	4		
9	2	3	100
16	1	1.5	76
32	0.5	0.75	58
60	0.25	0.375	43

Threshold friction velocities for several surface types have been determined by field measurements with a portable wind tunnel. These values are presented in Table 13.2.5-2.

Table 13.2.5-2 (Metric Units). THRESHOLD FRICTION VELOCITIES

Material	Threshold Friction Velocity (m/s)	Roughness Height (cm)	Threshold Wind Velocity At 10 m (m/s)	
			z_o = Act	z_o = 0.5 cm
Overburden[a]	1.02	0.3	21	19
Scoria (roadbed material)[a]	1.33	0.3	27	25
Ground coal (surrounding coal pile)[a]	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

[a] Western surface coal mine. Reference 2.
[b] Lightly crusted.
[c] Eastern power plant. Reference 3.

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-m reference height using Equation 1.

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

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

where:

u^* = friction velocity (m/s)

u_{10}^+ = fastest mile of reference anemometer for period between disturbances (m/s)

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.

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 2 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 13.2.5-2 corresponding to an actual pile height of 11 m, a reference (upwind) anemometer height of 10 m, and a pile surface roughness height (z_0) of 0.5 cm. The measured surface winds correspond to a height of 25 cm above the surface. The area fraction within each contour pair is specified in Table 13.2.5-3.

Table 13.2.5-3. SUBAREA DISTRIBUTION FOR REGIMES OF u_s/u_r [a]

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	NA	29	NA	NA
0.6a	48	26	29	28
0.6b	NA	24	22	26
0.9	12	14	15	14
1.1	NA	NA	3	4

[a] NA = not applicable.

The profiles of u_s/u_r in Figure 13.2.5-2 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:

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

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

2. Use the appropriate part of Figure 13.2.5-2 based on the pile shape and orientation to the fastest mile of wind, to obtain the corresponding surface wind speed distribution (u_s^+)

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

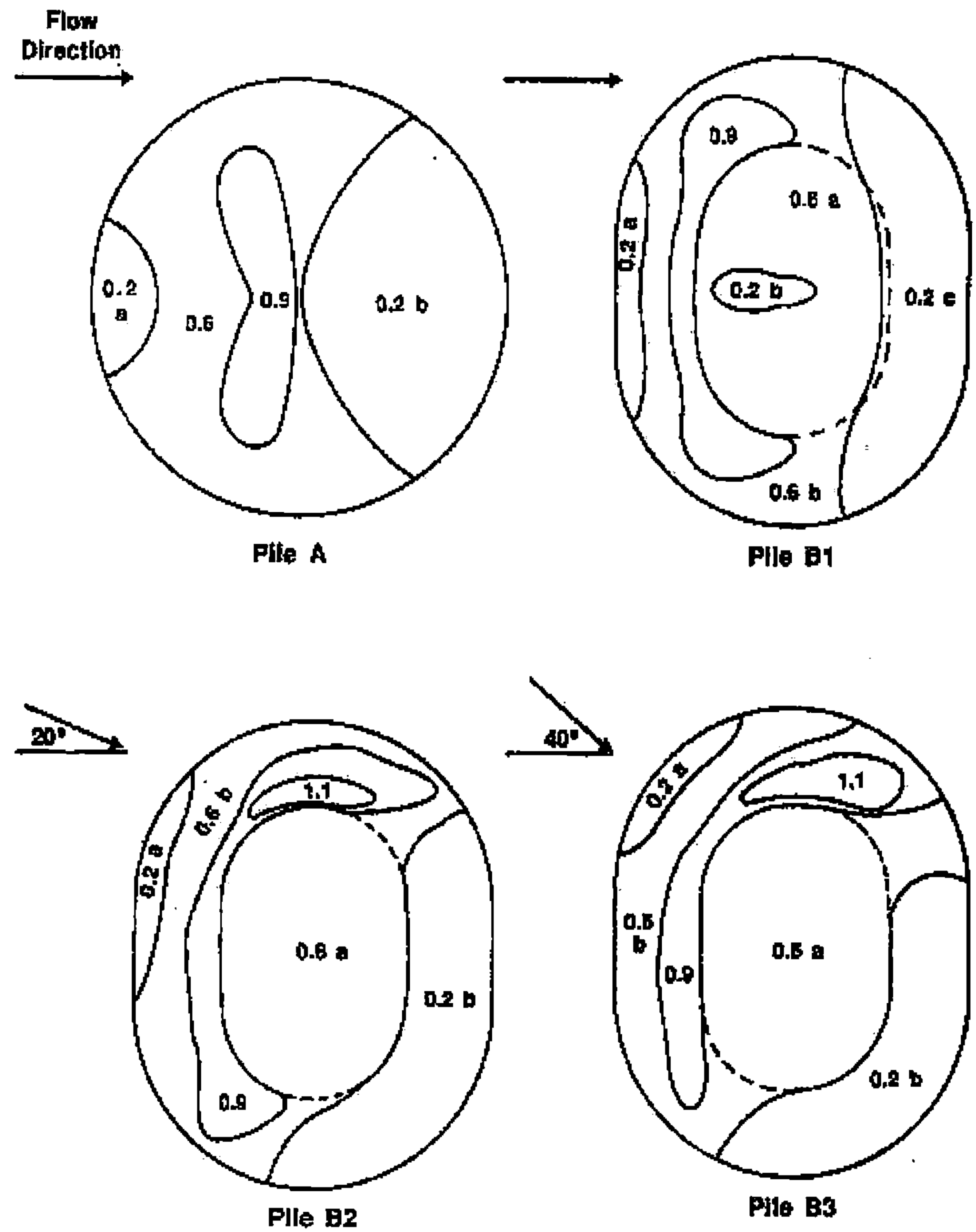


Figure 13.2.5-2. Contours of normalized surface windspeeds, u_s/u_r.

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^*):

$$u^* = \frac{0.4 u_s^+}{\frac{25}{\ln 0.5}} = 0.10 u_s^+ \qquad (7)$$

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 13.2.5-2 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 5.5

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 13.2.5-2 and Table 13.2.5-3) 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-hour (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.

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 half-life 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 that offset this apparent conservatism:

1. The fastest mile event contains peak winds that 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 that 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.

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

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

Coal is added to the pile by means of a fixed stacker and reclaimed by front-end loaders operating

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

at the base of the pile on the downwind side. In addition, every 3 days 250 Mg (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 m/s is obtained from Table 13.2.5-2.

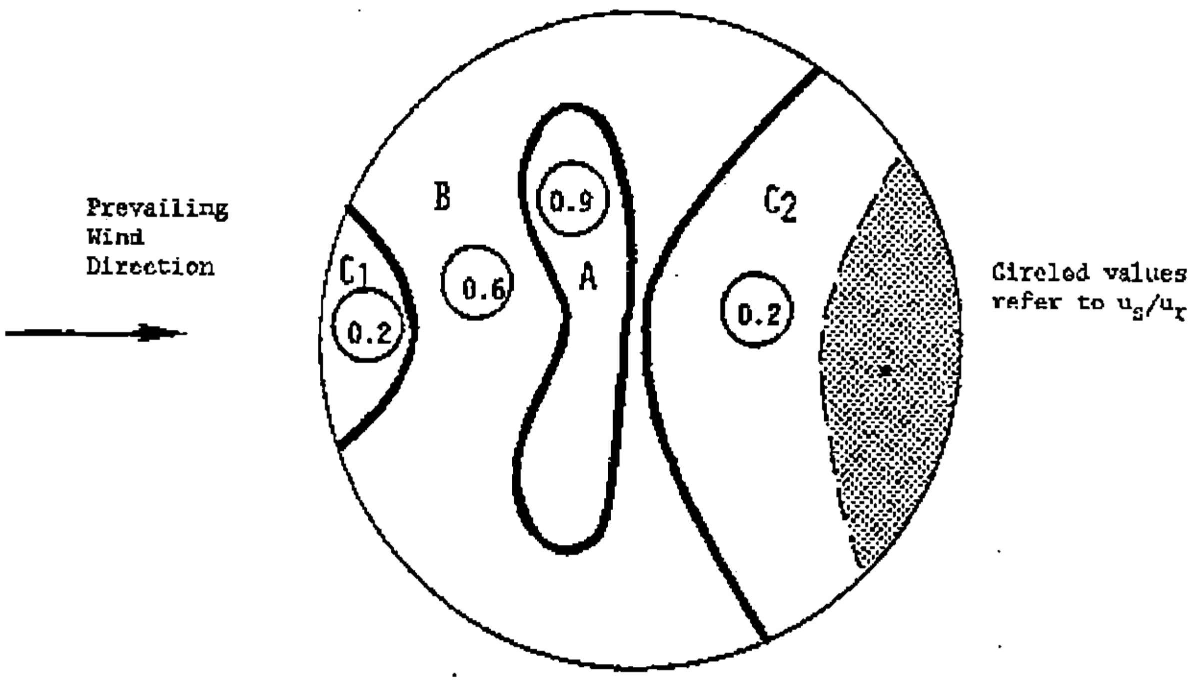
Step 2: Except for a small area near the base of the pile (see Figure 13.2.5-3), the entire pile surface is disturbed every 3 days, corresponding to a value of N = 120 per year. It will be shown that the contribution of the area where daily activity occurs is negligible so that it does not need to be treated separately in the calculations.

Step 3: The calculation procedure involves determination of the fastest mile for each period of disturbance. Figure 13.2.5-4 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 m, so that a height correction to 10 m 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



* A portion of C_2 is disturbed daily by reclaiming activities.

Area ID	$\frac{u_s}{u_r}$	Pile Surface %	Pile Surface Area (m^2)
A	0.9	12	101
B	0.6	48	402
$C_1 + C_2$	0.2	40	335
		Total	838

Figure 13.2.5-3. Example 1: Pile surface areas within each wind speed regime.

Local Climatological Data

Monthly Summary

Wind: Resultant Dir. (13)	Wind: Resultant Speed M.P.H. (14)	Wind: Average Speed M.P.H. (15)	Wind: Fastest Mile: Speed M.P.H. (16)	Wind: Fastest Mile: Direction (17)		Date (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	(29)	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	(21)	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 13.2.5-4. Example daily fastest miles wind for periods of interest.

equivalent friction velocities for each surface wind regime (i. e., u_s/u_r ratio) of the pile, using Equations 6 and 7. Figure 13.2.5-3 shows the surface wind speed pattern (expressed as a fraction of the approach wind speed at a height of 10 m). The surface areas lying within each wind speed regime are tabulated below the figure.

The calculated friction velocities are presented in Table 13.2.5-4. As indicated, only 3 of the periods contain a friction velocity which exceeds the threshold value of 1.12 m/s for an uncrusted coal pile. These 3 values all occur within the u_s/u_r = 0.9 regime of the pile surface.

Table 13.2.5-4 (Metric And English Units). EXAMPLE 1:
CALCULATION OF FRICTION VELOCITIES

	u_7^+		u_{10}^+		$u^* = 0.1u^+$ (m/s) s		
3-Day Period	mph	m/s	mph	m/s	u_s/u_r: 0.2	u_s/u_r: 0.6	u_s/u_r: 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

Step 5: This step is not necessary because there is only 1 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.

Steps 6 and 7: The final set of calculations (shown in Table 13.2.5-5) 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.

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

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

$$P_2 = 58(1.23 - 1.12)^2 + 25(1.23 - 1.12)$$

$$= 0.70 + 2.75 = 3.45 \text{ g/m}^2$$

Table 13.2.5-5 (Metric Units). EXAMPLE 1: CALCULATION OF PM-10 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

[a] Where $u_t^* = 1.12$ m/s for uncrusted coal and k = 0.5 for PM-10.

The emissions of particulate matter greater than 10 µm (PM-10) generated by each event are found as the product of the PM-10 multiplier (k = 0.5), the erosion potential (P), and the affected area of the pile (A).

As shown in Table 13.2.5-5, the results of these calculations indicate a monthly PM-10 emission total of 780 g.

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

A flat circular area 29.2 m 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:

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

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 13.2.5-2.

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

Step 3: From Figure 13.2.5-4, 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 $u^+_{10} = 33$ mph.

Step 4: Equation 4 is used to convert the fastest mile value of 14.6 m/s (33 mph) to an equivalent friction velocity of 0.77 m/s. 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 1 frequency of disturbance for the entire source area.

Steps 6 and 7: The PM-10 emissions generated by the erosion event are calculated as the product of the PM-10 multiplier (k = 0.5), the erosion potential (P) and the source area (A). The erosion potential is calculated from Equation 3 as follows:

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

$$P = 58(0.77 - 0.54)^2 + 25(0.77 - 0.54)$$

$$= 3.07 + 5.75$$

$$= 8.82 \text{ g/m}^2$$

Thus the PM-10 emissions for the 1-month period are found to be:

$$E = (0.5)(8.82 \text{ g/m}^2)(670 \text{ m}^2)$$

$$= 3.0 \text{ kg}$$

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