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SURFACE COAL MINE STUDY PLAN

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This report has been reviewed by the Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, and has been approved for publication. Any mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

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PREFACE

This report was prepared by Midwest Research Institute under U.S. Environmental Protection Agency (EPA) Contract No. 68-DO-0137, Work Assignment Nos. 10 and 68. The principal authors of this report are Dr. Gregory E. Muleski and Dr. Chatten Cowherd; they were assisted by Mr. Robert Dobson and Ms. Karen Connery of MRI. Mr. Dennis Shipman and Mr. Joe Touma of the Office of Air Quality Planning and Standards served as the EPA's technical monitors of the work assignment.

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SECTION 1

INTRODUCTION

At present, ambient particulate matter (PM-10) impacts from surface coal mining operations are assessed in the following ways:

1. The mine's operating plan is reviewed to identify major PM-10 emission sources, such as blasting, overburden removal, haul trucks, etc. The plan is also reviewed to determine source activity rates—such as tons of coal mined or tons of overburden removed per year—over the effective life of the mine.

2. An emission factor (mass emitted per unit source activity) is proposed for each major source. Factors are usually selected from Section 8.24 of AP-42.[1]

3. Values from items 1 and 2 above are combined to estimate annual and worst-case-day PM-10 emission rates from the mine.

4. Dispersion models (such as the Industrial Source Complex [ISC] model) are then used to simulate the atmospheric transport of the estimated emissions. Resulting ambient air concentration estimates are then compared against National Ambient Air Quality Standards (NAAQSs) or Prevention of Significant Deterioration (PSD) increments.

The field study described in this report addresses issues involving the modeling process described above for surface coal mines. Specifically, the Clean Air Act Amendments (CAAA) require the Administrator to "analyze the accuracy of. . . models and emission factors and make revisions as may be necessary to eliminate any significant overprediction." The objectives of this study are to:

I. Improve available emission factors for surface coal mines.

II. Develop a comprehensive data base of source activity levels, on-site meteorological conditions, and air quality data.

III. Conduct a model evaluation study to assess how the current methodology predicts the ambient air quality impact from mines.

In general terms, the study combines extensive long-term air quality, source activity, and meteorological monitoring with intensive short-term, source-directed testing to answer the following types of questions:

- Does the current methodology result in systematic overprediction of air concentrations?

- How well do ISC model results match measurements in time and space?

No matter how sophisticated, long-term monitoring of ambient "far-field" concentrations alone cannot answer questions such as the following:

- What portion or portions of the methodology are most responsible for overprediction?

- Can the identified portions be modified so that systematic overprediction is effectively removed?

- What fraction of material emitted at the bottom of the pit eventually escapes?

To answer these types of questions, the long-term monitoring program must be supplemented with the intensive short-term monitoring and pit retention tracer programs that incorporate more source-directed measurements. Quantitative examination of separate steps in the emission factor/dispersion model methodology is necessary to answer the "how" and "why" questions. Furthermore, the particulate tracer studies will provide a quantitative basis for development of a pit retention algorithm. This report describes the field study plan designed to meet the above objectives. The plan details the sampling methodology, data analysis, and quality assurance (QA) procedures to be followed.

The principal pollutant of interest in this report is "particulate matter" (PM), with special emphasis placed on "PM-10"—particulate matter no greater than 10 μmA (microns in aerodynamic diameter). PM-10 is the basis for the current NAAQSs and thus represents the size range of the greatest regulatory interest. Nevertheless, formal establishment of PM-10 as the standard basis is relatively recent, and almost all historical surface coal mine field measurements reflect a particulate size other than PM-10. Of these, the most important is "TSP," or Total Suspended Particulate, as measured by the standard high-volume (hi-vol) air sampler. TSP is a relatively coarse size fraction and was the basis for the previous NAAQSs and PSD increments. While the capture characteristics of the hi-vol sampler are dependent upon approach wind velocity, the effective D50 (i.e., 50% of the particles are captured and 50% are not) varies roughly from 25 to 50 μmA. To maintain comparability and compatibility, some field measurements will be referenced to TSP.

The field sampling program consists of extensive long-term air quality and meteorological monitoring combined with intensive, short-term source testing. In addition, pit retention will be studied under a separate set of experiments. To avoid confusion about what is meant by terms such as "ambient air" and "near-source," the following defines terms that are used throughout this document.

"Source tests" refer to air quality/meteorological measurements made in the immediate vicinity of an individual emission source (such as a road or material transfer operation) with the intention of characterizing that source. Most of these measurements are required for "exposure profiling," which relies on simultaneous multipoint concentration and wind speed measurements over the effective cross section of the dust plume to determine source strength and thus meet Objective I.

"Near-field air monitoring" refers to measurements made further away than source tests, but still within the vicinity of an individual source. A major difference is that near-field measurements do not normally span the plume cross section. Rather, these measurements at a height of 1 to 2 m are usually made for comparison with ISC or other model-generated concentration estimates. Unless otherwise specified, near-field measurements will be made within the pit.

"Far-field air monitoring" will refer to measurements made at a considerable downwind distance from the nearest emission source. As such, these measurements focus on characterizing the air quality impact of the mine as a whole rather than on any individual source or source category. Unless specifically stated otherwise, far-field measurements will be made beyond the rim of the pit (i.e., at surrounding grade). In this document, "ambient" and "far-field" are equivalent terms. These are the measurements that can be compared against dispersion model predictions in an overall evaluation of the current methodology (Objective III).

The remainder of this report is structured as follows: Section 2 describes how candidate test sites will be evaluated and how final sites will be selected. Section 3 describes the field emissions testing procedures to be used to develop improved emission factors. Section 4, on the other hand, describes the collection and analysis of other types of samples—such as source activity, meteorology, and air quality—that are necessary to reach objectives of this program. The proposed schedule is provided in Section 5 and references are listed in Section 6.

The sampling and analysis procedures to be followed in this field testing program are subject to certain quality assurance/quality control (QA/QC) guidelines. These guidelines are discussed in conjunction with the activities to which they apply. These procedures meet or exceed the requirements specified in the reports entitled "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II—Ambient Air Specific Methods" (EPA 600/4-77-027a) and "Ambient Monitoring Guidelines for Prevention of Significant Deterioration" (EPA 450/2-78-019).

As part of the QC program for this study, routine audits of sampling and analysis procedures will be performed. The purpose of the audits is to demonstrate that measurements are made within acceptable control conditions for particulate source sampling and to assess the source testing data for precision and accuracy. Examples of items to be audited include gravimetric analysis, flow rate calibration, data processing, and emission *factor calculation*. The mandatory use of specially designed reporting forms for sampling and analysis of data obtained in the field and laboratory aids in the auditing procedure. Further details on specific sampling and analysis procedures are provided in the following sections.

The field program represents an excellent opportunity for cooperative agreements between agency and coal companies/trade groups. A variety of participation levels are available.

- At a minimum, industry will be asked to provide historical source activity data, such as production rates and maintenance records for mine equipment. This information can be treated as "CBI"—confidential business information.

- Mines may also be asked to supply historical ambient air quality monitoring and meteorological data.

- With agreement from state and regional offices, minor modifications to some mine air quality or meteorological equipment operations may be useful to the study. This could range from requesting changes in practices (such as different sampling periods) to the relocation or even loaning of equipment for use at another mine during the long-term monitoring program.

- For mines selected that agree to act as test sites, higher levels of cooperation are possible, ranging from arranging for electrical power drops and for field laboratory space to providing technician help who, under direct supervision by the contractors, would assist in field team support.

Coal company and trade group participation is discussed further in the next section.

SECTION 2

SITE SELECTION

Table 1 presents a list of surface coal mine test sites, all of which are in the Powder River Basin. At the time of this writing, a meeting has been scheduled between mine and trade association representatives, EPA and Wyoming Department of Environmental Quality (DEQ) personnel, and MRI. The meeting will occur on March 5, 1992, in Gillette, Wyoming. As noted in Table 1, six mines are currently interested in being considered as potential test sites and will attend the March 5 meeting to learn more about the study.

2.1 SCREENING ACTIVITIES

The contact person for each candidate mine will participate in one or two telephone calls during which he/she will be asked to

- Provide an overview of mining operations (truck-shovel versus dragline, year in mine plan, etc.) and equipment used at the mine.
- Discuss current and anticipated levels of overburden, topsoil, and coal-related activities.
- Discuss past and current dust control programs at the mine.
- Provide a plot plan for the mine, showing current areas being worked and areas planned to be worked in the future, topography of the mine and surrounding area, locations of any air quality (AQ) and meteorological ("met") monitors.

Table 1. SUMMARY OF "REPRESENTATIVE" MINE ATTRIBUTES

Company/mine	Used in past emission factor studies, etc.	Relatively isolated from other mines[a]	Historical AQ data included in earlier model evaluations[b]	Prior working relationship with MRI, TRC	Comments
Western Energy Colstrip	X	+		X	Roads and pits well configured for both emission factor and model evaluation studies.
AMAX Eagle Butte[c] Belle Ayr	 X	 – –	 X	 X	Good accessibility to samplers reported. This mine was one of the sites during the EDS study.[d]
Powder River North Antelope[c] Rochelle[c]		 0 0			
Kerr McGee Jacobs Ranch[c]	0	+			Like Caballo, located at the northern end of a cluster of mines.
Cordero Cordero[c]	X	–	X	X	One of the test sites during the EDS study.[d]
Carter Mining Caballo Caballo Rojo		 0 –	 X X		Location at northern edge of a mining cluster may minimize influence from neighboring mines.
NERCO Antelope		0			
Thunder Basin Black Thunder[c]		–	X	X	With the largest permitted production in the U.S., this mine is probably an excellent choice for emission factor studies. Location in the middle of a mining cluster may complicate model evaluation.

[a] "+" = Reasonably well isolated from other mining areas; "–" = located in the middle of a cluster of mines with influence from other mines likely; "0" = located at the edge of a cluster, influence from neighboring mines less likely.

[b] Mine has been included in previous air quality monitoring and dispersion modeling evaluation studies; therefore a good historical base is available to build upon.

[c] These mines have agreed (as of this writing) to be considered as potential test sites and will participate in the March 4 meeting.

[d] Reference 2.

- Describe and, if requested, supply historical emission inventory, source activity, dispersion modeling analyses, etc. (This would probably take the form of response to a questionnaire.)

Mine sites will be selected by comparing each candidate mine's attributes against predetermined criteria of desired location, available data, site configuration, etc. The criteria given below represent guidelines rather than "hard and fast" rules. The process of site selection requires many qualitative and subjective decisions. Candidate mines will be judged on the following criteria:

- General Location. Although mines with existing PSD monitoring networks provide ready candidates, most PSD networks are not necessarily sited to provide the data needed in this study. Furthermore, mines that are relatively isolated from other mines would be preferred. While it may not be possible to find completely isolated mines, those located away from neighboring mines would be preferred over those in proximity to other mines. Finally, the site should be isolated from terrain features influencing local airflows. That is, the terrain immediately surrounding the mine should be fairly flat.

- Mine Activity. Quantification of the mining activity (traffic volumes, amount of coal removed, amount of overburden disturbed, etc.) is needed for the mine model validation effort. Candidate mines will be judged on the availability of historical data and on the ease with which these data could be collected during any field study.

- Logistics. There is a need to locate instruments near dust-producing activities, at locations up and downwind of the mine, and at the top of the mine pit highwall. The candidate mines will be evaluated on the basis of being able to accommodate the wide variety of sampling locations necessary.

- Representativeness. Preference will be given to mines that are neither at the start nor near the end of operation according to the mine plan. Furthermore, geographic diversity of the test sites is a desired goal.

Preliminary visits to the mine provide useful overview for the above items.

2.2 SITE SURVEYS

The site survey is expected to require a 1- or 2-day visit by two MRI representatives. At the start of the survey, the mine will provide a short orientation describing operations. At the mine's discretion, the orientation can include safety, liability insurance, or other issues. MRI will agree to requirements made by the mine, such as obeying all posted notices; using eye, hearing, and other protective equipment; and personnel and vehicle passes. Also at this meeting, MRI will describe the general sequence of events anticipated for the testing and will reaffirm its intention to cause minimal disruption to mine operations.

The remainder of the survey is to be spent visiting and characterizing potential emission test and monitoring sites in terms of orientation with respect to prevailing wind direction and pit axis, distance to highwall, observed level of activity, access to electrical power, proximity to other emission sources, etc.

For example, near-source measurements of traffic source generally require long stretches of roads that are approximately perpendicular to the prevailing wind. In addition, sources should be relatively isolated from other important PM-10 emission sources within the mine. The following is a list of example criteria to be applied to a site for roadway source testing.

1. There should be at least 10 m of flat, open terrain downwind of road.

2. There should be at least 30 m of flat, open terrain upwind of road.

3. The height of nearest downwind obstruction should be less than the distance from the road to the obstruction.

4. The height of nearest upwind obstruction should be less than one-third the distance from the road to the obstruction.

5. A line drawn perpendicular to the road orientation should form an angle of 0° to 45° with the mean daytime prevailing wind direction.

6. The mean daytime wind speed should be greater than 4 mph.

7. The test road should have an adequate number of vehicle passes per hour enabling completion of a test in no more than 3 h.

8. The traffic mix should be representative of the type of vehicles that regularly use the road.

Analogous criteria have been established for nonroad sources, such as material handling operations. These include isolation from other important sources and wind obstructions, accessibility to the emission source, and orientation of the source to prevailing winds.

2.3 FINAL SITE SELECTION

As a result of site visits, it is expected that one or more mines will be found to be suitable. Those mines will be reevaluated along the selection criteria lines given above, and a final site will be selected.

SECTION 3

SOURCE AIR SAMPLING METHODOLOGY

This section describes the procedures to be followed during the emission source testing portion of the study. A review of emission factors applicable to surface coal mines has been recently completed.[3] This review also presented recommendations for future source testing, which are summarized in Table 2. The proposed source testing program focuses on the following major sources:

- Coal and overburden
- Haul roads
- General traffic (light- and medium-duty)
- Overburden material handling operations
- Coal material handling operations

These sources typically account for 70% or more of particulate emissions at surface coal mines.[4] Similar findings were reported in a recent study of Wyoming mines.[5]

The source-directed field sampling will employ the "exposure profiling" concept to quantify source emission contributions and near-field concentrations.

As Table 2 indicates, there are two source types of interest here—"point" sources (i.e., the material handling operations) and "line" sources (i.e., the roadway sources). The differences between testing the two types are described below.

Table 2. **EMISSION SOURCES RECOMMENDED FOR EVALUATION**

	Recommended number of tests per mine[a]	Overall priority
Line sources (travel-related) to be considered[b]		
1. Haul trucks	3-6U, 6-12C	1
2. General mine traffic	3-6U, 6-12C	3
3. Haul trucks (overburden)	3-6U, 6-12C	2
"Grouped" approach to material handling emissions[c]		
1. Overburden removal and placement in trucks[d]	3-6	4T
2. Overburden replacement by dragline[d]	3-6	4T
3. Misc. overburden handling operations[d]	3-6	4T
4. Misc. coal handling operations[e]	3-6	8[f]

Notes:

[a] U = uncontrolled, C = controlled. Uncontrolled if not indicated.

[b] Depending on the road network at the mine, it may not be possible to separate various travel-related emissions. In that case, because of the importance of travel-related emissions, additional roads or other line sources (such as scraper travel [see note f below] or road grading) will be tested. These tests are expected to be of uncontrolled emissions.

[c] Emission factor development will group operations with like materials regardless of the equipment involved. This approach is expected to be particularly beneficial for overburden-related emissions from draglines, power shovels, truck dumps, etc. It is further expected that test results will be combined with the generic materials handling emission factor data base.

[d] Dependent upon the type of mine operation (i.e., dragline or shovel/truck).

[e] Including truck dumps, loadout for transit, etc. Again, emission factor development will group across operations with the same material.

[f] Scrapers in travel mode rated as 7th overall priority.

3.1 GENERAL AIR SAMPLING EQUIPMENT AND TECHNIQUES

The "exposure profiling" technique for source testing of open particulate matter sources is based on the isokinetic profiling concept that is used in conventional (stack) testing. The passage of airborne pollutant immediately downwind of the source is measured directly by means of simultaneous multipoint sampling over the cross section of the open dust source plume. This technique uses a mass flux measurement scheme similar to EPA Method 5 stack testing rather than requiring indirect emission rate calculation through the application of generalized atmospheric dispersion model.

For measurement of particulate emissions from roads, a vertical network of samplers (Figure 1) is positioned just downwind and upwind from the edge of the road. (For point sources, a two-dimensional array is needed.) The downwind distance of 5 m is far enough that interference with sampling due to traffic-generated turbulence is minimal but close enough to the source that the vertical plume extent can be adequately characterized with a maximum sampling height of 5 to 7 m. In a similar manner, the 15-m distance upwind from the road's edge is far enough from the source that (a) source turbulence does not affect sampling, and (b) a brief wind reversal would not substantially impact the upwind samplers. The 15-m distance is, however, close enough to the road to provide the representative background concentration values needed to determine the net (i.e., due to the source) mass flux. As shown in Figure 1, the deployment scheme is expected to use two independent downwind vertical sampling arrays, D1 and D2. Both downwind arrays (as well as the upwind array U) make use of high-volume (hi-vol) air samplers with electronic flow controllers.

The primary air sampling device in this program will be a standard high-volume air sampler fitted with a cyclone preseparator (Figure 2). The cyclone exhibits an effective 50% cutoff diameter (D_{50}) of approximately 10 μmA when operated at a flow rate of 40 cfm (68 m^3/h).

Samplers in the upwind and one of the two downwind arrays are fitted with the cyclone preseparator to sample PM-10 emissions. During half the test periods, samplers in the other downwind array will be fitted with cyclone preseparators; during the other test periods, standard hi-vol roofs will be used to sample TSP emissions. In this way, one TSP test will be conducted for every

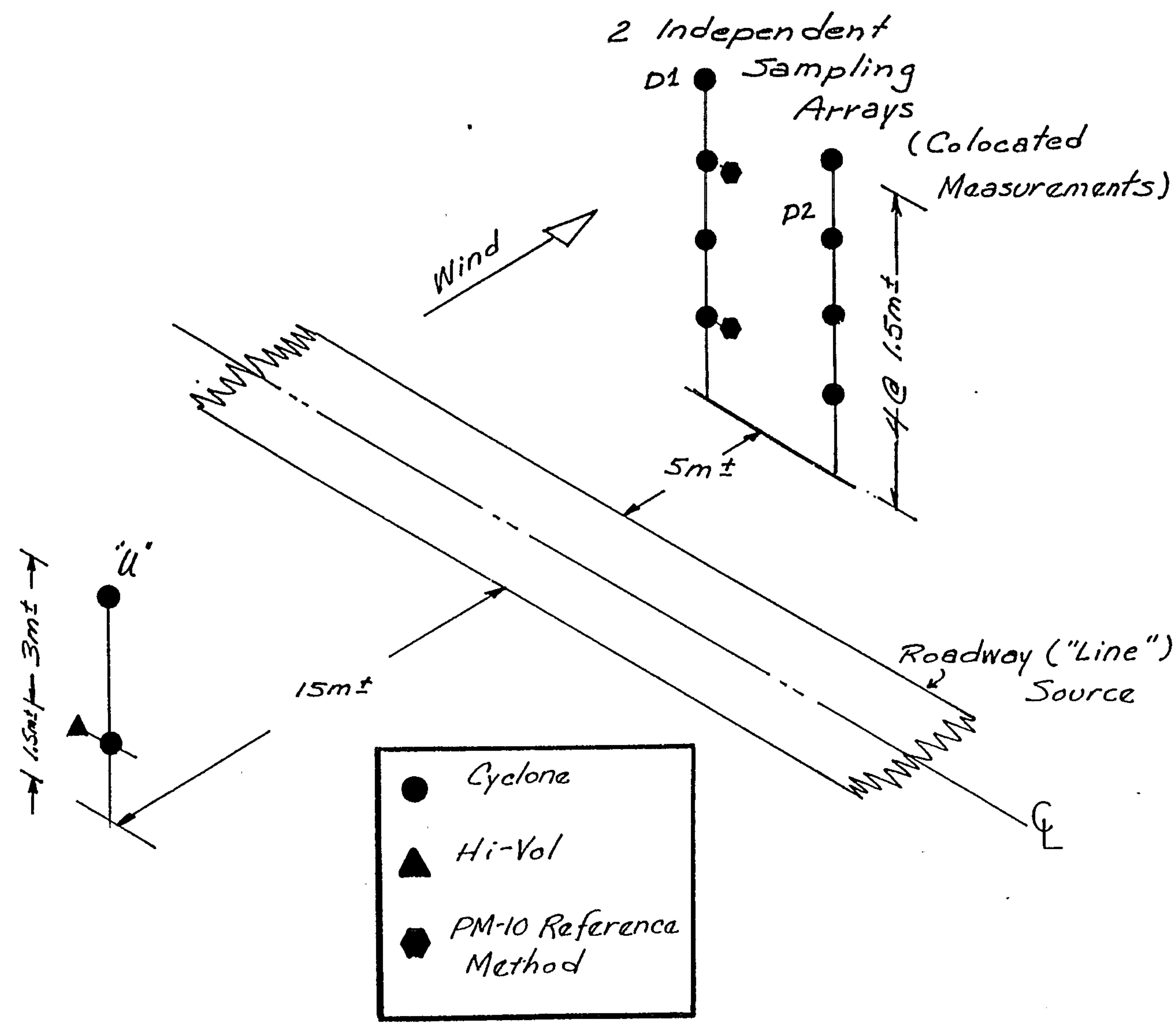

Figure 1. Sampling arrays U, D1, and D2.

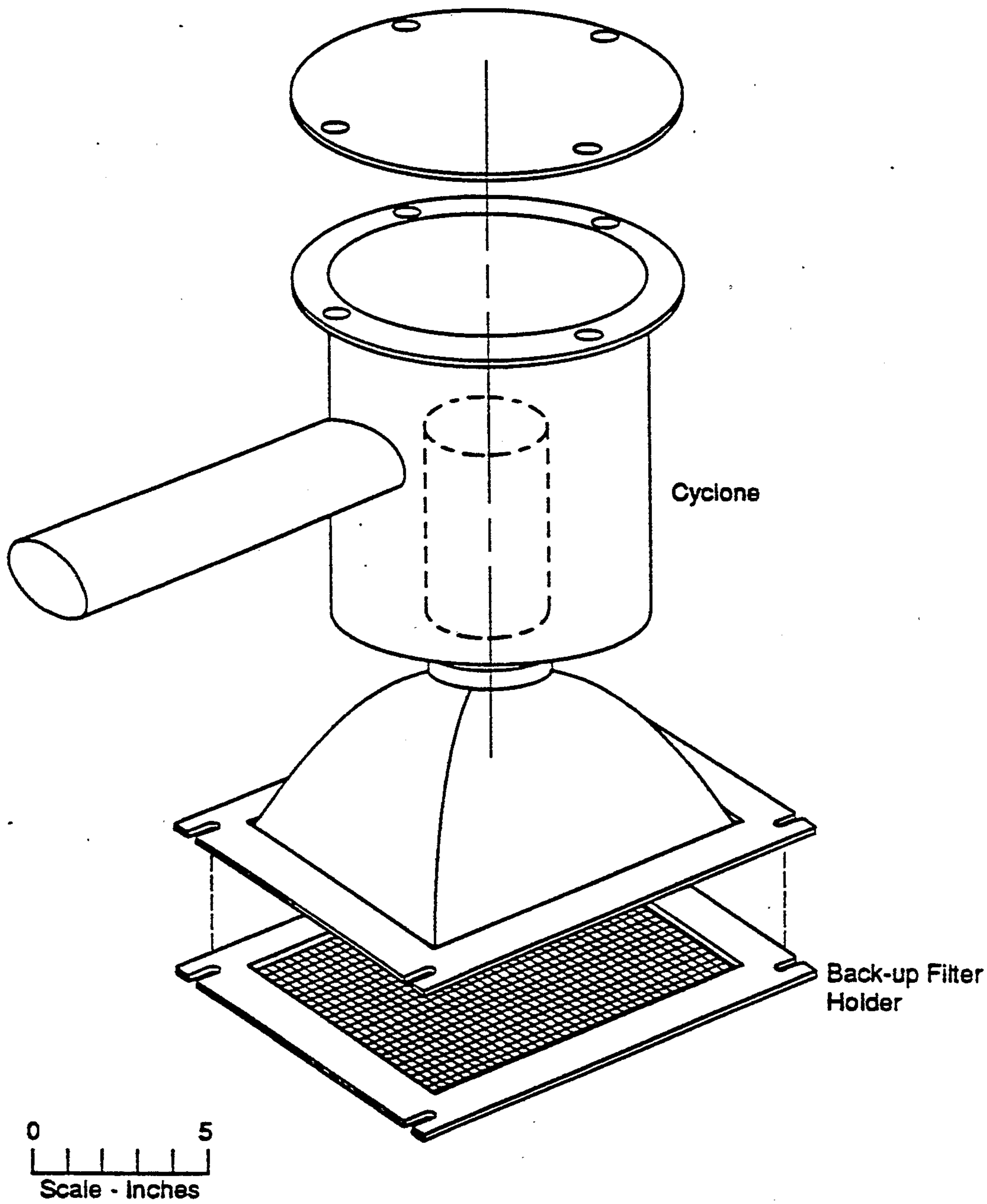

Figure 2. Cyclone preseparator.

three PM-10 tests. TSP measurements provide a useful link to past surface coal mine emission factor studies.

For the material handling-related "point" sources of PM emission, a two-dimensional sampling array (Figure 3) is required. The cyclone preseparator will serve as the primary air sampling device in this array as well. Note that sampling locations employ colocated cyclone and standard hi-vol samplers. In this way, a TSP emission factor can be estimated from the measurement-based PM-10 factor.

Throughout each test, wind speed will be monitored by warm-wire anemometers (Kurz Model 465) at two heights and the vertical wind speed profile determined by assuming a logarithmic distribution. An integrating Biram's vane anemometer, wind odometer, or an equivalent system, will serve as a backup. Horizontal wind direction will be monitored by a wind vane at a single height, with 5- to 15-min averages determined electronically prior to and during the test. The sampling intakes will be adjusted for proper directional orientation based on the monitored average wind direction.

Additional meteorological equipment may be deployed as part of an air quality monitoring program. Details are provided in Section 4.

3.2 TESTING PROCEDURES

3.2.1 Preparation of Sample Collection Media

Particulate samples will be collected on Type AE grade glass fiber filters. Prior to the initial weighing, the filters will be equilibrated for 24 h at constant temperature and humidity in a special weighing room. During weighing, the balance is to be checked at frequent intervals with standard (Class S) weights to ensure accuracy. The filters will remain in the same controlled environment for another 24 h, after which a second analyst will reweigh them as a precision check. If a filter cannot pass audit limits, the entire lot is to be reweighed. Ten percent of the filters taken to the field will be used as blanks. The quality

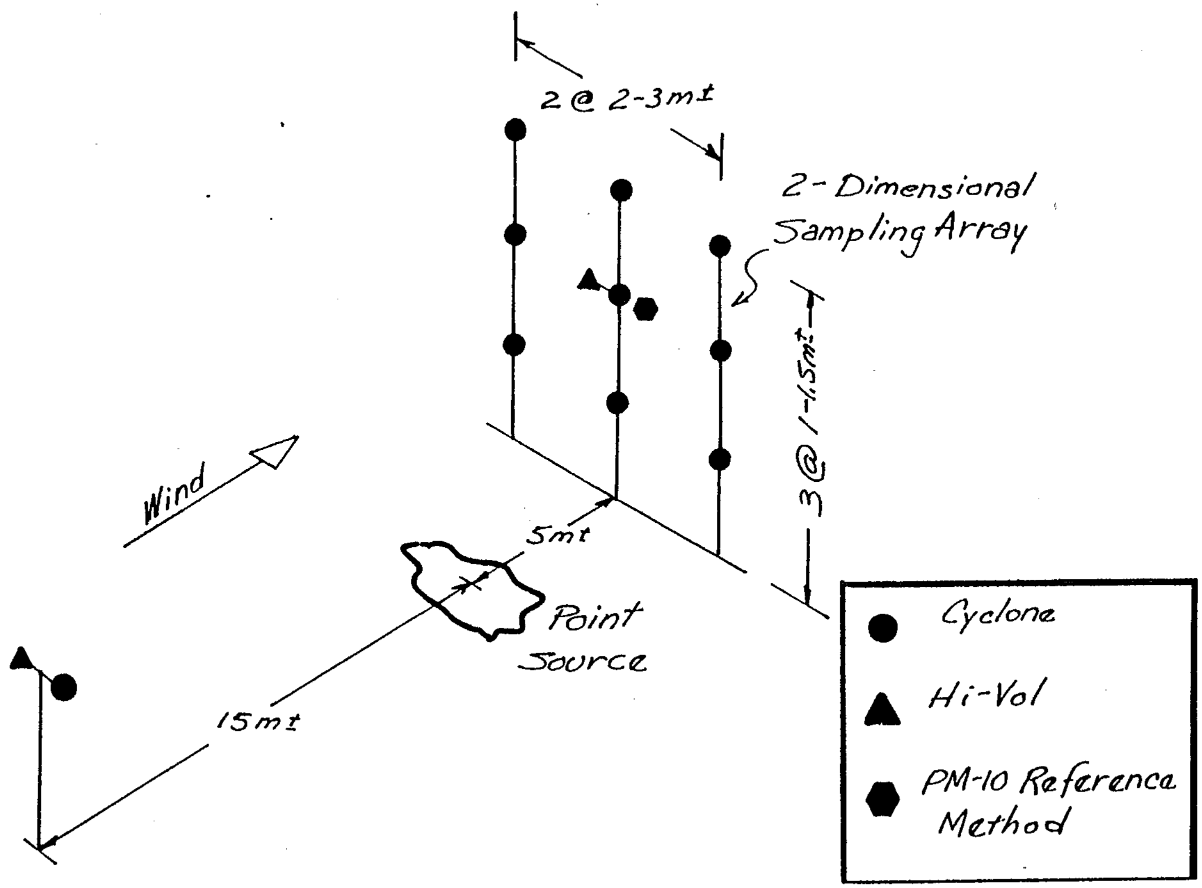

Figure 3. Two-dimensional sampling array.

assurance guidelines pertaining to preparation of sample collection media are presented in Table 3.

3.2.2 Pretest Procedures/Evaluation of Sampling Conditions

Prior to equipment deployment, a number of decisions will be made as to the potential for acceptable source testing conditions. These decisions shall be based on forecast information obtained from the local U.S. Weather Service office. If conditions are considered acceptable, the sampling equipment deployment will be initiated. At this time the sampling flow rates will be set for the various air sampling instruments. The quality control guidelines governing this activity are found in Table 4.

Once the source testing equipment is set up and the filters inserted, air sampling will commence. Information is recorded on specially designed reporting forms and includes:

a. Air samples—Start/stop times, wind speed profiles, flow rates, and wind direction relative to the roadway perpendicular (5- to 15-min average). See Table 5 for QA procedures.

b. Traffic count by vehicle type and speed.

c. General meteorology—Wind speed, wind direction, and temperature.

Sampling time will be long enough to provide sufficient particulate mass and to average over several cycles of the fluctuation in the emission rate (i.e., vehicle passes on the road). Occasionally sampling may be interrupted because of the occurrence of unacceptable meteorological conditions and then restarted when suitable conditions return. Table 6 presents the criteria used for suspending or terminating a source test.

Table 3. QUALITY ASSURANCE PROCEDURES FOR SAMPLING MEDIA

Activity	QA check/requirement
Preparation	Inspect and imprint glass fiber media with identification numbers.
Conditioning	Equilibrate media for 24 h in clean controlled room with relative humidity of less than 50% (variation of less than ±5%) and with temperature between 20° and 25°C (variation of less than ±3%).
Weighing	Weigh hi-vol filters to nearest 0.1 mg.
Auditing of weights	Independently verify final weights of 10% of filters (at least four from each batch). Reweigh batch if weights of any hi-vol filters deviate by more than ±2.0 mg. For tare weights, conduct a 100% audit. Reweigh tare weight of any filters that deviate by more than ±1.0 mg.
Correction for handling effects	Weigh and handle at least one blank for each 1 to 10 filters of each type for each test.
Calibration of balance	Balance to be calibrated once per year by certified manufacturer's representative. Check prior to each use with laboratory Class S weights.

Table 4. QUALITY ASSURANCE PROCEDURES FOR SAMPLING FLOW RATES

Activity	QA check/requirement
• High volume air samplers	Calibrate flows in operating ranges using calibration orifice upon arrival and every 2 weeks thereafter at each regional site prior to testing.
• Orifice and electronic calibrator	Calibrate against displaced volume test meter annually.

Table 5. QUALITY ASSURANCE PROCEDURES FOR SAMPLING EQUIPMENT

Activity	QA check/requirement[a]
Maintenance • All samplers	Check motors, gaskets, timers, and flow measuring devices at each plant prior to testing.
Operation • Timing	Start and stop all downwind samplers during time span not exceeding 1 min.
• Isokinetic sampling (cyclones)	Adjust sampling intake orientation whenever mean wind direction dictates. Change the cyclone intake nozzle whenever the mean wind speed approaching the sampler falls outside of the suggested bounds for that nozzle. This technique allocates no nozzle for wind speeds ranging from 0 to 10 mph, and unique nozzles for four wind speed ranges above 10 mph.
• Prevention of static mode deposition	Cap sampler inlets prior to and immediately after sampling.

[a] All means refer to 5- to 15-min averages.

Table 6. CRITERIA FOR SUSPENDING OR TERMINATING A TEST

A test may be suspended or terminated if:[a]

1. Rainfall ensues during equipment setup or when sampling is in progress.
2. Mean wind speed during sampling moves outside the 1.3- to 8.9-m/s (2- to 20-mph) acceptable range for more than 20% of the sampling time.
3. The angle between mean wind direction and the perpendicular to the path of the moving point source during sampling exceeds 45 degrees for two consecutive averaging periods.
4. Daylight is insufficient for safe equipment operation.
5. Source condition deviates from predetermined criteria (e.g., occurrence of truck spill or accidental water splashing prior to uncontrolled testing).

[a] "Mean" denotes a 5- to 15-min average.

3.2.3 Sample Handling and Analysis

To prevent particulate losses, the exposed media will be carefully transferred at the end of each run to protective containers for transportation. In the field laboratory, exposed filters will be placed in individual glassine envelopes and then into numbered file folders. When exposed filters and the associated blanks are returned to the MRI laboratory, they will be equilibrated under the same conditions as the initial weighing. After reweighing, 10% will be audited to check weighing accuracy.

3.3 EMISSION FACTOR CALCULATION PROCEDURE

To calculate emission rates, a conservation of mass approach is used. The passage of airborne particulate (i.e., the quantity of emissions per unit of source activity) is obtained by spatial integration of distributed measurements of exposure (mass/area) over the effective cross section of the plume. Exposure is the point value of the flux (mass/area-time) of airborne particulate integrated over the time of measurement, or equivalently, the net particulate mass passing through a unit area normal to the mean wind direction during the test. The steps in the calculation procedure are described below.

3.3.1. Particulate Concentrations

The concentration of particulate matter measured by a sampler is given by:

$$C = 10^3 \frac{m}{Qt}$$

where:
- C = particulate concentration ($\mu g/m^3$)
- m = particulate sample weight (mg)
- Q = sampler flow rate (m^3/min)
- t = duration of sampling (min)

To be consistent with the National Ambient Air Quality Standards, all concentrations and flow rates are expressed in standard conditions (25°C and 101 kPa or 77°F and 29.92 inHg).

The isokinetic flow ratio (IFR) is the ratio of a directional sampler's intake air speed to the mean wind speed approaching the sampler. It is given by:

$$IFR = \frac{Q}{aU}$$

where:
- Q = sampler flow rate (m^3/min)
- a = intake area of sampler (m^2)
- U = mean wind speed at height of sampler (m/min)

This ratio is of interest in the sampling of total particulate, since isokinetic sampling ensures that particles of all sizes are sampled without bias. Note, however, that because the primary interest in this program is directed to PM_{10} emissions, sampling under moderately nonisokinetic conditions poses no difficulty. It is readily agreed that 10 µm (aerodynamic diameter) and smaller particles have weak inertial characteristics at normal wind speeds and therefore are relatively unaffected by anisokinesis.[6]

Exposure represents the net passage of mass through a unit area normal to the direction of plume transport (wind direction) and is calculated by:

$$E = 10^{-7} \times CUt$$

where:
- E = particulate exposure (mg/cm^2)
- C = net concentration ($\mu g/m^3$)
- U = approaching wind speed (m/s)
- t = duration of sampling (s)

Exposure values vary over the spatial extent of the plume. If exposure is integrated over the plume effective cross section, then the quantity obtained represents the total passage of airborne particulate matter due to the source.

For a line source, a one-dimensional integration is used:

$$A1 = \int_{O}^{H} E \, dh$$

where: A1 = integrated exposure (m-mg/cm^2)
E = particulate exposure (mg/cm^2)
h = vertical distance coordinate (m)
H = effective extent of plume above ground (m)

For point sources, a two-dimensional integration is used:

$$A2 = \int_{\frac{-W}{2}}^{\frac{W}{2}} \int_{O}^{H} E \, dh \, dy$$

where the quantities are the same as before and

where: A2 = integrated mass (m^2-mg/cm^2)
W = effective plume width (m)
y = horizontal crosswind coordinate (m)

3.3.2 Particulate Emission Factors

The emission factor for particulate generated by vehicular traffic on a straight road segment expressed in grams of emissions per vehicle-kilometer traveled (VKT) is given by:

$$e = 10^4 \frac{A1}{N}$$

where: e = particulate emission factor (g/VKT)
A1 = integrated exposure (m-mg/cm^2)
N = number of vehicle passes (dimensionless)

For a point source, the emission factor is found as

$$e = 10 \frac{A2}{T}$$

where: e = particulate emission factor (g/Mg)
A2 = integrated mass (m^2-mg/cm^2)
T = mass of material handled (Mg)

SECTION 4

ANCILLARY SAMPLE COLLECTION AND ANALYSIS

This section describes the collection and analysis of samples taken to complement the air samples described in the last section. These samples provide information essential to achieving the first two objectives stated in the Introduction.

- Improve available emission factors.
- Develop a comprehensive data base of source activity levels, on-site meteorology, and air quality data.

The types of samples and information to be collected fall into the broad categories of:

- Roadway surface on aggregate material samples.
- Control application parameters.
- Source activity levels.
- Site-specific meteorology.
- Air quality monitoring data.

Each category is described in greater detail below.

4.1 SOURCE MATERIAL SAMPLE COLLECTION AND ANALYSIS

In conjunction with the emissions tests, samples will be taken from the in-place source material either covering the road surface or being handled as bulk aggregate (coal, overburden, etc.). These types of samples are needed not only to evaluate the performance of existing emission factor models but also to develop improved models.

The following describes the procedures used to collect unpaved road samples.

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 one 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-m (1-ft) width 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-L [5-gal] bucket) with a sealable polyethylene liner. Increments may be mixed within this container.

5. Record the required information on the sample collection sheet (Figure 4).

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 procedure described in Section 2 of "Open Source PM-10 Method Evaluation" 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 4. Example surface sample data form for unpaved roads.

For aggregate materials, the following steps are used to collect a sample.

1. Sketch plan and elevation views of the pile. Indicate if any portion is inaccessible. 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 the mid-height of the pile as practical.

   b. For a small pile, a sample should consist of 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 one 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 cm (4 to 6 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 2-m (6-ft) long sampling tube 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 5). Note the space for deviations from the summarized method.

For any of the procedures, the sample mass collected should be at least 5 kg (10 lb). When most materials are sampled with procedures 2.a or 2.b, 10 increments 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.

Regardless of origin, material samples undergo the same types of laboratory analyses. Upon return to MRI's main laboratories, samples undergo moisture and silt content determination. Moisture content is determined by weight loss upon oven drying. Silt content refers to the fraction of material smaller than 200 mesh, as determined by mechanical, dry sieving. The following steps describe the moisture content determination procedure:

1. Preheat the oven to approximately 110°C (230°F). Record oven temperature.

2. Record the make, capacity, and smallest division of the scale.

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 a 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 procedure described in Section 4 of "Open Source PM-10 Method Evaluation" 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 on plant or area map for pile/sample identification. Indicate each sampling location on map.

Figure 5. Example data form for storage piles.

3. Weigh the empty laboratory sample containers which will be placed in the oven to determine their tare weight. Weigh containers with the lids on if they have lids. Record the tare weight(s). Check zero before each weighing.

4. Weigh the laboratory sample(s) in the container(s). For materials with high moisture content, ensure that any standing moisture is included in the laboratory sample container. Record the combined weight(s). Check zero before each weighing.

5. Place sample in oven and dry overnight. Materials composed of hydrated minerals or organic material like coal and certain soils should be dried for only 1½ h.

6. Remove sample container from oven and (a) weigh immediately if uncovered, being careful of the hot container; or (b) place the tight-fitting lid on the container and let cool before weighing. Record the combined sample and container weight(s). Check zero reading on the balance before weighing.

7. Calculate the moisture as the initial weight of the sample and container minus the oven-dried weight of the sample and container divided by the initial weight of the sample alone. Record the value.

8. Calculate the sample weight to be used in the silt analysis as the oven-dried weight of the sample and container minus the weight of the container. Record the value. (See Figure 6.)

The oven-dried sample then undergoes silt analysis:

1. Select the appropriate 20-cm (8-in) diameter, 5-cm (2-in) deep sieve sizes. Recommended U.S. Standard Series sizes are 3/8 in, No. 4, No. 40, No. 100, No. 140, No. 200, and a pan. Comparable Tyler Series sizes can also be utilized. The No. 20 and the No. 200 are mandatory. The others can be varied if the recommended sieves are not available or if buildup on one

MOISTURE ANALYSIS

Date: ____________ By: ____________

Sample No: ____________
Material: ____________

Split Sample Balance:
Make ____________
Capacity ____________
Smallest Division ____________

Total Sample Weight: ____________
(Excl. Container)
Number of Splits: ____________

Split Sample Weight (before drying)
Pan + Sample: ____________
Pan: ____________
Wet Sample: ____________

Oven Temperature: ____________
Date In ____________ Date Out ____________
Time In ____________ Time Out ____________
Drying Time ____________

Sample Weight (after drying)
Pan + Sample: ____________
Pan: ____________
Dry Sample: ____________

MOISTURE CONTENT:
(A) Wet Sample Wt. ____________
(B) Dry Sample Wt. ____________
(C) Difference Wt. ____________

$\frac{C \times 100}{A}$ = ____________ % Moisture

Figure 6. Example moisture analysis form.

particulate sieve during sieving indicates that an intermediate sieve should be inserted.

2. Obtain a mechanical sieving device such as vibratory shaker or a Roto-Tap without the tapping function.

3. Clean the sieves with compressed air and/or a soft brush. Material lodged in the sieve openings or adhering to the sides of the sieve should be removed (if possible) without handling the screen roughly.

4. Obtain a scale (capacity of at least 1,600 g or 3.5 lb) and record make, capacity, smallest division, date of last calibration, and accuracy.

5. Weigh the sieves and pan to determine tare weights. Check the zero before every weighing. Record weights.

6. After nesting the sieves in decreasing order with pan at the bottom, dump dried laboratory sample (preferably immediately after moisture analysis) into the top sieve. The sample should weigh between ~ 400 and 1,600 g (0.9 to 3.5 lb). This amount will vary for finely textured materials; 100 to 300 g may be sufficient with 90% of the sample passing a No. 8 (2.36 mm) sieve. Brush fine material adhering to the sides of the container into the top sieve, and cover the top sieve with a special lid normally purchased with the pan.

7. Place nested sieves into the mechanical sieving device and sieve for 10 min. Remove pan containing minus No. 200 and weigh. Repeat the sieving in 10-min intervals until the difference between two successive pan sample weighings (where the tare weight of the pan has been subtracted) is less than 3.0%. Do not sieve longer than 40 min.

8. Weigh each sieve and its contents and record the weight. Check the zero reading on the balance before every weighing.

9. Collect the laboratory sample and place the sample in a separate container if further analysis is expected.

10. Calculate the percent of mass less than the 200 mesh screen (75 µm). This is the silt content. See Figure 7.

4.2 CONTROL APPLICATION PARAMETERS

It is expected that the test mine will have an unpaved road dust control program in place. Example programs include wet suppression by water truck or "rainbird" system, or chemical treatment from periodic applications of petroleum resins, acrylics, asphalt emulsions, or other commercially available products. It is important that any emission test conducted of a controlled road (or of a controlled material-handling operation, for that matter) be associated with an adequate description of the control measure.

For unpaved roads treated chemically, this would include a history of control applications, with "intensity" (as measured by the volume of solution applied per unit area of road surface), the dilution ratio, and the date of each application recorded. Analogous (but less detailed) information is needed for an unpaved watering program. Finally, for wet suppression of handling emissions, flow rates and nozzle types need to be identified. MRI will work closely with mine personnel to obtain the above types of information.

To measure the application intensity of water or chemical suppressants, MRI will place tared sampling pans at various locations on the test strips prior to application. Special attention is to be paid to the problem associated with the chemical dust suppressant splashing off the bottom of the pan. To reduce this potential source of error, an absorbent material will be used to line the bottom of the pan. Once the control is applied, the sample pans will be reweighed and the density of the solution will be measured. The application intensity measured by each pan is given by

SILT ANALYSIS

Date ______________ By ______________

Sample No: ______________ Sample Weight (after drying)

Material: ______________ Pan + Sample: ______________

Pan: ______________

Split Sample Balance: Dry Sample: ______________

Make ______________

Capacity ______________ Final Weight: ______________

Smallest Division ______________

$$\% \text{ Silt} = \frac{\text{Net Weight } <200 \text{ Mesh}}{\text{Total Net Weight}} \times 100 = \_\_\_\_\_ \%$$

SIEVING

Time: Start:	Weight (Pan Only)
Initial (Tare):	
20 min:	
30 min:	
40 min:	

Screen	Tare Weight (Screen)	Final Weight (Screen + Sample)	Net Weight (Sample)	%
3/8 in.				
4 mesh				
10 mesh				
20 mesh				
40 mesh				
100 mesh				
140 mesh				
200 mesh				
Pan				

Figure 7. Example silt analysis form.

$$a = \frac{m_f - m_t}{\rho A}$$

where:
- a = application intensity (volume/area)
- m_f = final weight of the pan and solution (mass)
- m_t = tare weight of the pan (mass)
- ρ = weight density of solution (mass/volume)
- A = area of the pan (area)

The individual application intensities obtained will be examined to determine any significant spatial variations and to obtain an average value.

Note that the performance of unpaved road dust controls is strongly dependent upon not only the service environment (such as the weight and number of vehicles traveling the road after control application) but also ambient meteorological conditions (such as temperature, insolation, and freeze/thaw cycles). Service environment factors are described in the next section, while on-site meteorology is discussed in Section 4.4.

4.3 SOURCE ACTIVITY MONITORING

One potentially significant difference from the study described here and past field studies at surface coal mines is the development of a "source activity data base." As noted earlier, the impact of PM_{10} emissions from SCMs is typically based on annual averages (of coal production, etc.) presented in a mine's operating plan or obtained from an active mine. Worst-case emissions are usually calculated under the assumptions (a) that natural moisture mitigation is negligible and (b) that the worst-case emissions from all sources under consideration occur at the same time. Worst-case activity levels are often scaled from the annual average by an assumed factor (such as a factor of 2).

In contract to this approach, a "dynamic" emissions inventory will be obtained to accomplish the goals of this program. Unlike most regulatory modeling exercises, which are interested in "annual average" or "worst-case" conditions, this program will track actual source activity over time. Source activity levels will be recorded during the entire period that field test crews are present at surface coal mines.

Source extent activity data will be collected with a variety of tools. For example, in addition to visual observation and note taking, video cameras and/or time-lapse photography may be used to determine activity on roads or at other mining sources. For roads and other travel-related sources (such as coal or overburden truck dumps), pneumatic axle counters will be used to supplement other approaches.

This monitoring activity will make use of pneumatic and other types of traffic counters; these can be removed for road grading, etc. The monitoring also calls for some videotaping, requiring two or three enclosed or sheltered areas in which to set up equipment. The areas should have standard AC power and be relatively clean and secure. At present it is anticipated that approximately three to six pneumatic counters and two to three video cameras will be able to provide the necessary information for the major emission sources.

The use of a variety of data acquisition methods aids in resolving source activity levels on an appropriate temporal basis. Source activity (both rate and physical location) will be resolved to 4-h or shorter time periods. The 4-h period corresponds to one-half work shift at a mine. It is likely that most emission sources at a surface mine can be viewed as relatively constant in time and space over a work shift. The use of a half-shift as the basic time averaging unit provides a margin of safety. In addition, at the start of each day, the field crew chief will ask the mine superintendent or his designee to describe any unusual events (equipment downtime, etc.) during the past 24 h.

4.4 METEOROLOGICAL MONITORING

The collection of valid, applicable meteorological data is essential in meeting the objectives of the proposed program. These data must be representative of atmospheric dispersion conditions at the source and at locations where the source may have a significant impact on air quality or where air quality is monitored. The representativeness of the data is dependent upon (1) the proximity of the meteorological monitoring site to the area under consideration, (2) the complexity of the topography of the area, (3) the exposure of the meteorological sensors, and (4) the period of time during which the data are collected.

According to the EPA's PSD guidelines, a data base representative of the meteorological monitoring site should consist of at least the following data:

1. Hourly average wind speed and direction.

2. Hourly average atmospheric stability based on Pasquill stability category or wind fluctuations (σ_θ), or vertical temperature gradient combined with wind speed.

3. Hourly surface temperature at standard height for climatological comparisons and plume rise calculations.

4. Hourly precipitation amounts for climatological comparisons.

Mines agreeing to serve as test sites may already have active PSD-type meteorological monitoring programs. The suitability of any existing meteorological monitoring network will be reexamined once a mine has been selected as a field test site. In any event, at least a backup meteorological monitoring station will be deployed during this field program.

As with the particulate monitoring sites to be discussed in Section 4.5, it is essential to ensure that microscale source, topographic, and meteorological influences do not bias the data obtained with the weather station. This consideration is critical because of the generally large areas which are to be represented by the station.

Following PSD guidelines, the wind monitor should be sited:

1. To monitor representative wind field.

2. Near the source of particulates.

3. Away from undesired microscale flows.

4. Away from the influence of trees and obstructions (at a distance from an obstacle approximately five times the obstacle's height).

5. At a height of 10 m.

6. Adjacent to particulate sampler if possible.

Analogously, the ambient temperature sensor must be protected against thermal radiation from the sun, sky, earth, and any surrounding objects and must be adequately ventilated. The temperature sensor suggested for this study is housed on the meteorological mast just below the wind sensors and is protected by a radiation shield.

The rain gauge used in the study should be located at ground level in a sheltered area to prevent undue effects from atmospheric turbulence. Ideally, the gauge site should be carefully leveled and protected in all directions by objects of uniform height (trees, buildings, etc.). If this cannot be accomplished, an effort should be made to site the instrument where it will be shielded from up- and down-valley flows. The heights of the surrounding objects should be between one-half and one times their distance from the gauge.

Because no site surveys have been done at the time of this writing, it is not now possible to completely define what meteorological monitoring equipment will be employed. The following discussion represents a "best guess" at this time.

At present it is anticipated that each "primary" air quality monitoring station (as defined in Section 4.5) will be equipped with at least a recording meteorological station, such as Meteorology Research Inc. Model 1077 or a Climatronics bi-vane weather station. Because the bi-vane unit stores digitized data, it would serve as the principal monitoring device. The Climatronics unit is capable of providing a good indication of hourly gauge atmospheric stability class as well as hourly wind speed and direction.

The Model 1077 weather station, on the other hand, has been proven to be a reliable field monitor for wind speed and direction, temperature, and windfall. This reliability makes the Model 1077 a good backup system. To be sure, much of the reliability is due to the fact that a strip chart is used to record data. The choice of recording device, however, makes the estimation of stability class more tenuous. In short, the standard deviation of azimuth wind direction is estimated by a procedure developed by Markee.[7]

$$\sigma_\theta = \frac{R_\theta}{6}$$

where: σ_θ = standard deviation of wind direction

R_θ = hourly range of wind direction

The quantity σ_θ is then used to convert to the stability class as follows:

σ_θ	Pasquill stability class
> 22.5	A
17.5 - 22.5	B
12.5 - 17.5	C
7.5 - 12.5	D
3.8 - 7.5	E
< 3.8	F

4.5 AIR QUALITY MONITORING

Present discussions indicate that a model evaluation may be performed at a surface coal mine in later years. As such, some results from this study may be used in that field evaluation. The following paragraphs describe the type of field program anticipated at a later date.

As was the case for meteorological monitoring, it is likely that mines selected as field test sites will have active PSD-type air quality monitoring programs. Unlike the meteorological stations, however, it is improbable that existing air quality monitoring networks will prove entirely suitable for model evaluation purposes. For this reason, a flexible air quality monitoring program has been included as part of this field program.

Like the source activity monitoring, the air quality monitoring program will differ from past studies in that finer time resolution is of interest. Past studies have generally had to "make do" with available data. Nevertheless, the time period over which ambient measurements are made, over which emission rates are computed, and over which source locations are idealized should be as short as practicable. The performance of an air quality model should improve when the input data have finer resolution. Nevertheless, any analysis of a model's performance in predicting PM_{10} concentrations must consider 24-h time intervals because many mines have more difficulty demonstrating compliance with 24-h rather than annual increments or standards.

Various time averaging periods are possible for PM_{10} concentrations. In the regulatory sense, 24-h concentrations are most important because the NAAQSs and PSD increments are based on that time period. On the other hand, currently available dispersion models typically use hourly meteorological data to predict hourly concentrations. The hourly predictions are then combined to provide longer-period averages.

Until recently, ambient PM_{10} concentrations could only be sampled by reference methods for periods on the order of 24 h. Within the past year, several equivalent PM_{10} measurement methods have become available, providing far greater time resolution than the older high-volume sampling methods. Table 7 summarizes the advantages and disadvantages of various field sampling equipment that could be used.

If a network consisting of only continuous PM_{10} monitors were to be established, concentration at each monitoring location can be averaged on a 1-h basis. Although these monitors provide the finest time resolution possible, they typically require temperature-controlled enclosures and "clean" electric power. The enclosure and power requirements accentuate the high purchase cost of continuous samplers. In summary, continuous monitors provide a very high degree of temporal resolution but can provide adequate spatial coverage only at a very high level of cost.

The present field program, however, seeks to combine the best features of the available PM_{10} sampling methods by combining two or three continuous monitors with 6 to 10 high-volume samplers and with 10 to 20 "saturation" samplers. In this way, a high degree of temporal resolution is accomplished at a few locations within a generally well-monitored geographic area.

This combination is viewed as providing the greatest spatial coverage possible at a reasonable cost while still providing the type of data needed to assess the scientific component of the dispersion model. Specifically, the following types of equipment are proposed for the study.

1. Two or three primary monitoring stations, each station with:

   a. A continuous PM_{10} monitor such as a beta gauge or tapered element oscillating microbalance.

   b. At least one each Andersen size-selective-inlet (SSI) and Wedding PM_{10} inlet mounted on a high-volume sampler.

   c. At least one saturation sampler.

   d. A recording meteorological station.

   The different samplers will be colocated. Furthermore, the "whole-air" (i.e., noncontinuous) samplers will be operated over the same time periods. If only one set of high-volume samplers is available, then they will be operated on a 24-h schedule. If more than one of

Table 7. PM_{10} SAMPLING OPTIONS

Type	Representative samplers	Time averaging period	Advantages	Disadvantages
High volume	Wedding, Andersen	6 to 24 h	EPA Reference Method for PM_{10} Averaging period comparable to Can operate on portable generator power	Requires AC power Cannot provide fine time resolution of concentrations
Continuous	Beta gauge, TEOM (tapered element oscillating microbalance)	Continuous	Provides very fine time resolution of concentration	Requires "clean" AC power, and does not run well on portable generators Generally requires temperature-controlled enclosure for reliable operation Most expensive option
Saturation	"PRO-2"	6 to 24 h	Battery-powered Least expensive option Relatively rugged and easily deployed/moved	Not an equivalent method Cannot provide fine time resolution of concentration

each type is available, then shorter periods (such as 8 and 12 h) are recommended.

Each of the primary sampling locations will be equipped with a trailer and either a power drop or a heavy-duty diesel generator to provide the "clean" electrical power needed to operate the continuous monitors. (If generators are used, special precautions will be taken to avoid sample contamination by exhaust.)

2. Approximately 10 to 20 saturation samplers deployed throughout the geographic area downwind of the mine.

The siting of air quality monitoring devices is highly dependent upon the characteristics of the test site, factors such as the distances and orientation of major PM_{10} sources, prevailing wind directions, mines, and surrounding topography. Because site surveys have yet to be conducted, monitor siting can only be discussed in general terms. For illustration purposes, a hypothetical power shovel mine will be used as an example (see Figure 8).

At the example mine, the major sources are found to be coal haul trucks, overburden haul trucks, overburden handling, and overburden dumping. General traffic is also important but is confined to the two roads shown in the figure.

Mining activity rates and locations at the example mine have been evaluated along with the site-specific meteorological data to determine prevailing wind direction and the sampler locations. It is proposed that at least three portable samplers be placed in an arc immediately downwind of the major sources.

Significant mining emission sources are rarely grouped together; rather the sources may be spread over distances on the order of miles. To measure the cumulative effect of separate sources, the model should be tested at not only the points of maximum concentration from individual sources but also at points where the combined effect is greatest. A second set of samplers is placed at the points where emissions from individual sources combine to produce a secondary maximum (see Figure 8). To determine what the background contribution is,

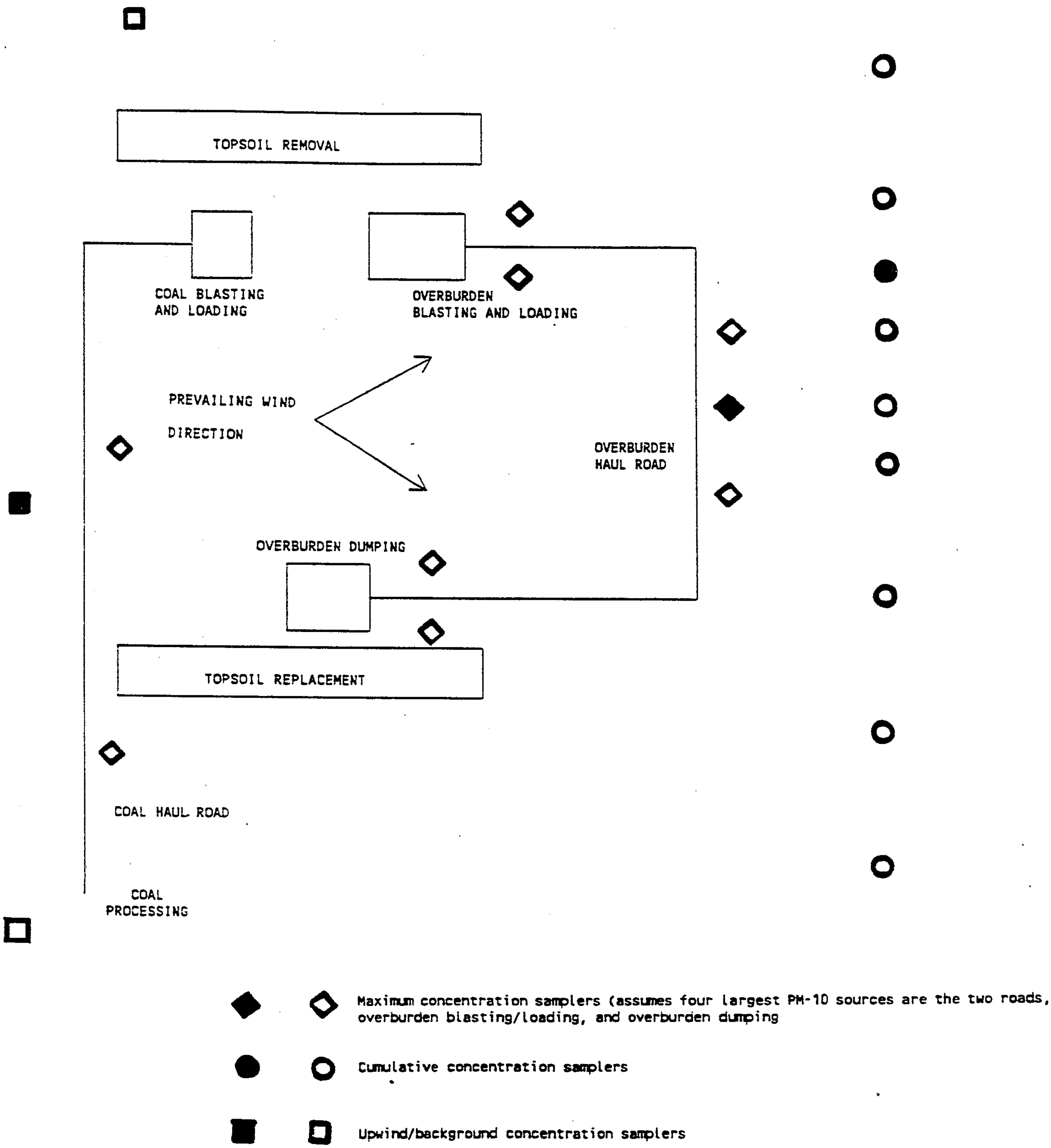

Figure 8. Proposed sampling arrays at a stylized truck-shovel mine. Filled symbols represent primary sampling locations, hollow symbols represent saturation samples.

three additional locations are proposed, placed in upwind and crosswind directions from the mining activities. Roughly half of the saturation PM_{10} samplers will be sited to sample combined concentrations.

The exact placement of samplers at the actual mines tested will be a function of both the configuration of the mine and the local meteorology. Until the time that an actual test site is decided upon, exact placement of samplers cannot be made.

SECTION 5

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16. ABSTRACT

This report outlines the test protocols and plans to be used for improving emission factors for western surface coal mines in response to the requirements of Section 234 of the Clean Air Act of 1990.

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