SECTION 2.10

Reference Method for the Determination of Particulate Matter as PM10 in the Atmosphere (Dichotomous Sampler Method)

2.10.0 INTRODUCTION

As described in 40 CFR 50, Appendix J, the reference method for PM10 sampling (i.e., sampling particulate matter with an aerodynamic diameter less than or equal to a nominal 10 µm), a PM10 sampler draws a measured quantity of ambient air at a constant flow rate through a specially designed particle size discrimination inlet. Particles in the PM10 size range are then collected on one or more filters during the specified 24-hour sampling period. Each sample filter is weighed before and after sampling to determine the net weight (mass) gain of the collected PM10 sample.

The total volume of air sampled is determined from the measured volumetric flow rate and the sampling time. The concentration of PM10 in the ambient air is computed as the total mass of collected particles in the PM10 size range divided by the volume of air sampled. This sampled volume must be corrected to EPA reference conditions (25 °C, 760 mm Hg or 101 kPa), and PM10 data are expressed as micrograms per standard cubic meter (µg/std. m^3). The particle size discrimination characteristics (sampling effectiveness) of the sampler inlet over the PM10 size range, and particularly the particle size at which the sampling effectiveness is 50%, are functional specifications tested in accordance with explicit procedures prescribed in 40 CFR 53. Sampling methods for PM10 that meet all requirements in both Parts 50 and 53 are designated as PM10 reference methods for use in SLAMS and PSD monitoring. These designated methods are usually identified by the name of the manufacturer and by the model of the sampler.

Two types of samplers that meet designation requirements are the high volume PM10 sampler (HV PM10) and the dichotomous sampler. Only the dichotomous sampler is discussed in this section of the Handbook; the HV PM10 sampler is discussed in Section 2.11.

The most common commercially available dichotomous samplers are low flow rate (16.7-L/min) samplers that collect particles with an aerodynamic diameter up to a nominal size of 10 µm. (Note: In reference to PM10 samplers, all particle sizes are specified by their aerodynamic rather than physical diameter.) Dichotomous samplers further divide the sample into fine (0- to 2.5-µm) and coarse (2.5- to 10-µm) fractions, which are collected on separate filters.

Particles with aerodynamic diameters greater than 10 µm are removed from the air sample by inertial separation in a specially designed fractionating inlet such as the one illustrated in Figure 0.1. Particle-laden air is drawn into the inlet and deflected downwards into the acceleration jet of an impactor. Because of their greater inertia, particles larger than 10 µm are removed by the impactor. Particles smaller than 10 µm are drawn through the vent tube into a virtual impactor assembly, which further separates the particles into fine and coarse size fractions. Figure 0.2 illustrates the principle used to achieve this division. The air stream containing PM10 particles is forced through an acceleration nozzle into the virtual impactor assembly where the air flow is split. Most of the fine particles make a sharp turn to follow the higher velocity flow stream and pass on to the fine particle filter. Because of their greater inertia, the coarse particles continue into the virtual impactor receiver tube and are collected on the coarse particle filter. Because a small proportion of the fine particles are also

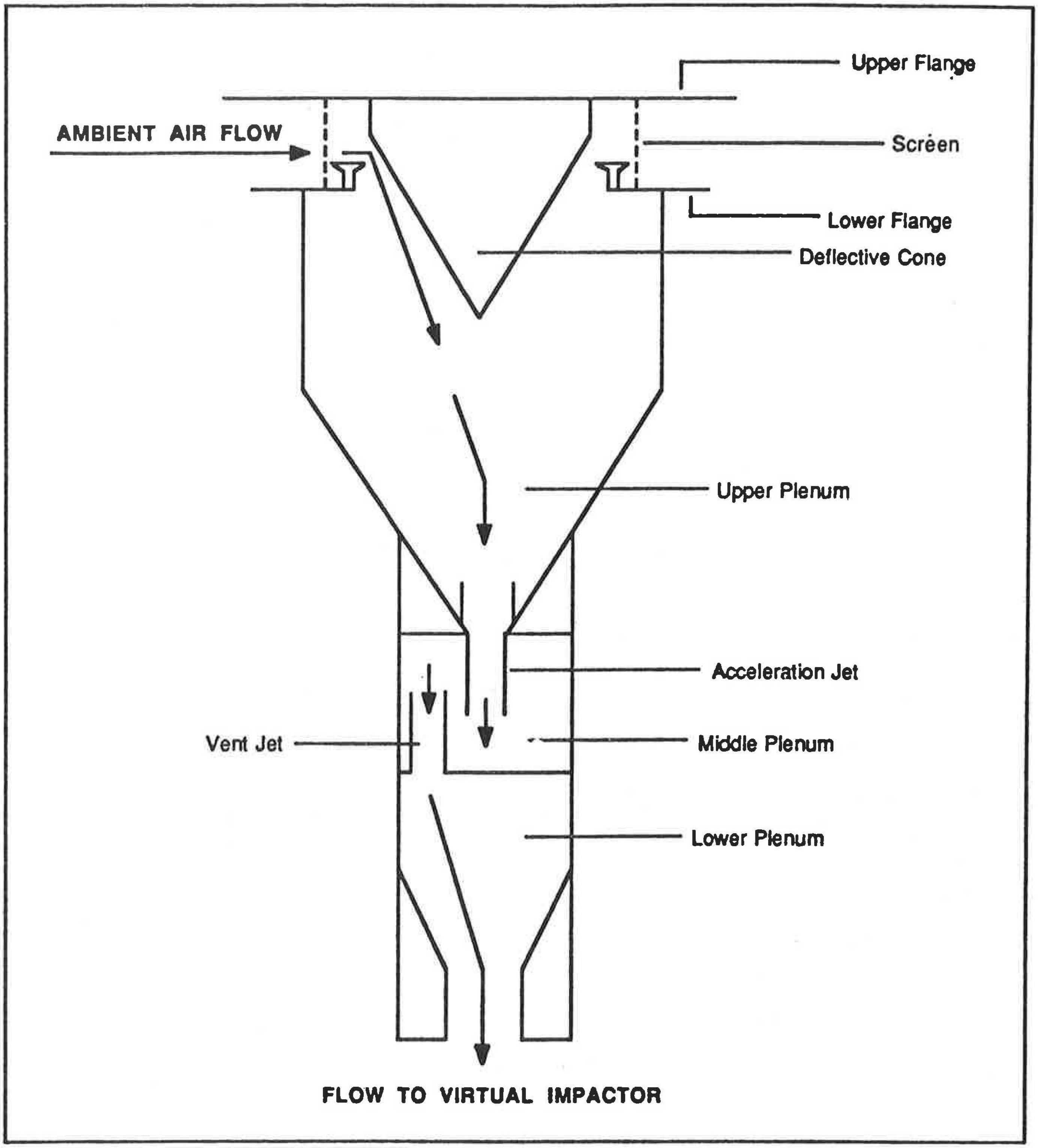


Figure 0.1. Example of a PM10 dichotomous sampler inlet head.

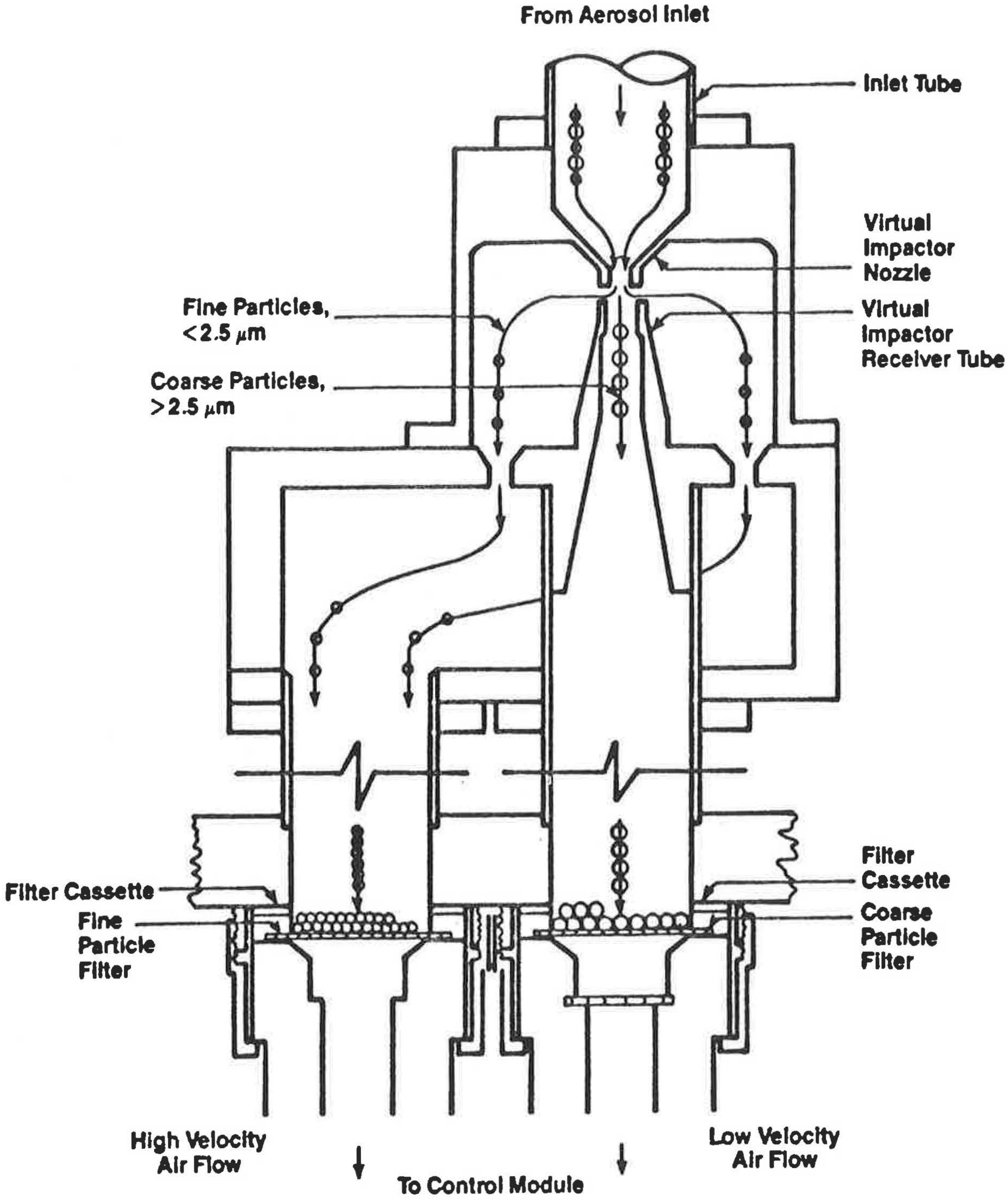


Figure 0.2. Principle of the secondary (2.5 μm) particle size separation in a dichotomous sampler by virtual impaction.

collected on the coarse particle filter, a correction must be made when fine and coarse particle concentrations are calculated.

Method Highlights

The procedures provided in this document are designed to serve as guidelines for the development of quality assurance (QA) programs associated with the operation of dichotomous samplers. Since recordkeeping is a critical part of QA activities, several data forms are included to aid in the documentation of necessary data. The blank data forms (Subsection 12) may be used as they are, or they may serve as guidelines for preparing forms more specific to the needs of the individual monitoring agency. Partially filled-in forms are included at appropriate places in the text to illustrate their uses.

Tables at the end of some sections summarize the material covered in the text subsections. The material covered in the various subsections of this section is summarized here:

1. Subsection 1, Procurement of Equipment and Supplies, describes recommended procurement procedures, equipment selection criteria, and minimum accuracy requirements. It also provides an example of a permanent procurement record.

2. Subsection 2, Calibration Procedures, provides detailed calibration procedures for the dichotomous sampler. References are provided for calibration procedures for the flow-rate transfer standards and other monitoring equipment. A table is provided at the end of this subsection that summarizes the acceptance limits for calibration.

3. Subsection 3, Field Operations, details procedures for filter installation, performance of operational quality control (QC) checks, sample handling, and data documentation. Complete documentation of background information during sampling is one of several QA activities that are important to future data validation; particularly important are any unusual conditions existing during collection of the sample. Such conditions should be noted.

4. Subsection 4, Filter Preparation and Analysis, presents important considerations for the handling, integrity, equilibration, and weighing of filters. A high quality filter is recommended for use when additional chemical analyses are expected. Subsection 2.10.4 also briefly describes minimum laboratory QC procedures. The analytical balance must be calibrated annually, and the filters must be equilibrated in a controlled environment.

5. Subsection 5, Calculations, Validations, and Reporting of PM10 Data, presents calculations for determining PM10 mass concentrations and minimum data validation requirements. The final data review and validation, including standardized reporting procedures, are all important parts of a QA program. Independent checks of the data and calculations are required to ensure that the reported data are both accurate and precise.

6. Subsection 6, Maintenance, recommends periodic maintenance schedules to ensure that the equipment is capable of performing as specified. Minimum maintenance requirements and procedures are outlined. The objective of a routine maintenance program is to increase measurement system reliability.

7. Subsection 7, Auditing Procedures, presents independent audit activities and laboratory evaluations that provide performance checks of flow-rate measurements and data processing. Filter weighing procedures and balance operation evaluations and a system audit checklist are also provided. Independent audits evaluate data validity.

8. Subsection 8, Assessment of Monitoring Data for Precision and Accuracy, describes the assessment procedures for determining the accuracy and precision of the data. The precision check is performed by using collocated samplers.

9. Subsection 9, Recommended Standards for Establishing Traceability, discusses the traceability of monitoring equipment to establish standards of higher accuracy, a necessary prerequisite for obtaining accurate data.

10. Subsections 10 and 11 contain the PM10 Reference Method and pertinent references, respectively, used to prepare this document. Subsection 12 provides blank data forms for the convenience of the user.

2.10.1 PROCUREMENT OF EQUIPMENT AND SUPPLIES

The establishment of an ambient PM10 air monitoring network requires the procurement of specialized equipment and supplies for field operations and subsequent filter analysis. Information in this section has been provided to assist the agency in selecting the proper equipment. Subsection 1.1 presents minimum sampling equipment necessary to conduct field operations. Recommended laboratory instrumentation is presented in Subsection 1.2.

In addition to field operations and laboratory equipment, a data handling system (including forms, logs, files, and reporting procedures) must be developed and implemented.

It is recommended that each agency establish minimum monitoring equipment requirements and budgetary limits before the procurement procedures are initiated. Upon receipt of the sampling equipment and supplies, appropriate procurement checks should be conducted to determine their acceptability, and whether they are accepted or rejected should be recorded in a procurement log. Figure 1.1 is an example of such a log. This log will serve as a permanent record for procurements and provide fiscal projections for future programs. It will also help to provide the continuity of equipment and supplies. Table 1.1, at end of the subsection, lists the major equipment needed, how it should be tested, suggested acceptance limits, and actions to be taken if acceptance limits are not met.

1.1 Procurement Prerequisites--Field Operations

1.1.1 Dichotomous Samplers -

The individual sampler must meet U.S. EPA operational standards and be a model designated as a reference or equivalent method. A complete listing of minimum sampler requirements (i.e., 40 CFR 50, Appendix J) is contained in the reference method reproduced in Subsection 10. Dichotomous samplers not designated as reference or equivalent methods may not be used for reporting data to determine attainment of the National Ambient Air Quality Standard (NAAQS) for particulate matter. Cost for dichotomous samplers will vary with the manufacturer and the sophistication of the sampler. Basic considerations include the flow control and measurement system, maintenance requirements, reliability, and ease of operation.

Using only one model of sampler in a network will minimize the variety of spare parts required to keep the network in operation. An in-house inventory of general maintenance supplies and replacement parts is recommended. These include various hand tools, general all-purpose cleaner, penetrating oil, distilled water, Kimwipes (or equivalent), soft brush, and cotton swabs. Spare parts for the sampler may be supplied by the manufacturer or many may be purchased locally.

1.1.2 Calibration Equipment -

Calibration activities require specialized equipment that will not necessarily be used in routine monitoring. At a minimum, the following equipment is required:

ITEM	Description	Qty	Purchase Order No.	VENDOR	DATE		COST	Initials	Accept/ Reject	COMMENTS
					Ord.	Rec'd.				
1 Case Filters	2μ Pore 37mm	60	806-5187	WIZ Supply	5/1/90	6/15/90	88.29	DAW	Accepted	None

Figure 1.1. Example procurement log.

- A thermometer capable of accurately measuring ambient temperatures to the nearest ±1°C and referenced to a National Institute of Standards and Technology (NIST) or an American Society for Testing Materials (ASTM) thermometer within ±2°C (NIST is the former National Bureau of Standards [NBS]).

- A barometer capable of accurately measuring barometric pressure over a range of 500 to 800 mm Hg (66 to 106 kPa) to the nearest millimeter of Hg and referenced at least annually to a standard of known accuracy within ±5 mm Hg. For laboratory measurements, a Fortin-type, mercury-column barometer is appropriate. For field measurements, a portable, aneroid barometer (e.g., a climber's or engineer's altimeter) is appropriate.

- Flow-rate transfer standards capable of accurately measuring the total, fine, and coarse flow rates of a dichotomous sampler. Tables 2.1 and 2.2 (Subsection 2, Calibration Procedures) present a variety of recommended transfer standards, their optimum flow ranges, and support equipment necessary for determining these flow rates. For the most commonly available commercial sampler, flow-rate transfer standards capable of accurately measuring flow rates from 12.0 to 19.0 L/min and 1.4 to 1.9 L/min are required. The transfer standard calibration relationship must be referenced annually and be within ±2% of the NIST-traceable primary standard.

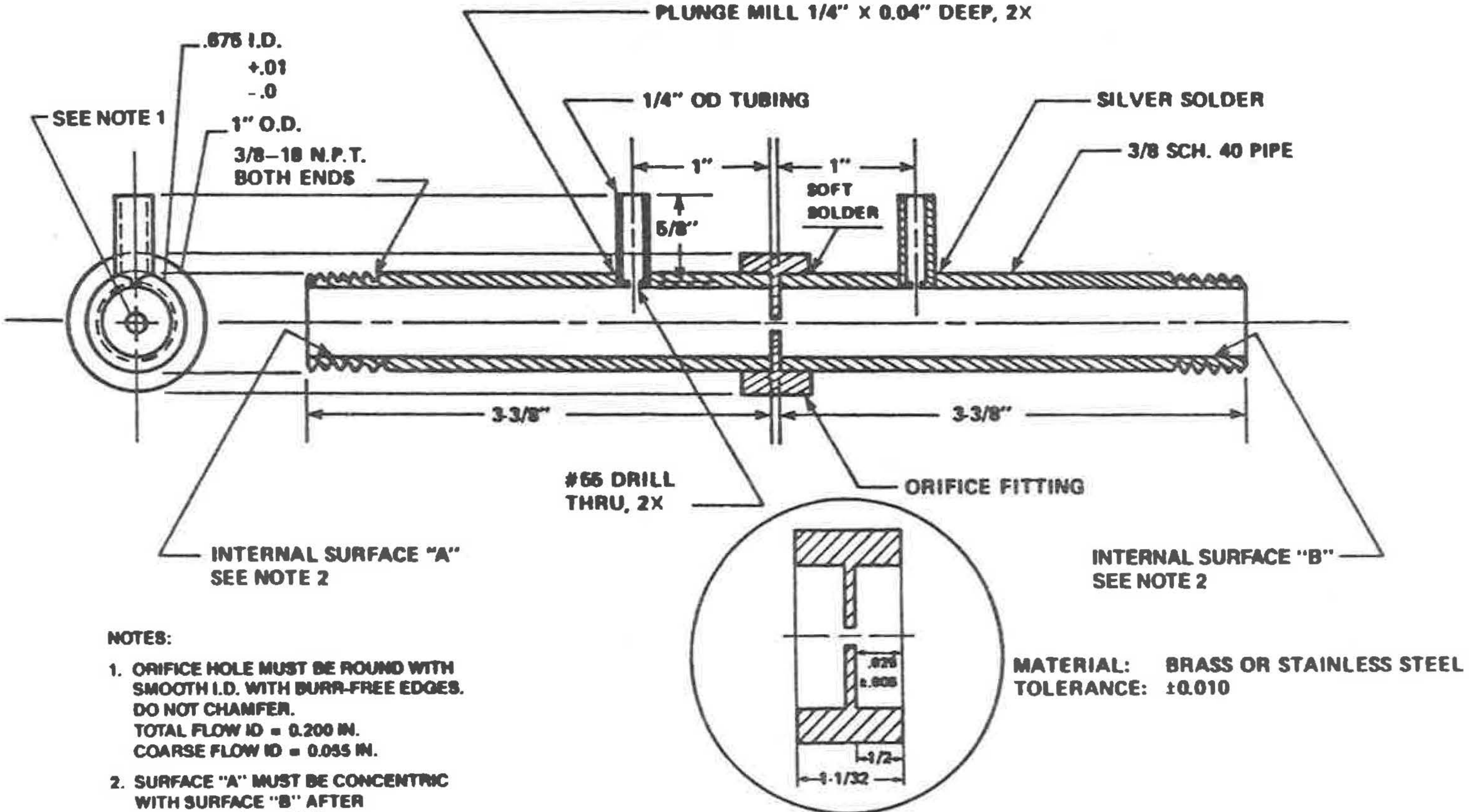
- An adapter of the correct dimensions that will connect the transfer standard outlet to the dichotomous sampler inlet and form a leak-proof seal. All interconnecting tubing should be flexible and crimp-resistant.

- Miscellaneous calibration supplies include a 9.53-mm (3/8-in.) or 6.35-mm (1/4-in.) Swagelok cap. If a soap film flowmeter is used, a rubber stopper with a tubing adapter is necessary to be able to measure flows under vacuum. The stopper may be obtained through a local scientific supply company.

1.1.3 QC Flow-Check Device -

A QC flow-check device is required for routine operation of the dichotomons sampler. Using calibrated orifice devices is a simple, accurate method for determining flow rates during routine operations.

The QC flow-check devices can be fabricated in-house or ordered through a manufacturer. Figure 1.2 provides orifice device dimensions for both total and coarse flows. In the total flow range, the orifice must have an NIST-traceable calibration and be able to accurately measure flows between 12.0 and 19.0 L/min. In the coarse flow range, the orifice must have an NIST-traceable calibration and be able to accurately measure flows between 1.4 and 1.9 L/min. The calibration relationships must be referenced annually and be within ±2% of the NIST-traceable primary standard. As a minimum, both the total and coarse flows should be checked.



NOTES:

1. ORIFICE HOLE MUST BE ROUND WITH SMOOTH I.D. WITH BURR-FREE EDGES. DO NOT CHAMFER.
   TOTAL FLOW ID = 0.200 IN.
   COARSE FLOW ID = 0.055 IN.
2. SURFACE "A" MUST BE CONCENTRIC WITH SURFACE "B" AFTER ASSEMBLY ± 0.02 T.I.R.

MATERIAL: BRASS OR STAINLESS STEEL
TOLERANCE: ±0.010

Figure 1.2. Orifice dimensions for both the total and coarse flows. These total and coarse flow orifice dimensions will provide approximately 1 inch of water pressure drop at 16.7 and 1.67 L/min, respectively.

1.1.4 Audit Equipment -

The equipment needed for auditing is similar to the calibration equipment; however, the audit orifice transfer standard MUST be a different device from the one that is used for routine calibration and flow checks.

1.2 Procurement Prerequisites--Laboratory Operations

1.2.1 Filter Media -

No commercially available filter is ideal in all respects. The sampling program should determine the relative importance of certain filter evaluation criteria (e.g., physical and chemical characteristics, ease of handling, cost). The reference method presents basic criteria that must be met regardless of the filter type selected. These are as follows:

- Collection efficiency - Greater than 99% as measured by DOP test (ASTM-2988) with 0.3-μm particles at the sampler's operating face velocity.
- Integrity - ±5 μg/m^3 (assuming sampler's nominal 24-h air sample volume), measured as the concentration equivalent corresponding to the difference between the initial and final weights of the filter when weighed and handled under simulated sampling conditions (equilibration, initial weighing, placement on inoperative sampler, removal from a sampler, re-equilibration, and final weighing).
- Alkalinity - Less than 0.005 milliequivalents/gram of filter as measured by the procedure given in Reference 13 of the reference method (Subsection 10) following at least 2 months' storage at ambient temperature and relative humidity.

Note: Some filters may not be suitable for use with all samplers. Due to filter handling characteristics or rapid increases in flow resistance due to episodic loading, some filters, although they meet the above criteria, may not be compatible with the model of sampler chosen. It would be prudent to evaluate more than one filter type before purchasing large quantities for network use.

1.2.2 Filter Protection -

Filter support cassettes (see Figure 4.1) are required for sampling with most dichotomous samplers and may be purchased through the manufacturer or a local scientific supply company. A sufficient number of cassettes must be purchased to allow insertion and removal of the filters in the laboratory. Under no circumstances should filter changes be attempted in the field.

Filter media [particularly the 37-mm (1.5-in.), 2-μm pore size filter used with most commonly available commercial samplers] are especially delicate and easily damaged. Post-sampling particle loss and filter damage will occur if proper handling procedures are not followed. To ensure the integrity of the sample, some type of protective covering is required for sample recovery and laboratory analysis. A plastic petri dish is recommended (Figure 4.1). The dish should be of comparable size (large enough to allow easy removal of the filter, yet small enough to prevent excess movement within the petri dish) and have a tight-fitting lid to prohibit damage or loss of particles during transportation to the analytical laboratory. A label can be affixed to the dish to allow proper documentation when sampling. A sufficient number of petri dishes must be available to provide (1) protection for the filter in transportation to and from the monitoring location, and (2) storage of an exposed filter for subsequent gravimetric or chemical analysis.

1.2.3 Laboratory Equipment -

The analytical balance must be suitable for weighing the type and size of the dichotomous filters used. The range and sensitivity are dependent upon routine tare weights and expected loadings. A minimum sensitivity of ±1 μg, and an accuracy of ±4 μg at zero and ±2 μg at 10 mg, is required. (The zero and 10 mg weight checks are internal standards of the analytical balance.) The balance must be calibrated at installation and recalibrated as specified by the manufacturer, but no less than once per year.

Prior to their weighing, filters must be conditioned in an environment where the mean relative humidity (RH) is between 20 and 45 percent and controlled within ±5 percent, and mean temperature is between 15° and 30°C and controlled within ±3°C. Temperature and RH readings must be recorded daily, either manually or by hygrothermograph. Among the options available to ensure compliance with the reference method specifications are a sling psychrometer and a calibrated precision thermometer (capable of measuring temperatures over a range of 10° to 30°C [283 to 303 K] to the nearest ±1°C) that have been checked against an NIST or ASTM thermometer to within ±2°C.

Regardless of the filter media, all filters must be handled with nonserrated forceps and gloves. This will help eliminate interference with body oils, hydroscopic particles, and static electricity during weighing operations. These forceps can be obtained with a balance weight kit from a scientific supply company.

It is impossible to present a complete procurement package that would provide for unexpected contingencies in any monitoring network. Therefore, each agency must determine the extent of its in-house inventory and the items that should be ordered before sampling can begin. The agency must also be prepared to order any additional equipment required over and above that outlined in this subsection.

TABLE 1.1. ACCEPTANCE TESTS AND LIMITS FOR PROCUREMENT OF EQUIPMENT AND SUPPLIES

Equipment	Acceptance check	Acceptance limits	Action if requirements are not met
Field operations			
Sampler	Sampler complete; no evidence of damage. Model designated as reference or equivalent method.	Specifications outlined in 40 CFR 50, Appendix J.	Reject sampler.
Calibration-QC/QA supplies	Check against NIST-traceable standards.	Within accuracy limits presented in text.	Adjust or reject.
Laboratory operations			
Filters	Meets requirements. Filter undamaged and suitable for sampling.	Specifications outlined in 40 CFR 50, Appendix J. Compatible with individual samplers.	Reject filters.
Filter handling materials	No evidence of damage.	Allows for minimum filter damage and loss of particles.	Reject materials or improve method for transporting filters.
Laboratory equipment and instrumentation	Check against ASTM or NIST-traceable standards.	Within accuracy limits presented in text.	Adjust or reject.

2.10.2 CALIBRATION PROCEDURES

Before a PM10 monitoring program is undertaken, all sampling and analysis equipment must be properly calibrated. Careful, accurate calibrations of sampling instrumentation and associated equipment provide the backbone for any monitoring network. The requirements specified in this subsection may serve as initial acceptance checks. All the required data and calculations should be recorded in a calibration log book or on calibration data sheets. A separate section of the log book should be designated for each apparatus and sampler used in the program.

According to 40 CFR 50, Appendix J (Subsection 10), the PM10 dichotomous sampler must be calibrated in terms of actual conditions (Qa). Reported data, however, must be corrected to EPA reference standard conditions [Qstd (298 K, 760 mm Hg or 101 kPa)]. Calculations necessary to convert these flow rates are presented in Subsection 5.

Although the basic principle of operation for the dichotomous sampler is presented in Subsection 0, more detailed information regarding calibration and operational procedures can be found in the instrument manufacturer's manual.

This subsection presents the following aspects of calibration procedures:

- A discussion of Qa and Qstd flow-rate designations and their applicability in a PM10 monitoring program (Subsection 2.1).
- Basic calibration procedures, calculations, and rotameter "set point" adjustments for the dichotomous sampler (Subsection 2.2).
- Recommended transfer standards and calibration equipment (Tables 2.1 and 2.2).
- Sampler calibration frequency requirements (Subsection 2.3).
- Dichotomous sampler minimum accuracy requirements and calibration procedure references (Table 2.3).

2.1 Discussion of Flow-Rate Measurement and General Aspects of PM10 Sampler Calibration

As discussed in Subsection 0, a dichotomous sampler consists of three basic components: a specially designed inlet, a size fractionating virtual impactor, and a flow controlling system. The particle size discrimination characteristics of both the inlet and the virtual impactor depend critically on specified air velocities; a change in velocity will result in a change in the nominal particle size collected. For this reason, it is imperative that the flow rate through the sampler be maintained at a constant value that is as close as possible to the design flow rates. The design flow rates for a given sampler are specified in the sampler's instruction manual. The manual may also provide tolerance or upper and lower limits within which the sampler flows must be maintained. If the tolerance is not specified by the manufacturer, it should be assumed to be ±10%. For example, if no tolerance is given and the design inlet flow rate is specified as 16.7 L/min, the acceptable flow rate range would be 15.0 to 18.4 L/min.

TABLE 2.1. RECOMMENDED STANDARDS AND ASSOCIATED EQUIPMENT - TOTAL AND FINE FLOW RATES

Transfer standard[a]	Optimum flow range Q_a	Equipment	Comments	Calibration equation[b,c]	Calibration of transfer standard reference
LFE (laminar flow element)	12.0-19.0 L/min	LFE Thermometer/barometer[d] Manometer[e] Filters Adapter	Should have filtered air entering LFE. Subject to fluctuations due to temperature changes. Manometer must be used in its temperature range. Must equilibrate.	$(\Delta H_2O)(CF) = Q_{std}$	U.S. Environmental Protection Agency. Procedures for Calibrating a Laminar Flow Element (LFE) Against an NBS Calibrated LFE: Standard Operating Procedures. EMSL/RTP SOP-QAD-003, November 1981.
MFM (mass flow meter)	12.0-19.0 L/min	MFM Thermometer/barometer[d] Filters Adapter	Recommended LCD display for outdoor use. Must equilibrate to ambient conditions.	$(Volts)(CF) = Q_{std}$	Quality Assurance Handbook for Air Pollution Measurement Systems - Vol. II, Ambient Air Specific Methods, Section 2.1. EPA 600/4-77-027A, May 1977.
DGM 10 L/rev. (dry gas meter)	12.0-19.0 L/min	DGM Thermometer/barometer[d] Stopwatch[f] Filters Adapter	Should time through 5 revolutions. Repeat each timing 3 times.	$\frac{\underline{Vol\ meas}}{time}(CF) = Q_{std}$	Quality Assurance Handbook for Air Pollution Measurement Systems - Vol. II, Ambient Air Specific Methods, Section 3.3. EPA 600/4-77-027B, August 1977.
Orifice	12.0-19.0 L/min	Orifice Thermometer/barometer[d] Manometer[e] Filters Adapter	Good only in range $\Delta P \le 8$ in.	$m\left[\Delta H_2O\ \frac{Pa}{Ta}\right]^{1/2} + b = Q_{std}$	Quality Assurance Handbook for Air Pollution Measurement Systems - Vol. II, Ambiebt Air Specific Methods, Section 2.2. EPA 600/4-77-027B, May 1977.

[a] Transfer standard should not cause more than 8.0 inches of H_2O flow resistance to the sampler flow.

[b] Traceable and referenced to EPA standard conditions:

$$Q_a = Q_{std}\left(\frac{T_a}{P_a}\right)\left(\frac{P_{std}}{T_{std}}\right)$$

[c] Calibration equations for determining flow rates may vary from those presented due to the transfer standard calibration relationship. CF = correction factor.

[d] Thermometer capable of measuring temperature to the nearest ±1°C. Barometer capable of accurately measuring barometric pressure to the nearest ±1 mm Hg.

[e] The design or size of the LFE or orifice will determine the manometer range necessary and the resolution. The manometer resolution must be able to detect a flow change of 1% and represent a flow resistance less than 8.0 inches H_2O.

[f] Stopwatch or timer capable of accurately measuring time intervals of 30 s to several minutes to nearest 0.1 s.

TABLE 2.2. RECOMMENDED STANDARDS AND ASSOCIATED EQUIPMENT - COARSE FLOW RATE

Transfer standard[a]	Optimum flow range Q_a	Equipment	Comments	Calibration equation[b,c]	Calibration of transfer standard reference
LFE (laminar flow element)	1-2 L/min	LFE Thermometer/barometer[d] Incline manometer 0-2.0 in., scale to hundredths[e] Adapter Filters	Should have filtered air entering LFE. Subject to fluctuations due to temperature changes. Manometer must be used in its temperature range. Must equilibrate.	$(\Delta H\ 0)(CF) = Q_{std}$	U.S. Environmental Protection Agency. Procedures for Calibrating a Laminar Flow Element (LFE) Against an NBS Calibrated LFE: Standard Operating Procedures. EMSL/RTP SOP-QAD-003, November 1981.
MFM (mass flowmeter)	1-2 L/min	MFM Thermometer/barometer[d] Adapter Filters	Recommended LCD display for outdoor use. Must equilibrate to ambient conditions.	$(Volts)(CF) = Q_{std}$	Quality Assurance Handbook for Air Pollution Measurement Systems - Vol. II, Ambient Air Specific Methods, Section 2.1. EPA 600/4-77-027A, May 1977.
DGM 1L/Rev Dry gas meter	1-2 L/min	DGM Thermometer/barometer[d] Stopwatch[f] Adapter Filters	Should time through 5 revolutions. Repeat each timing 3 times.	$\frac{Vol\ meas}{time}(CF) = Q_{std}$	Quality Assurance Handbook for Air Pollution Measurement Systems - Vol. III, Stationary Source Specific Methods. EPA 600/4-77-027B, August 1977.
Orifice	1-2 L/min	Orifice Thermometer/barometer[d] Manometer[e]	Good only in range $\Delta P < 4$ in.	$m\left[\Delta H_2O\ \frac{Pa}{Ta}\right]^{1/2} + b = Q_{std}$	Quality Assurance Handbook for Air Pollution Measurement System--Vol II, Ambient Air Specific Methods, Section 2.2. EPA 600/4-77-027B, May 1977.
SFFM Soap film flowmeter	0-2 L/min	SFFM Stopwatch[f] Plug with adapter Filters	Caution - can break. Flow in Q_a . 3 timings. Flow rate in terms of actual conditions.	$\frac{Vol\ meas}{time}(CF) = Q_a$	Upon receipt, traceable to NIST.

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[a] Transfer standard should not cause more than 4.0 inches of H_2O flow resistance to the sampler flow.

[b] Traceable and referenced to EPA standard conditions:

$$Q_a = Q_{std}\left(\frac{T_a}{P_a}\right)\left(\frac{P_{std}}{T_{std}}\right)$$

[c] Calibration equations for determining flow rates may vary from those presented due to the transfer standard calibration relationship. CF = correction factor.

[d] Thermometer capable of measuring temperature to the nearest ±1°C. Barometer capable of accurately measuring barometric pressure to the nearest ±5 mm Hg.

[e] The design or size of the LFE or orifice will determine the manometer range necessary and the resolution. The manometer resolution must be able to detect a flow change of 1% and represent a flow resistance of less than 4 in. H_2O.

[f] Stopwatch or timer capable of accurately measuring time intervals of 30 s to several minutes to nearest 0.1 s.

TABLE 2.3. EQUIPMENT CALIBRATION REQUIREMENTS

Equipment	Frequency and method of measurement	Acceptance limits	Action if requirements are not met
Sampler	Calibrate with certified transfer standard upon receipt, after maintenance on sampler, and any time audits or flow checks deviate more than ±7% from the indicated flow rate or ±10% from the design flow rate.	Indicated flow rate = true flow rate ±4%.	Recalibrate.
Flow-rate transfer standard	Check upon receipt and at least at 1-yr intervals against primary standard; recalibrate or replace if damage is evident.	Indicated flow rate from previous calibration = actual flow rate ±2%.	Adopt new calibration curve.
On/off timer	Check at purchase and routinely on sample recovery days.	±30 min/24 h.	Adjust or repair.
Elapsed-time meter[a]	Compare with a standard timepiece of known accuracy upon receipt and at 6-month intervals.	±2 min/24 h.	Adjust or replace time indicator to attain acceptance limits.
Analytical balance	Gravimetric test-weighing at purchase and during periodic calibration checks; use three to five standard weights covering normal range of filter weights.	Sensitivity = 1 µg Accuracy: at 10 mg[b] = ± 2 µg at zero[b] = ± 4 µg	Have balance replaced and/or recalibrated.
Relative humidity indicator	Compare with readings of wet/dry bulb psychrometer upon receipt and at 6-month intervals.	Indicator reading = psychrometer reading ±6%.	Adjust or replace to attain acceptance limits.

[a] Optional with a continuous flow rate recorder.

[b] Zero and 10-µg weight checks are internal standards of the analytical balance.

As indicated above, the true or actual flow through the sampler inlet must be known and controlled to ensure that only those particles nominally less than 10 μm are being collected. A common source of error in a PM10 monitoring program is confusion between various air measurement units. Although the sampler must operate in terms of actual flow rate (Qa), flow rates must be corrected to EPA standard conditions of temperature and pressure (Qstd) before data can be submitted. Thus, both Qa and Qstd flow rates are used for PM10 measurements. Before calibration procedures are initiated, the operating agency personnel should review the following flow-rate designations:

> <u>Qa</u>: Actual volumetric air flow rates that are measured and expressed at existing conditions of temperature and pressure are denoted by Qa (Qactual). Typical units are L/min and m^3/min. Inlet design flow rates are always given in actual volumetric flow units.
>
> <u>Qstd</u>: Air flow rates that have been corrected to EPA standard conditions of temperature and pressure (25°C or 298 K, and 760 mm Hg or 101 kPa) are denoted by Qstd (Qstandard). Typical units are std. L/min and std. m^3/min. Standard volume flow rates are often used by engineers and scientists and are equivalent to mass flow units. Standard volumes (derived from standard volume flow rates) are also required to be used in the calculation of mass concentration (μg/std. m^3) in reporting PM10 measurements.

These Qa and Qstd measurement units must not be confused or interchanged. The flow rate units can be converted as follows, provided the existing temperature and pressure (or in some cases the average temperature and pressure over a sampling period) are known:

$$Qstd = Qa(Pa/Pstd)(Tstd/Ta) \qquad \text{(Eq. 1)}$$

$$\overline{Qstd} = \overline{Qa}(Pav/Pstd)(Tstd/Tav) \qquad \text{(Eq. 1a)}$$

$$Qa = Qstd(Ta/Pa)(Pstd/Tstd) \qquad \text{(Eq. 2)}$$

where:

Qstd = standard volume flow rate, std. m^3/min
Qa = actual volume flow rate, actual m^3/min
Pa = ambient barometric pressure, mm Hg (or kPa)
Pstd = EPA standard barometric pressure, 760 mm Hg (or 101 kPa)
Tstd = EPA standard temperature, 298 K
Ta = ambient temperature, K (K = °C + 273)
$\overline{Qstd}$ = average standard volume flow rate for the sample period, std. m^3/min
$\overline{Qa}$ = average actual volume flow rate for the sample period, m^3/min
Pav = average ambient barometric pressure during the sample period, mm Hg (or kPa)
Tav = average ambient temperature during the sample period, K.

2.2 Sampler Calibration

This subsection presents flow-rate calibration procedures for the most common, commercially available dichotomous samplers. Calibration procedures may have to be adapted for other sampler models.

The dichotomous sampler operates at a total actual flow rate of 16.7 L/min. To ensure correct fractionation of particles at the inlet, this flow rate must be maintained within ±10% of 16.7 L/min. The coarse flow rate is approximately 10% of the total, or 1.67 actual L/min. It must also be maintained to ensure correct fractionation within the sampler's secondary separation system.

Accurate calibration data for each dichotomous sampler are essential for the following:

1. To determine sampler flow rate set points.
2. To establish sampler flow rate control limits.
3. To calculate sampler flow rate during routine QC field flow checks and QA performance audits.
4. To calculate total sample volume for the computation of PM10 mass concentrations.

Calibration of the sampler rotameters must be traceable to NIST standards. A primary standard is used to calibrate a transfer standard, which in turn is used to calibrate the sampler rotameters.

Several commercially available transfer standards can be used in calibrations. Tables 2.1 and 2.2 list recommended standards, their applicable flow ranges, references for transfer standard calibration procedures, and the equipment necessary to perform sampler calibrations. The following are essential considerations in choosing a transfer standard for subsequent rotameter calibrations.

1. The transfer standard must be traceable to NIST through the calibration procedures referenced.
2. The transfer standard must be calibrated in the appropriate flow range. A minimum range of 12 to 19 L/min (total) and 1.4 to 1.9 L/min (coarse) is recommended.

   Note: If the transfer standard has been calibrated in terms of EPA reference conditions, indicated flow rates for each rotameter setting must be corrected to actual flow rates (Qa) to determine the sampler's set point.

As indicated in Tables 2.1 and 2.2, each transfer standard has a certain value. The operating agency should carefully choose the method that best utilizes equipment on hand and minimizes difficulties in establishing traceability.

Regardless of the transfer standard employed, a leak-tight adaptive device must be used to connect the transfer standard to the sampler inlet. Figure 2.1 illustrates such an adapter. These may be purchased commercially or fabricated in-house. Obviously, the corresponding outlet on the transfer standard will determine whether a pipe thread or tube fitting will be attached.

Tables 2.1 and 2.2 present only the basic apparatus necessary to perform calibrations. In addition to those listed, the operator will need a few miscellaneous supplies. These include a 9.53-mm (3/8-in.) Swagelok cap, 6.35-mm (1/4-in.) Swagelok cap, and hand tools.

A station log book or calibration data sheet must be used to document calibration information. This information includes, but is not limited to, instrument and transfer standard model and serial numbers, transfer standard traceability and calibration information, ambient temperature and pressure conditions, and the collected calibration data (rotameter units versus indicated flow rate).

2.2.1 Precalibration System Check -

Procedures for the precalibration system check are as follows:

1. Place a pair of filters into the dichotomous sampler filter holders. Filters used for flow rate calibrations should not be used for subsequent sampling.

2. Remove the sampler's inlet. Turn on the sampler and allow it to warm up to full operating temperature (at least 5 min).

3. While the sampler is energized, slowly close off the inlet tube with a rubber stopper or duct tape and observe the total vacuum gauge. If the sampler is equipped with an overload feature, it should shut down the system when approximately 15 in. of vacuum is reached.

4. If the sampler is equipped with the overload feature, disconnect. Next, perform a system leak check by opening both rotameters completely and sealing the inlet tube with a rubber stopper or duct tape. When a maximum indication on the total vacuum gauge is reached, shut off power to the unit, record the maximum reading on a data sheet, and observe the rate of decline in the readings of the vacuum gauges.

   Note: Leak-free systems should indicate a vacuum of 10 to 15 in. or more, and the rate of decline to 0 in. indication should require 60 s or more. If these conditions are not met and the control module was successfully leak-tested previously, a leak exists either in the interconnecting tubing or in the sample module.

5. If applicable, reconnect the overload feature. Conduct a pump performance check. Open the inlet tube and apply power to the unit. When stable flow is achieved, adjust both rotameter control valve to 90% of the rotameter scale. Observe the total vacuum gauge indication.

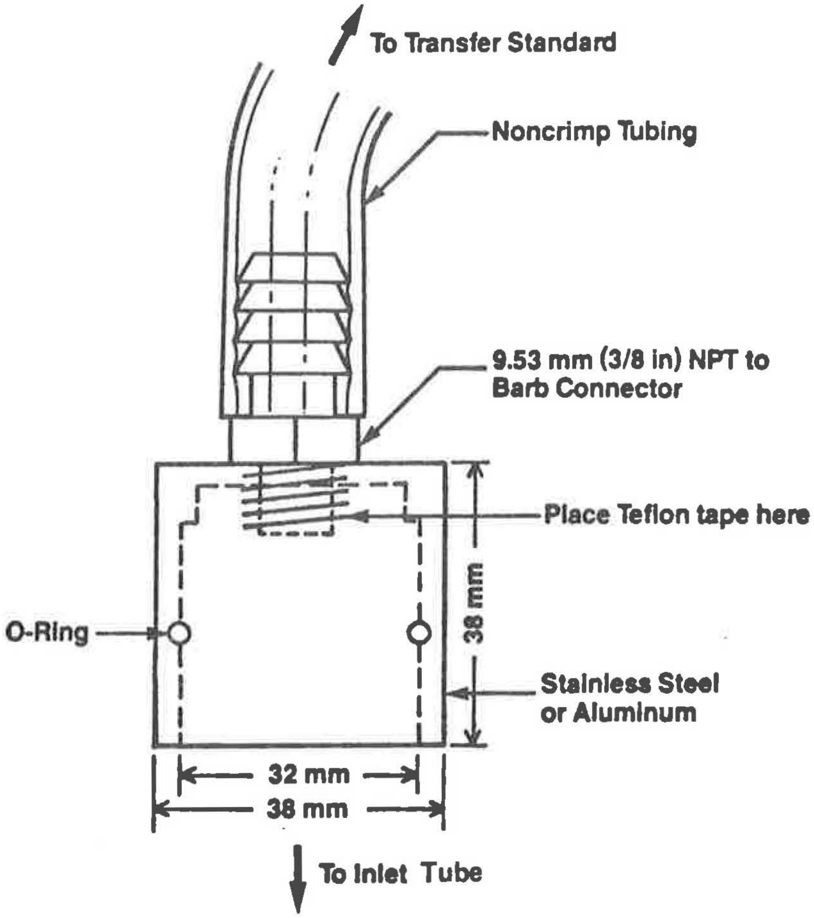


Figure 2.1. Inlet adapter that may be used to connect the transfer standard to the sampler's inlet tube.

Note: Consult manufacturer's instruction manual for minimum vacuum indication. Readings lower than specified vacuum readings indicate possible pump diaphragm or reedvalve problems, which should be investigated and corrected before continuing with the calibration.

2.2.2 Total Rotameter Calibration -

Procedures for calibrating the total rotameter are as follows:

1. Set up calibration system as illustrated in Figure 2.2. The inlet of the transfer standard is open to the ambient air; the outlet of the transfer standard is connected to the inlet tube of the dichotomous sampler.

2. Turn on the sampler and allow it to warm up to normal operating temperature (at least 5 min). If an electronic transfer standard is used, it must also equilibrate before proceeding with the calibration.

3. Adjust the total flow control valve to approximately 90% of the rotameter scale. Adjust the coarse flow control valve to indicate a nominal flow of 1.67 L/min.

4. Read the following parameters and record them on a data form (Figure 2.3) or in a log book:

    - Ambient temperature (Ta), K

    - Barometric pressure (Pa), mm Hg or kPa

    - Transfer standard readings (TS), volts, ΔH_2O, timings, etc.

    - Sampler total rotameter indication (I), arbitrary units.

5. Repeat procedure for rotameter settings representing flow rates of 75, 60, 40, and 20% of the established operating range (12 to 19 L/min). For each calibration point, record the rotameter indication and corresponding transfer standard output.

2.2.3 Coarse Rotameter Calibration -

1. Turn off the sampler, disconnect the fine flow vacuum line [9.53-mm (3/8-in.) o.d. line], and cap the fine flow outlet port with a 9.53-mm (3/8-in.) Swagelok cap (see Figure 2.4). This step keeps the fine flow line open to the vacuum pump. It is recommended that a particle-free filter be attached to the detached fine flow line to prevent particles from entering the system. Install the coarse flow rate transfer standard.

2. Energize the sampler and the transfer standard (if electronic). Allow both to warm up again to full operating temperature.

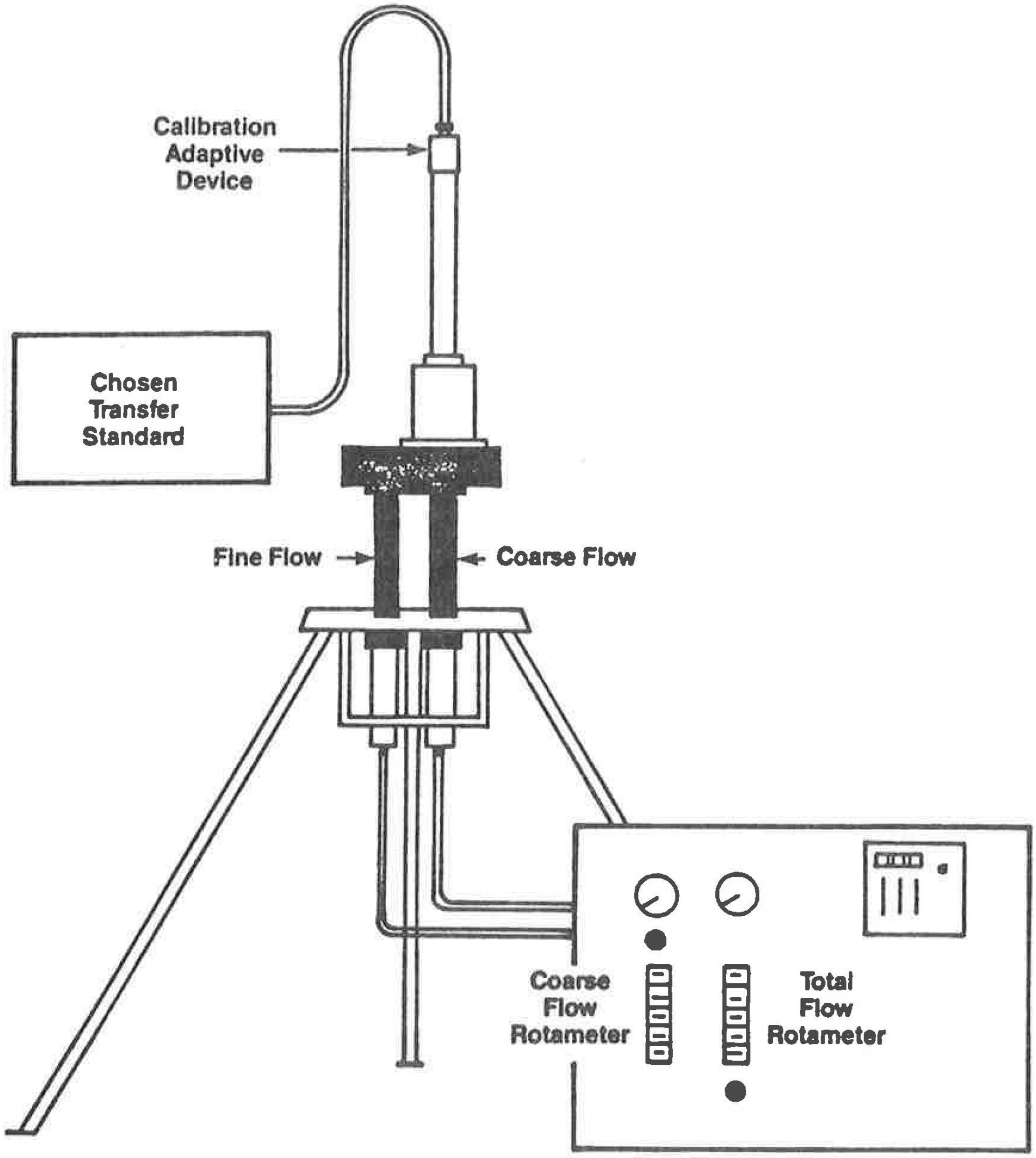


Figure 2.2. Calibration assembly and dichotomous sampler with transfer standard connected.

Dichotomous Sampler Calibration Data Sheet

Station Location Raleigh, NC Date 9/3/89 Unusual Conditions none
Sampler Model 244E S/N 619 EPA # 387265
Pa 748 mm Hg Ps 751 mm Hg Ta 17 [✓ °C] or K Ts 20 [✓ °C] or K
Leak check, maximum vacuum 19 in. Notes overload feature disconnected
Total Trans. Std. Model MFM S/N 2913 Cal. Date 7/1/89
Qa Cal. relationship m = 0.942 b = 0.00 r = 0.999
Coarse Trans. Std. Model SFFM S/N VK1 Cal. Date 12/11/88
Qa Cal. relationship m = 1.0 b = 0 r = – no correction (1000 cc)

Total Cal. Point	Transfer Std. Indication (TS) (vdc)	TQa Flow Rate (L/min)	Rotameter Response (I)	Corr. Response $I(Ta/Pa)^{1/2}$ (AC)
90%	20.60	19.4	15.3	9.53
75%	19.07	17.9	14.2	8.84
60%	16.77	15.8	13.3	8.28
40%	15.57	14.7	12.4	7.72
20%	14.57	13.7	11.7	7.29

Coarse Cal. Point	Transfer Std. Indication (TS) (min)	CQa Flow Rate (L/min)	Rotameter Response (I)	Corr. Response $I(Ta/Pa)^{1/2}$ (AC)
90%	0.497	2.01	12.2	7.60
75%	0.589	1.70	10.5	6.54
60%	0.624	1.60	9.5	5.92
40%	0.679	1.47	9.0	5.60
20%	0.712	1.40	8.5	5.29

Sampler Cal. Relationship (Qa, x-axis; corrected recorder response, AC, y-axis).

Total: m = 0.379 b = 2.15 r = 0.995 Coarse: m = 3.806 b = −0.04 r = 0.995
TFR 16.60 TSP 13.55 CFR 1.66 CSP 10.08
$TFR = 16.7\,(Ps/Pa)(Ta/Ts)$ $CFR = 1.67\,(Ps/Pa)(Ta/Ts)$
$TSP, CSP = \{[m\,(TFR, CFR) + b]\,[(Pa/Ta)^{1/2}]\}$

Operator Robert Murdoch

Figure 2.3. Example dichotomous sampler calibration data sheet.

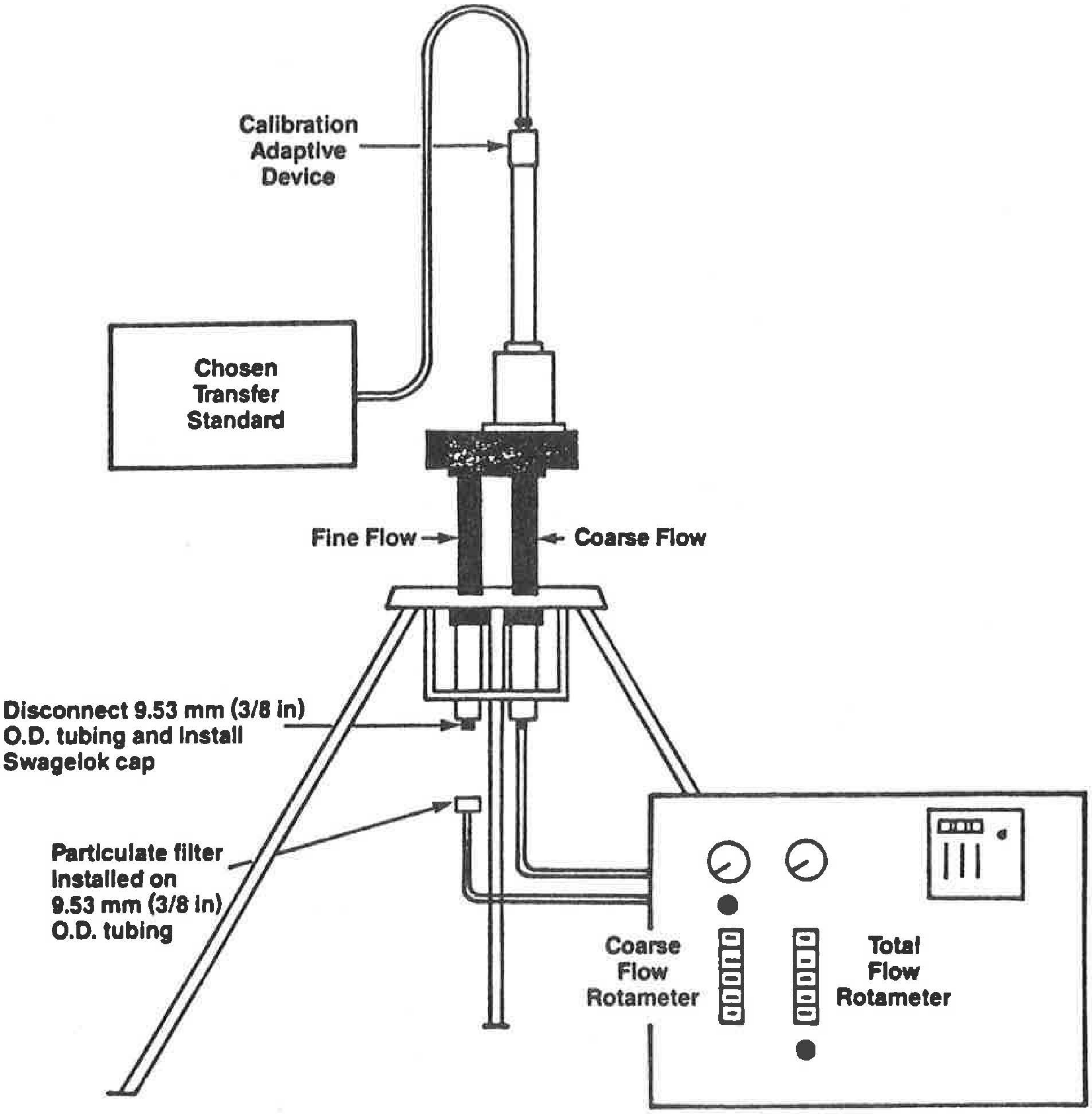


Figure 2.4. Calibration assembly and dichotomous sampler set up to calibrate the coarse flow rotameter.

3. Adjust the coarse rotameter flow-control valve to an approximate value of 90% of the rotameter scale. Adjust the total flow control valve to indicate a nominal flow of 16.7 L/min.

4. Read the following parameters and record them on a data form (Figure 2.3) or in a log book:

   - Ambient temperature (Ta) if variation has occurred, K
   - Barometric pressure (Pa) if variation has occurred, mm Hg or kPa
   - Transfer standard readings (TS), volts, ΔH_2O, timings, etc.
   - Sampler coarse rotameter indication (I), arbitrary units.

5. Repeat procedure for rotameter settings representing flow rates of 75, 60, 40, and 20% of the established operating range (1.4 to 1.9 L/min). For each calibration point, record the rotameter indication and corresponding transfer standard output.

6. Turn off sampler, and reconnect the fine flow line and the sampler's inlet.

2.2.4 Calibration Calculations -

Gather together all the calibration data, including the transfer standard calibration information and the dichotomous sampler calibration data sheet. The following calibration calculation procedures are recommended.

Note: These calculations should be done at the time of the calibration, rather than later. This approach will allow additional calibration points to be taken if questions arise about the data that have already been obtained.

1. Verify that the transfer standard calibration equation is current and traceable to an acceptable primary standard.

2. Calculate Qa for each calibration point as determined by the transfer standard calibration equation.

   Note: It may be necessary to correct the indicated transfer standard flow rates from Qstd to Qa. This can be accomplished by Equation 1.

$$Qa = Qstd(Ta/Pa)(Pstd/Tstd) \qquad \text{(Eq. 2)}$$

where

Qa = flow rate at actual conditions, L/min
Qstd = flow rate corrected to standard temperature and pressure (25°C, 298 K; 760 mm Hg, 101 kPa), L/min
Ta = ambient temperature, K (K = °C + 273)
Pa = ambient barometric pressure, mm Hg or kPa
Pstd, Tstd = standard barometric pressure and temperature, respectively.

3. Calculate and record the total and coarse rotameter actual corrections (AC) for each calibration point as:

$$AC = I(Ta/Pa)^{1/2} \qquad \text{(Eq. 3)}$$

where

AC = actual correction
I = rotameter response, arbitrary units
Ta = ambient temperature, K
Pa = ambient barometric pressure, mm Hg or kPa.

4. On a sheet of graph paper, plot the sampler corrected total rotameter units (y-axis) versus the corresponding calculated transfer standard total flow rates (x-axis) to obtain the dichotomous sampler total flow-rate calibration relationship.

5. Repeat Step 4, plotting corrected coarse rotameter units vs. the corresponding calculated coarse flow rates.

Because the determination of the sampler's average operational flow rate (Qa) during a sample period depends on the ambient average temperature and pressure, use of a graphic plot of the calibration relationship is not recommended for subsequent data reduction. This plot is used only to visually assess the calibration points to see if any should be rerun.

Plot the regression line on the same graph paper as the calibration data. For the regression model $y = mx + b$, let $y = AC = I(Ta/Pa)^{1/2}$ and $x = Qa$ so that the model is given by:

$$AC = m[Qa(\text{transfer standard})] + b \qquad \text{(Eq. 4)}$$

Using a programmable calculator or a calculation data form, determine the linear regression slope (m), intercept (b), and correlation coefficient (r) and record them on the data sheet. A five-point calibration should yield a regression equation with a correlation coefficient of $r > 0.990$, with no point deviating more than 0.5 L/min for total or 0.05 L/min for coarse rotameter calibrations from the value predicted by the regression equation. Plot the regression line on the same graph paper that has the individual calibration points.

6. For subsequent sample periods, the sampler's average actual operational flow rate $\overline{TQa}$ or $\overline{CQa}$ is calculated from the calibration slope and intercept using Equation 5:

$$\overline{TQa} \text{ or } \overline{CQa} = 1/m[\overline{I}(Tav/Pav)^{1/2} - b] \qquad \text{(Eq. 5)}$$

where

$\overline{TQa}$, $\overline{CQa}$ = sampler total or coarse average flow rate, actual L/min
$\overline{I}$ = average total or coarse rotameter response, arbitrary units
Tav = average ambient temperature for the run day, K
Pav = average ambient barometric pressure for the run day, mm Hg or kPa
m = slope of the total or coarse flow-rate calibration relationship
b = intercept of the total or coarse flow-rate calibration relationship.

Note: The expression $[\overline{I}(Tav/Pav)^{1/2}]$ is the "y" term of linear regression equation: $y = mx + b$, or $x = (y-b)/m$.

Note: Tav and Pav readings may be recorded on-site or from a nearby U.S. National Weather Service station or airport weather station. Barometric pressure readings obtained from remote sources must be at station pressure (not corrected to sea level), and they may have to be corrected for differences between the elevation of the monitoring site and that of the airport. If ambient temperature and pressure readings are not available, seasonal average temperature (Ts) and barometric pressure (Ps) can also be used. Care must be taken, however, that the actual conditions at the site can be reasonably represented by such averages. It is therefore recommended that seasonal values represent actual values within 20 °C and 40 mm Hg.

2.2.5 Rotameter Set Point Adjustment Procedure -

1. Calculate and record on the calibration data sheet the total and coarse seasonal flow rates. These values will be used to determine the seasonal set points for both rotameters.

$$TFR = 16.7(Ps/Pa)(Ta/Ts) \qquad \text{(Eq. 6)}$$

where

TFR = total flow rate for adjustment of the sampler total rotameter
16.7 = design flow rate as specified by the manufacturer, L/min
Ps, Pa = seasonal average and ambient barometric pressure, respectively, mm Hg or kPa
Ts, Ta = seasonal average and ambient temperature, respectively, K.

$$CFR = 1.67(Ps/Pa)(Ta/Ts) \qquad \text{(Eq. 7)}$$

where

CFR = coarse flow rate for adjustment of the sampler coarse rotameter
1.67 = design flow rate as specified by the manufacturer, L/min
Ps, Pa = seasonal average or ambient barometric pressure, respectively, mm Hg or kPa
Ts, Ta = seasonal average or ambient temperature, respectively, K.

2. Calculate and record on the sampler's calibration data sheet the set point rotameter responses that correspond to TFR and CFR calculated in Step 1.

$$TSP = \{[m(TFR) + b](Pa/Ta)^{1/2}\} \qquad \text{(Eq. 8)}$$

where

TSP = total rotameter set point, arbitrary units
TFR = total flow rate, L/min
Pa = ambient barometric pressure, mm Hg or kPa
Ta = ambient temperature, K
m = slope of the total flow-rate calibration relationship
b = intercept of the total flow-rate calibration relationship.

$$CSP = \{[m(CFR) + b](Pa/Ta)^{1/2}\} \qquad \text{(Eq. 9)}$$

where

CSP = coarse rotameter set point, arbitrary units
CFR = coarse flow rate, L/min
Pa = ambient barometric pressure, mm Hg or kPa
Ta = ambient temperature, K
m = slope of the coarse flow-rate calibration relationship
b = intercept of the coarse flow-rate calibration relationship.

Adjusting the sampler rotameter to seasonal average conditions will help minimize data loss caused by exceeding the manufacturer's design condition specifications.

1. Energize the sampler and allow it to warm up to operating temperature (3 to 5 min).

2. Following the manufacturer's instructions, adjust the total rotameter until the sampler response indicates the total flow-rate set point (TSP) as calculated in Step 2 above.

3. Following the manufacturer's instructions, adjust the coarse rotameter until the sampler response indicates the coarse flow-rate set point (CSP) as calculated in Step 2 above.

4. Verify that the sampler will maintain these flow rates for at least 10 min. Turn off the sampler.

5. The sampler can now be prepared for the next sample run day.

2.3 Sampler Calibration Frequency

To ensure accurate measurement of the PM10 concentrations, calibrate the sampler upon installation and then recalibrate it as follows:

1. At least annually.

2. After any repairs that might affect sampler calibration.

3. If the field calibration flow check results exceed QC limits (±10% from the sampler's required design condition flow rate or ±7% from the sampler's indicated flow rate).

4. Whenever an audit indicates that the sampler is out of calibration (±10% from the sampler's required design condition flow rate or ±7% from the sampler's indicated flow rate).

2.10.3 FIELD OPERATIONS

3.1 Siting Requirements

As with any type of air monitoring study in which sample data are used to draw conclusions about a general population, the validity of the conclusions depends on the representativeness of the sample data. Therefore, the primary goal of a PM10 monitoring project is to select a site where the collected sample mass is representative of the monitoring area.

Spatial and temporal scale considerations are important in dichotomous sampler siting. Spatial scales may range from a small (0.1- to 0.5-square kilometer) area to large regional areas exceeding tens of hundreds of square kilometers. Whether the potential impact of particulate pollution is generated by a local or general source category will affect the decision on the size of the spatial monitoring scale. In addition, the siting of the samplers within a monitoring network should reflect whether the expected impact will be limited to a small area (a few city blocks) or extend to larger areas (metropolitan or rural).

With regard to the temporal scale, interest focuses on either an annual geometric mean concentration or a 24-h average concentration. Because siting of a dichotomous sampler requires that consideration be given to prevailing wind direction, a sampler sited for monitoring trends in air quality over a period of a year will not necessarily be ideal for measuring 24-h concentrations. Thus, the choice of temporal scale will also affect the sampler location.

Although spatial and temporal scales must be considered in site selection, the following guidelines should be observed regardless of the scale:

1. The dichotomous sampler must have unobstructed air flow for a minimum of 2 m in all directions.

2. The sampler inlet should be placed at a height of 2 to 15 m above ground level.

3. If a dichotomous sampler is collocated with any other particulate sampler, the minimum spacing between sampler inlets must be 2 m and the maximum spacing must be 4 m. All inlet heights should be within 1 vertical meter of one another.

Complete siting requirements are outlined in 40 CFR 58, Appendix E.

Additional factors must be considered in determining where the actual sampler will be deployed. These include accessibility under all weather conditions, availability of adequate electricity, and security of the monitoring equipment.

A dichotomous sampler used for routine sampling must be situated where the operator can reach it safely regardless of weather conditions. If the sampler is located on a rooftop, care should be taken that the operator's personal safety is not jeopardized by a slippery roof surface during inclement weather. Considerations also should be given to the fact that routine operation (i.e., calibrations, sample installation and recovery, flow checks, and audits) involves transporting supplies and equipment to and from the monitoring site.

A dichotomous sampler will require a minimum continuous operating current of 3 to 5 A (120 V a.c., 60 Hz) and may require a higher startup current, which necessitates a slow-blow fuse. Although most dichotomous samplers are equipped with timers, there is often no recording device provided to indicate short-term power interruptions. This lack necessitates a stable power source for the monitoring site.

The security of the sampler itself depends largely on its location. Rooftop sites with locked access and ground-level sites with fences are common. In all cases, the security of the operating personnel as well as the sampler should be considered.

3.2 Sampler Installation Procedures

1. On receipt of a dichotomous sampler from the manufacturer, visually inspect the sampler to ensure that all components are accounted for. Compare equipment delivered with the enclosed packing slip. Notify the manufacturer immediately of any missing or damaged equipment.

2. Before transporting the sampler to the field site, perform a quick laboratory check to determine if the sampler is operational. Energize the sampler and observe rotameter responses, vacuum gauges, and pump performance.

3. Carefully transport the sampler to the monitoring site.

4. Bolt down the sampling module to a secure mounting surface.

5. Install the control module. This module can be bolted down adjacent to the sampling module (no closer than 2 m), or it can be located remotely (e.g., inside a monitoring station). It is recommended that the control module be no more than 10 to 15 m away from the sampling module to avoid a pressure drop along the flow lines.

6. Connect the vacuum lines between the sampling module and the control module. First, hand-tighten the nuts on the tube connectors as much as possible, and then wrench-tighten them 1-1/4 revolutions. Be careful not to cross-thread the fittings.

7. Check all tubing for crimps, cracks, or breaks.

8. Plug the power cord into a line voltage outlet. The use of waterproof interlocking electrical connectors is recommended to ensure operator safety and to avoid shorts and/or power interruptions. Do not allow any

electrical connections to be submerged during periods of inclement weather.

9. Perform a multipoint flow-rate calibration as described in Subsection 2.

3.3 Sampling Operations

Sampling operations provided here are specific to one type of commercially available dichotomous sampler. Because operational procedures may vary among sampler models, the manufacturer's instrument manual should be consulted before the sampler is put into operation. Sampling procedure checks are summarized in Table 3.1.

3.3.1 Filter Installation

Care must be taken to ensure that clean filters are not damaged before they are installed in a dichotomous sampler. Filter cassettes should be kept in their protective petri dishes (see Figure 4.1), and any damaged filters must be discarded.

The procedure used to install filters in a dichotomous sampler is presented here. Each dichotomous sampler is equipped with two filter holders, and the petri dish should be marked to indicate which filter will be used for coarse particle sampling, which will be used for fine particle sampling, the filter and sampler ID number, and the sampling run date.

1. Switch mechanical or digital timer to "OFF."

2. The coarse-particle filter holder is the one with the 6.35-mm (1/4-in.) o.d. tubing, and the fine-particle filter holder is the one with the 9.53-mm (3/8-in.) o.d. tubing. As shown in Figure 3.1, the filter holders can also be distinguished by the fact that the coarse-particle filter holder is on the center line of the virtual impactor head and aerosol inlet, whereas the fine-particle filter holder is offset. Unscrew (by hand) the knurled filter-holder assembly underneath the receiver tube assembly. Install each cassette containing the preweighed filters in its respective filter holder. Do not attempt to install both filters simultaneously, as this could cause damage and/or transpose the coarse and fine filters. This transposition of filters is a common error found in the operation of dichotomous samplers. The lower half of the filter cassette, which goes over the screen, is also the side with the shorter distance (approximately 2.0 mm) to the filter surface. Each filter holder has an "O" ring that seals the filter holder to the virtual impaction assembly. Visually ascertain that the "O" rings are present and secure. Do not sample without these "O" rings installed, as the system will no longer be leak-free. Tighten both knurled filter holder nuts by hand, making sure the nuts are not cross-threaded. Record on a data sheet, similar to Figure 3.2, the fine and coarse filter ID numbers.

TABLE 3.1. SAMPLING PROCEDURE CHECKS

Procedure	Frequency and method	Requirements	Action if requirements are not met
Filter installation	Visually check each filter. Designate as coarse or fine on petri dish. Install filters one at a time. Hand-tighten knurled rings.	Filters are provided with ID numbers. Filters are tare-weighed and undamaged.	Void the filter; install substitute filter.
Sample validation and documentation	Visually check each sample and the sample data sheet for completeness.	Sampling date, filter and sampler ID, station location, flow rates, sample time, and unusual conditions recorded on data sheet. Petri dishes marked to indicate coarse or fine filter.	Complete or correct the documentation; if unavailable, void the sample.
Post sample inspection	Visually check each sample for tears, missing pieces, or leakage.	No evidence of filter damage or sampler malfunction.	Void the sample; correct the case of malfunction.
Flow checks	Check flow rate at least monthly.	Sampler flow rate must be within ±7% of the specified flow rate.	Determine cause of flow problem and correct. Calibrate the sampler.

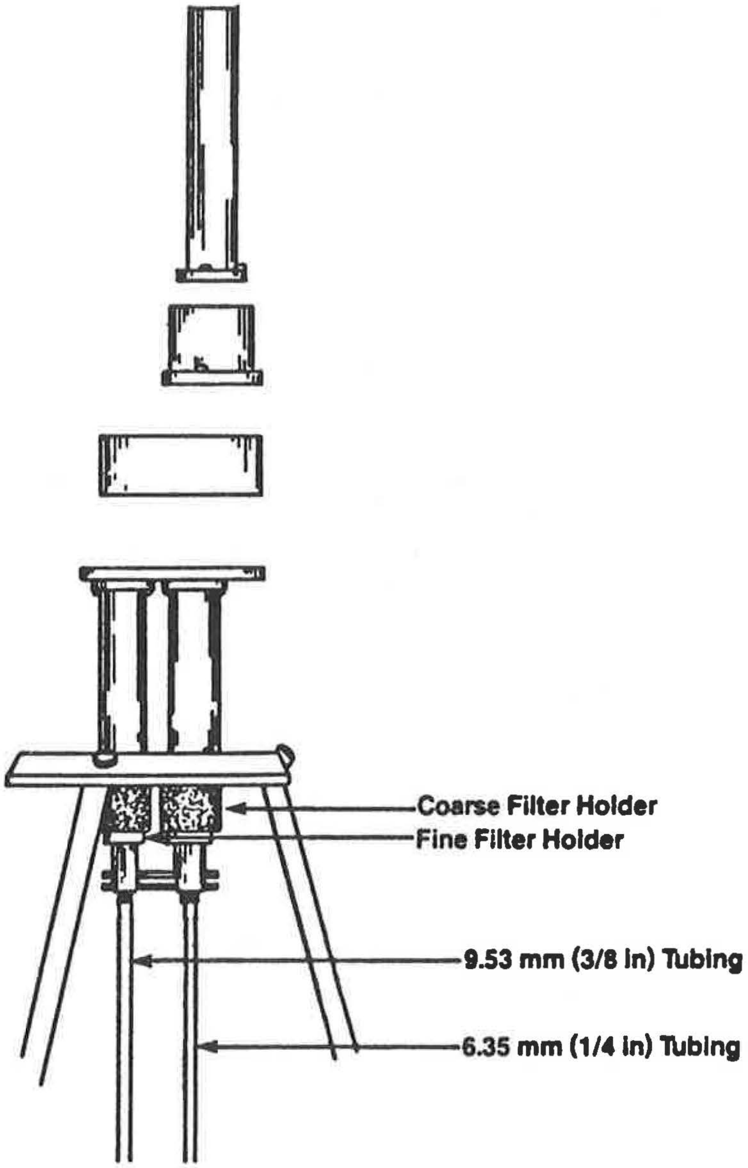


Figure 3.1. Location of the filter holders on the sampling module.

Dichotomous Sampler Field Data Sheet

Station Location Cary, NC Run Date 12/1/89 SAROAD Number 372346789

Sampler Model 244E S/N 619 EPA Number 387265

Filter ID Numbers: Fine: BR549 Coarse: BR550

Total Cal. Relationship: m = 0.379 b = 2.15 r = 0.995 TFR 16.60 L/min

Coarse Cal. Relationship: m = 3.806 b = -0.04 r = 0.995 CFR 1.66 L/min

Vacuum Gauge Indications: Total Initial 1.5 Total Final 1.6 Coarse Initial 0

Coarse Final 0

Pav 741 mmHg Tav 23 °C 296 K Elapsed Time Sampled 1445 min

Rotameter Responses:

TSP* 13.55 Final Total 13.5 Ave. Total ($\overline{T}$) 13.5 $\overline{TQa}$ 16.84 L/min

CSP* 10.08 Final Coarse 10.0 Ave. Coarse ($\overline{T}$) 10.0 $\overline{CQa}$ 1.67 L/min

$\overline{TQa}, \overline{CQa} = 1/m\,[\overline{T}(Tav/Pav)^{1/2} - b]$

Total Act. Volume (TVa) = TQa X min sampled = 24334 L/min FQa = 15.17 L/min

Coarse Act. Volume (CVa) = CQa X min sampled = 2413 L/min FQa = TQa — CQa

Comments: Grass fire in adjacent field; a lot of smoke blowing away from the sampler while on-site.

Operator Lisa Wall

Laboratory Calculations

Std. Volumes (Vstd): TVstd 23.89 m³ CVstd 2.37 m³

TVstd, CVstd = (Va)(10^{-3}) [(Pav/Tav) (298/760)]

FVstd 21.52 m³

FVstd = TVstd – CVstd

Filter Weights:

Fine: Gross Weight (Wg) 100.136 mg
Tare Weight (Wt) 99.211 mg
Net Weight (Mf) 0.925 mg

Coarse: Gross Weight (Wg) 105.067 mg
Tare Weight (Wt) 104.413 mg
Net Weight (Mc) 0.654 mg

PM10 Concentration 66.09 µg/m³ µg/m³ = (Mf + Mc)(10^3)/TVstd

*Total or coarse set points, initial rotameter response.

Figure 3.2. Example dichotomous sampler field data sheet.

3. Open the front cover of the control module by turning the knob latch counterclockwise. The cover is released by turning the indicator one-quarter turn counterclockwise, and it is locked by reversing this process.

4. Switch the mechanical or digital timer to "ON." If the sampler has a digital timer/programmer equipped with a POWER switch, turn on the vacuum pump. Allow the pump to run for at least 5 min to establish operating temperature conditions. While the sampler equilibrates, record on the data sheet station documentary information (i.e., location, SAROAD designation, sampler model, and S/N) and the run date of the sample. The sampler's calibration relationships and the total and coarse set points (TSP and CSP) should be recorded. Set point calculations are presented in Subsection 2.

5. Set the total flow rate by adjusting the rotameter to the calculated TSP value. Observe and record the total vacuum gauge indication. The vacuum gauge should show a pressure drop (ΔP) of approximately 1 to 2 in. Hg for a 2-μm pore filter.

6. Set the coarse flow rate by adjusting the rotameter to the calculated CSP value. Observe and record the coarse vacuum gauge indication; it should read approximately zero. Turn off the sampler.

7. The sampler is now ready to sample. Set the master timer (according to the manufacturer's instructions) to energize the sampler for the next sampling period. Reset the elapsed time indicator to zero.

8. Close the front cover of the control module and visually inspect the monitoring site to ensure that all sampling components (sampling inlet and control module) are in readiness for the next run day.

3.3.2 Filter Recovery Procedure -

1. After sampling, record the elapsed-time indicator value and energize the sampler. Allow the sampler to warm up to operating temperature and record the final total and coarse rotameter readings and the final total and coarse vacuum gauge indications on the data sheet. Turn the sampler off.

2. Reverse the filter installation procedure and remove each filter one at a time. Put the filter cassettes in their original marked plastic petri dishes. Verify that filter ID numbers match numbers recorded on the data sheet.

3. Calculate and record the total and coarse average rotameter readings as:

$$\overline{I} = (TSP \text{ or } CSP + IF)/2 \qquad \text{(Eq. 10)}$$

where

$\bar{I}$ = average total or coarse rotameter response, arbitrary units
TSP, CSP = total or coarse rotameter set points, arbitrary units
IF = indicated final total or coarse rotameter response, arbitrary units.

4. Record the average ambient temperature [Tav (K)] and barometric pressure [Pav (mm Hg or kPa)] for the run day on the field data sheet.

5. Calculate and record the total and coarse average actual flow rates (TQa and CQa), as determined by the sampler's calibration relationships.

$$\overline{TQa} \text{ or } \overline{CQa} = 1/m[\bar{I}(Tav/Pav)^{1/2} - b] \qquad \text{(Eq. 5)}$$

where

$\overline{TQa}$, $\overline{CQa}$ = sampler total or coarse average flow rate, actual L/min
$\bar{I}$ = average total or coarse rotameter response, arbitrary units
Tav = average ambient temperature for the run day, K
Pav = average ambient pressure for the run day, mm Hg or kPa
m = slope of the dichotomous sampler total or coarse calibration relationship
b = intercept of the dichotomous sampler total or coarse calibration relationship.

<u>Note</u>: Refer to Subsection 5 for a description of Tav and Pav measurements.

6. Calculate the actual fine flow rate by subtracting the calculated Qa coarse from the Qa total, and record.

7. Observe conditions around the monitoring site; note any activities that may affect filter particle loading (paving, mowing, fire) and record this information on the field data sheet.

3.3.3 Sample Validation -

Validation Criteria - The following criteria have been established to assist the operator in determining whether or not a sample is valid.

1. Timing:

   - All samplers must turn ON and OFF within 1/2 h of midnight.

   - All samplers must operate for at least 23 but not more than 25 h (1,330 to 1,500 min).

2. Flow Rates:

   The average flow rates must be within 7% of 16.7 L/min (total) and 1.67 L/min (coarse) at actual conditions. If these limits are exceeded, investigate the cause. Use the following criteria as a basis for sample invalidation:

   - Decreases in flow rate during sampling (due to mechanical failure) of more than 7% from the initial set point require a field calibration check (Subsection 3.4). If the sampler's calibration check indicates that the sampler flow was not within ±7% of the designed flow, the sampler should be invalidated.

   - If the sampler flow rate decreases because of heavy particulate loading on the filter, a post-sampling check of the vacuum gauges will indicate increased vacuum. These filters should not be invalidated because they may indicate an episodic situation.

   - Changes in flow-rate calibration of more than 7%, as determined by a field calibration check, will invalidate all samples collected back to the last acceptable flow-rate check. Recalibrate the sampler.

3. Filter Quality:

   - Any filter that is obviously damaged (i.e., is torn, frayed, or has pin holes) should be invalidated.

3.3.4 Sample Handling -

Handling of a Valid Sample -

1. Calculate the total, coarse, and fine flow rates and complete the data sheet.

2. Promptly deliver the filter cassettes in their protective petri dish, accompanied by the completed data sheet, to the analytical laboratory.

Handling of an Invalid Sample -

1. Complete as much of the data sheet as possible and explain any omissions.

2. Mark "VOID" on the data sheet accompanying the filter and record in the site log book.

3. Do not discard the filter.

4. Promptly deliver the filter cassettes in their petri dish and the data sheet to the analytical laboratory, where a final decision on sample validity will be made.

Handling of a Questionable Sample -

If uncertain whether or not a sample should be voided:

1. Complete as much of the data sheet as possible and explain any factors that may affect the sample validity.

2. Put a question mark in the upper right corner of the data sheet.

3. Record as "Questionable" in the site log book.

4. Promptly deliver the filter cassettes in their petri dish and the data sheet to the analytical laboratory, where a final decision on sample validity will be made.

3.4 Operator's QC Field-Calibration-Check Procedure

For dichotomous samplers, a field calibration check of the total and coarse flow rates is recommended after each month of operation. The purpose of this check is to track the sampler calibration stability. Control charts presenting flow-check data (indicated vs. observed) should be maintained. These charts provide a quick reference of instrument flow-rate drift patterns and will indicate when flow limits (±7% variation from the indicated or design condition flow rate) have been exceeded. The field check is made by installing a measuring device (which is traceable to NIST and is calibrated within the range of the total or coarse flow rate) on the inlet of the sampler. Calibration procedures for the measurement device are referenced in Table 2.1.

Calibration checks of the sampler flow rate require that the instrument be running. The following flow-check procedures are specific to an orifice device. A variety of transfer standards may be used with this same procedure; however, necessary apparatus and subsequent calculations to determine the sampler's flow rates will vary.

3.4.1 Field-Check Apparatus -

The following equipment is required for a field calibration check:

- A thermometer capable of accurately measuring temperature to the nearest ±1°C and referenced to an NIST or ASTM thermometer within ±2°C at least annually.

- A barometer capable of accurately measuring ambient barometric pressure to the nearest ±1 mm Hg and referenced to an NIST or ASTM barometer within ±5 mm Hg at least annually.

- Two calibrated orifice devices and calibration relationships (one for total and one for coarse).

- The sampler's calibration information.

- Two clean flow-check filters.
- Dichotomous sampler flow-check data sheet (Figure 3.3) or log book.

3.4.2 Procedure for Field-Calibration Check -

1. Insert clean filters (designated "flow-check filters") into both the fine and coarse filter holders of the sampler as described in the operating procedure in Subsection 3.3.1. Flow-check filters should never be used for subsequent sampling, as particles larger than 10 µm can impact on the filter when the inlet is removed and bias the sample.

2. Turn on the sampler and allow it to warm up to operating temperature (approximately 5 min).

3. Read and record the following parameters on the sampler flow check data sheet (Figure 3.3):

   - Ambient temperature (Ta), °C and K
   - Ambient barometric pressure (Pa), mm Hg or kPa
   - Sampler S/N and model
   - Orifice S/Ns and calibration relationships
   - Date, location, and operator's signature
   - Sampler rotameter's calculated flow rates and set points: TFR, TSP; CFR, CSP.

4. Adjust both the total and coarse rotameters to their respective calculated set points (TSP, CSP).

5. Remove the inlet from the sampler, replace it with the flow-check orifice device, and recheck the rotameter set points.

6. Observe the ΔH_2O across the total flow orifice by reading the manometer deflection (at the bottom of the meniscus), and determine the corresponding flow rate from the orifice calibration data. Record both values (manometer deflection and corresponding flow rate) on the flow-check data sheet. Using the sampler's calibration relationship, calculate the sampler's indicated total actual flow rate (TQa) and record.

7. Turn the sampler off. Disconnect the fine flow vacuum line and cap the fine flow outlet port with a 9.53-mm (3/8-in.) Swagelok cap. This opens the fine flow to the vacuum pump. It is recommended that a particle-free filter be attached to the detached line to prevent particles from entering the system. Install the coarse-flow-rate orifice and turn the sampler on.

Dichotomous Sampler Flow Check Data Sheet

Station Location Cary, NC Date 12/2/89 SAROAD Number 372346789
Sampler Model 244E S/N 619 EPA Number 387265
Pa 742 mm Hg Ta 19 °C 292 K Unusual Conditions None
Orifice S/N 317 (Total) Orifice S/N 316 (coarse) Orifice Calibration Date 10/1/89
Orifice Qa (Total) Calibration Relationship: m = 24.691 b = +0.89 r = 0.999
Orifice Qa (Coarse) Calibration Relationship: m = 2.493 b = +0.04 r = 0.999

Sampler Total Calibration Relationship:
m = 0.379 b = +2.15 r = 0.995, TFR 16.60 L/min, TSP 13.55

Sampler Coarse Calibration Relationship:
m = 3.806 b = -0.04 r = 0.995, CFR 1.66 L/min, CSP 10.08

Flow Rate Description		ΔH_2O (in.)	Orifice Flow Rate* (L/min)	Sampler** TQa or CQa (L/min)	Difference L/min	Difference %
Total Flow		0.95	15.99	16.60	0.61	3.8
	Design Cond.***	0.95	15.99	16.7	0.71	4.4
Coarse Flow		0.97	1.58	1.66	0.08	5.1
	Design Cond.***	0.97	1.58	1.67	0.09	5.7

* TQa or CQa = $m[(\Delta P)(Ta/Pa)]^{1/2} + b$

**TQa or CQa = $1/m\,[(\text{TSP or CSP})(Ta/Pa)^{1/2} - b]$

$$\text{QC \% Difference} = \frac{(\text{TQa or CQa}) - \text{Orifice Flow Rate}\ (100)}{\text{Orifice Flow Rate}}$$

$$\text{***Design condition \% Difference} = \frac{\text{Orifice Flow Rate} - (16.7 \text{ or } 1.67)\ (100)}{(16.7 \text{ or } 1.67)}$$

Operator Lisa Wall

Figure 3.3. Example dichotomous sampler flow-check data sheet.

8. Observe the ΔH_2O across the coarse orifice by reading the manometer deflection and determine the corresponding flow rate from the orifice calibration data. Record both values on the flow-check data sheet. Using the sampler's calibration relationship, calculate indicated coarse <u>actual</u> flow rate (CQa) and record.

9. Using the above information, calculate the QC percentage difference as:

$$\text{\% Difference} = \frac{(\text{TQa or CQa}) - \text{Orifice flow rate}}{\text{Orifice flow rate}} (100) \qquad \text{(Eq. 11)}$$

10. Determine the percentage difference between the sampler design flow rate (16.7 L/min or 1.67 L/min) and the orifice determined flow rate as:

$$\text{\% Difference} = \frac{\text{Orifice flow rate} - (16.7 \text{ or } 1.67)}{16.7 \text{ or } 1.67} (100) \qquad \text{(Eq. 12)}$$

11. If the sampler flow rate is within 93 to 107% of the 16.7 L/min or 1.67 L/min flow rate (at actual conditions), the sampler is operating properly. If these limits are exceeded, investigate and correct any malfunction. If necessary, recalibrate the sampler before sampling is resumed.

12. Turn off the sampler, remove the orifice device, replace the inlet, and reconnect the fine flow vacuum line.

13. Remove the filters from both fine and coarse filter holders.

14. Set up the sampler for the next sampling period according to the operating procedure in Subsection 3.3.1.

3.5 Documentation

The responsible persons should record the following information on the filter petri dish, the field data sheet, and in the log book.

3.5.1 Operator Who Starts the Sample -

Mark on the filter petri dish:

1. Sampler ID number.

2. Filter number.

3. Sample date.

4. Designation [e.g., whether it is a coarse (C) or fine (F) filter].

Mark on the field data sheet and record in the log book:

1. Site designation and location.
2. Sampler ID number.
3. Filter ID number.
4. Sample date.
5. Initial flow rates and rotameter readings. Initial temperature and barometric pressure, if required.
6. Unusual conditions that may affect the results (e.g., subjective evaluation of pollution that day, construction activity, weather conditions).
7. Signature.

3.5.2 Operator Who Removes the Samples -

Mark on the field data sheet and record in the log book:

1. Elapsed time of the sample run.
2. Final flow rates and rotameter readings. Final temperature and barometric pressure, if required.
3. Existing conditions that may affect the results.
4. Explanations for voided or questionable samples.
5. Signature.

2.10.4 FILTER PREPARATION AND ANALYSIS

The accuracy of a PM10 sampling program depends on several factors. A primary consideration is the analytical laboratory staff's attention to detail and balance technique. This section offers guidelines to enhance the accuracy of laboratory operation and hence the mass concentration determinations of PM10.

Balance accuracy, precision, calibration requirements, and recommended filter media are outlined in Subsection 1. Laboratory activities are summarized in a table at the end of this subsection (Table 4.1).

4.1 Filter Handling

It is recommended that enough filters to last at least for a 1-month sampling period be numbered and weighed at one time. During weighing, analysts must wear nylon gloves and handle the filters carefully with nonserrated forceps. This reduces the potential effect from body moisture or oils contacting the filters and subsequently affecting measured weights, and it also restricts static electricity interference. Filters should be packed so that each is encased in a filter cassette and a petri dish for convenience in filter weighing, transportation, and storage (see Figure 4.1). A label should be attached to the dish that identifies the filter number. This label will also be used at the time of sampling to identify sample date, size fraction (coarse/fine), and sampling site. To improve filter inventory control, care should be taken to stack the filters in the box in numerical order so that the operator will use the proper filter first.

If samples are to be mailed, the field operator should be supplied with reinforced envelopes or some other method (in addition to the petri dish) of protecting the exposed filters during their delivery to the analytical laboratory.

4.2 Filter Integrity Check

All filters must be visually inspected for defects before the initial weighing. A filter must be rejected if any defects are found. Batches of filters containing a high number of defects should be returned to the supplier.

Specific defects to look for are:

1. Pinhole--A small hole appearing (a) as a distinct and obvious bright point of light when examined over a light table or screen, or (b) as a dark spot when viewed over a black surface.
2. Separation of ring--Any separation or lack of seal between the filter and the filter border reinforcing ring.
3. Chaff or flashing--Any extra attached residual material on the reinforcing, polyolefin ring, or heat seal area that would prevent an airtight seal when the ring is placed under compression.

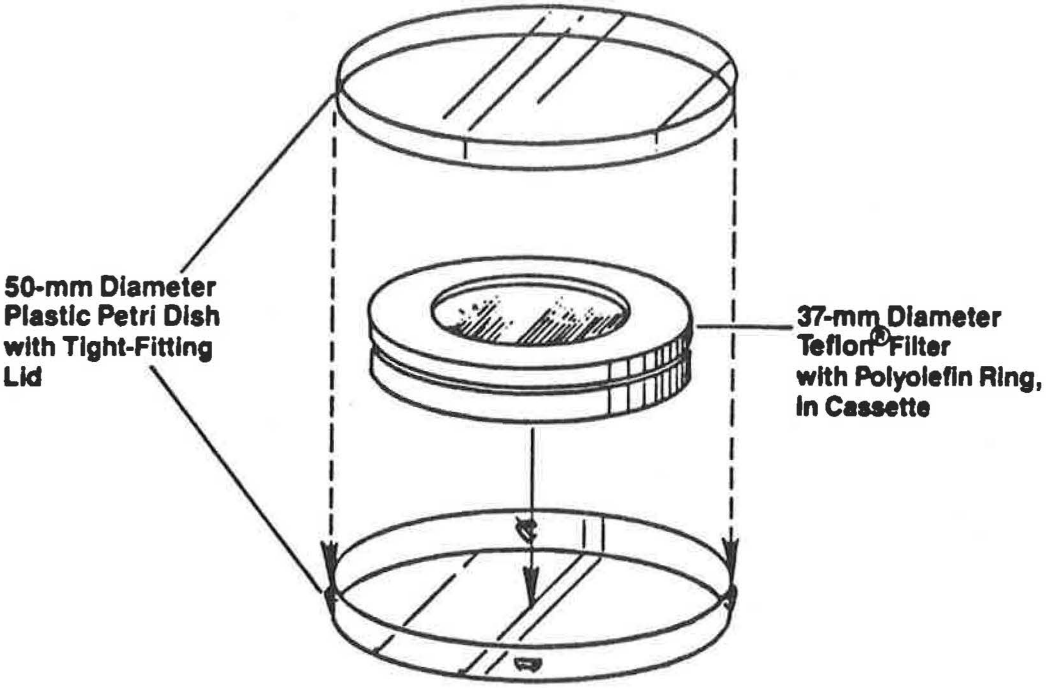


Figure 4.1. Dichotomous filter cassette and petri dish.

4. Loose material--Any extra loose material or dirt particles on the filter that require removal by brushing prior to weighing.

5. Discoloration--Any obvious visible discoloration that might be evidence of a contaminant.

6. Filter nonuniformity--Any obvious visible nonuniformity in the appearance of the filter when viewed over a light table or black surface that might indicate gradations in porosity across the face of the filter.

7. Other--A filter with any imperfection not described above, such as irregular surfaces or other results of poor workmanship.

4.3 Filter Equilibration

Filters must be equilibrated in a conditioning environment for at least 24 h before being weighed. Relative humidity (RH) should be held constant at a mean value between 20 and 45%, with a variability of not more than ±5%. Temperature should be held constant with a mean value between 15 and 30°C, with a variability of not more than ±3°C. An air-conditioned room may be used for equilibration if it can be maintained at this RH and in this temperature range while the filters are equilibrating. RH and temperature must be checked and recorded on equilibration days (either manually or by hygrothermograph) to assure compliance with these guidelines. Equilibration chamber malfunctions, discrepancies, and maintenance activities also should be recorded in the equilibration chamber or laboratory log book.

Filters should be conditioned in their protective petri dishes with the lids (on which the filter ID is recorded) removed and placed beneath the bottom half of the petri dish. Placing the lid beneath the bottom half will make certain that no mix-up occurs.

4.4 Initial Weighing Procedures (Tare Weight)

This subsection presents procedures specific for a common commercially available analytical balance. Calibration, QC checks (and acceptable tolerances) and operational procedures may have to be adapted to other analytical balance models.

Filters must be weighed on a microbalance with a minimum resolution of 0.001 mg and a precision of ±0.001 mg (1 μg). Each balance used in the weighing procedures must be identified by a balance number. The procedures follow.

NOTE: Make sure that the balance has been calibrated (at least annually) and maintained according to manufacturer's recommendations. If out of calibration, have the balance calibrated according to manufacturer's directions.

1. Turn on the balance and allow it to warm up for at least 15 min. If it is used daily, leave it on at all times.

2. Zero the balance according to manufacturer's directions.

3. Have the QC supervisor perform the "standard" filter QC check (Subsection 4.5.2) to increase the validity of subsequent tare weight values.

4. If filters must be weighed outside the conditioning chamber, use caution to avoid interference with ambient hydroscopic particles and begin the weighing procedure within 30 s. Weigh the filter according to manufacturer's directions, making sure a stable reading is obtained.

5. Place the tared filter, with the reinforcing ring side up, in a comparably sized petri dish.

6. It is recommended that each balance be assigned a block of filter numbers to be used sequentially. Assign a filter ID number and take extreme care to avoid duplication or missed numbers.

7. Legibly record the assigned filter number on the petri dish, leaving sufficient room for one more letter designating size fraction [(F) for fine or (C) for coarse] to be written following the number.

   Suggestion: The operator may decide to include three additional digits on the petri dish label to represent the tare weight of the filter (e.g., 101, 99, 105, etc.).

8. Record the balance number, the assigned filter number, and the tare weight on the data/coding form (Figure 4.2). Number each form sequentially in the upper right-hand corner.

9. Perform regular QC checks as detailed in Subsection 4.5.

10. Install the filter into a cassette, and return the filter/cassette assembly to its individual petri dish.

4.5 Internal QC

4.5.1 Operator QC -

After every fifth weighing, the operator should recheck the zero and calibration of the balance and record these check values on the Laboratory Internal Quality Control Log (Figure 4.3). (The zero and 10-mg weight checks are internal standards of the analytical balance.) Zero QC checks within 4 µg of true zero and calibration QC checks within 2 µg of 10 mg are acceptable. Larger discrepancies should be corrected immediately. When QC checks are unacceptable, the previous five filters must be reweighed. Any filter weight outside of the normal range of 80 to 110 mg must be investigated immediately.

Note: An electrostatic charge will prevent a microbalance from operating properly. Static charge is the accumulation of electrical charges on the surface

Laboratory Data/Coding Form

Date	Bal. No.	Filter No.	Balance Tare	Tare Wt.	Gross Wt.	*	Date	Bal. No.	Filter No.	Balance Tare	Tare Wt.	Gross Wt.	*

*Balance operator's or QC supervisor's initials

Figure 4.2. Example laboratory data/coding sheet.

Quality Control Log

Supervisor QC							Operator QC				
BID[a]	Date	Filter Number	Original Value	Obs. Value	±20 µg Y/N	Action Taken	BID	Date	Filter No.	Zero Check Value[c]	Cal Check Value[d]
028	6/10/89	6428	91.628	91.630	yes	—	028	6/10/89	6420	0.001	10.001
028	6/10/89	6429	98.290	98.285	yes	—	028	6/10/89	6421	0.002	10.000
028	6/12/89	6427	95.617	95.730	NO	dessication not complete					
028	6/13/89	6427	95.617	95.620	yes	—					

[a] Balance ID number
[b] For standard filter check and unexposed filters
[c] ± 4 µg of zero
[d] ± 2 µg of 10 mg.

Figure 4.3. Example internal quality control log sheet.

of a non-conductive material. Common symptoms of this problem include noisy read-out, drift, and sudden read-out shifts. To reduce static charge within the balance, it may be necessary to place a radioactive ionizing unit (i.e., Polonium 210) in the weighing chamber. It may also be necessary to pass the filters over an ionizing unit before they are weighed. For more information about static and how to minimize its effects, see the Technical Note, "Static Control for Balances," prepared by Cahn Instruments, Inc.

4.5.2 Supervisory QC Procedures -

1. Keep a bound QC notebook. These notebooks must contain all QC data, including the balance calibration and maintenance information, internal routine QC checks, and independent audits. It is recommended that control charts be maintained on each balance and included in this notebook. These charts may indicate any excess drift that could flag an instrument malfunction.

2. For cross-checking, reference all QC data on the Quality Control Log Form to the laboratory QC notebook.

3. At the beginning of each weighing day, after the operator has completed the zeroing and calibration checks of the balances, tare weigh one arbitrarily selected filter from a set of "standard" filters (10% of the total number of filters to be weighed). Because these filters represent a repetitive QC check, do not use them for subsequent sampling. These weights must be repeatable for each balance to within 20 μg of the original value. If not, the balance performance is unacceptable; troubleshoot and reweigh the filters as necessary. If more than one balance is used, take care that the filter is weighed on the same balance that determined the original tare value. Unless this procedure is adhered to, many samples may have to be invalidated.

4. Reweigh five to seven exposed and unexposed filters per balance each day of operation. Weights should be within ±20 μg of original values; if not, troubleshoot and reweigh. Because of the loss of volatile components, no limits are set for exposed filters. Record all data on the Quality Control Log Form and in the QC notebook.

5. Certify acceptability of filter weights and data completeness daily on the laboratory data/coding forms and initial. When bound, these serve as a laboratory notebook. Sign each completed form.

4.6 Post-Sampling Documentation and Inspection

Upon receipt of the sample from the field, the sample custodian should follow this procedure:

1. Examine the field data sheet. Determine whether all data needed to verify sample validity and to calculate mass concentration are provided (e.g., average flow rate, ambient temperature and barometric pressure, and elapsed time). Void the sample if data are missing or unobtainable from a field operator or if a sampler malfunction is evident.

2. If the exposed filter was packaged for shipment, remove the filter from its protective pertri dish and examine the petri dish. If sample material has been dislodged from a filter, recover as much as possible by brushing it from the petri dish onto the deposit on the filter with a soft camel's-hair brush.

3. Match the filter ID number with the correct laboratory data/coding form on which the original balance ID number, filter ID number, filter tare weight, and other information are inscribed. The sample custodian should group filters according to their recorded balance ID numbers. Initial separation of filters by balance ID number will decrease the probability of a balance error that could result from the use of different balances for tare and gross weights.

4. Remove the filter from both the petri dish and the filter cassette. The filters must be handled with clean, nonserrated forceps; they must not be touched by the hands. Inspect the filters for any damage that may have occurred during sampling. Reject the filter for mass concentration determination or any additional analysis if defects are found.

5. Return filters with no defects to their original petri dish and forward to the laboratory. File the data sheets for subsequent mass concentration calculations.

6. Return defective filters with the type of defect (or combination of defects) to their original petri dish, labeled by defect type(s), and submit to laboratory supervisor for final approval of filter validity.

4.7 Final Weighing Procedure (Gross Weight)

1. Group filters according to their recorded balance numbers. (Filters should be separated initially by balance ID number; this will lower the incidence of balance error that would occur if different balances were used for tare and gross weights.) Reweigh each filter on the same balance on which its tare weight was obtained.

2. In an environmentally controlled area, open the petri dish, making certain that the lid (with the filter ID inscribed) is placed beneath the bottom and that no mix-up occurs.

3. Cover the open petri dish with a clean laboratory paper towel and place it in the conditioning environment. Allow the filter to equilibrate according to procedures outlined in Subsection 4.3.

4. Repeat Steps 1 through 5 of the dichotomous filter tare weighing procedure (Subsection 4.4).

5. Perform the internal QC checks described in Subsection 4.5 to ensure validity of reweighing.

6. Record the indicated gross weight on the laboratory data/coding form.

7. If the dichotomous filter is not to receive additional analysis, place it back into the corresponding petri dish. Deliver weighed filters to the sample custodian for archiving.

8. If the filter is to receive further analysis, return it to the petri dish and note on the petri dish what additional analyses are required. Place an asterisk after the gross weight column on the laboratory data/coding form to indicate that the filter requires additional analysis. Carefully place each filter thus packaged in a box, and deliver to the sample custodian who will forward it to the laboratory responsible for the additional analysis.

4.8 Calculation of Net Mass Filter Loading

The gross weight minus the tare weight of a dichotomous filter is the net mass of the particulate for that filter. Each calculation of this process must be independently validated. Refer to Subsection 5 for information regarding the calculation of PM10 mass concentration.

TABLE 4.1. FILTER PREPARATION AND ANALYSIS CHECKS

Activity	Method and frequency	Requirements	Action if requirements are not met
Handling	Observe handling procedure.	Use nonserrated forceps and nylon gloves. Place filters in protective petri dishes and number sequentially.	Improve technique.
Integrity check	Visually inspect each filter.	No pinholes, tears, etc.	Discard filter.
Identification	Visually check each filter number assigned.	Filter ID must be legible and recorded on the laboratory data/coding form and on the petri dish.	Identify properly.
Equilibration (tare and gross desiccation)	Observe and record the equilibration room or chamber conditions. Observe the minimum equilibration period for each sample.	Equilibration in controlled environment for >24 h; RH between 20 and 45% with less than ±5% variation and temperature between 15 and 30°C with less than ±3°C variation.	Repeat equilibration.
Tare weighing procedure	Observe weighing procedure; perform all internal QC procedures.	Indicated filter weight determined to nearest ±1 µg. Begin weighing within 30 s after removing from the equilibration chamber.	Reweigh after re-equilibration.
Post-sampling inspection, documentation, and verification	Visually check all samples and documentation.	No pin holes, tears, etc.; complete documentation; no evidence of malfunction or sample loss.	Void the affected samples; report to supervisor.
Gross weighing procedure	Observe filter weighing procedure; perform all internal QC procedures.	Indicated weight obtained to nearest ±1 µg; begin weighing within 30 s after removal from equilibration chamber.	Reweigh after equilibration.

2.10.5 CALCULATIONS, VALIDATIONS, AND REPORTING OF PM10 DATA

Measurements of PM10 mass concentration in the atmosphere that are used to determine attainment of the National Ambient Air Quality Standards for particulate matter must be expressed in units of micrograms per standard cubic meter (μg/std. m^3) of air. For these measurements, "standard" means EPA-standard conditions of temperature and pressure, which are 25 °C (298 K) and 760 mm Hg (101 kPa), respectively. This section presents the calculations required to compute and report ambient PM10 concentrations. A summary of all calculation formulas and associated symbols presented in Section 2.10 is given in Table 5.1.

Particle size discrimination by inertial separation requires that specific air velocities be maintained in the sampler's air inlet system. These design velocities are obtained when a specified "design flow rate" is maintained. The design flow rate is specified as an actual flow rate (TQa and CQa), measured at existing conditions of temperature (Ta) and pressure (Pa).

The sampler's operational flow rate (i.e., the actual flow rate when the sampler is operating normally to collect a PM10 sample) should, of course, be very close to the design flow rate. All PM10 samplers have some means for measuring the operational flow rate, and that flow rate measurement system must be calibrated periodically with a certified flow rate transfer standard. Usually, measurements (or estimates) of ambient temperature and barometric pressure are required to get an accurate indication of the operational flow rate. For determining the average sampler flow rate over a sample period, use of average temperature (Tav) and average barometric pressure (Pav) over the sample period is recommended. If average temperature and pressure values (or reasonable estimates) cannot be obtained for each sample period, however, seasonal average temperature (Ts) and barometric pressure (Ps) for the site may be substituted.

Tav and Pav readings may be recorded on-site or estimated from data obtained from a nearby U.S. National Weather Service Forecast Office or airport weather station. Barometric pressure readings obtained from airports or other sources must be at station pressure (i.e., not corrected to sea level), and they may have to be corrected for differences between the elevation of the monitoring site and that of the airport. If individual Tav and Pav readings cannot be obtained for each sample period and seasonal averages for the site are routinely substituted, care must be taken that the actual temperature and barometric pressure at the site can be reasonably represented by such averages. It is therefore recommended that seasonal average temperature and pressure values (Ts and Ps) for the site be used only when these values are within 20 K and 40 mm Hg (5 kPa) of the actual average temperature and barometric pressure (Tav and Pav) for the sample period.

The calculations presented in this subsection assume that the sampler has been calibrated in actual flow rate units (TQa and CQa) and that individual average temperature and barometric pressure values are used for each sample period. If seasonal average temperature and pressure values for the site are to be used, Ts may be substituted for Tav, and Ps may be substituted for Pav in Equations 1, 5, and 13.

TABLE 6.1. FORMULAS ASSOCIATED WITH PM10 MONITORING

Calculation	Formula	Equation	Subsection
Conversion of flow rates from actual to standard conditions	$Qstd = Qa(Pa/Pstd)(Tstd/Ta)$	Eq. 1	2.1
Conversion of average flow rates from actual to standard conditions	$\overline{Qstd} = \overline{Qa}(Pav/Pstd)(Tstd/Tav)$	Eq. 1a	2.1
Conversion of flow rates from standard to actual conditions	$Qa = Qstd\ (Ta/Pa)(Pstd/Tstd)$	Eq. 2	2.1
Total and coarse rotameter actual corrections	$AC = I(Ta/Pa)^{1/2}$	Eq. 3	2.2.4
Rotameter calibration, actual correction vs. transfer standard flow, actual conditions	$AC = m[Qa(\text{transfer standard})] + b$	Eq. 4	2.2.4
Slope, intercept, and linearity of total and coarse flow rate calibration	$\overline{TQa}$ or $\overline{CQa} = 1/m\ [\bar{I}(Tav/Pav)^{1/2} - b]$	Eq. 5	2.2.4
Total and coarse flow rates	$TFR = 16.7\ (Ps/Pa)(Ta/Ts)$ $CFR = 1.67\ (Ps/Pa)(Ta/Ts)$	Eq. 6 Eq. 7	2.2.4 2.2.4
Total rotameter set point response	$TSP = \{[m(TFR) + b](Pa/Ta)^{1/2}\}$	Eq. 8	2.2.4
Coarse rotameter set point response	$CSP = \{[m(CFR) + b](Pa/Ta)^{1/2}\}$	Eq. 9	2.2.4
Total and coarse average rotameter readings	$\bar{I} = (TSP \text{ or } CSP + IF)/2$	Eq. 10	3.3.2
QC percentage difference	$\%\ Diff. = \dfrac{TQa \text{ or } CQa - \text{Orifice flow rate}}{\text{Orifice flow rate}}\ (100)$	Eq. 11	3.4.2

(continued)

TABLE 5.1. (continued)

Calculation	Formula	Equation	Subsection
Percentage difference between sampler design flow rate and orifice-determined flow rate	$\% \text{ Diff.} = \frac{\text{Orifice flow rate} - (16.7 \text{ or } 1.67)}{(16.7 \text{ or } 1.67)} (100)$	Eq. 12	3.4.2
Conversion of average flow rates from actual to standard conditions	$\overline{TQstd} \text{ or } \overline{CQstd} = [(\overline{TQa} \text{ or } \overline{CQa})(10^{-3})(Pav/Tav)(Tstd/Pstd)]$	Eq. 13	5.1.1
Total volume of air sampled	$V = (TQstd)t$	Eq. 14	5.1.2
Total mass concentration	$\text{PM10 total mass concentration} = \frac{(Mf + Mc)(10^3)}{(V)}$	Eq. 15	5.1.2
Concentration of fine particle fraction	$[F] = \frac{Mf(10^3)}{(\overline{FQ\ std})t}$	Eq. 16	5.4
Concentration of coarse particulate fraction	$[C] = \frac{Mc(10^3) - [F]\ (\overline{CQstd})t}{(\overline{TQstd})t}$	Eq. 17	5.4
Percentage difference between sampler-indicated and audit-measured flow rates	$\% \text{ Diff.} = \frac{Qa(\text{sampler}) - Qa(\text{audit})}{Qa(\text{audit})} (100)$	Eq. 18	7.1.4
Percentage difference between sampler design flow rates and Qa(audit) flow rates	$\% \text{ Diff.} = \frac{Qa(\text{audit}) - \text{Design flow rate}}{\text{Design flow rate}} (100)$	Eq. 19	7.1.4

5.1 Calculations

5.1.1 Flow-Rate Calculations -

The total and coarse flow rates are calculated by first averaging the sampler's initial rotameter set points (TSP or CSP) and final indicated rotameter responses (IF).

$$\bar{I} = (\mathrm{TSP\ or\ CSP} + \mathrm{IF})/2 \qquad \text{(Eq. 10)}$$

where

$\bar{I}$ = average total or coarse rotameter response, arbitrary units
TSP, CSP = total or coarse rotameter set points, arbitrary units
IF = indicated final total or coarse rotameter response, arbitrary units.

These values are then applied to the sampler's total or coarse calibration relationship.

$$\overline{\mathrm{TQa}} \text{ or } \overline{\mathrm{CQa}} = 1/m[\bar{I}(\mathrm{Tav}/\mathrm{Pav})^{1/2} - b] \qquad \text{(Eq. 5)}$$

where

$\overline{\mathrm{TQa}}$, $\overline{\mathrm{CQa}}$ = sampler total or coarse average flow rate, actual L/min
$\bar{I}$ = average total or coarse rotameter response, arbitrary units
Tav = average ambient temperature for the run day, K
Pav = average ambient pressure for the run day, mm Hg or kPa
m = slope of the total or coarse flow-rate calibration relationship
b = intercept of the total or coarse flow-rate calibration relationship.

The average flow rates are then corrected to EPA reference standard conditions by using Equation 13. Note: For the subsequent calculation of PM10 concentrations, only the $\overline{\mathrm{TQstd}}$ flow rate is considered.

$$\overline{\mathrm{TQstd}} \text{ or } \overline{\mathrm{CQstd}} = [(\overline{\mathrm{TQa}} \text{ or } \overline{\mathrm{CQa}})(10^{-3})(\mathrm{Pav}/\mathrm{Tav})(\mathrm{Tstd}/\mathrm{Pstd})] \qquad \text{(Eq. 13)}$$

where

$\overline{\mathrm{TQstd}}$ or $\overline{\mathrm{CQstd}}$ = total or coarse flow rate corrected to standard conditions, std. m^3/min
$\overline{\mathrm{TQa}}$ or $\overline{\mathrm{CQa}}$ = sampler total or coarse flow rate, actual L/min
10^{-3} = conversion factor for L/min to m^3/min
Pav, Tav = ambient barometric pressure, mm Hg, kPa; temperature, K
Tstd, Pstd = standard temperature and pressure 25°C, 298 K, 760 mm Hg, or 101 kPa.

5.1.2 PM10 Concentrations Calculation -

The reporting of total PM10 mass concentration data requires the calculation of the total volume of air sampled (Equation 14) and the computation for total mass concentration (Equation 15).

$$V = (\overline{TQstd})t \qquad \text{(Eq. 14)}$$

where

V = total sample volume in standard volume units, m^3
$\overline{TQstd}$ = total flow rate corrected to standard conditions (see Equation 13), std. m^3/min
t = elapsed total sampling time, minutes.

$$PM10 = \frac{(Mf + Mc)(10^3)}{(V)} \qquad \text{(Eq. 15)}$$

where

$PM10$ = mass concentration of PM10, $\mu g/std.\ m^3$
Mf = net mass of particulate of the fine filter, mg
Mc = net mass of particulate of the coarse filter, mg
10^3 = conversion factor for mg to μg
V = total sample volume in standard volume units, m^3.

5.2 Calculation Validation

Data necessary to compute the mass concentration of PM10 originate from two main sources--field operations and laboratory operations--and must be validated. The validation procedure ensures that all reported data are accurate relative to the overall scope of the QA program. When the final mass concentration of PM10 in a sample has been computed, the validation procedure will not only check these computations, but will also aid in flagging questionable mass concentrations (i.e., extremely high or low values). Should a mass concentration approach the primary or secondary ambient air quality standard, this validation procedure will provide checks for all preliminary field and laboratory operations. The steps of the calculation validation procedure are as follows:

1. Gather the following data for each sample:

    - Total sampling time and the average total flow rate corrected to standard conditions; minutes, std. m^3/min.

    - Tare, gross, and net weights of both coarse and fine filters; mg.

2. Compute the total mass concentration of PM10 for seven samples per 100 (minimum of four per lot) as specified in Subsection 5.1.1 or 5.1.2. These suggested starting frequencies may be altered, based on experience and data quality. Decrease the frequency if past experience indicates that data are of good quality, or increase it if data are of poor quality. It is more important to be sure that the validation check is representative of the various conditions that may influence data quality than to adhere to a fixed frequency. If calculation errors are found, all values in that sample lot should be recalculated.

3. Scan all total mass concentration values, note those that appear excessively high or low, and investigate. Repeat Step 2 for these samples. Compare validated PM10 concentration to the originally reported value. Correct any errors that are found, initial them, and indicate the date of correction.

4. If all mass concentration computations appear correct and questionably high or low value(s) still exist, review all raw data (i.e., sample time, average actual total flow rate and its subsequent correction to standard conditions, and total net particle mass for coarse and fine filters) for completeness and correctness.

5.3 Data Reporting

The primary standards for particulate matter in the ambient air are based on the measured mass concentration of PM10. Information on reporting and interpretation of PM10 data with respect to the attainment of these standards is covered in 40 CFR 50, Appendix K.

5.4 Additional Calculations

This section outlines the procedures and computations necessary to calculate the mass concentration for the fine and coarse particle fractions of a dichotomous sample. The following calculations are not required to determine attainment of the primary or secondary standards; rather, they are supplemental and may not be necessary. The dichotomous sampler is designed to fractionate a total PM10 sample into two discrete size ranges [fine particles (less than 2.5 μm) and coarse particles (less than 10 μm, but greater than 2.5 μm)]. Note: A correction is required for the relatively small mass of fine particles collected on the coarse filter, as illustrated in Equation 17.

First determine the concentration of the fine particle fraction as calculated by Equation 16.

$$[F] = \frac{Mf(10^3)}{(\overline{FQstd})t} \qquad \text{(Eq. 16)}$$

where

$[F]$ = mass concentration of fine particles, µg/std. m^3
Mf = net mass of particulate on fine filter, obtained gravimetrically, mg
10^3 = conversion factor for mg to µg
$\overline{FQstd}$ = average fine-flow rate corrected to standard conditions and calculated as $\overline{TQstd} - \overline{CQstd}$, std. m^3/min
t = elapsed total sampling time, min.

The calculation to determine the concentration of the coarse particulate fraction is presented in Equation 17.

$$[C] = \frac{Mc(10^3) - [F]\ (\overline{CQstd})t}{(\overline{TQstd})t} \qquad \text{(Eq. 17)}$$

where

$[C]$ = mass concentration of coarse particles, µg/std. m^3
Mc = net mass of particulate on coarse filter, obtained gravimetrically, mg
10^3 = conversion factor for mg to µg
$[F]$ = mass concentration of fine particles as determined by Equation 16, µg/std. m^3
$\overline{CQstd}$ = average coarse flow rate corrected to standard conditions, std. m^3/min
$\overline{TQstd}$ = average total flow rate corrected to standard conditions, std. m^3/min
t = the elapsed total sampling time, min.

2.10.6 MAINTENANCE

Preventive maintenance is defined as a program of positive actions aimed toward preventing failure of monitoring and analytical systems. The overall objective of a routine preventive maintenance program is to increase measurement system reliability and to provide for more complete data acquisition.

This subsection outlines general maintenance procedures for a specific commercially available dichotomous sampler. For more complete information on a particular sampler, or on laboratory equipment maintenance, refer to the manufacturer's instruction manual for the individual instrument.

Records should be maintained for the maintenance schedule of each dichotomous sampler. Files should reflect the history of maintenance, including all replacement parts, suppliers, cost expenditures, and an inventory of on-hand spare equipment for each sampler.

6.1 Maintenance Procedures

6.1.1 Recommended Supplies for Maintenance Procedures -

An alcohol-based general-purpose cleaner, cotton swabs, a small soft-bristle brush, paper towels, distilled water, and miscellaneous handtools are required maintenance supplies for dichotomous samplers. A compressed-air source is recommended, but not required.

6.1.2 Sampling Module -

The sampling module of the dichotomous sampler consists of the sampler inlet and the virtual impaction assembly. Figure 6.1 shows a disassembled sampling inlet, and Figure 6.2 illustrates the virtual impactor assembly. All parts are sealed with "O" rings.

CAUTION: SOME PM10 DICHOTOMOUS SAMPLER INLETS SHOULD NOT BE DISMANTLED. CHECK WITH MANUFACTURER'S SPECIFICATIONS BEFORE PROCEEDING.

To dismantle the sampler inlet:

- Mark each assembly point of the sampler inlet with pen or pencil to provide "match marks" during reassembly.
- Disassemble the unit in accordance with manufacturer's instructions, taking care to retain all "O" rings and miscellaneous parts. <u>Note</u>: If the assembly screws appear frozen, the application of penetrating oil or commercial lubricant will make removal easier.
- Clean all interior surfaces with the general-purpose cleaner or compressed-air source, paying particular attention to small openings and crevices. Cotton swabs and/or a small brush would be most helpful in these areas. Completely dry all components.

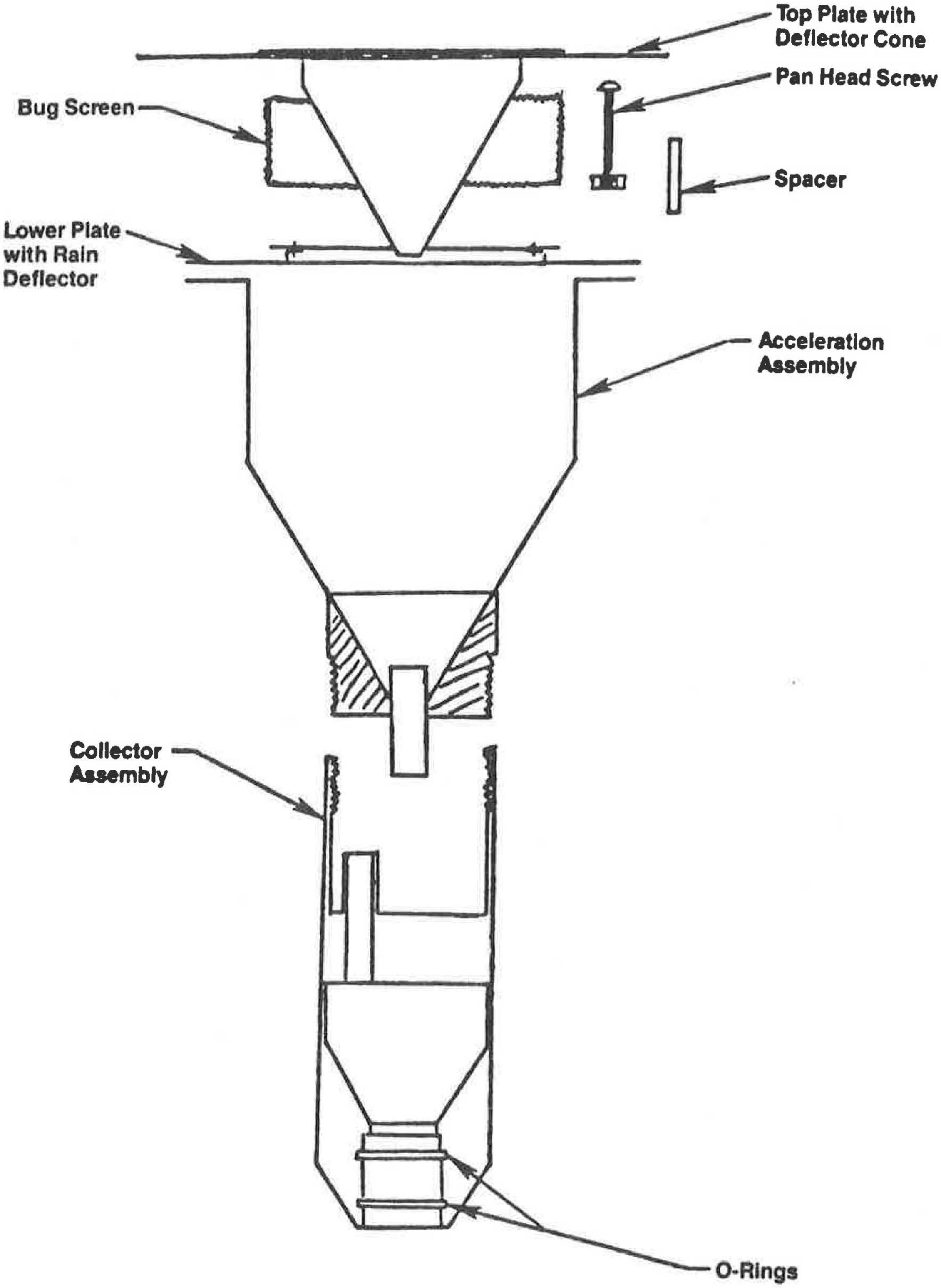


Figure 6.1. Dichotomous sampler inlet.

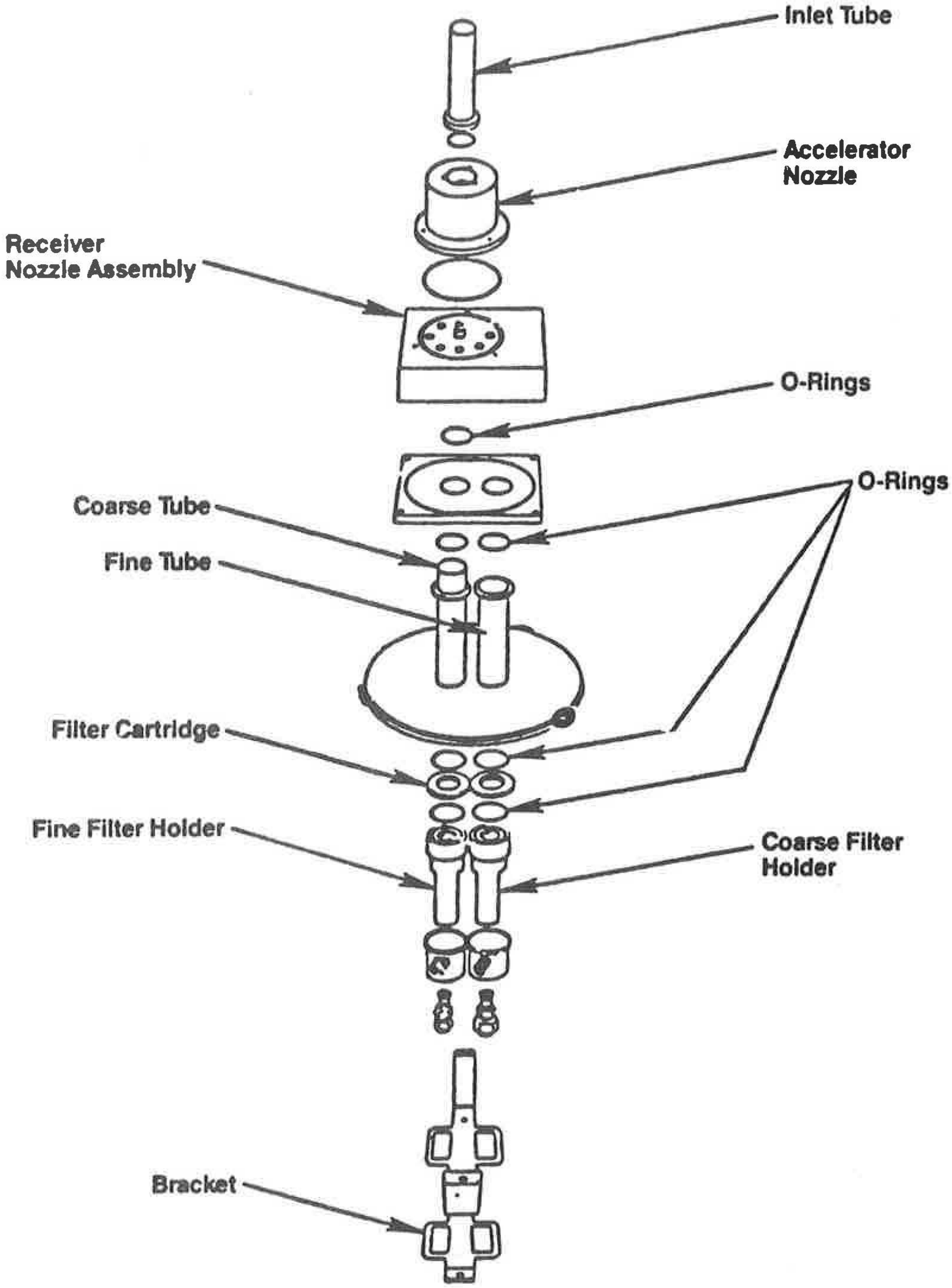


Figure 6.2. Dichotomous sampler virtual impaction assembly.

- Reassemble the unit in accordance with the previously scribed match marks. Take particular care to ensure that all "O" ring seals are properly sealed and that all screws are uniformly tightened.

The "O" rings in the aerosol inlet should be removed periodically and conditioned with vacuum grease. This will inhibit breakdown and fraying of the "O" ring caused by friction on the inlet tube. The bug screen protecting the aerosol sampler inlet should be cleaned periodically during the summer months. The bug screen is exposed for cleaning by pulling the sampler inlet off the receiver tube assembly. An "O" ring in the sampler inlet acts as the seal. Many samplers are equipped with an inlet that also has a primary water trap on the exterior of the unit. If this trap is glass, care should be taken not to crack or break it, as the sampler will not maintain adequate vacuum during operation. The glass trap may either be replaced with a plastic jar or wrapped with insulating tape to minimize the danger of accidental breakage.

Virtual Impactor Assembly - Internal particulate deposits accumulate primarily on the outer and inner surfaces of the tip (closest to sampler inlet) of the inlet tube. Thus, the inlet tube should be inspected periodically for such particulate deposits and cleaned as required. An inlet tube cleaning schedule of every 3 to 4 months is typical; the remaining inner surfaces should be cleaned every 6 to 12 months. Use alcohol or water and a soft-bristle brush for cleaning.

Examine sample module vacuum tubing periodically for crimps, cracks, or breaks and replace as necessary. Examine connecting fittings for cross-threading, and replace fittings if necessary.

6.1.3 Control Module

CAUTION: UNPLUG THE POWER CORD FROM ITS RECEPTACLE BEFORE REMOVING OR OPENING THE FRONT PANEL OF THE DICHOTOMOUS CONTROL MODULE.

Control Module Cleaning Procedures -

1. Remove or open the front panel and blow out loose dust and dirt if compressed air is available. Wipe down all surfaces with the general-purpose cleaner and towels.

2. Make note of any obvious problems in the unit and take action to correct them before completion of cleaning. Refer to the manufacturer's instruction manual.

3. Check rotameters for cleanliness. If they are dirty and/or contain water, they must be removed and cleaned. (If water is found, the interior of the vacuum pump may be damaged. It should be opened for inspection and possible repair.) To clean the rotameters, take the following steps:

- Remove the tubing from the total rotameter output port and any other connecting tubing that may prove too inflexible to allow removal of the rotameters.

- Remove the screws securing the rotameter assembly to the front panel.

- Slip the assembly back from the front panel enough to gain access to the Allen screws in the top of each rotameter and remove the protective cover.

- While holding the glass rotameter with one hand, loosen the Allen screws just enough to allow removal of each of the graduated glass tubes.

- Clean the two rotameters with an alcohol-based cleaner and rinse thoroughly in distilled water. For proper cleaning of the unit, the float and its retainers also should be removed. The retainers are easily removed with the aid of a wire hook fashioned from a paper clip.

- Allow the tubes to dry thoroughly and reassemble.

4. Remove and clean all filter jars. Check each for possible cracks, and replace if necessary. Should a filter jar become cracked or loosened, the dichotomous sampler will not maintain an adequate vacuum during system leak tests. Be certain that each filter jar is tightened and sealed properly. Clean or replace any dirty filter elements. These elements may become dirty in routine operation or if the sampler is inadvertently energized without sample filters installed.

5. Clean the cooling fan's blades and housing with compressed air or a small brush. Check the housing for any dirt that could cause the fan to lock up.

6. Clean exterior surfaces of the vacuum pump; be sure that all cooling vents are open. Take care that fluids do not run inside the pump. Check all mounting brackets to ensure that they are tight and in good condition.

Vacuum Pump - It is recommended that the diaphragm and the flapper valves of the vacuum pump be replaced routinely (at 1-year intervals) or if a sudden reduction in sampler vacuum occurs and a leak check indicates there are no other obvious leaks in the system.

To replace the diaphragm, remove the finned head of the pump by removing the head screws. Remove the screws that hold down the diaphragm and replace the diaphragm. Wipe down the head and interior valves to remove any small particles of diaphragm rubber that might be present. To reassemble, reverse the procedure, making sure that the screw clearance cavity in the plate is lined up under the intake valve screw heads. All head screws must be tightened evenly. Diaphragms are often available through local suppliers or they may be purchased through the manufacturer.

When all cleaning and routine maintenance operations have been completed, close the control module, reassemble and connect the sample module, and recalibrate the instrument (if necessary). Refer to Subsection 2 for calibration procedures.

6.2 Refurbishment of Dichotomous Samplers

Dichotomous samplers that have been operated in the field for extended periods may require major repairs or complete refurbishment. In these cases, the manufacturer's instrument manual must be referred to before work is undertaken. A dichotomous sampler that has been subject to major repairs or refurbishment must be leak-checked and calibrated prior to sample collection.

2.10.7 AUDITING PROCEDURES

The operating agency must perform QA audits and process evaluations to determine the accuracy of the PM10 monitoring system and, hence, the data it produces. The primary goal of an auditing program is to identify system errors that may result in suspect or invalid data. The efficiency of the monitoring system (i.e., labor input vs. valid data output) is contingent upon effective QA activities. This true assessment of the accuracy and efficiency of the PM10 measurement system can only be achieved by conducting an audit under the following guidelines:

- Without special preparation or adjustment of the system to be audited.
- By an individual with a thorough knowledge of the instrument or process being evaluated, but not by the routine operator.
- With accurate, calibrated, NIST-traceable transfer standards that are completely independent of those used for routine calibration and QC flow checks.
- With complete documentation of audit information for submission to the operating agency. The audit information includes, but is not limited to, types of instruments and audit transfer standards, instrument model and serial numbers, transfer-standard traceability, calibration information, and collected audit data.

The audit procedures described in this subsection produce two quantitative estimates of a PM10 sampler's performance: the audit flow rate percentage difference and the design flow rate percentage difference. The audit flow rate percentage difference determines the accuracy of the sampler's indicated flow rate by comparing it with a flow rate from the audit transfer standard. The design flow rate percentage difference determines how closely the sampler's flow rate matches the inlet design flow rate under normal operating conditions.

An independent observer should be present for the audit, preferably the routine operator of the sampling equipment. This practice not only contributes to the integrity of the audit, but also allows the operator to offer any explanations and information that will help the auditor to determine the possible causes of discrepancies between audit-standard values and the sampling equipment values.

To determine whether differences in flow rate (between audit flow and sampler flow) are a result of sampling equipment malfunction or operator technique, an auditor may request permission to observe the routine field flow-check procedure performed by the operator.

Audits and evaluations of the following individual portions of the total PM10 measurement system are detailed in this subsection:

- Flow-rate performance audit.
- System audit of data processing.

- Analytical process system evaluation.

These audits and evaluations are summarized in a table at the end of this subsection (Table 7.1). Refer to Section 2.0.11 of this volume for detailed procedures for systems audits.

Proper implementation of an auditing program serves a twofold purpose: to ensure the integrity of the data and to assess the accuracy of the data. Additional information on assessing the accuracy of the data is given in Section 2.0.8 of this volume of the Handbook.

7.1 Flow-Rate Performance Audit

The following subsection presents audit procedures specific to commercially available dichotomous samplers which operate at an actual total flow of 16.7 L/min and a coarse flow of 1.67 L/min. Audit techniques may vary between different models of samplers due to differences in required flow rates and the sampler's sampling configuration.

The dichotomous sampler flow rate audit method involves using two transfer standards. One is calibrated in the flow range of the total and fine flow rates and the second is calibrated within the range of the coarse flow rate. This enables the auditor to measure the critical flow rates directly without compounding transfer standard error through subtraction. Obviously, the optimum audit method would incorporate one transfer standard calibrated over the entire range of the sampler's accepted flow limits (1.5 L/min to 18.4 L/min). Accuracy over this flow range is difficult to achieve within acceptable limits. Consequently, it is recommended to conduct audits using transfer standards within specific ranges to measure the sampler's indicated flow rates.

Since the accurate measurement of PM10 mass concentration is dependent upon flow rates under actual conditions, the auditor must also audit in terms of actual conditions. If the audit transfer standard's calibration data have been corrected to EPA reference conditions (298 K, 760 mm Hg or 101 kPa), a conversion must be calculated to adjust the standard L/min flow rate (Qstd) to an actual L/min flow rate (Qa).

7.1.1 Audit Apparatus -

Any type of flow-rate transfer device acceptable for use in calibration of dichotomous samplers may be used as the audit flow-rate reference standard; however, the audit standard must be a different device from the one used to calibrate the sampler. The audit standard must be calibrated against a primary standard traceable to the NIST. Refer to Subsection 2, Tables 2.1 and 2.2, which reference flow-rate transfer standard calibration procedures. Assemble the audit apparatus as indicated in Figures 7.1 through 7.3. In addition to that which is presented in the tables, a few miscellaneous supplies are required. These include a 9.53-mm (3/8-in.) Swagelok cap, 6.35-mm (1/4-in.) Swagelok cap, hand tools, and an adapter to connect the transfer standard outlet to the sampler inlet.

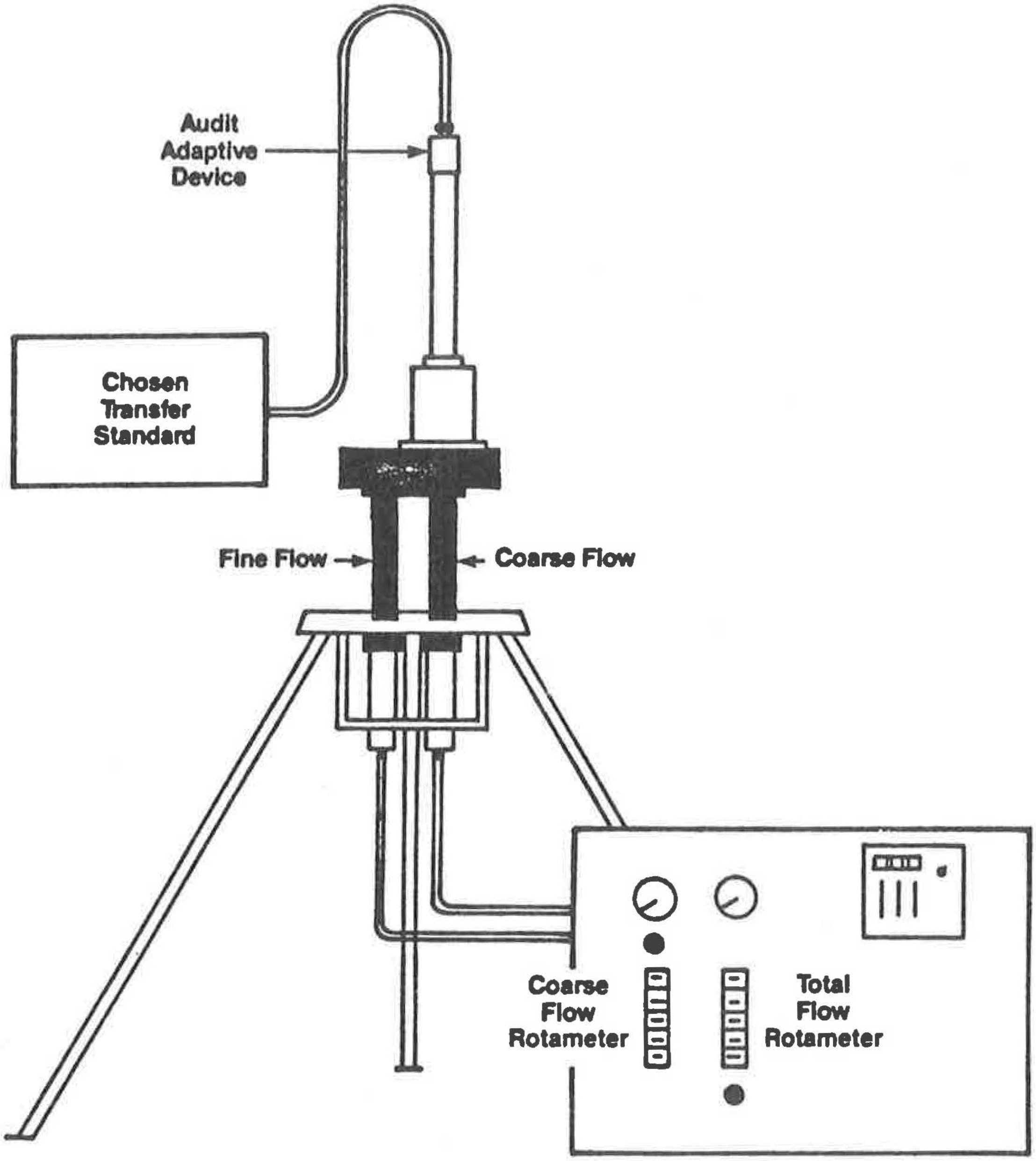


Figure 7.1. Audit assembly and dichotomous sampler set up to audit total flow (TQa).

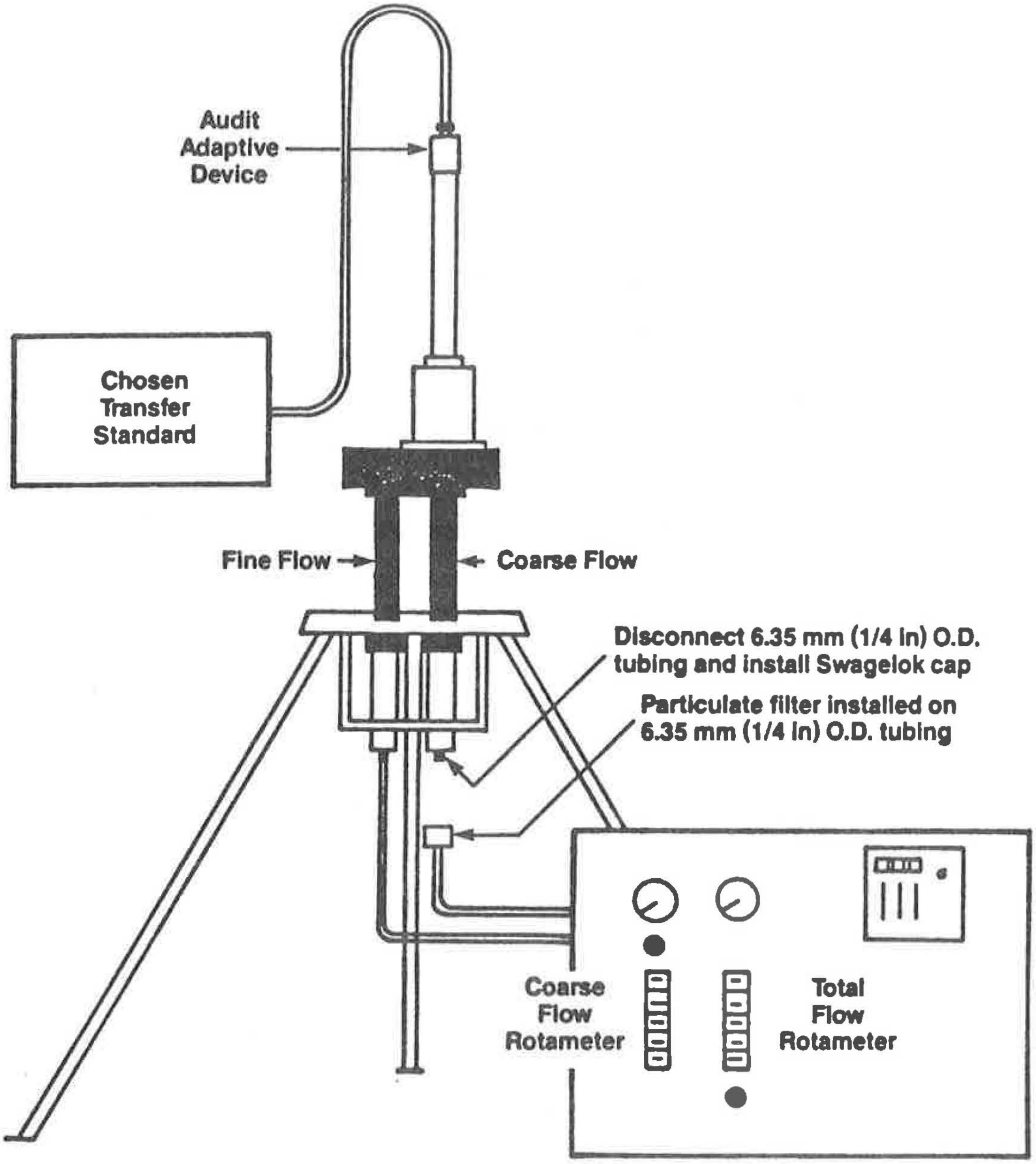


Figure 7.2. Audit assembly and dichotomous sampler set up to audit fine flow (FQa).

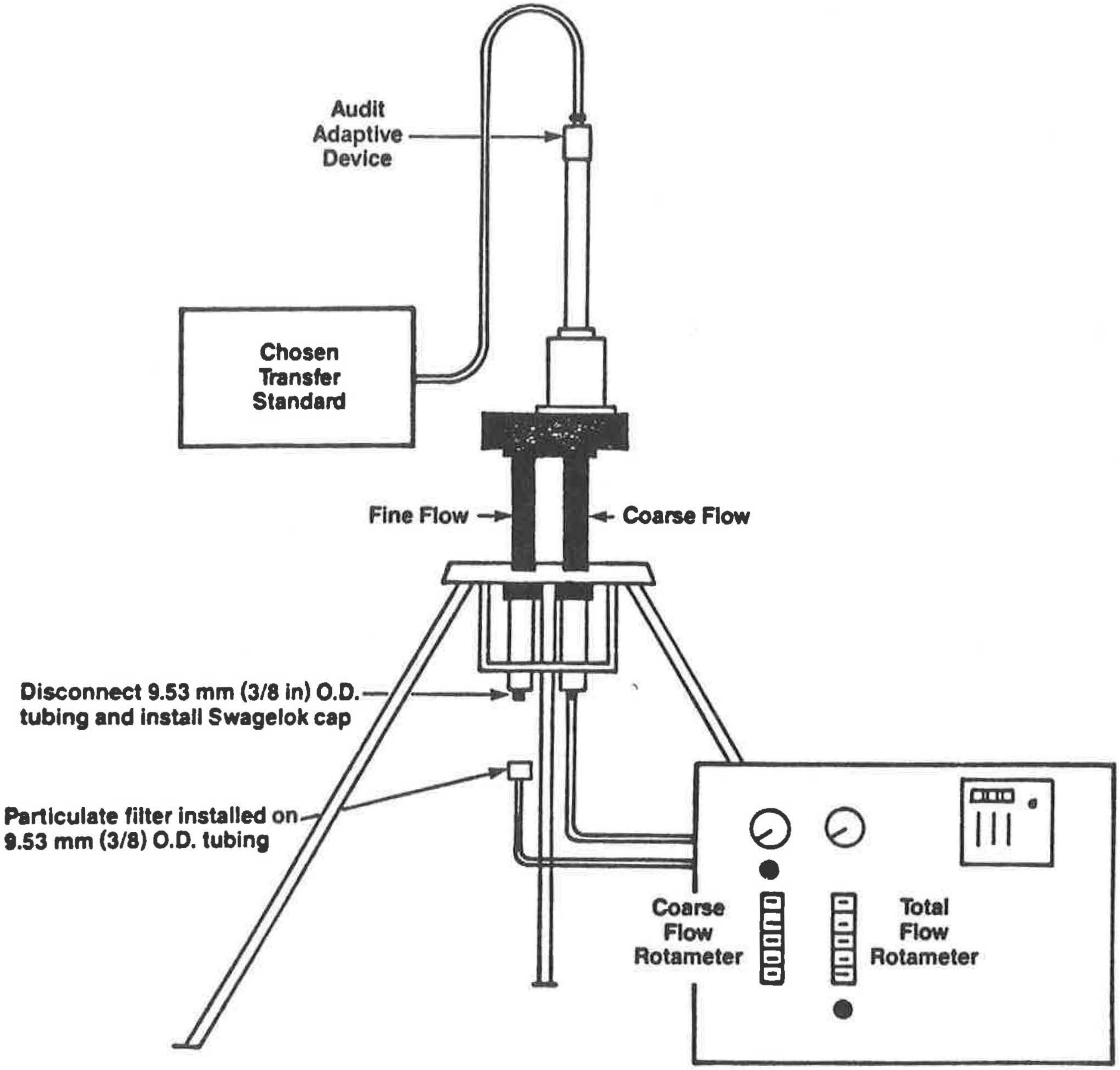


Figure 7.3. Audit assembly and dichotomous sampler set up to audit coarse flow (CQa).

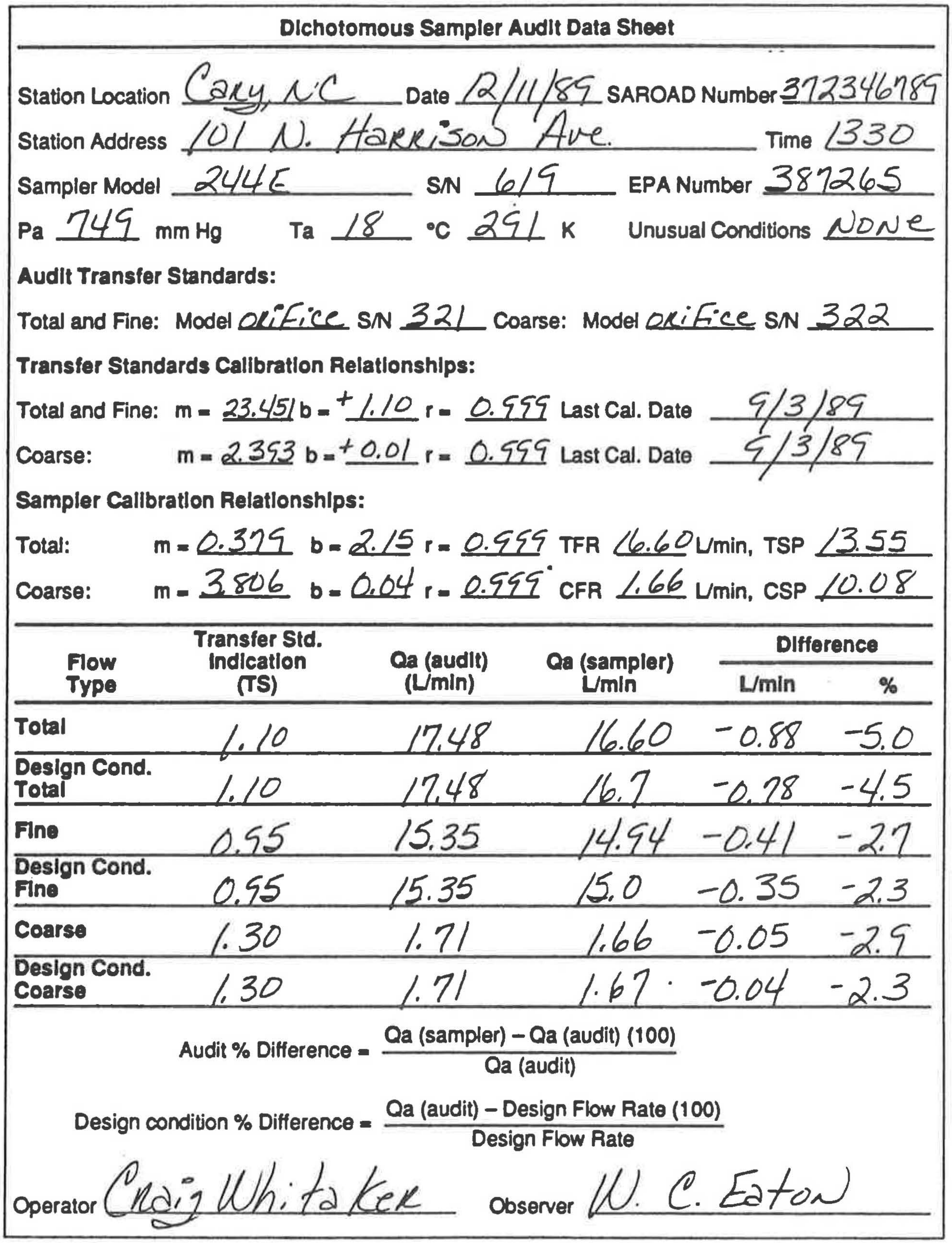
An audit data sheet similar to Figure 7.4 must be used to document audit information. This information includes, but is not limited to, sampler and audit transfer standard type, model and serial numbers, transfer standard traceability and calibration information, ambient temperature and pressure conditions, and collected audit data.

7.1.2 Total Flow-Rate Audit Procedures -

1. Instruct the operator to install new filters in both the fine and coarse filter holders and energize the sampler. Filters used for flow rate audits should not be used for sampling.
2. Instruct the operator to adjust the rotameter flow-control valves to set the total and coarse rotameters to their operational set points for routine sampling. These set points should correspond to the calculated set points (TSP, CSP) determined by the sampler's calibration relationship.
3. Allow the sampler to warm up for a minimum of 5 min while maintaining the proper total and coarse rotameter set points.
4. Complete the top half of the data sheet with the required information, including ambient temperature (Ta) and ambient barometric pressure (Pa). Record both the TSP and CSP values and the corresponding flow rates.
5. Remove the sampler inlet and replace with the transfer standard adaptive device (see Figure 2.1).
6. Connect the adapter to the transfer standard outlet with flexible tubing, being careful not to crimp the tubing. If the transfer standard is electronic, it must equilibrate to operating conditions. A warmup time of at least 5 min is recommended.
7. Recheck rotameter settings; if different from designated set points, record new value and the corresponding flow rate as determined by the sampler's calibration relationship.
8. Record on the audit data sheet the transfer standard (TS) readings (volts, ΔH_2O, timings, etc.).

7.1.3 Fine Flow Rate Audit Procedures -

1. Turn the sampler off and disconnect the coarse-flow 6.53-mm (1/4-in.) line. Cap the coarse-flow outlet port located beneath the dichotomous sampler filter holder with a 6.53-mm (1/4-in.) Swagelok cap. This opens the coarse line to the vacuum pump. To prevent particle entrapment within the system, it is recommended that a particle-free filter be attached to the line.



Dichotomous Sampler Audit Data Sheet

Station Location Cary, NC Date 12/11/89 SAROAD Number 372346789
Station Address 101 N. Harrison Ave. Time 1330
Sampler Model 244E S/N 619 EPA Number 387265
Pa 749 mm Hg Ta 18 °C 291 K Unusual Conditions None

Audit Transfer Standards:

Total and Fine: Model orifice S/N 321 Coarse: Model orifice S/N 322

Transfer Standards Calibration Relationships:

Total and Fine: m = 23.451 b = +1.10 r = 0.999 Last Cal. Date 9/3/89
Coarse: m = 2.393 b = +0.01 r = 0.999 Last Cal. Date 9/3/89

Sampler Calibration Relationships:

Total: m = 0.379 b = 2.15 r = 0.999 TFR 16.60 L/min, TSP 13.55
Coarse: m = 3.806 b = 0.04 r = 0.999 CFR 1.66 L/min, CSP 10.08

Flow Type	Transfer Std. Indication (TS)	Qa (audit) (L/min)	Qa (sampler) L/min	Difference	
				L/min	%
Total	1.10	17.48	16.60	-0.88	-5.0
Design Cond. Total	1.10	17.48	16.7	-0.78	-4.5
Fine	0.55	15.35	14.94	-0.41	-2.7
Design Cond. Fine	0.95	15.35	15.0	-0.35	-2.3
Coarse	1.30	1.71	1.66	-0.05	-2.9
Design Cond. Coarse	1.30	1.71	1.67	-0.04	-2.3

$$\text{Audit \% Difference} = \frac{\text{Qa (sampler)} - \text{Qa (audit)}\ (100)}{\text{Qa (audit)}}$$

$$\text{Design condition \% Difference} = \frac{\text{Qa (audit)} - \text{Design Flow Rate}\ (100)}{\text{Design Flow Rate}}$$

Operator Craig Whitaker Observer W. C. Eaton

Figure 7.4. Example dichotomous sampler audit data sheet.

2. Turn the sampler on and check the rotameter set points. If variation has occurred since the total flow rate audit, record the total and coarse rotameter units and their corresponding flow rate values determined from the sampler's calibration. A small flow imbalance occurs when the coarse line is disconnected; this may cause rotameter fluctuations.

3. Record on the audit data sheet the transfer standard (TS) readings (volts, ΔH_2O, timings, etc.).

7.1.4 Coarse Flow Rate Audit Procedures -

1. Turn the sampler off and exchange the total and fine flow rate transfer standard for the coarse flow transfer standard. If necessary, allow this transfer standard to equilibrate to ambient conditions (at least 5 min).

2. Reconnect the coarse flow line and disconnect the fine flow 9.53-mm (3/8-in.) line. Cap the fine flow outlet port located beneath the dichotomous sampler filter holders with a 9.53-mm (3/8-in.) Swagelok cap. This opens the fine line to the vacuum pump. To prevent particle entrapment within the system, it is recommended that a particle-free filter be attached to the line.

3. Turn the sampler on and check rotameter set points. If variation has occurred since the total flow rate audit, record the total and coarse rotameter units and their corresponding flow rate values determined from the sampler's calibration. A small flow imbalance occurs when the fine line is disconnected; this may cause rotameter fluctuations.

4. Record on the audit data sheet the transfer standard (TS) readings (volts, ΔH_2O, timings, etc.).

7.1.5 Audit Data Calculations -

1. Calculate and record the audit total, fine, and coarse flow rates by using the calibration curve accompanying the transfer standard. Record these values to the nearest 0.01 L/min (e.g., 1.67 L/min) on the audit data sheet.

   Note: It may be necessary to correct audit flow rates to actual conditions. If a soap film flowmeter has been used to determine the coarse flow rate, no water vapor corrections are necessary for this audit flow.

$$Q_a = Q_{std}(T_a/P_a)\,(P_{std}/T_{std}) \qquad \text{(Eq. 1)}$$

where

Q_a = flow rate at actual conditions, L/min
Q_{std} = flow rate corrected to standard temperature and pressure (25 °C, 298 K; 760 mm Hg or 101 kPa), L/min
T_a = ambient temperature, K
P_a = ambient barometric pressure, mm Hg or kPa
P_{std}, T_{std} = standard barometric pressure and temperature, respectively.

2. Instruct the operator to calculate (using the sampler's calibration relationship) the corresponding sampler flow rates and record.

3. Determine the percentage difference between the sampler-indicated flow rates and the audit-measured flow rates as:

$$\% \text{ Difference} = \frac{Qa(\text{sampler}) - Qa(\text{audit})}{Qa(\text{audit})} (100) \qquad \text{(Eq. 18)}$$

4. Determine the percentage difference between the sampler design flow rates and the Qa(audit) flow rates as:

$$\% \text{ Difference} = \frac{Qa(\text{audit}) - \text{Design flow rate}}{\text{Design flow rate}} \qquad \text{(Eq. 19)}$$

   Note: For most common dichotomous samplers, the design flow rates are 16.7 L/min (total), 15.0 L/min (fine), and 1.67 L/min (coarse) at actual conditions.

5. Record percent difference. If the difference is less than or equal to ±7%, the sampler calibration is acceptable. Differences exceeding ±7% require sampler recalibration. Differences exceeding ±10% may result in invalidation of all data subsequent to the last calibration or valid flow check. Before invalidating any data, double-check the sampler's calibration, the audit orifice transfer standard's certification, and all calculations.

6. Before leaving the site, a comparison between the flows determined should be made (i.e., fine + coarse = total). If the sum of the individual flows (fine and coarse) does not equal the total flow (within ±2%), the audit data should be checked. If necessary, the audit should be repeated.

7.1.5 Performance Audit Frequency -

The frequency of audits of the flow rate depends on the use of the data (e.g., for PSD air monitoring or for SLAMS). For PSD monitoring, the flow rate of each sampler must be audited at least once each sampling quarter. For SLAMS, audit the flow rate of at least 25% of the samplers per monitoring network each quarter. Each sampler, therefore, is audited at least once per year. If there are fewer than four PM10 samplers within a reporting organization, reaudit one or more randomly selected samplers so that one sampler is audited each calendar quarter.

7.2 Systems Audit

A systems audit is an on-site inspection and review of the quality of the total measurement system (sample collection, sample analysis, data processing, etc.). This audit is normally conducted at the startup of a new monitoring system and as appropriate thereafter. Subsections 7.2.1 and 7.2.2 present systems audit procedures to evaluate data processing and laboratory operations.

Subsections 2.0.11 and 2.0.12 of this volume provide detailed procedures and forms for systems audits and performance audits, respectively.

7.2.1 Systems Audit of Data Processing -

It is recommended that data processing be audited soon after the original calculations have been performed. This allows corrections to be made immediately and also allows for possible retrieval of additional explanatory data from field personnel when necessary. A minimum frequency of seven samples per 100 (minimum of four per lot) is recommended. The procedure is as follows:

1. Use the operational flow rates as reported on the sample data sheets.

2. Beginning with the raw data on the dichotomous sample data sheet and the filter net and tare weights, independently compute the concentration (μg/std. m^3) and compare it with the corresponding concentration originally reported. If the mass concentration computed by the audit check (μg/std. m^3) does not agree with the original value within round-off error, recheck all samples in the lot.

3. Record the audit values on a data sheet, and report them, along with the original values, to the supervisor for review. The audit value is always given as the correct value based on the assumption that a discrepancy between the two values is always double-checked by the auditor.

7.2.2 Analytical Process System Evaluation -

A performance audit of the microbalances used to weigh dichotomous filters would require the use of ASTM Class 1 standard weights. Since microbalances are extremely delicate instruments and should not be operated by inexperienced personnel, it is recommended that the performance evaluation of the filter weighing process be done in the following manner:

1. Review the maintenance and calibration log for each balance. Routine balance maintenance and calibrations must be performed by the manufacturer's service representative at manufacturer-specified scheduled intervals. In no case should the interval between calibrations exceed 1 year.

2. Review QC data records for the filter-weighing process. Ensure that the following QC activities have been performed and documented:

   - Zero and calibration checks after every five filter weighings.

   - Standard filter weighing every day of the balance operation.

   - Duplicate filter weighing for every five to seven filters.

   If QC checks were out of limits, note what action was taken.

- Select randomly and have the balance operator reweigh four equilibrated filters out of every group of 50 or less. For groups of 50 to 100, reweigh 7 from each group. It is of primary importance to be sure that the sample is representative of the various conditions that may influence data quality.

- Record the original values and the audit weights on the audit form. Calculate the weight difference for each filter as follows:

Difference = Original weight (mg) - Audit weight (mg)

For unexposed filters, the difference should be less than ±20 μg (0.020 mg). For exposed filters, the potential loss of volatile particles prohibits acceptance/rejection limits to be established. Forward the audit data to the laboratory supervisor for review.

TABLE 7.1. AUDITING REQUIREMENTS

Procedure	Frequency and/or method	Acceptance limits	Action if requirements are not met
Flow rate audit	Once each quarter - PSD monitoring; once per year - SLAMS.	Percentage difference between the sampler-indicated flow rates and the audit-measured flow rate is within ±7%.	Recalibrate before resuming sampling; if difference exceeds ±10%, double-check calculations. If difference still exceeds ±10%, invalidate since last calibration or valid flow check.
Analytical evaluation			
Filter weighing	Perform seven audits/100 filters, or four audits/≤50 filters, use microbalance, condition filters for at least 24 h before weighing.	Audit weight = original weight ±20 mg for unexposed filters; no limit for exposed.	Reweigh all filters in the lot.
Balance	Observe weighing technique. Review balance maintenance and calibration log.	Balance maintained and calibrated at least annually.	Reweigh all filters; calibrate balance.
Data processing audit	Independently repeat calculation of PM10 concentration from data record for 7 samples per 100 (minimum of 4 per lot).	Audit concentration agrees with original report concentration within round-off error.	Recheck all calculations.
Systems audit	At beginning of a new monitoring system and periodically as appropriate, observe procedures and use checklist.	Method described in this subsection and Subsection 2.0.11 of this Handbook.	Initiate improved methods and/or training programs.

2.10.8 ASSESSMENT OF MONITORING DATA FOR PRECISION AND ACCURACY

8.1 Precision

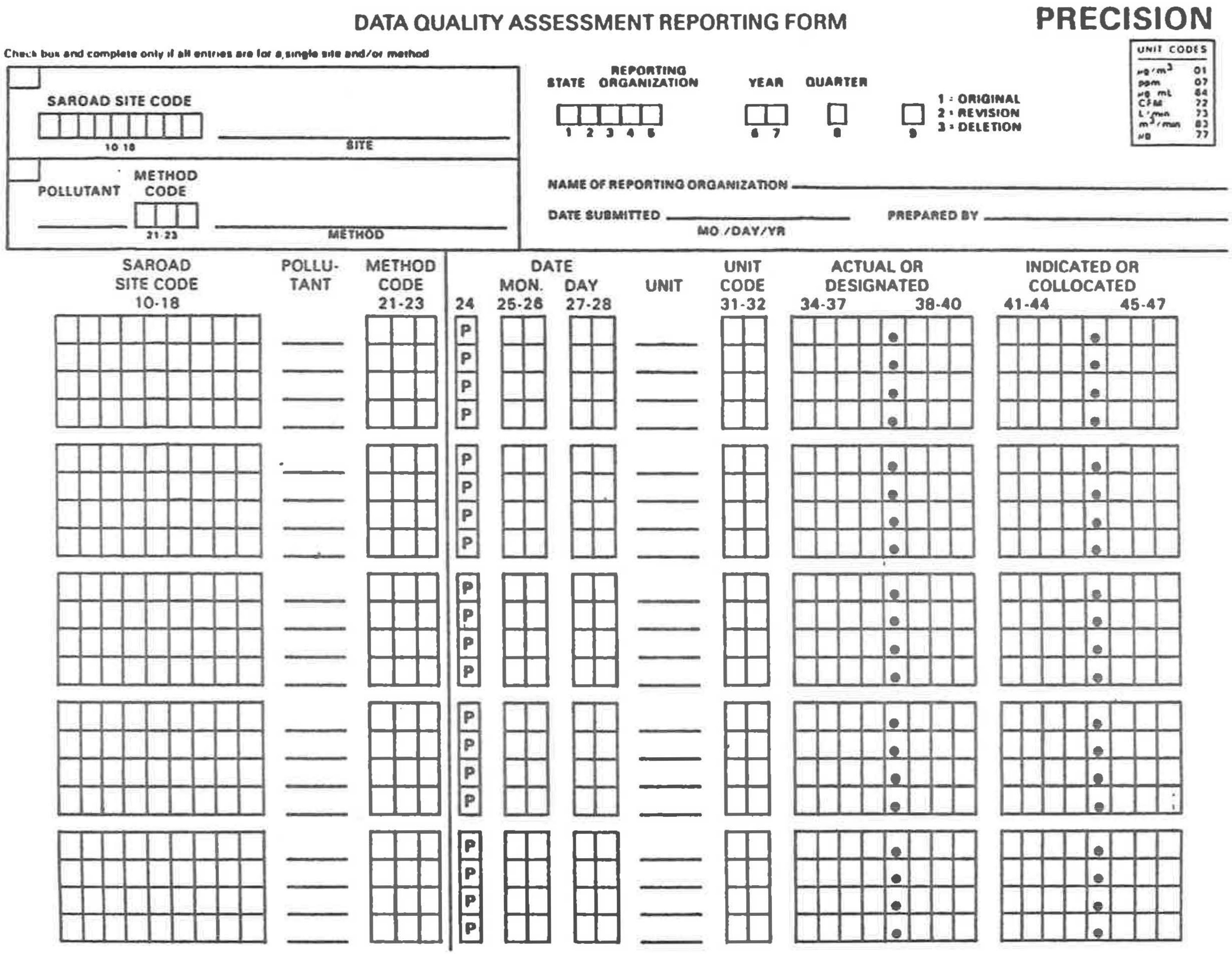
One or more monitoring sites within the reporting organization are selected for duplicate collocated sampling as follows: for a network of 1 to 5 sites, 1 site is selected; for a network of 6 to 20 sites, 2 sites are selected; and for a network of more than 20 sites, 3 sites are selected. Where possible, additional collocated sampling is encouraged. Annual mean particulate matter concentrations of the selected sites should be among the highest 25% of the annual mean PM10 concentrations for all the sites in the network. If such sites are impractical, however, alternate sites approved by the Regional Administrator may be selected.

Collocated PM10 samplers being used for assessment of precision should generally be of the same type. That is, they should have similar flow rates (e.g., high, medium, or low), similar inlet types (e.g., impaction or cyclonic), and similar flow controller types (e.g., MFC or rotameters). Where a PM10 network contains more than one type of sampler, each type should be represented by at least one collocated sampler pair, if possible.

The two collocated samplers must be within 4 m of each other, but at least 2 m apart to preclude air flow interference. Calibration, sampling, and analysis must be the same for both collocated samplers and all other samplers in the network. One of each pair of collocated samplers is designated as the primary sampler from which samples will be used to report air quality for the site; the other is designated as the duplicate sampler. Each duplicate sampler must be operated concurrently with its associated routine sampler at least once a week. The operation schedule should be selected so that the sampling days are distributed evenly over the year and over the 7 days of the week. The every-6th-day schedule used by many monitoring agencies is recommended. The measurements from both samplers at each collocated sampling site are reported. An example precision data reporting form is presented in Figure 8.1. The percentage differences in measured concentrations (μg/std. m^3) between the two collocated samplers are used to calculate precision as described in 40 CFR 58, Appendix A.

8.2 Accuracy

The accuracy of the dichotomous sampler method in the measurement of PM10 is assessed by auditing the performance of the sampler (at its specified flow rate) as described in Subsection 7. Both the audit flow rate and the corresponding sampler flow rate are reported. An example accuracy data reporting form is presented in Figure 8.2. The percentage differences between these flow rates are used to calculate accuracy as described in 40 CFR 58, Appendix A.



DATA QUALITY ASSESSMENT REPORTING FORM

PRECISION

Check box and complete only if all entries are for a single site and/or method

☐ SAROAD SITE CODE ☐☐☐☐☐☐☐☐☐ 10-18 ____________ SITE

☐ POLLUTANT ____________ METHOD CODE ☐☐☐ 21-23 ____________ METHOD

STATE ☐☐ 1 2 REPORTING ORGANIZATION ☐☐☐ 3 4 5 YEAR ☐☐ 6 7 QUARTER ☐ 8 ☐ 9

1 = ORIGINAL
2 = REVISION
3 = DELETION

UNIT CODES	
μg/m³	01
ppm	07
μg/mL	64
CFM	72
L/min	73
m³/min	83
μg	77

NAME OF REPORTING ORGANIZATION ____________

DATE SUBMITTED ____________ MO./DAY/YR PREPARED BY ____________

SAROAD SITE CODE 10-18	POLLU-TANT	METHOD CODE 21-23	DATE 24	MON. 25-26	DAY 27-28	UNIT	UNIT CODE 31-32	ACTUAL OR DESIGNATED 34-37	38-40	INDICATED OR COLLOCATED 41-44	45-47
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Figure 8.1. Precision data quality assessment form.

DATA QUALITY ASSESSMENT REPORTING FORM

ACCURACY

UNIT CODES	
$\mu g/m^3$	01
ppm	07
$\mu g/mL$	64
CFM	72
L/min	73
m^3/min	83
μg	77

Check box and complete only if all entries are for a single site and/or method

☐ **SAROAD SITE CODE** ☐☐☐☐☐☐☐☐☐ (10-18) ______ SITE

☐ **POLLUTANT** ______ **METHOD CODE** ☐☐☐ (21-23) ______ METHOD

STATE ☐☐ **REPORTING ORGANIZATION** ☐☐☐ (1 2 3 4 5)

YEAR ☐☐ (6 7) **QUARTER** ☐ (8)

☐ (9) 1 = ORIGINAL 2 = REVISION 3 = DELETION

NAME OF REPORTING ORGANIZATION ______

DATE SUBMITTED ______ MO./DAY/YR PREPARED BY ______

SAROAD SITE CODE	POLLUTANT	METHOD CODE		DATE MON DAY	T¹	S²	UNIT	UNIT CODE		ACTUAL	INDICATED	ACTUAL	INDICATED
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10-18		21-23	24	25-28	29	30		31-32	33	34-37 38-40	41-44 45-47	48-51 52-54	55-58 59-61
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[1] Type of audit

1 Audit conducted by reporting organization, audit standard certified by reporting organization
2 Audit conducted by reporting organization, audit standard certified by another organization
3 Audit conducted by other than reporting organization

[2] SOURCE of local primary standard.

GAS STANDARDS
A NBS SRM
B EPA reference gas
C Commercial CRM
D Photometer, uncertified
E Other ______
F Photometer, verified by comparison to an SRP

FLOW STANDARDS
L Laminar flow element
M Rotameter, certified <1 yr.
N Rotameter, not cert <1 yr.
P Certified orifice device
Q Wet test meter
S Dry gas meter
T Bubble flow meter
U Other: ______

CHEMICAL STANDARDS
W Reagent grade chemical weighed with balance
X Other: ______

SEND COMPLETED FORM TO REGIONAL OFFICE

Figure 8.2. Accuracy data quality assessment form.

2.10.9 RECOMMENDED STANDARDS FOR ESTABLISHING TRACEABILITY

Two factors are essential for attainment of data of the desired quality: (1) the measurement process must be under statistical control at the time of the measurement, and (2) the combination of systematic errors and random variation (measurement errors) must yield a suitably small uncertainty. Evidence of good quality data requires the performance of QC checks, independent audits of the measurement process, careful documentation of data, and the use of equipment and instrumentation that can be traced to an appropriate primary standard.

The following standards are recommended for establishing traceability:

1. ASTM Class 1 weights are recommended for the laboratory microbalance calibration. See Subsection 4.5 for details on balance calibration checks.

2. A positive-displacement primary standard or laminar flow element is recommended for calibrating the flow-rate transfer standard that is used to calibrate the dichotomous sampler. See Subsection 2 for details on dichotomous sampler calibration.

3. A positive-displacement primary standard is recommended for calibrating the transfer standard used to audit the dichotomous flow-rate calibration. See Subsection 7.1 for details on the flow-rate performance audits.

4. The elapsed-time meter should be checked semiannually against an accurate timepiece, and it must be accurate within 15 min/day.

5. Accuracy checks of associated monitoring equipment (i.e., thermometers, barometers, stopwatches, etc.) should be conducted at routine intervals and against standards of known accuracy and traceable to NIST.

APPENDIX J—REFERENCE METHOD FOR THE DETERMINATION OF PARTICULATE MATTER AS PM_{10} IN THE ATMOSPHERE

1.0 *Applicability.*

1.1 This method provides for the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}) in ambient air over a 24-hour period for purposes of determining attainment and maintenance of the primary and secondary national ambient air quality standards for particulate matter specified in § 50.6 of this chapter. The measurement process is nondestructive, and the PM_{10} sample can be subjected to subsequent physical or chemical analyses. Quality assurance procedures and guidance are provided in Part 58, Appendices A and B, of this chapter and in References 1 and 2.

2.0 *Principle.*

2.1 An air sampler draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one or more size fractions within the PM_{10} size range. Each size fraction in the PM_{10} size range is then collected on a separate filter over the specified sampling period. The particle size discrimination characteristics (sampling effectiveness and 50 percent cutpoint) of the sampler inlet are prescribed as performance specifications in Part 53 of this chapter.

2.2 Each filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM_{10}. The total volume of air sampled, corrected to EPA reference conditions (25° C, 101.3 kPa), is determined from the measured flow rate and the sampling time. The mass concentration of PM_{10} in the ambient air is computed as the total mass of collected particles in the PM_{10} size range divided by the volume of air sampled, and is expressed in micrograms per standard cubic meter ($\mu g/std\ m^3$). For PM_{10} samples collected at temperatures and pressures significantly different from EPA reference conditions, these corrected concentrations sometimes differ substantially from actual concentrations (in micrograms per actual cubic meter), particularly at high elevations. Although not required, the actual PM_{10} concentration can be calculated from the corrected concentration, using the average ambient temperature and barometric pressure during the sampling period.

2.3 A method based on this principle will be considered a reference method only if (a) the associated sampler meets the requirements specified in this appendix and the requirements in Part 53 of this chapter, and (b) the method has been designated as a reference method in accordance with Part 53 of this chapter.

3.0 *Range.*

3.1 The lower limit of the mass concentration range is determined by the repeatability of filter tare weights, assuming the nominal air sample volume for the sampler. For samplers having an automatic filter-changing mechanism, there may be no upper limit. For samplers that do not have an automatic filter-changing mechanism, the upper limit is determined by the filter mass loading beyond which the sampler no longer maintains the operating flow rate within specified limits due to increased pressure drop across the loaded filter. This upper limit cannot be specified precisely because it is a complex function of the ambient particle size distribution and type, humidity, filter type, and perhaps other factors. Nevertheless, all samplers should be capable of measuring 24-hour PM_{10} mass concentrations of at least 300 $\mu g/std\ m^3$ while maintaining the operating flow rate within the specified limits.

4.0 *Precision.*

4.1 The precision of PM_{10} samplers must be 5 $\mu g/m^3$ for PM_{10} concentrations below 80 $\mu g/m^3$ and 7 percent for PM_{10} concentrations above 80 $\mu g/m^3$, as required by Part 53 of this chapter, which prescribes a test procedure that determines the variation in the PM_{10} concentration measurements of identical samplers under typical sampling conditions. Continual assessment of precision via collocated samplers is required by Part 58 of this chapter for PM_{10} samplers used in certain monitoring networks.

5.0 *Accuracy.*

5.1 Because the size of the particles making up ambient particulate matter varies over a wide range and the concentration of particles varies with particle size, it is difficult to define the absolute accuracy of PM_{10} samplers. Part 53 of this chapter provides a specification for the sampling effectiveness of PM_{10} samplers. This specification requires that the expected mass concentration calculated for a candidate PM_{10} sampler, when sampling a specified particle size distribution, be within ±10 percent of that calculated for an ideal sampler whose sampling effectiveness is explicitly specified. Also, the particle size for 50 percent sampling effectivensss is required to be 10±0.5 micrometers. Other specifications related to accuracy apply to flow measurement and calibration, filter media, analytical (weighing) procedures, and artifact. The flow rate accuracy of PM_{10} samplers used in certain monitoring networks is required by Part 58 of this chapter to be assessed periodically via flow rate audits.

6.0 *Potential Sources of Error.*

6.1 *Volatile Particles.* Volatile particles collected on filters are often lost during shipment and/or storage of the filters prior to the post-sampling weighing [3]. Although shipment or storage of loaded filters is sometimes unavoidable, filters should be reweighed as soon as practical to minimize these losses.

6.2 *Artifacts.* Positive errors in PM_{10} concentration measurements may result from retention of gaseous species on filters [4,5]. Such errors include the retention of sulfur dioxide and nitric acid. Retention of sulfur dioxide on filters, followed by oxidation to sulfate, is referred to as artifact sulfate formation, a phenomenon which increases with increasing filter alkalinity [6]. Little or no artifact sulfate formation should occur using filters that meet the alkalinity specification in section 7.2.4. Artifact nitrate formation, resulting primarily from retention of nitric acid, occurs to varying degrees on many filter types, including glass fiber, cellulose ester, and many quartz fiber filters [4,5,8,9,10]. Loss of true atmospheric particulate nitrate during or following sampling may also occur due to dissociation or chemical reaction. This phenomenon has been observed on Teflon® filters [8] and inferred for quartz fiber filters [11,12]. The magnitude of nitrate artifact errors in PM_{10} mass concentration measurements will vary with location and ambient temperature; however, for most sampling locations, these errors are expected to be small.

6.3 *Humidity.* The effects of ambient humidity on the sample are unavoidable. The filter equilibration procedure in section 9.0 is designed to minimize the effects of moisture on the filter medium.

6.4 *Filter Handling.* Careful handling of filters between presampling and postsampling weighings is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. Use of a filter cartridge or cassette may reduce the magnitude of these errors. Filters must also meet the integrity specification in section 7.2.3.

6.5 *Flow Rate Variation.* Variations in the sampler's operating flow rate may alter the particle size discrimination characteristics of the sampler inlet. The magnitude of this error will depend on the sensitivity of the inlet to variations in flow rate and on the particle distribution in the atmosphere during the sampling period. The use of a flow control device (section 7.1.3) is required to minimize this error.

6.6 *Air Volume Determination.* Errors in the air volume determination may result from errors in the flow rate and/or sampling time measurements. The flow control device serves to minimize errors in the flow rate determination, and an elapsed time meter (section 7.1.5) is required to minimize the error in the sampling time measurement.

7.0 *Apparatus.*

7.1 *PM_{10} Sampler.*

7.1.1 The sampler shall be designed to:

a. Draw the air sample into the sampler inlet and through the particle collection filter at a uniform face velocity.

b. Hold and seal the filter in a horizontal position so that sample air is drawn downward through the filter.

c. Allow the filter to be installed and removed conveniently.

d. Protect the filter and sampler from precipitation and prevent insects and other debris from being sampled.

e. Minimize air leaks that would cause error in the measurement of the air volume passing through the filter.

f. Discharge exhaust air at a sufficient distance from the sampler inlet to minimize the sampling of exhaust air.

g. Minimize the collection of dust from the supporting surface.

7.1.2 The sampler shall have a sample air inlet system that, when operated within a specified flow rate range, provides particle size discrimination characteristics meeting all of the applicable performance specifications prescribed in Part 53 of this chapter. The sampler inlet shall show no significant wind direction dependence. The latter requirement can generally be satisfied by an inlet shape that is circularly symmetrical about a vertical axis.

7.1.3 The sampler shall have a flow control device capable of maintaining the sampler's operating flow rate within the flow rate limits specified for the sampler inlet over normal variations in line voltage and filter pressure drop.

7.1.4 The sampler shall provide a means to measure the total flow rate during the sampling period. A continuous flow recorder is recommended but not required. The flow measurement device shall be accurate to ±2 percent.

7.1.5 A timing/control device capable of starting and stopping the sampler shall be used to obtain a sample collection period of 24 ±1 hr (1,440 ±60 min). An elapsed time meter, accurate to within ±15 minutes, shall be used to measure sampling time. This meter is optional for samplers with continuous flow recorders if the sampling time measurement obtained by means of the recorder meets the ±15 minute accuracy specification.

7.1.6 The sampler shall have an associated operation or instruction manual as required by Part 53 of this chapter which includes detailed instructions on the calibration, operation, and maintenance of the sampler.

7.2 *Filters.*

7.2.1 *Filter Medium.* No commercially available filter medium is ideal in all respects for all samplers. The user's goals in sampling determine the relative importance of various filter characteristics (e.g., cost, ease of handling, physical and chemical characteristics, etc.) and, consequently, determine the choice among acceptable filters. Furthermore, certain types of filters may not be suitable for use with some samplers, particularly under heavy loading conditions (high mass concentrations), because of high or rapid increase in the filter flow resistance that would exceed the capability of the sampler's flow control device. However, samplers equipped with automatic filter-changing mechanisms may allow use of these types of filters. The specifications given below are minimum requirements to ensure acceptability of the filter medium for measurement of PM_{10} mass concentrations. Other filter evaluation criteria should be considered to meet individual sampling and analysis objectives.

7.2.2 *Collection Efficiency.* >99 percent, as measured by the DOP test (ASTM-2986) with 0.3 μm particles at the sampler's operating face velocity.

7.2.3 *Integrity.* $\pm 5\ \mu g/m^3$ (assuming sampler's nominal 24-hour air sample volume). Integrity is measured as the PM_{10} concentration equivalent corresponding to the average difference between the initial and the final weights of a random sample of test filters that are weighed and handled under actual or simulated sampling conditions, but have no air sample passed through them (i.e., filter blanks). As a minimum, the test procedure must include initial equilibration and weighing, installation on an inoperative sampler, removal from the sampler, and final equilibration and weighing.

7.2.4 *Alkalinity.* <25 microequivalents/gram of filter, as measured by the procedure given in Reference 13 following at least two months storage in a clean environment (free from contamination by acidic gases) at room temperature and humidity.

7.3 *Flow Rate Transfer Standard.* The flow rate transfer standard must be suitable for the sampler's operating flow rate and must be calibrated against a primary flow or volume standard that is traceable to the National Bureau of Standards (NBS). The flow rate transfer standard must be capable of measuring the sampler's operating flow rate with an accuracy of ±2 percent.

7.4 *Filter Conditioning Environment.*

7.4.1 Temperature range: 15° to 30° C.

7.4.2 Temperature control: ±3° C.

7.4.3 Humidity range: 20% to 45% RH.

7.4.4 Humidity control: ±5% RH.

7.5 *Analytical Balance.* The analytical balance must be suitable for weighing the type and size of filters required by the sampler. The range and sensitivity required will depend on the filter tare weights and mass loadings. Typically, an analytical balance with a sensitivity of 0.1 mg is required for high volume samplers (flow rates $>0.5\ m^3/min$). Lower volume samplers (flow rates $<0.5\ m^3/min$) will require a more sensitive balance.

8.0 *Calibration.*

8.1 *General Requirements.*

8.1.1 Calibration of the sampler's flow measurement device is required to establish traceability of subsequent flow measurements to a primary standard. A flow rate transfer standard calibrated against a primary flow or volume standard shall be used to calibrate or verify the accuracy of the sampler's flow measurement device.

8.1.2 Particle size discrimination by inertial separation requires that specific air velocities be maintained in the sampler's air inlet system. Therefore, the flow rate through the sampler's inlet must be maintained throughout the sampling period within the design flow rate range specified by the manufacturer. Design flow rates are specified as actual volumetric flow rates, measured at existing conditions of temperature and pressure (Q_a). In contrast, mass concentrations of PM_{10} are computed using flow rates corrected to EPA reference conditions of temperature and pressure (Q_{std}).

8.2 *Flow Rate Calibration Procedure.*

8.2.1 PM_{10} samplers employ various types of flow control and flow measurement devices. The specific procedure used for flow rate calibration or verification will vary depending on the type of flow controller and flow indicator employed. Calibration in terms of actual volumetric flow rates (Q_a) is generally recommended, but other measures of flow rate (e.g., Q_{std}) may be used provided the requirements of section 8.1 are met. The general procedure given here is based on actual volumetric flow units (Q_a) and serves to illustrate the steps involved in the calibration of a PM_{10} sampler. Consult the sampler manufacturer's instruction manual and Reference 2 for specific guidance on calibration. Reference 14 provides additional information on the use of the commonly used measures of flow rate and their interrelationships.

8.2.2 Calibrate the flow rate transfer standard against a primary flow or volume standard traceable to NBS. Establish a calibration relationship (e.g., an equation or family of curves) such that traceability to the primary standard is accurate to within 2 percent over the expected range of ambient conditions (i.e., temperatures and pressures) under which the transfer standard will be used. Recalibrate the transfer standard periodically.

8.2.3 Following the sampler manufacturer's instruction manual, remove the sampler inlet and connect the flow rate transfer standard to the sampler such that the transfer standard accurately measures the sampler's flow rate. Make sure there are no leaks between the transfer standard and the sampler.

8.2.4 Choose a minimum of three flow rates (actual m^3/min), spaced over the acceptable flow rate range specified for the inlet (see 7.1.2) that can be obtained by suitable adjustment of the sampler flow rate. In accordance with the sampler manufacturer's instruction manual, obtain or verify the calibration relationship between the flow rate (actual m^3/min) as indicated by the transfer standard and the sampler's flow indicator response. Record the ambient temperature and barometric pressure. Temperature and pressure corrections to subsequent flow indicator readings may be required for certain types of flow measurement devices. When such corrections are necessary, correction on an individual or daily basis is preferable. However, seasonal average temperature and average barometric pressure for the sampling site may be incorporated into the sampler calibration to avoid daily corrections. Consult the sampler manufacturer's instruction manual and Reference 2 for additional guidance.

8.2.5 Following calibration, verify that the sampler is operating at its design flow rate (actual m^3/min) with a clean filter in place.

8.2.6 Replace the sampler inlet.

9.0 *Procedure.*

9.1 The sampler shall be operated in accordance with the specific guidance provided in the sampler manufacturer's instruction manual and in Reference 2. The general procedure given here assumes that the sampler's flow rate calibration is based on flow rates at ambient conditions (Q_a) and serves to illustrate the steps involved in the operation of a PM_{10} sampler.

9.2 Inspect each filter for pinholes, particles, and other imperfections. Establish a filter information record and assign an identification number to each filter.

9.3 Equilibrate each filter in the conditioning environment (see 7.4) for at least 24 hours.

9.4 Following equilibration, weigh each filter and record the presampling weight with the filter identification number.

9.5 Install a preweighed filter in the sampler following the instructions provided in the sampler manufacturer's instruction manual.

9.6 Turn on the sampler and allow it to establish run-temperature conditions. Record the flow indicator reading and, if needed, the ambient temperature and barometric pressure. Determine the sampler flow rate (actual m^3/min) in accordance with the instructions provided in the sampler manufacturer's instruction manual. NOTE.—No onsite temperature or pressure measurements are necessary if the sampler's flow indicator does not require temperature or pressure corrections or if seasonal average temperature and average barometric pressure for the sampling site are incorporated into the sampler calibration (see step 8.2.4). If individual or daily temperature and pressure corrections are required, ambient temperature and barometric pressure can be obtained by on-site measurements or from a nearby weather station. Barometric pressure readings obtained from airports must be station pressure, not corrected to sea level, and may need to be corrected for differences in elevation between the sampling site and the airport.

9.7 If the flow rate is outside the acceptable range specified by the manufacturer, check for leaks, and if necessary, adjust the flow rate to the specified setpoint. Stop the sampler.

9.8 Set the timer to start and stop the sampler at appropriate times. Set the elapsed time meter to zero or record the initial meter reading.

9.9 Record the sample information (site location or identification number, sample date, filter identification number, and sampler model and serial number).

9.10 Sample for 24±1 hours.

9.11 Determine and record the average flow rate ($\bar{Q}_a$) in actual m^3/min for the sampling period in accordance with the instructions provided in the sampler manufacturer's instruction manual. Record the elapsed time meter final reading and, if needed, the average ambient temperature and barometric pressure for the sampling period (see note following step 9.6).

9.12 Carefully remove the filter from the sampler, following the sampler manufacturer's instruction manual. Touch only the outer edges of the filter.

9.13 Place the filter in a protective holder or container (e.g., petri dish, glassine envelope, or manila folder).

9.14 Record any factors such as meteorological conditions, construction activity, fires or dust storms, etc., that might be pertinent to the measurement on the filter information record.

9.15 Transport the exposed sample filter to the filter conditioning environment as soon as possible for equilibration and subsequent weighing.

9.16 Equilibrate the exposed filter in the conditioning environment for at least 24 hours under the same temperature and humidity conditions used for presampling filter equilibration (see 9.3).

9.17 Immediately after equilibration, reweigh the filter and record the postsampling weight with the filter identification number.

10.0 *Sampler Maintenance.*

10.1 The PM_{10} sampler shall be maintained in strict accordance with the maintenance procedures specified in the sampler manufacturer's instruction manual.

11.0 *Calculations.*

11.1 Calculate the average flow rate over the sampling period corrected to EPA reference conditions as Q_{std}. When the sampler's flow indicator is calibrated in actual volumetric units (Q_a), Q_{std} is calculated as:

$Q_{std}=Q_a\times(P_{av}/T_{av})(T_{std}/P_{std})$

where

Q_{std}=average flow rate at EPA reference conditions, std m^3/min;

Q_a=average flow rate at ambient conditions, m^3/min;

P_{av}=average barometric pressure during the sampling period or average barometric pressure for the sampling site, kPa (or mm Hg);

T_{av}=average ambient temperature during the sampling period or seasonal average ambient temperature for the sampling site, K;

T_{std}=standard temperature, defined as 298 K;

P_{std}=standard pressure, defined as 101.3 kPa (or 760 mm Hg).

11.2 Calculate the total volume of air sampled as:

$V_{std}=Q_{std}\times t$

where

V_{std}=total air sampled in standard volume units, std m^3;

t=sampling time, min.

11.3 Calculate the PM_{10} concentration as:

$PM_{10}=(W_f-W_i)\times 10^6/V_{std}$

where

PM_{10}=mass concentration of PM_{10}, µg/std m^3;

W_f, W_i=final and initial weights of filter collecting PM_{10} particles, g;

10^6=conversion of g to µg.

NOTE: If more than one size fraction in the PM_{10} size range is collected by the sampler, the sum of the net weight gain by each collection filter [$\Sigma(W_f-W_i)$] is used to calculate the PM_{10} mass concentration.

12.0 *References.*

1. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I, Principles. EPA-600/9-76-005, March 1976. Available from CERI, ORD Publications, U.S. Environmental Protection Agency, 26 West St. Clair Street, Cincinnati, Ohio 45268.

2. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Specific Methods. EPA-600/4-77-027a, May 1977. Available from CERI, ORD Publications, U.S. Environmental Protection Agency, 26 West St. Clair Street, Cincinnati, Ohio 45268.

3. Clement, R.E., and F.W. Karasek. Sample Composition Changes in Sampling and Analysis of Organic Compounds in Aerosols. Int. J. Environ. Analyt. Chem., 7:109, 1979.

4. Lee, R.E., Jr., and J. Wagman. A Sampling Anomaly in the Determination of Atmospheric Sulfate Concentration. Amer. Ind. Hyg. Assoc. J., 27:266, 1966.

5. Appel, B.R., S.M. Wall, Y. Tokiwa, and M. Haik. Interference Effects in Sampling Particulate Nitrate in Ambient Air. Atmos. Environ., 13:319, 1979.

6. Coutant, R.W. Effect of Environmental Variables on Collection of Atmospheric Sulfate. Environ. Sci. Technol., 11:873, 1977.

7. Spicer, C.W., and P. Schumacher. Interference in Sampling Atmospheric Particulate Nitrate. Atmos. Environ., 11:873, 1977.

8. Appel, B.R., Y. Tokiwa, and M. Haik. Sampling of Nitrates in Ambient Air. Atmos. Environ., 15:283, 1981.

9. Spicer, C.W., and P.M. Schumacher. Particulate Nitrate: Laboratory and Field Studies of Major Sampling Interferences. Atmos. Environ., 13:543, 1979.

10. Appel, B.R. Letter to Larry Purdue, U.S. EPA, Environmental Monitoring and Support Laboratory. March 18, 1982, Docket No. A-82-37, II-I-1.

11. Pierson, W.R., W.W. Brachaczek, T.J. Korniski, T.J. Truex, and J.W. Butler. Artifact Formation of Sulfate, Nitrate, and Hydrogen Ion on Backup Filters: Allegheny Mountain Experiment. J. Air Pollut. Control Assoc., 30:30, 1980.

12. Dunwoody, C.L. Rapid Nitrate Loss From PM_{10} Filters. J. Air Pollut. Control Assoc., 36:817, 1986.

13. Harrell, R.M. Measuring the Alkalinity of Hi-Vol Air Filters. EMSL/RTP-SOP-QAD-534, October 1985. Available from the U.S. Environmental Protection Agency, EMSL/QAD, Research Triangle Park, North Carolina 27711.

14. Smith, F., P.S. Wohlschlegel, R.S.C. Rogers, and D.J. Mulligan. Investigation of Flow Rate Calibration Procedures Associated With the High Volume Method for Determination of Suspended Particulates. EPA-600/4-78-047, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, 1978.

[52 FR 24664, July 1, 1987; 52 FR 29467, Aug. 7, 1987]

2.10.11 REFERENCES

40 CFR Parts 50, 53, and 58. National Ambient Air Quality Standards for Particulate Matter, Ambient Air Quality Surveillance for Particulate Matter, and Ambient Air Monitoring Reference and Equivalent Methods.

Inhalable Particulate Network Operations and Quality Assurance Manual, Research Triangle Park, North Carolina. March 1983.

Quality Assurance Handbook for Air Pollution Measurement Systems - Vol. II, Ambient Air Specific Methods. EPA 600/4-77-027A, May 1977.

Quality Assurance Handbook for Air Pollution Measurement Systems - Vol. III, Stationary Source Specific Methods. EPA 600/4-77-027B, August 1977.

Sierra Instruments, Inc., Model 244E Dichotomous Sampler (Virtual Impactor). Addendum to Series 244 Dichotomous Sampler (Virtual Impactor) and Accessories. Carmel, California. Undated.

Standard Operating Procedure for the Sierra Series 233E Dichotomous Sampler, EMSL/RTP-SOP-EMD-201. January 1983.

U.S. Environmental Protection Agency. Procedures for Calibrating a Laminar Flow Element (LFE) Against an NBS Calibrated LFE: Standard Operating Procedures. EMSL/RTP-SOP-QAD-003. November 1981.

2.10.12 DATA FORMS

Blank data forms are provided on the following pages for the convenience of the Handbook user. Each blank form has the customary descriptive title centered at the top of the page and has retained its original figure number designation. The following data forms are included in this section:

ITEM	Description	Qty	Purchase Order No.	VENDOR	DATE		COST	Initials	Accept/ Reject	COMMENTS
					Ord.	Rec'd.				

Figure 1.1. Example procurement log.

Dichotomous Sampler Calibration Data Sheet

Station Location ____________ Date ________ Unusual Conditions ______

Sampler Model __________ S/N ____________ EPA # ____________

Pa ______ mm Hg Ps _____ mm Hg Ta ___°C or K Ts ___°C or K

Leak check, maximum vacuum ________________ Notes ________

Total Trans. Std. Model ________ S/N __________ Cal. Date ____________

Qa Cal. relationship m = ______ b = ______ r ______

Coarse Trans. Std. Model ______ S/N __________ Cal. Date ____________

Qa Cal. relationship m = ______ b = ______ r = ______

Total Cal. Point	Transfer Std. Indication (TS)	TQa Flow Rate (L/min)	Rotameter Response (I)	Corr. Response $I(Ta/Pa)^{1/2}$ (AC)

Coarse Cal. Point	Transfer Std. Indication (TS)	CQa Flow Rate (L/min)	Rotameter Response (I)	Corr. Response $I(Ta/Pa)^{1/2}$ (AC)

Sampler Cal. Relationship (Qa, x-axis; corrected recorder response, AC, y-axis).

Total: m = _____ b = _____ r = ______ Coarse: m = _____ b = _____ r = _____

TFR __________ TSP __________ CFR __________ CSP __________

TFR = 16.7 (Ps/Pa)(Ta/Ts) CFR = 1.67 (Ps/Pa)(Ta/Ts)

TSP, CSP = $\{[m\ (TFR, CFR) + b]\ [(Pa/Ta)^{1/2}]\}$

Operator ____________________

Figure 2.3. Example dichotomous sampler calibration data sheet.

Dichotomous Sampler Field Data Sheet

Station Location ____________ Run Date ____________ SAROAD Number ____________

Sampler Model ____________ S/N ____________ EPA Number ____________

Filter ID Numbers: Fine: ____________ Coarse: ____________

Total Cal. Relationship: m = ______ b = ______ r = ______ TFR______ L/min

Coarse Cal. Relationship: m = ______ b = ______ r = ______ CFR______ L/min

Vacuum Gauge Indications: Total Initial ______ Total Final ______ Coarse Initial ______

Coarse Final ______

Pav ______ mmHg Tav ____°C ____K Elapsed Time Sampled ______min

Rotameter Responses:

TSP* ______ Final Total ______ Ave. Total ($\overline{T}$)______ $\overline{TQa}$ ______ L/min

CSP* ______ Final Coarse ______ Ave. Coarse ($\overline{T}$)______ $\overline{CQa}$ ______ L/min

$\overline{TQa}, \overline{CQa} = 1/m\,[\overline{T}(Tav/Pav)^{1/2} - b]$

Total Act. Volume (TVa) = TQa X min sampled = ______L/min FQa = ______ L/min

Coarse Act. Volume (CVa) = CQa X min sampled = ______ L/min FQa = TQa — CQa

Comments: ____

____

____

Operator ____

Laboratory Calculations

Std. Volumes (Vstd): TVstd ______ m^3 CVstd ______ m^3

$TVstd, CVstd = (Va)(10^{-3})\,[(Pav/Tav)\,(298/760)]$

FVstd ______ m^3

$FVstd = TVstd - CVstd$

Filter Weights:

Fine: Gross Weight (Wg) ______ mg Coarse: Gross Weight (Wg) ______ mg

Tare Weight (Wt) ______ mg Tare Weight (Wt) ______ mg

Net Weight (Mf) ______ mg Net Weight (Mc) ______ mg

PM10 Concentration ______ $\mu g/m^3$ $\mu g/m^3 = (Mf + Mc)(10^3)/TVstd$

*Total or coarse set points, initial rotameter response.

Figure 3.2. Example dichotomous sampler field data sheet.

Dichotomous Sampler Flow Check Data Sheet

Station Location ____________ Date ____________ SAROAD Number ____________

Sampler Model ____________ S/N ____________ EPA Number ____________

Pa ________ mm Hg Ta ________ °C ________ K Unusual Conditions ____________

Orifice S/N ________ Orifice S/N ________ Orifice Calibration Date ____________

Orifice Qa (Total) Calibration Relationship: m = ________ b = ________ r = ________

Orifice Qa (Coarse) Calibration Relationship: m = ________ b = ________ r = ________

Sampler Total Calibration Relationship:

m = ________ b = ________ r = ________ , TFR ________ L/min, TSP ____________

Sampler Coarse Calibration Relationship:

m = ________ b = ________ r = ________ , CFR ________ L/min, CSP ____________

Flow Rate Description	ΔH_2O (in.)	Orifice Flow Rate* (L/min)	Sampler** TQa or CQa (L/min)	Difference	
				L/min	%
Total Flow					
Design Cond.***			16.7		
Coarse Flow					
Design Cond.***			1.67		

* TQa or CQa = $m[(\Delta P)(Ta/Pa)]^{1/2} + b$

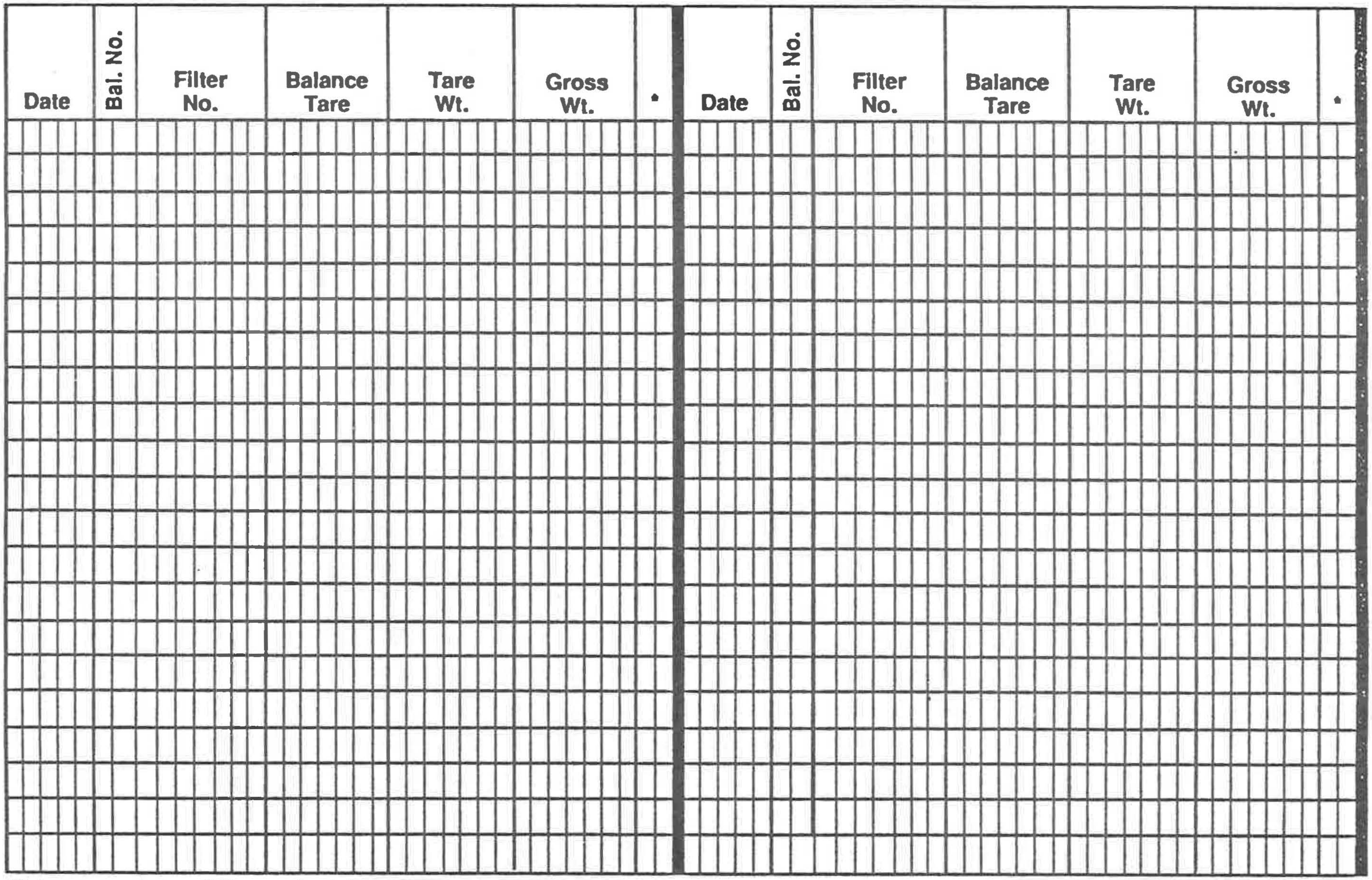
**TQa or CQa = $1/m\ [(TSP \text{ or } CSP)(Ta/Pa)^{1/2} - b]$

$$\text{QC \% Difference} = \frac{(\text{TQa or CQa}) - \text{Orifice Flow Rate}\ (100)}{\text{Orifice Flow Rate}}$$

$$\text{***Design condition \% Difference} = \frac{\text{Orifice Flow Rate} - (16.7 \text{ or } 1.67)\ (100)}{(16.7 \text{ or } 1.67)}$$

Operator ____________________

Figure 3.3. Example dichotomous sampler flow-check data sheet.



Laboratory Data/Coding Form

Date	Bal. No.	Filter No.	Balance Tare	Tare Wt.	Gross Wt.	*	Date	Bal. No.	Filter No.	Balance Tare	Tare Wt.	Gross Wt.	*

*Balance operator's or QC supervisor's initials

Figure 4.2. Example laboratory data/coding sheet.

Quality Control Log

Supervisor QC							Operator QC				
BID[a]	Date	Number	Original Value	Obs. Value	±20 µg Y/N	Action Taken	BID	Date	Filter No.	Zero Check Value [c]	Cal Check Value [d]

[a] Balance ID number
[b] For standard filter check and unexposed filters
[c] ± 4 µg of zero
[d] ± 2 µg of 10 mg.

Figure 4.3. Example internal quality control log sheet.

Dichotomous Sampler Audit Data Sheet

Station Location ______ Date ______ SAROAD Number ______

Station Address ______ Time ______

Sampler Model ______ S/N ______ EPA Number ______

Pa ______ mm Hg Ta ______ °C ______ K Unusual Conditions ______

Audit Transfer Standards:

Total and Fine: Model ______ S/N ______ Coarse: Model ______ S/N ______

Transfer Standards Calibration Relationships:

Total and Fine: m = ______ b = ______ r = ______ Last Cal. Date ______

Coarse: m = ______ b = ______ r = ______ Last Cal. Date ______

Sampler Calibration Relationships:

Total: m = ______ b = ______ r = ______ TFR ______ L/min, TSP ______

Coarse: m = ______ b = ______ r = ______ CFR ______ L/min, CSP ______

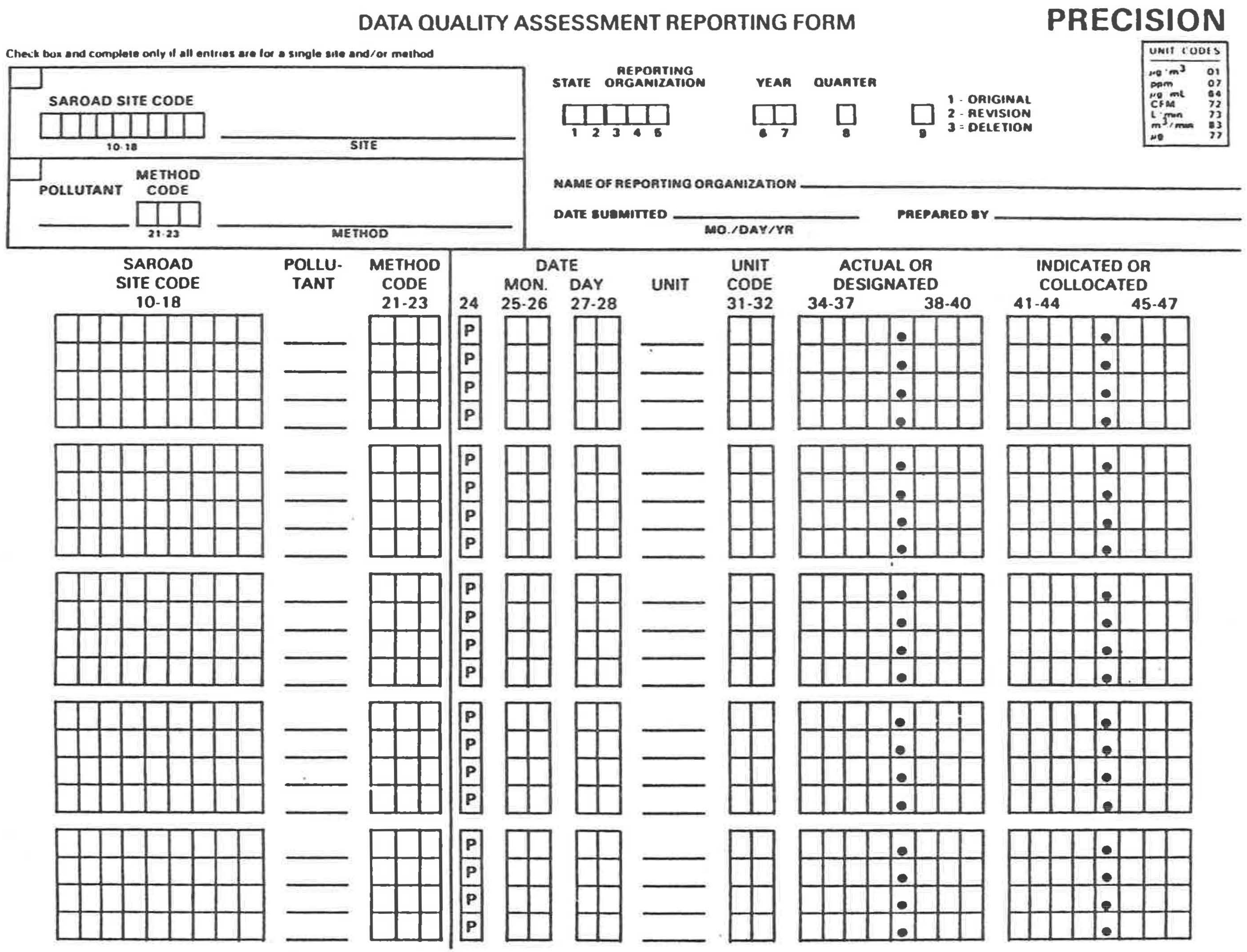
Flow Type	Transfer Std. Indication (TS)	Qa (audit) (L/min)	Qa (sampler) L/min	Difference	
				L/min	%
Total					
Design Cond. Total					
Fine					
Design Cond. Fine					
Coarse					
Design Cond. Coarse					

$$\text{Audit \% Difference} = \frac{\text{Qa (sampler)} - \text{Qa (audit)}\ (100)}{\text{Qa (audit)}}$$

$$\text{Design condition \% Difference} = \frac{\text{Qa (audit)} - \text{Design Flow Rate}\ (100)}{\text{Design Flow Rate}}$$

Operator ______ Observer ______

Figure 7.4. Example dichotomous sampler audit data sheet.



DATA QUALITY ASSESSMENT REPORTING FORM

PRECISION

Check box and complete only if all entries are for a single site and/or method

☐ SAROAD SITE CODE ☐☐☐☐☐☐☐☐☐ 10-18 ______ SITE

☐ POLLUTANT ______ METHOD CODE ☐☐☐ 21-23 ______ METHOD

STATE / REPORTING ORGANIZATION ☐☐☐☐☐ 1 2 3 4 5

YEAR ☐☐ 6 7

QUARTER ☐ 8

☐ 9

1 - ORIGINAL
2 - REVISION
3 = DELETION

UNIT CODES	
$\mu g/m^3$	01
ppm	07
$\mu g/mL$	84
CFM	72
L/min	73
m^3/min	83
μg	77

NAME OF REPORTING ORGANIZATION ______

DATE SUBMITTED ______ MO./DAY/YR

PREPARED BY ______

SAROAD SITE CODE 10-18	POLLU-TANT	METHOD CODE 21-23	24	DATE MON. 25-26	DATE DAY 27-28	UNIT	UNIT CODE 31-32	ACTUAL OR DESIGNATED 34-37	ACTUAL OR DESIGNATED 38-40	INDICATED OR COLLOCATED 41-44	INDICATED OR COLLOCATED 45-47
			P								
			P								
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			P								
			P								

Figure 8.1. Precision data quality assessment form.

DATA QUALITY ASSESSMENT REPORTING FORM

ACCURACY

UNIT CODES	
µg/m³	01
ppm	07
µg/mL	64
CFM	72
L/min	73
m³/min	83
µg	77

Check box and complete only if all entries are for a single site and/or method

☐ **SAROAD SITE CODE** ☐☐☐☐☐☐☐☐☐ (10-18) ____________ SITE

☐ **POLLUTANT** ________ **METHOD CODE** ☐☐☐ (21-23) ____________ METHOD

STATE	REPORTING ORGANIZATION	YEAR	QUARTER	
☐☐	☐☐☐	☐☐	☐	☐
1 2	3 4 5	6 7	8	9

1 - ORIGINAL
2 - REVISION
3 - DELETION

NAME OF REPORTING ORGANIZATION ____________________

DATE SUBMITTED ____________ MO./DAY/YR PREPARED BY ____________________

SAROAD SITE CODE	POLLUTANT	METHOD CODE		DATE MON DAY	T¹	S²	UNIT	UNIT CODE		LEVEL 1 ACTUAL	LEVEL 1 INDICATED	LEVEL 2 ACTUAL	LEVEL 2 INDICATED
☐☐☐☐☐☐☐☐☐	___	☐☐☐	A	☐☐☐☐	☐	☐	___	☐☐	0	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐
10-18		21-23	24	25-28	29	30		31-32	33	34-37 38-40	41-44 45-47	48-51 52-54	55-58 59-61
										LEVEL 3		LEVEL 4	
									1	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐
									33	34-37 38-40	41-44 45-47	48-51 52-54	55-58 59-61
										LEVEL 1		LEVEL 2	
☐☐☐☐☐☐☐☐☐	___	☐☐☐	A	☐☐☐☐	☐	☐	___	☐☐	0	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐
										LEVEL 3		LEVEL 4	
									1	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐
										LEVEL 1		LEVEL 2	
☐☐☐☐☐☐☐☐☐	___	☐☐☐	A	☐☐☐☐	☐	☐	___	☐☐	0	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐
										LEVEL 3		LEVEL 4	
									1	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐
										LEVEL 1		LEVEL 2	
☐☐☐☐☐☐☐☐☐	___	☐☐☐	A	☐☐☐☐	☐	☐	___	☐☐	0	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐
										LEVEL 3		LEVEL 4	
									1	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐
										LEVEL 1		LEVEL 2	
☐☐☐☐☐☐☐☐☐	___	☐☐☐	A	☐☐☐☐	☐	☐	___	☐☐	0	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐
										LEVEL 3		LEVEL 4	
									1	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐	☐☐☐☐.☐☐☐

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[1] Type of audit

1 Audit conducted by reporting organization, audit standard certified by reporting organization
2 Audit conducted by reporting organization, audit standard certified by another organization
3 Audit conducted by other than reporting organization

[2] Source of local primary standard

GAS STANDARDS
A NBS SRM
B [illegible] reference gas
C Commercial CRM
D Photometer, uncertified
E Other ________
F Photometer, verified by comparison to an SRP

FLOW STANDARDS
L Laminar flow element
M Rootsmeter, certified <1 yr.
N Rootsmeter, not cert. <1 yr.
P Certified orifice device
R Wet test meter
S Dry gas meter
T Bubble flow meter
U Other ________

CHEMICAL STANDARDS
W Reagent grade chemical weighed with balance
X Other ________

SEND COMPLETED FORM TO REGIONAL OFFICE

Figure 8.2. Accuracy data quality assessment form.