

APPENDIX C.1

PROCEDURES FOR SAMPLING SURFACE/BULK DUST LOADING

Appendix C.1

Procedures For Sampling Surface/Bulk Dust Loading

This appendix presents procedures recommended for the collection of material samples from paved and unpaved roads and from bulk storage piles. (AP-42, Appendix C.2, "Procedures For Laboratory Analysis Of Surface/Bulk Dust Loading Samples", presents analogous information for the analysis of the samples.) These recommended procedures are based on a review of American Society For Testing And Materials (ASTM) methods, such as C-136 (sieve analysis) and D-2216 (moisture content). The recommendations follow ASTM standards where practical, and where not, an effort has been made to develop procedures consistent with the intent of the pertinent ASTM standards.

This appendix emphasizes that, before starting any field sampling program, one must first define the study area of interest and then determine the number of samples that can be collected and analyzed within the constraints of time, labor, and money available. For example, the study area could be defined as an individual industrial plant with its network of paved/unpaved roadways and material piles. In that instance, it is advantageous to collect a separate sample for each major dust source in the plant. This level of resolution is useful in developing cost-effective emission reduction plans. On the other hand, if the area of interest is geographically large (say a city or county, with a network of public roads), collecting at least 1 sample from each source would be highly impractical. However, in such an area, it is important to obtain samples representative of different source types within the area.

C.1.1 Samples From Unpaved Roads

Objective -

The overall objective in an unpaved road sampling program is to inventory the mass of particulate matter (PM) emissions from the roads. This is typically done by:

1. Collecting "representative" samples of the loose surface material from the road;
2. Analyzing the samples to determine silt fractions; and
3. Using the results in the predictive emission factor model given in AP-42, Section 13.2.2, Unpaved Roads, together with traffic data (e. g., number of vehicles traveling the road each day).

Before any field sampling program, it is necessary to define the study area of interest and to determine the number of unpaved road samples that can be collected and analyzed within the constraints of time, labor, and money available. For example, the study area could be defined as a very specific industrial plant having a network of roadways. Here it is advantageous to collect a separate sample for each major unpaved road in the plant. This level of resolution is useful in developing cost-effective emission reduction plans involving dust suppressants or traffic rerouting. On the other hand, the area of interest may be geographically large, and well-defined traffic information may not be easily obtained. In this case, resolution of the PM emission inventory to specific road segments would not be feasible, and it would be more important to obtain representative road-type samples within the area by aggregating several sample increments.

Procedure -

For a network consisting of many relatively short roads contained in a *well-defined study area* (as would be the case at an industrial plant), it is recommended that one collect a sample for each 0.8 kilometers (km) (0.5 miles [mi]) length, or portion thereof, for each major road segment. Here, the term "road segment" refers to the length of road between intersections (the nodes of the network)

with other paved or unpaved roads. Thus, for a major segment 1 km (0.6 mi) long, 2 samples are recommended.

For longer roads in *study areas that are spatially diverse*, it is recommended that one collect a sample for each 4.8 km (3 mi) length of the road. Composite a sample from a minimum of 3 incremental samples. Collect the first sample increment at a random location within the first 0.8 km (0.5 mi), with additional increments taken from each remaining 0.8 km (0.5 mi) of the road, up to a maximum length of 4.8 km (3 mi). For a road less than 1.5 mi in length, an acceptable method for selecting sites for the increments is based on drawing 3 random numbers (x_1 , x_2 , x_3) between zero and the length. Random numbers may be obtained from tabulations in statistical reference books, or scientific calculators may be used to generate pseudorandom numbers. See Figure C.1-1.

The following steps describe the collection method for samples (increments).

1. Ensure that the site offers an unobstructed view of traffic and that sampling personnel are visible to drivers. If the road is heavily traveled, use 1 person to "spot" and route traffic safely around another person collecting the surface sample (increment).
2. Using string or other suitable markers, mark a 0.3 meters (m) (1 foot [ft]) wide portion across the road. (WARNING: *Do not mark the collection area with a chalk line or in any other method likely to introduce fine material into the sample.*)
3. With a whisk broom and dustpan, remove the loose surface material from the hard road base. Do not abrade the base during sweeping. Sweeping should be performed slowly so that fine surface material is not injected into the air. NOTE: *Collect material only from the portion of the road over which the wheels and carriages routinely travel* (i. e., not from berms or any "mounds" along the road centerline).
4. Periodically deposit the swept material into a clean, labeled container of suitable size, such as a metal or plastic 19 liter (L) (5 gallon [gal]) bucket, having a sealable polyethylene liner. Increments may be mixed within this container.
5. Record the required information on the sample collection sheet (Figure C.1-2).

Sample Specifications -

For uncontrolled unpaved road surfaces, a gross sample of 5 kilograms (kg) (10 pounds [lb]) to 23 kg (50 lb) is desired. Samples of this size will require splitting to a size amenable for analysis (see Appendix C.2). For unpaved roads having been treated with chemical dust suppressants (such as petroleum resins, asphalt emulsions, etc.), the above goal may not be practical in well-defined study areas because a very large area would need to be swept. In general, a minimum of 400 grams (g) (1 lb) is required for silt and moisture analysis. Additional increments should be taken from heavily controlled unpaved surfaces, until the minimum sample mass has been achieved.

C.1.2 Samples From Paved Roads

Objective -

The overall objective in a paved road sampling program is to inventory the mass of particulate emissions from the roads. This is typically done by:

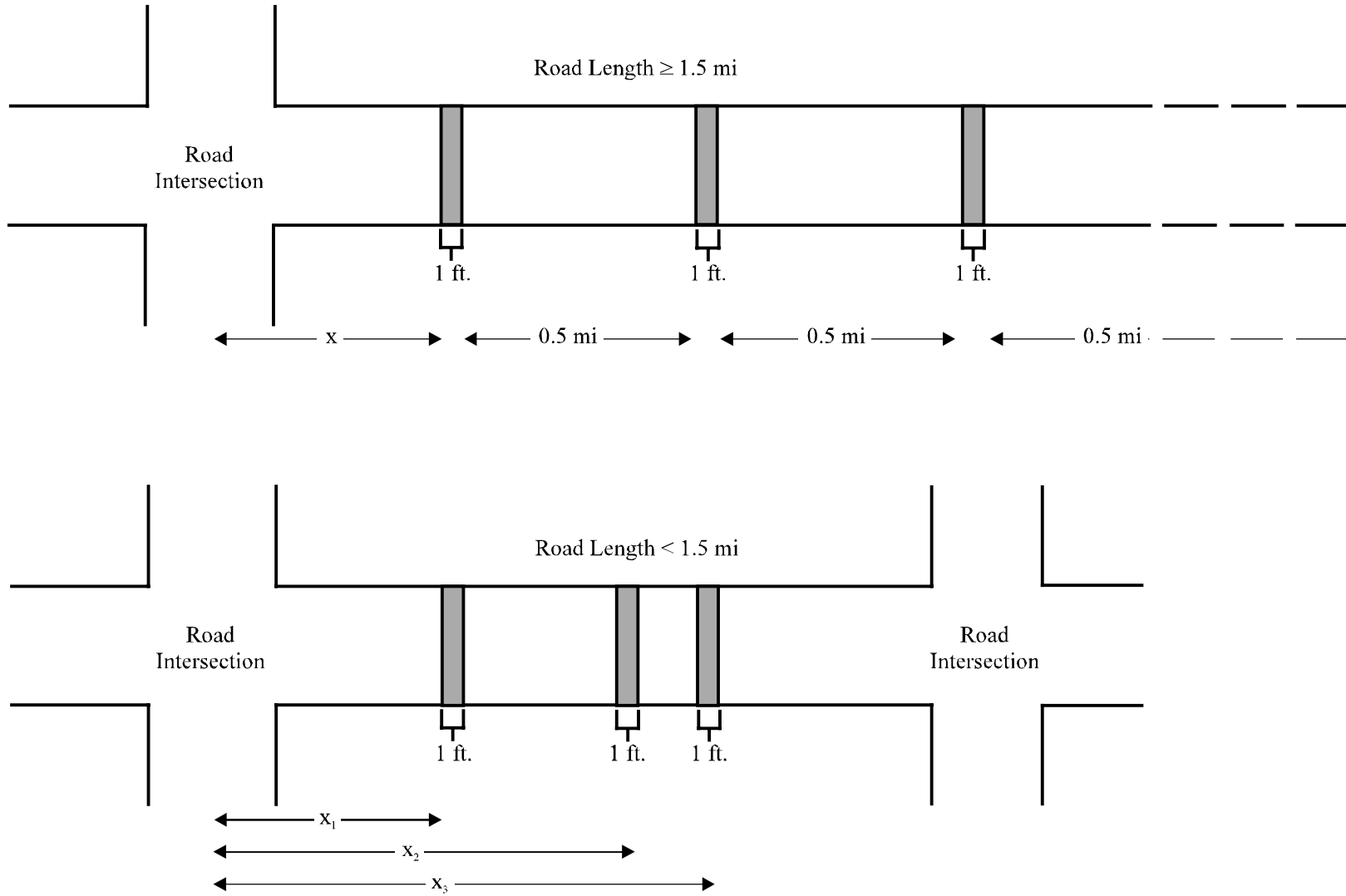


Figure C.1-1. Sampling locations for unpaved roads.

SAMPLING DATA FOR UNPAVED ROADS

Date Collected _____

Recorded by _____

Road Material (e.g., gravel, slag, dirt, etc.):* _____

Site of Sampling: _____

METHOD:

1. Sampling device: whisk broom and dustpan
2. Sampling depth: loose surface material (do not abrade road base)
3. Sample container: bucket with sealable liner
4. Gross sample specifications:
 - a. Uncontrolled surfaces -- 5 kg (10 lb) to 23 kg (50 lb)
 - b. Controlled surfaces -- minimum of 400 g (1 lb) is required for analysis

Refer to AP-42 Appendix B.1 for more detailed instructions.

Indicate any deviations from the above: _____

SAMPLING DATA COLLECTED:

Sample No.	Time	Location +	Surf. Area	Depth	Mass of Sample

- * Indicate and give details if roads are controlled.
- + Use code given on plant or road map for segment identification. Indicate sampling location on map.

Figure C.1-2. Example data form for unpaved road samples.

1. Collecting "representative" samples of the loose surface material from the road;
2. Analyzing the sample to determine the silt fraction; and
3. Combining the results with traffic data in a predictive emission factor model.

The remarks above about definition of the study area and the appropriate level of resolution for sampling unpaved roads are equally applicable to paved roads. Before a field sampling program, it is necessary first to define the study area of interest and then to determine the number of paved road samples that can be collected and analyzed. For example, in a well-defined study area (e. g., an industrial plant), it is advantageous to collect a separate sample for each major paved road, because the resolution can be useful in developing cost-effective emission reduction plans. Similarly, in geographically large study areas, it may be more important to obtain samples representative of road types within the area by aggregating several sample increments.

Compared to unpaved road sampling, planning for a paved road sample collection exercise necessarily involves greater consideration as to types of equipment to be used. Specifically, provisions must be made to accommodate the characteristics of the vacuum cleaner chosen. For example, paved road samples are collected by cleaning the surface with a vacuum cleaner with "tared" (i. e., weighed before use) filter bags. Upright "stick broom" vacuums use relatively small, lightweight filter bags, while bags for industrial-type vacuums are bulky and heavy. Because the mass collected is usually several times greater than the bag tare weight, uprights are thus well suited for collecting samples from lightly loaded road surfaces. On the other hand, on heavily loaded roads, the larger industrial-type vacuum bags are easier to use and can be more readily used to aggregate incremental samples from all road surfaces. These features are discussed further below.

Procedure -

For a network of many relatively short roads *contained in a well-defined study area* (as would be the case at an industrial plant), it is recommended that one collect a sample for each 0.8 km (0.5 mi) length, or portion thereof, for each major road segment. For a 1 km long (0.6 mi) segment, then, 2 samples are recommended. As mentioned, the term "road segment" refers to the length of road between intersections with other paved or unpaved roads (the nodes of the network).

For longer roads *in spatially heterogeneous study areas*, it is recommended that one collect a sample for each 4.8 km (3 mi) of sampled road length. Create a composite sample from a minimum of 3 incremental samples. Collect the first increment at a random location within the first 0.8 km (0.5 mi), with additional increments taken from each remaining 0.8 km (0.5 mi) of the road, up to a maximum length of 4.8 km (3 mi.) For a road less than 2.4 km (1.5 mi) long, an acceptable method for selecting sites for the increments is based on drawing 3 random numbers (x_1 , x_2 , x_3) between zero and the length (See Figure C.1-3). Random numbers may be obtained from tabulations in statistical reference books, or scientific calculators may be used to generate pseudorandom numbers.

The following steps describe the collection method for samples (increments).

1. Ensure that the site offers an unobstructed view of traffic and that sampling personnel are visible to drivers. If the road is heavily traveled, use 1 crew member to "spot" and route traffic safely around another person collecting the surface sample (increment).
2. Using string or other suitable markers, mark the sampling portion across the road. (WARNING: *Do not mark the collection area with a chalk line or in any other method likely to introduce fine material into the sample.*) The widths may be varied between 0.3 m (1 ft) for visibly dirty roads and 3 m (10 ft) for clean roads. When an industrial-

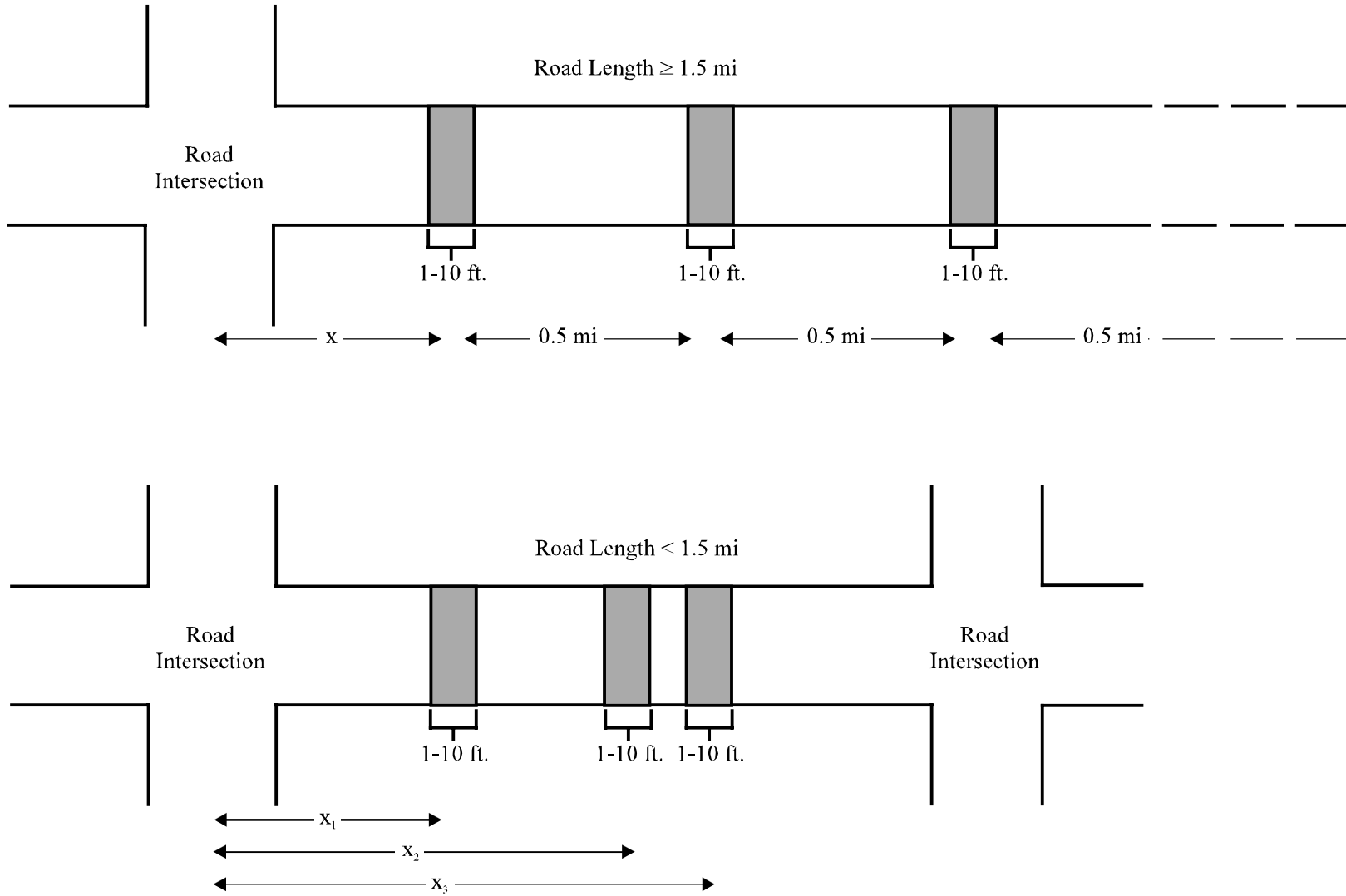


Figure C.1-3. Sampling locations for paved roads.

type vacuum is used to sample lightly loaded roads, a width greater than 3 m (10 ft) may be necessary to meet sample specifications, unless increments are being combined.

3. If large, loose material is present on the surface, it should be collected with a whisk broom and dustpan. NOTE: *Collect material only from the portion of the road over which the wheels and carriages routinely travel* (i. e., not from berms or any "mounds" along the road centerline). On roads with painted side markings, collect material "from white line to white line" (but avoid centerline mounds). Store the swept material in a clean, labeled container of suitable size, such as a metal or plastic 19 L (5 gal) bucket, with a sealable polyethylene liner. Increments for the same sample may be mixed within the container.
4. Vacuum the collection area using a portable vacuum cleaner fitted with an empty tared (preweighed) filter bag. NOTE: *Collect material only from the portion of the road over which the wheels and carriages routinely travel* (i. e., not from berms or any "mounds" along the road centerline). On roads with painted side markings, collect material "from white line to white line" (but avoid centerline mounds). The same filter bag may be used for different increments for 1 sample. For heavily loaded roads, more than 1 filter bag may be needed for a sample (increment).
5. Carefully remove the bag from the vacuum sweeper and check for tears or leaks. If necessary, reduce samples (using the procedure in Appendix C.2) from broom sweeping to a size amenable to analysis. Seal broom-swept material in a clean, labeled plastic jar for transport (alternatively, the swept material may be placed in the vacuum filter bag). Fold the unused portion of the filter bag, wrap a rubber band around the folded bag, and store the bag for transport.
6. Record the required information on the sample collection sheet (Figure C.1-4).

Sample Specifications -

When broom swept samples are collected, they should be at least 400 g (1 lb) for silt and moisture analysis. Vacuum swept samples should be at least 200 g (0.5 lb). Also, the weight of an "exposed" filter bag should be at least 3 to 5 times greater than when empty. Additional increments should be taken until these sample mass goals have been attained.

C.1.3 Samples From Storage Piles

Objective -

The overall objective of a storage pile sampling and analysis program is to inventory particulate matter emissions from the storage and handling of materials. This is done typically by:

1. Collecting "representative" samples of the material;
2. Analyzing the samples to determine moisture and silt contents; and
3. Combining analytical results with material throughput and meteorological information in an emission factor model.

As initial steps in storage pile sampling, it is necessary to decide (a) what emission mechanisms - material load-in to and load-out from the pile, wind erosion of the piles - are of interest, and (b) how many samples can be collected and analyzed, given time and monetary constraints. (In general, annual average PM emissions from material handling can be expected to be

SAMPLING DATA FOR PAVED ROADS

Date Collected _____ Recorded by _____

Sampling location* _____ No. of Lanes _____

Surface type (e.g., asphalt, concrete, etc.) _____

Surface condition (e.g., good, rutted, etc.) _____

* Use code given on plant or road map for segment identification. Indication sampling location on map.

METHOD:

1. Sampling device: portable vacuum cleaner (whisk broom and dustpan if heavy loading present)
2. Sampling depth: loose surface material (do not sample curb areas or other untravelled portions of the road)
3. Sample container: tared and numbered vacuum cleaner bags (bucket with sealable liner if heavy loading present)
4. Gross sample specifications: Vacuum swept samples should be at least 200 g (0.5 lb), with the exposed filter bag weight should be at least 3 to 5 times greater than the empty bag tare weight.

Refer to AP-42 Appendix C.1 for more detailed instructions.

Indicate any deviations from the above: _____

SAMPLING DATA COLLECTED:

Sample No.	Vacuum Bag		Sampling Surface Dimensions (l x w)	Time	Mass of Broom-Swept Sample +
	ID	Tare Wgt (g)			

+ Enter "0" if no broom sweeping is performed.

Figure C.1-4. Example data form for paved roads.

much greater than those from wind erosion.) For an industrial plant, it is recommended that at least 1 sample be collected for each major type of material handled within the facility.

In a program to characterize load-in emissions, representative samples should be collected from material recently loaded into the pile. Similarly, representative samples for load-out emissions should be collected from areas that are worked by load-out equipment such as front end loaders or clamshells. For most "active" piles (i. e., those with frequent load-in and load-out operations), 1 sample may be considered representative of both loaded-in and loaded-out materials. Wind erosion material samples should be representative of the surfaces exposed to the wind.

In general, samples should consist of increments taken from all exposed areas of the pile (i. e., top, middle, and bottom). If the same material is stored in several piles, it is recommended that piles with at least 25 percent of the amount in storage be sampled. For large piles that are common in industrial settings (e. g., quarries, iron and steel plants), access to some portions may be impossible for the person collecting the sample. In that case, increments should be taken no higher than it is practical for a person to climb carrying a shovel and a pail.

Procedure -

The following steps describe the method for collecting samples from storage piles:

1. Sketch plan and elevation views of the pile. Indicate if any portion is not accessible. Use the sketch to plan where the N increments will be taken by dividing the perimeter into N-1 roughly equivalent segments.
 - a. For a large pile, collect a minimum of 10 increments, as near to mid-height of the pile as practical.
 - b. For a small pile, a sample should be a minimum of 6 increments, evenly distributed among the top, middle, and bottom.

"Small" or "large" piles, for practical purposes, may be defined as those piles which can or cannot, respectively, be scaled by a person carrying a shovel and pail.
2. Collect material with a straight-point shovel or a small garden spade, and store the increments in a clean, labeled container of suitable size (such as a metal or plastic 19 L [5 gal] bucket) with a sealable polyethylene liner. Depending upon the ultimate goals of the sampling program, choose 1 of the following procedures:
 - a. To characterize emissions from *material handling operations at an active pile*, take increments from the portions of the pile which most recently had material added and removed. Collect the material with a shovel to a depth of 10 to 15 centimeters (cm) (4 to 6 inches [in]). Do not deliberately avoid larger pieces of aggregate present on the surface.
 - b. To characterize *handling emissions from an inactive pile*, obtain increments of the core material from a 1 m (3 ft) depth in the pile. A sampling tube 2 m (6 ft) long, with a diameter at least 10 times the diameter of the largest particle being sampled, is recommended for these samples. Note that, for piles containing large particles, the diameter recommendation may be impractical.

- c. If characterization of *wind erosion*, rather than material handling is the goal of the sampling program, collect the increments by skimming the surface in an upwards direction. The depth of the sample should be 2.5 cm (1 in), or the diameter of the largest particle, whichever is less. Do not deliberately avoid collecting larger pieces of aggregate present on the surface.

In most instances, collection method "a" should be selected.

3. Record the required information on the sample collection sheet (Figure C.1-5). Note the space for deviations from the summarized method.

Sample Specifications -

For any of the procedures, the sample mass collected should be at least 5 kg (10 lb). When most materials are sampled with procedures 2a or 2b, 10 increments will normally result in a sample of at least 23 kg (50 lb). Note that storage pile samples usually require splitting to a size more amenable to laboratory analysis.

SAMPLING DATA FOR STORAGE PILES

Date Collected _____

Recorded by _____

Type of material sampled _____

Sampling location* _____

METHOD:

1. Sampling device: pointed shovel (hollow sampling tube if inactive pile is to be sampled)
2. Sampling depth:
 For material handling of active piles: 10-15 cm (4-6 in.)
 For material handling of inactive piles: 1 m (3 ft)
 For wind erosion samples: 2.5 cm (1 in.) or depth of the largest particle (whichever is less)
3. Sample container: bucket with sealable liner
4. Gross sample specifications:
 For material handling of active or inactive piles: minimum of 6 increments with total sample weight of 5 kg (10 lb) [10 increments totalling 23 kg (50 lb) are recommended]
 For wind erosion samples: minimum of 6 increments with total sample weight of 5 kg (10 lb)

Refer to AP-42 Appendix C.1 for more detailed instructions.

Indicate any deviations from the above: _____

SAMPLING DATA COLLECTED:

Sample No.	Time	Location* of Sample Collection	Device Used S/T **	Depth	Mass of Sample

* Use code given of plant or area map for pile/sample identification. Indicate each sampling location on map.
 ** Indicate whether shovel or tube.

Figure C.1-5. Example data form for storage piles.