SUBCHAPTER C—AIR PROGRAMS—(Continued)

PART 53—AMBIENT AIR MONITORING REFERENCE AND EQUIVALENT METHODS

Subpart A—General Provisions

Sec.

Subpart B—Procedures for Testing Performance Characteristics of Automated Methods for SO$_2$, CO, O$_3$, and NO$_2$

Subpart C—Procedures for Determining Comparability Between Candidate Methods and Reference Methods

Subpart D—Procedures for Testing Performance Characteristics of Methods for PM$_{10}$

Subpart E—Procedures for Testing Physical (Design) and Performance Characteristics of Reference Methods and Class I Equivalent Methods for PM$_{2.5}$

Subpart F—Procedures for Testing Performance Characteristics of Class II Equivalent Methods for PM$_{2.5}$

Authority: Sec. 301(a) of the Clean Air Act (42 U.S.C. sec. 1857g(a)), as amended by sec. 15(c)(2) of Pub. L. 91–604, 84 Stat. 1713, unless otherwise noted.

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Subpart A—General Provisions

Source: 62 FR 38784, July 18, 1997, unless otherwise noted.

§ 53.1 Definitions.

Terms used but not defined in this part shall have the meaning given them by the Act.

Act means the Clean Air Act (42 U.S.C. 1857–1857l), as amended.

Administrator means the Administrator of the Environmental Protection Agency or the Administrator's authorized representative.

Agency means the Environmental Protection Agency.

Applicant means a person or entity who submits an application for a reference or equivalent method determination under § 53.4, or a person or entity who assumes the rights and obligations of an applicant under § 53.7. Applicant may include a manufacturer, distributor, supplier, or vendor.

Automated method or analyzer means a method for measuring concentrations of an ambient air pollutant in which sample collection (if necessary), analysis, and measurement are performed automatically by an instrument.

Candidate method means a method for measuring the concentration of an air pollutant in the ambient air for which an application for a reference method determination or an equivalent method determination is submitted in accordance with § 53.4, or a method tested at the initiative of the Administrator in accordance with § 53.7.

Class I equivalent method means an equivalent method for $PM_{2.5}$ which is based on a sampler that is very similar to the sampler specified for reference methods in appendix L of this part, with only minor deviations or modifications, as determined by EPA.

Class II equivalent method means an equivalent method for $PM_{2.5}$ that utilizes a $PM_{2.5}$ sampler in which an integrated $PM_{2.5}$ sample is obtained from the atmosphere by filtration and is subjected to a subsequent filter conditioning process followed by a gravimetric mass determination, but which is not a Class I equivalent method because of substantial deviations from the design specifications of the sampler specified for reference methods in appendix L of part 50 of this chapter, as determined by EPA.

Class III equivalent method means an equivalent method for $PM_{2.5}$ that has been determined by EPA not to be a Class I or Class II equivalent method. This fourth type of $PM_{2.5}$ method includes alternative equivalent method samplers and continuous analyzers, based on designs and measurement principles different from those specified for reference methods (e.g., a means for estimating aerosol mass concentration other than by conventional integrated filtration followed by equilibration and gravimetric analysis. These samplers (or monitors) are those deemed to be substantially different from reference method samplers and are likely to use components and methods other than those specified for reference method samplers.

Collocated describes two or more air samplers, analyzers, or other instruments which sampler the ambient air that are operated silmultaneously while located side by side, separated by a distance that is large enough to preclude the air sampled by any of the devices from being affected by any of the other devices, but small enough so that all devices obtain identical or uniform ambient air samples that are equally representative of the general area in which the group of devices is located.

Equivalent method means a method for measuring the concentration of an air pollutant in the ambient air that has been designated as an equivalent method in accordance with this part; it does not include a method for which an equivalent method designation has been canceled in accordance with §53.11 or §53.16.

ISO 9001-registered facility means a manufacturing facility that is either:

(1) An International Organization for Standardization (ISO) 9001-registered manufacturing facility, registered to the ISO 9001 standard (by the Registrar Accreditation Board (RAB) of the American Society for Quality Control (ASQC) in the United States), with registration maintained continuously.

(2) A facility that can be demonstrated, on the basis of information submitted to the EPA, to be operated according to an EPA-approved and periodically audited quality system which meets, to the extent appropriate, the same general requirements as an ISO 9001-registered facility for the design and manufacture of designated reference and equivalent method samplers and monitors.

ISO-certified auditor means an auditor who is either certified by the Registrar Accreditation Board (in the United States) as being qualified to audit quality systems using the requirements of recognized standards such as ISO 9001, or who, based on information submitted to the EPA, meets the same general requirements as provided for ISO-certified auditors.

Manual method means a method for measuring concentrations of an ambient air pollutant in which sample collection, analysis, or measurement, or some combination therof, is performed manually. A method for PM_{10} or $PM_{2.5}$ which utilizes a sampler that requires manual preparation, loading, and weighing of filter samples is considered a manual method even though the sampler may be capable of automatically collecting a series of sequential samples.

$PM_{2.5}$ sampler means a device, associated with a manual method for measuring $PM_{2.5}$, designed to collect $PM_{2.5}$ from an ambient air sample, but lacking the ability to automatically analyze or measure the collected sample to determine the mass concentrations of $PM_{2.5}$ in the sampled air.

PM_{10} sampler means a device, associated with a manual method for measuring PM_{10}, designed to collect PM_{10} from an ambient air sample, but lacking the ability to automatically analyze or measure the collected sample to determine the mass concentrations of PM_{10} in the sampled air.

Reference method means a method of sampling and analyzing the ambient air for an air pollutant that is specified as a reference method in an appendix to part 50 of this chapter, or a method that has been designated as a reference method in accordance with this part; it does not include a method for which a reference method designation has been canceled in accordance with §53.11 or §53.16.

Sequential samples for PM samplers means two or more PM samples for sequential (but not necessarily contiguous) time periods that are collected automatically by the same sampler without the need for intervening operator service.

Test analyzer means an analyzer subjected to testing as part of a candidate method in accordance with subparts B, C, D, E, or F of this part, as applicable. Test sampler means a PM_{10} sampler or a $PM_{2.5}$ sampler subjected to testing as part of a candidate method in accordance with subparts C, D, E, or F of this part.

Ultimate purchaser means the first person or entity who purchases a reference method or an equivalent method for purposes other than resale.

§ 53.2 General requirements for a reference method determination.

The following general requirements for a reference method determination are summarized in table A–1 of this subpart.

(a) *Manual methods.* (1) For measuring sulfur dioxide (SO_2) and lead, Appendices A and G of part 50 of this chapter specify unique manual reference methods for those pollutants. Except as provided in § 53.16, other manual methods for SO_2 and lead will not be considered for reference method determinations under this part.

(2) A reference method for measuring PM_{10} must be a manual method that meets all requirements specified in appendix J of part 50 of this chapter and must include a PM_{10} sampler that has been shown in accordance with this part to meet all requirements specified in subparts A and D of this part.

(3) A reference method for measuring $PM_{2.5}$ must be a manual method that meets all requirements specified in appendix L of part 50 of this chapter and must include a $PM_{2.5}$ sampler that has been shown in accordance with this part to meet the applicable requirements specified in subparts A and E of this part. Further, reference method samplers must be manufactured in an ISO 9001-registered facility, as defined in § 53.1 and as set forth in § 53.51, and the Product Manufacturing Checklist set forth in subpart E of this part must be completed by an ISO-certified auditor, as defined in § 53.1, and submitted to EPA annually to retain a $PM_{2.5}$ reference method designation.

(b) *Automated methods.* An automated reference method for measuring carbon monoxide (CO), ozone (O_3), and nitrogen dioxide (NO_2) must utilize the measurement principle and calibration procedure specified in the appropriate appendix to part 50 of this chapter and must have been shown in accordance with this part to meet the requirements specified in subpart B of this part.

§ 53.3 General requirements for an equivalent method determination.

(a) *Manual methods.* A manual equivalent method must have been shown in accordance with this part to satisfy the applicable requirements specified in subpart C of this part. In addition, PM_{10} or $PM_{2.5}$ samplers associated with manual equivalent methods for PM_{10} or $PM_{2.5}$ must have been shown in accordance with this part to satisfy the following additional requirements:

(1) A PM_{10} sampler associated with a manual method for PM_{10} must satisfy the requirements of subpart D of this part.

(2) A $PM_{2.5}$ Class I equivalent method sampler must satisfy all requirements of subparts C and E of this part, which include appropriate demonstration that each and every deviation or modification from the reference method sampler specifications does not significantly alter the performance of the sampler.

(3) A $PM_{2.5}$ Class II equivalent method sampler must satisfy the applicable requirements of subparts C, E, and F of this part.

(4) Requirements for $PM_{2.5}$ Class III equivalent method samplers are not provided in this part because of the wide range of non-filter-based measurement technologies that could be applied and the likelihood that these requirements will have to be specifically adapted for each such type of technology. Specific requirements will be developed as needed and may include selected requirements from subparts C, E, or F of this part or other requirements not contained in this part.

(5) All designated equivalent methods for $PM_{2.5}$ must be manufactured in an ISO 9001-registered facility, as defined in § 53.1 and as set forth in § 53.51, and the Product Manufacturing Checklist set forth in subpart E of this part must be completed by an ISO-certified auditor, as defined in § 53.1, and submitted to EPA annually to retain a $PM_{2.5}$ equivalent method designation.

(b) *Automated methods.* (1) Automated equivalent methods for pollutants other than $PM_{2.5}$ or PM_{10} must have been shown in accordance with this part to satisfy the requirements specified in subparts B and C of this part.

(2) Automated equivalent methods for PM_{10} must have been shown in accordance with this part to satisfy the requirements of subparts C and D of this part.

(3) Requirements for $PM_{2.5}$ Class III automated equivalent methods for

$PM_{2.5}$ are not provided in this part because of the wide range of non-filter-based measurement technologies that could be applied and the likelihood that these requirements will have to be specifically adapted for each such type of technology. Specific requirements will be developed as needed and may include selected requirements from subparts C, E, or F of this part or other requirements not contained in this part.

(4) All designated equivalent methods for $PM_{2.5}$ must be manufactured in an ISO 9001-registered facility, as set forth in subpart E of this part, and the Product Manufacturing Checklist set forth in subpart E of this part must be completed by an ISO-certified auditor and submitted to EPA annually to retain a $PM_{2.5}$ equivalent method designation.

[62 FR 38784, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

§53.4 Applications for reference or equivalent method determinations.

(a) Applications for reference or equivalent method determinations shall be submitted in duplicate to: Director, National Exposure Research Laboratory, Department E (MD-77B), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

(b) Each application shall be signed by an authorized representative of the applicant, shall be marked in accordance with §53.15 (if applicable), and shall contain the following:

(1) A clear identification of the candidate method, which will distinguish it from all other methods such that the method may be referred to unambiguously. This identification must consist of a unique series of descriptors such as title, identification number, analyte, measurement principle, manufacturer, brand, model, etc., as necessary to distinguish the method from all other methods or method variations, both within and outside the applicant's organization.

(2) A detailed description of the candidate method, including but not limited to the following: The measurement principle, manufacturer, name, model number and other forms of identification, a list of the significant components, schematic diagrams, design drawings, and a detailed description of the apparatus and measurement procedures. Drawings and descriptions pertaining to candidate methods or samplers for $PM_{2.5}$ must meet all applicable requirements in reference 1 of appendix A of this subpart, using appropriate graphical, nomenclature, and mathematical conventions such as those specified in references 3 and 4 of appendix A of this subpart.

(3) A copy of a comprehensive operation or instruction manual providing a complete and detailed description of the operational, maintenance, and calibration procedures prescribed for field use of the candidate method and all instruments utilized as part of that method (under §53.9(a)).

(i) As a minimum this manual shall include:

(A) Description of the method and associated instruments.

(B) Explanation of all indicators, information displays, and controls.

(C) Complete setup and installation instructions, including any additional materials or supplies required.

(D) Details of all initial or startup checks or acceptance tests and any auxiliary equipment required.

(E) Complete operational instructions.

(F) Calibration procedures and required calibration equipment and standards.

(G) Instructions for verification of correct or proper operation.

(H) Trouble-shooting guidance and suggested corrective actions for abnormal operation.

(I) Required or recommended routine, periodic, and preventative maintenance and maintenance schedules.

(J) Any calculations required to derive final concentration measurements.

(K) Appropriate references to appendix L of part 50 of this chapter; reference 6 of appendix A of this subpart; and any other pertinent guidelines.

(ii) The manual shall also include adequate warning of potential safety hazards that may result from normal use and/or malfunction of the method and a description of necessary safety precautions. (See §53.9(b).) However, the previous requirement shall not be interpreted to constitute or imply any warranty of safety of the method by

EPA. For samplers and automated methods, the manual shall include a clear description of all procedures pertaining to installation, operation, preventive maintenance, and troubleshooting and shall also include parts identification diagrams. The manual may be used to satisfy the requirements of paragraphs (b)(1) and (b)(2) of this section to the extent that it includes information necessary to meet those requirements.

(4) A statement that the candidate method has been tested in accordance with the procedures described in subparts B, C, D, E, and/or F of this part, as applicable.

(5) Descriptions of test facilities and test configurations, test data, records, calculations, and test results as specified in subparts B, C, D, E, and/or F of this part, as applicable. Data must be sufficiently detailed to meet appropriate principles described in paragraphs 4 through 6 of reference 2 of appendix A of this subpart, part b, sections 3.3.1 (paragraph 1) and 3.5.1 (paragraphs 2 and 3) and in paragraphs 1 through 3 of reference 5 (section 4.8, Records) of appendix A of this subpart. Salient requirements from these references include the following:

(i) The applicant shall maintain and include records of all relevant measuring equipment, including the make, type, and serial number or other identification, and most recent calibration with identification of the measurement standard or standards used and their National Institute of Standards and Technology (NIST) traceability. These records shall demonstrate the measurement capability of each item of measuring equipment used for the application and include a description and justification (if needed) of the measurement setup or configuration in which it was used for the tests. The calibration results shall be recorded and identified in sufficient detail so that the traceability of all measurements can be determined and any measurement could be reproduced under conditions close to the original conditions, if necessary, to resolve any anomalies.

(ii) Test data shall be collected according to the standards of good practice and by qualified personnel. Test anomalies or irregularities shall be documented and explained or justified. The impact and significance of the deviation on test results and conclusions shall be determined. Data collected shall correspond directly to the specified test requirement and be labeled and identified clearly so that results can be verified and evaluated against the test requirement. Calculations or data manipulations must be explained in detail so that they can be verified.

(6) A statement that the method, analyzer, or sampler tested in accordance with this part is representative of the candidate method described in the application.

(c) For candidate automated methods and candidate manual methods for PM_{10} and $PM_{2.5}$, the application shall also contain the following:

(1) A detailed description of the quality system that will be utilized, if the candidate method is designated as a reference or equivalent method, to ensure that all analyzers or samplers offered for sale under that designation will have essentially the same performance characteristics as the analyzer(s) or samplers tested in accordance with this part. In addition, the quality system requirements for candidate methods for $PM_{2.5}$ must be described in sufficient detail, based on the elements described in section 4 of reference 1 (Quality System Requirements) of appendix A of this subpart. Further clarification is provided in the following sections of reference 2 of appendix A of this subpart: part A (Management Systems), sections 2.2 (Quality System and Description), 2.3 (Personnel Qualification and Training), 2.4 (Procurement of Items and Services), 2.5 (Documents and Records), and 2.7 (Planning); part B (Collection and Evaluation of Environmental Data), sections 3.1 (Planning and Scoping), 3.2 (Design of Data Collection Operations), and 3.5 (Assessment and Verification of Data Usability); and part C (Operation of Environmental Technology), sections 4.1 (Planning), 4.2 (Design of Systems), and 4.4 (Operation of Systems).

(2) A description of the durability characteristics of such analyzers or samplers (see § 53.9(c)). For methods for $PM_{2.5}$, the warranty program must ensure that the required specifications (see table A–1 of this subpart) will be

met throughout the warranty period and that the applicant accepts responsibility and liability for ensuring this conformance or for resolving any nonconformities, including all necessary components of the system, regardless of the original manufacturer. The warranty program must be described in sufficient detail to meet appropriate provisions of the ANSI/ASQC and ISO 9001 standards (references 1 and 2 in appendix A of this subpart) for controlling conformance and resolving nonconformance, particularly sections 4.12, 4.13, and 4.14 of reference 1 in appendix A of this subpart.

(i) Section 4.12 in appendix A of this subpart requires the manufacturer to establish and maintain a system of procedures for identifying and maintaining the identification of inspection and test status throughout all phases of manufacturing to ensure that only instruments that have passed the required inspections and tests are released for sale.

(ii) Section 4.13 in appendix A of this subpart requires documented procedures for control of nonconforming product, including review and acceptable alternatives for disposition; section 4.14 in appendix A of this subpart requires documented procedures for implementing corrective (4.14.2) and preventive (4.14.3) action to eliminate the causes of actual or potential nonconformities. In particular, section 4.14.3 requires that potential causes of nonconformities be eliminated by using information such as service reports and customer complaints to eliminate potential causes of nonconformities.

(d) For candidate reference or equivalent methods for $PM_{2.5}$, the applicant shall provide to EPA for test purposes one sampler or analyzer that is representative of the sampler or analyzer associated with the candidate method. The sampler or analyzer shall be shipped FOB destination to Department E, (MD-77B), U.S. EPA, 79 T.W. Alexander Drive, Research Triangle Park, NC 27711, scheduled to arrive concurrent with or within 30 days of the arrival of the other application materials. This analyzer or sampler may be subjected to various tests that EPA determines to be necessary or appropriate under § 53.5(f), and such tests may include special tests not described in this part. If the instrument submitted under this paragraph malfunctions, becomes inoperative, or fails to perform as represented in the application before the necessary EPA testing is completed, the applicant shall be afforded an opportunity to repair or replace the device at no cost to EPA. Upon completion of EPA testing, the analyzer or sampler submitted under this paragraph shall be repacked by EPA for return shipment to the applicant, using the same packing materials used for shipping the instrument to EPA unless alternative packing is provided by the applicant. Arrangements for, and the cost of, return shipment shall be the responsibility of the applicant. EPA does not warrant or assume any liability for the condition of the analyzer or sampler upon return to the applicant.

§ 53.5 Processing of applications.

After receiving an application for a reference or equivalent method determination, the Administrator will publish notice of the application in the FEDERAL REGISTER and, within 120 calendar days after receipt of the application, take one or more of the following actions:

(a) Send notice to the applicant, in accordance with § 53.8, that the candidate method has been determined to be a reference or equivalent method.

(b) Send notice to the applicant that the application has been rejected, including a statement of reasons for rejection.

(c) Send notice to the applicant that additional information must be submitted before a determination can be made and specify the additional information that is needed (in such cases, the 120-day period shall commence upon receipt of the additional information).

(d) Send notice to the applicant that additional test data must be submitted and specify what tests are necessary and how the tests shall be interpreted (in such cases, the 120-day period shall commence upon receipt of the additional test data).

(e) Send notice to the applicant that the application has been found to be substantially deficient or incomplete and cannot be processed until additional information is submitted to complete the application and specify the general areas of substantial deficiency.

(f) Send notice to the applicant that additional tests will be conducted by the Administrator, specifying the nature of and reasons for the additional tests and the estimated time required (in such cases, the 120-day period shall commence 1 calendar day after the additional tests have been completed).

§ 53.6 Right to witness conduct of tests.

(a) Submission of an application for a reference or equivalent method determination shall constitute consent for the Administrator or the Administrator's authorized representative, upon presentation of appropriate credentials, to witness or observe any tests required by this part in connection with the application or in connection with any modification or intended modification of the method by the applicant.

(b) The applicant shall have the right to witness or observe any test conducted by the Administrator in connection with the application or in connection with any modification or intended modification of the method by the applicant.

(c) Any tests by either party that are to be witnessed or observed by the other party shall be conducted at a time and place mutually agreeable to both parties.

§ 53.7 Testing of methods at the initiative of the Administrator.

(a) In the absence of an application for a reference or equivalent method determination, the Administrator may conduct the tests required by this part for such a determination, may compile such other information as may be necessary in the judgment of the Administrator to make such a determination, and on the basis of the tests and information may determine that a method satisfies applicable requirements of this part.

(b) In the absence of an application requesting the Administrator to consider revising an appendix to part 50 of this chapter in accordance with § 53.16, the Administrator may conduct such tests and compile such information as may be necessary in the Administrator's judgment to make a determination under § 53.16(d) and on the basis of the tests and information make such a determination.

(c) If a method tested in accordance with this section is designated as a reference or equivalent method in accordance with § 53.8 or is specified or designated as a reference method in accordance with § 53.16, any person or entity who offers the method for sale as a reference or equivalent method thereafter shall assume the rights and obligations of an applicant for purposes of this part, with the exception of those pertaining to submission and processing of applications.

§ 53.8 Designation of reference and equivalent methods.

(a) A candidate method determined by the Administrator to satisfy the applicable requirements of this part shall be designated as a reference method or equivalent method (as applicable), and a notice of the designation shall be submitted for publication in the FEDERAL REGISTER not later than 15 days after the determination is made.

(b) A notice indicating that the method has been determined to be a reference method or an equivalent method shall be sent to the applicant. This notice shall constitute proof of the determination until a notice of designation is published in accordance with paragraph (a) of this section.

(c) The Administrator will maintain a current list of methods designated as reference or equivalent methods in accordance with this part and will send a copy of the list to any person or group upon request. A copy of the list will be available for inspection or copying at EPA Regional Offices.

§ 53.9 Conditions of designation.

Designation of a candidate method as a reference method or equivalent method shall be conditioned to the applicant's compliance with the following requirements. Failure to comply with any of the requirements shall constitute a ground for cancellation of the designation in accordance with § 53.11.

(a) Any method offered for sale as a reference or equivalent method shall be accompanied by a copy of the manual referred to in § 53.4(b)(3) when delivered to any ultimate purchaser.

(b) Any method offered for sale as a reference or equivalent method shall generate no unreasonable hazard to operators or to the environment during normal use or when malfunctioning.

(c) Any analyzer, PM_{10} sampler, or $PM_{2.5}$ sampler offered for sale as part of a reference or equivalent method shall function within the limits of the performance specifications referred to in § 53.20(a), § 53.30(a), § 53.50, or § 53.60, as applicable, for at least 1 year after delivery and acceptance when maintained and operated in accordance with the manual referred to in § 53.4(b)(3).

(d) Any analyzer, PM_{10} sampler, or $PM_{2.5}$ sampler offered for sale as a reference or equivalent method shall bear a prominent, permanently affixed label or sticker indicating that the analyzer or sampler has been designated by EPA as a reference method or as an equivalent method (as applicable) in accordance with this part and displaying any designated method identification number that may be assigned by EPA.

(e) If an analyzer is offered for sale as a reference or equivalent method and has one or more selectable ranges, the label or sticker required by paragraph (d) of this section shall be placed in close proximity to the range selector and shall indicate clearly which range or ranges have been designated as parts of the reference or equivalent method.

(f) An applicant who offers analyzers, PM_{10} samplers, or $PM_{2.5}$ samplers for sale as reference or equivalent methods shall maintain an accurate and current list of the names and mailing addresses of all ultimate purchasers of such analyzers or samplers. For a period of 7 years after publication of the reference or equivalent method designation applicable to such an analyzer or sampler, the applicant shall notify all ultimate purchasers of the analyzer or $PM_{2.5}$ or PM_{10} sampler within 30 days if the designation has been canceled in accordance with § 53.11 or § 53.16 or if adjustment of the analyzer or sampler is necessary under § 53.11(b).

(g) If an applicant modifies an analyzer, PM_{10} sampler, or $PM_{2.5}$ sampler that has been designated as a reference or equivalent method, the applicant shall not sell the modified analyzer or sampler as a reference or equivalent method nor attach a label or sticker to the modified analyzer or sampler under paragraph (d) or (e) of this section until the applicant has received notice under § 53.14(c) that the existing designation or a new designation will apply to the modified analyzer, PM_{10} sampler, or $PM_{2.5}$ sampler or has applied for and received notice under § 53.8(b) of a new reference or equivalent method determination for the modified analyzer or sampler.

(h) An applicant who has offered $PM_{2.5}$ samplers or analyzers for sale as part of a reference or equivalent method may continue to do so only so long as the facility in which the samplers or analyzers are manufactured continues to be an ISO 9001-registered facility, as set forth in subpart E of this part. In the event that the ISO 9001 registration for the facility is withdrawn, suspended, or otherwise becomes inapplicable, either permanently or for some specified time interval, such that the facility is no longer an ISO 9001-registered facility, the applicant shall notify EPA within 30 days of the date the facility becomes other than an ISO 9001-registered facility, and upon such notification, EPA shall issue a preliminary finding and notification of possible cancellation of the reference or equivalent method designation under § 53.11.

(i) An applicant who has offered $PM_{2.5}$ samplers or analyzers for sale as part of a reference or equivalent method may continue to do so only so long as updates of the Product Manufacturing Checklist set forth in subpart E of this part are submitted annually. In the event that an annual Checklist update is not received by EPA within 12 months of the date of the last such submitted Checklist or Checklist update, EPA shall notify the applicant within 30 days that the Checklist update has not been received and shall, within 30 days from the issuance of such notification, issue a preliminary finding and notification of possible cancellation of the reference or equivalent method designation under § 53.11.

§ 53.10 Appeal from rejection of application.

Any applicant whose application for a reference or equivalent method determination has been rejected may appeal the Administrator's decision by taking one or more of the following actions:

(a) The applicant may submit new or additional information in support of the application.

(b) The applicant may request that the Administrator reconsider the data and information already submitted.

(c) The applicant may request that any test conducted by the Administrator that was a material factor in the decision to reject the application be repeated.

§ 53.11 Cancellation of reference or equivalent method designation.

(a) *Preliminary finding.* If the Administrator makes a preliminary finding on the basis of any available information that a representative sample of a method designated as a reference or equivalent method and offered for sale as such does not fully satisfy the requirements of this part or that there is any violation of the requirements set forth in § 53.9, the Administrator may initiate proceedings to cancel the designation in accordance with the following procedures.

(b) *Notification and opportunity to demonstrate or achieve compliance.* (1) After making a preliminary finding in accordance with paragraph (a) of this section, the Administrator will send notice of the preliminary finding to the applicant, together with a statement of the facts and reasons on which the preliminary finding is based, and will publish notice of the preliminary finding in the FEDERAL REGISTER.

(2) The applicant will be afforded an opportunity to demonstrate or to achieve compliance with the requirements of this part within 60 days after publication of notice in accordance with paragraph (b)(1) of this section or within such further period as the Administrator may allow, by demonstrating to the satisfaction of the Administrator that the method in question satisfies the requirements of this part, by commencing a program to make any adjustments that are necessary to bring the method into compliance, or by taking such action as may be necessary to cure any violation of the requirements of § 53.9. If adjustments are necessary to bring the method into compliance, all such adjustments shall be made within a reasonable time as determined by the Administrator. If the applicant demonstrates or achieves compliance in accordance with this paragraph (b)(2), the Administrator will publish notice of such demonstration or achievement in the FEDERAL REGISTER.

(c) *Request for hearing.* Within 60 days after publication of a notice in accordance with paragraph (b)(1) of this section, the applicant or any interested person may request a hearing as provided in § 53.12.

(d) *Notice of cancellation.* If, at the end of the period referred to in paragraph (b)(2) of this section, the Administrator determines that the reference or equivalent method designation should be canceled, a notice of cancellation will be published in the FEDERAL REGISTER and the designation will be deleted from the list maintained under § 53.8(c). If a hearing has been requested and granted in accordance with § 53.12, action under this paragraph (d) will be taken only after completion of proceedings (including any administrative review) conducted in accordance with § 53.13 and only if the decision of the Administrator reached in such proceedings is that the designation in question should be canceled.

§ 53.12 Request for hearing on cancellation.

Within 60 days after publication of a notice in accordance with § 53.11(b)(1), the applicant or any interested person may request a hearing on the Administrator's action. If, after reviewing the request and supporting data, the Administrator finds that the request raises a substantial issue of fact, a hearing will be granted in accordance with § 53.13 with respect to such issue. The request shall be in writing, signed by an authorized representative of the applicant or interested person, and shall include a statement specifying:

(a) Any objections to the Administrator's action.

(b) Data or other information in support of such objections.

§ 53.13 Hearings.

(a)(1) After granting a request for a hearing under § 53.12, the Administrator will designate a presiding officer for the hearing.

(2) If a time and place for the hearing have not been fixed by the Administrator, the hearing will be held as soon as practicable at a time and place fixed by the presiding officer, except that the hearing shall in no case be held sooner than 30 days after publication of a notice of hearing in the FEDERAL REGISTER.

(3) For purposes of the hearing, the parties shall include EPA, the applicant or interested person(s) who requested the hearing, and any person permitted to intervene in accordance with paragraph (c) of this section.

(4) The Deputy General Counsel or the Deputy General Counsel's representative will represent EPA in any hearing under this section.

(5) Each party other than EPA may be represented by counsel or by any other duly authorized representative.

(b)(1) Upon appointment, the presiding officer will establish a hearing file. The file shall contain copies of the notices issued by the Administrator pursuant to § 53.11(b)(1), together with any accompanying material, the request for a hearing and supporting data submitted therewith, the notice of hearing published in accordance with paragraph (a)(2) of this section, and correspondence and other material data relevant to the hearing.

(2) The hearing file shall be available for inspection by the parties or their representatives at the office of the presiding officer, except to the extent that it contains information identified in accordance with § 53.15.

(c) The presiding officer may permit any interested person to intervene in the hearing upon such a showing of interest as the presiding officer may require; provided that permission to intervene may be denied in the interest of expediting the hearing where it appears that the interests of the person seeking to intervene will be adequately represented by another party (or by other parties), including EPA.

(d)(1) The presiding officer, upon the request of any party or at the officer's discretion, may arrange for a prehearing conference at a time and place specified by the officer to consider the following:

(i) Simplification of the issues.

(ii) Stipulations, admissions of fact, and the introduction of documents.

(iii) Limitation of the number of expert witnesses.

(iv) Possibility of agreement on disposing of all or any of the issues in dispute.

(v) Such other matters as may aid in the disposition of the hearing, including such additional tests as may be agreed upon by the parties.

(2) The results of the conference shall be reduced to writing by the presiding officer and made part of the record.

(e)(1) Hearings shall be conducted by the presiding officer in an informal but orderly and expeditious manner. The parties may offer oral or written evidence, subject to exclusion by the presiding officer of irrelevant, immaterial, or repetitious evidence.

(2) Witnesses shall be placed under oath.

(3) Any witness may be examined or cross-examined by the presiding officer, the parties, or their representatives. The presiding officer may, at his/her discretion, limit cross-examination to relevant and material issues.

(4) Hearings shall be reported verbatim. Copies of transcripts of proceedings may be purchased from the reporter.

(5) All written statements, charts, tabulations, and data offered in evidence at the hearing shall, upon a showing satisfactory to the presiding officer of their authenticity, relevancy, and materiality, be received in evidence and shall constitute part of the record.

(6) Oral argument shall be permitted. The presiding officer may limit oral presentations to relevant and material issues and designate the amount of time allowed for oral argument.

(f)(1) The presiding officer shall make an initial decision which shall include written findings and conclusions and the reasons therefore on all the material issues of fact, law, or discretion presented on the record. The findings, conclusions, and written decision shall be provided to the parties and made part of the record. The initial decision shall become the decision of the Administrator without further proceedings unless there is an appeal to, or review on motion of, the Administrator within 30 calendar days after the initial decision is filed.

(2) On appeal from or review of the initial decision, the Administrator will have all the powers consistent with making the initial decision, including the discretion to require or allow briefs, oral argument, the taking of additional evidence or the remanding to the presiding officer for additional proceedings. The decision by the Administrator will include written findings and conclusions and the reasons or basis therefore on all the material issues of fact, law, or discretion presented on the appeal or considered in the review.

§ 53.14 Modification of a reference or equivalent method.

(a) An applicant who offers a method for sale as a reference or equivalent method shall report to the EPA Administrator prior to implementation any intended modification of the method, including but not limited to modifications of design or construction or of operational and maintenance procedures specified in the operation manual (see § 53.9(g)). The report shall be signed by an authorized representative of the applicant, marked in accordance with § 53.15 (if applicable), and addressed as specified in § 53.4(a).

(b) A report submitted under paragraph (a) of this section shall include:

(1) A description, in such detail as may be appropriate, of the intended modification.

(2) A brief statement of the applicant's belief that the modification will, will not, or may affect the performance characteristics of the method.

(3) A brief statement of the probable effect if the applicant believes the modification will or may affect the performance characteristics of the method.

(4) Such further information, including test data, as may be necessary to explain and support any statement required by paragraphs (b)(2) and (b)(3) of this section.

(c) Within 30 calendar days after receiving a report under paragraph (a) of this section, the Administrator will take one or more of the following actions:

(1) Notify the applicant that the designation will continue to apply to the method if the modification is implemented.

(2) Send notice to the applicant that a new designation will apply to the method (as modified) if the modification is implemented, submit notice of the determination for publication in the FEDERAL REGISTER, and revise or supplement the list referred to in § 53.8(c) to reflect the determination.

(3) Send notice to the applicant that the designation will not apply to the method (as modified) if the modification is implemented and submit notice of the determination for publication in the FEDERAL REGISTER.

(4) Send notice to the applicant that additional information must be submitted before a determination can be made and specify the additional information that is needed (in such cases, the 30-day period shall commence upon receipt of the additional information).

(5) Send notice to the applicant that additional tests are necessary and specify what tests are necessary and how they shall be interpreted (in such cases, the 30-day period shall commence upon receipt of the additional test data).

(6) Send notice to the applicant that additional tests will be conducted by the Administrator and specify the reasons for and the nature of the additional tests (in such cases, the 30-day period shall commence 1 calendar day after the additional tests are completed).

(d) An applicant who has received a notice under paragraph (c)(3) of this section may appeal the Administrator's action as follows:

(1) The applicant may submit new or additional information pertinent to the intended modification.

(2) The applicant may request the Administrator to reconsider data and information already submitted.

(3) The applicant may request that the Administrator repeat any test conducted that was a material factor in the Administrator's determination. A representative of the applicant may be present during the performance of any such retest.

§53.15 Trade secrets and confidential or privileged information.

Any information submitted under this part that is claimed to be a trade secret or confidential or privileged information shall be marked or otherwise clearly identified as such in the submittal. Information so identified will be treated in accordance with part 2 of this chapter (concerning public information).

§53.16 Supersession of reference methods.

(a) This section prescribes procedures and criteria applicable to requests that the Administrator specify a new reference method, or a new measurement principle and calibration procedure on which reference methods shall be based, by revision of the appropriate appendix to part 50 of this chapter. Such action will ordinarily be taken only if the Administrator determines that a candidate method or a variation thereof is substantially superior to the existing reference method(s).

(b) In exercising discretion under this section, the Administrator will consider:

(1) The benefits, in terms of the requirements and purposes of the Act, that would result from specifying a new reference method or a new measurement principle and calibration procedure.

(2) The potential economic consequences of such action for State and local control agencies.

(3) Any disruption of State and local air quality monitoring programs that might result from such action.

(c) An applicant who wishes the Administrator to consider revising an appendix to part 50 of this chapter on the ground that the applicant's candidate method is substantially superior to the existing reference method(s) shall submit an application for a reference or equivalent method determination in accordance with §53.4 and shall indicate therein that such consideration is desired. The application shall include, in addition to the information required by §53.4, data and any other information supporting the applicant's claim that the candidate method is substantially superior to the existing reference method(s).

(d) After receiving an application under paragraph (c) of this section, the Administrator will publish notice of its receipt in the FEDERAL REGISTER and, within 120 calendar days after receipt of the application, take one of the following actions:

(1) Determine that it is appropriate to propose a revision of the appendix to part 50 of this chapter in question and send notice of the determination to the applicant.

(2) Determine that it is inappropriate to propose a revision of the appendix to part 50 of this chapter in question, determine whether the candidate method is a reference or equivalent method, and send notice of the determinations, including a statement of reasons for the determination not to propose a revision, to the applicant.

(3) Send notice to the applicant that additional information must be submitted before a determination can be made and specify the additional information that is needed (in such cases, the 120-day period shall commence upon receipt of the additional information).

(4) Send notice to the applicant that additional tests are necessary, specifying what tests are necessary and how the test shall be interpreted (in such cases, the 120-day period shall commence upon receipt of the additional test data).

(5) Send notice to the applicant that additional tests will be conducted by the Administrator, specifying the nature of and reasons for the additional tests and the estimated time required (in such cases, the 120-day period shall commence 1 calendar day after the additional tests have been completed).

(e)(1)(i) After making a determination under paragraph (d)(1) of this section, the Administrator will publish a notice of proposed rulemaking in the FEDERAL REGISTER. The notice of proposed rulemaking will indicate that the Administrator proposes:

(A) To revise the appendix to part 50 of this chapter in question.

(B) Where the appendix specifies a measurement principle and calibration procedure, to cancel reference method designations based on the appendix.

(C) To cancel equivalent method designations based on the existing reference method(s).

(ii) The notice of proposed rulemaking will include the terms or substance of the proposed revision, will indicate what period(s) of time the Administrator proposes to allow for replacement of existing methods under section 2.3 of appendix C to part 58 of this chapter, and will solicit public comments on the proposal with particular reference to the considerations set forth in paragraphs (a) and (b) of this section.

(2)(i) If, after consideration of comments received, the Administrator determines that the appendix to part 50 in question should be revised, the Administrator will, by publication in the FEDERAL REGISTER:

(A) Promulgate the proposed revision, with such modifications as may be appropriate in view of comments received.

(B) Where the appendix to part 50 (prior to revision) specifies a measurement principle and calibration procedure, cancel reference method designations based on the appendix.

(C) Cancel equivalent method designations based on the existing reference method(s).

(D) Specify the period(s) that will be allowed for replacement of existing methods under section 2.3 of appendix C to part 58 of this chapter, with such modifications from the proposed period(s) as may be appropriate in view of comments received.

(3) Canceled designations will be deleted from the list maintained under § 53.8(c). The requirements and procedures for cancellation set forth in § 53.11 shall be inapplicable to cancellation of reference or equivalent method designations under this section.

(4) If the appendix to part 50 of this chapter in question is revised to specify a new measurement principle and calibration procedure on which the applicant's candidate method is based, the Administrator will take appropriate action under § 53.5 to determine whether the candidate method is a reference method.

(5) Upon taking action under paragraph (e)(2) of this section, the Administrator will send notice of the action to all applicants for whose methods reference and equivalent method designations are canceled by such action.

(f) An applicant who has received notice of a determination under paragraph (d)(2) of this section may appeal the determination by taking one or more of the following actions:

(1) The applicant may submit new or additional information in support of the application.

(2) The applicant may request that the Administrator reconsider the data and information already submitted.

(3) The applicant may request that any test conducted by the Administrator that was a material factor in making the determination be repeated.

TABLE A–1 TO SUBPART A—SUMMARY OF APPLICABLE REQUIREMENTS FOR REFERENCE AND EQUIVALENT METHODS FOR AIR MONITORING OF CRITERIA POLLUTANTS

Pollutant	Ref. or Equivalent	Manual or Automated	Applicable Part 50 Appendix	Applicable Subparts of Part 53					
				A	B	C	D	E	F
SO_2	Reference	Manual	A						
	Manual	....	✔	....	✔				
	Equivalent	Automated	....	✔	✔	✔			
CO	Reference	Automated	C	✔	✔				
	Manual	....	✔	....	✔				
	Equivalent	Automated	....	✔	✔	✔			
O_3	Reference	Automated	D	✔	✔				
	Manual	....	✔	....	✔				
	Equivalent	Automated	....	✔	✔	✔			
NO_2	Reference	Automated	F	✔	✔				
	Manual	....	✔	....	✔				
	Equivalent	Automated	....	✔	✔	✔			
Pb	Reference	Manual	G						
	Equivalent	Manual	....	✔	....	✔			
PM_{10}	Reference	Manual	J	✔	....	....	✔		
	Manual	....	✔	....	✔	✔			
	Equivalent	Automated	....	✔	....	✔	✔		
$PM_{2.5}$	Reference	Manual	L	✔	....	....	....	✔	

TABLE A–1 TO SUPBART A—SUMMARY OF APPLICABLE REQUIREMENTS FOR REFERENCE AND EQUIVALENT METHODS FOR AIR MONITORING OF CRITERIA POLLUTANTS—Continued

Pollutant	Ref. or Equivalent	Manual or Automated	Applicable Part 50 Appendix	Applicable Subparts of Part 53					
				A	B	C	D	E	F
	Equivalent Class I	Manual	L	✔	....	✔	....	✔	
	Equivalent Class II	Manual	L	✔	....	✔	....	✔	✔
	Equivalent Class III	Manual or Automated	....	✔	....	✔[1]	....	✔[1]	✔[1]

[1] NOTE: Because of the wide variety of potential devices possible, the specific requirements applicable to a Class III candidate equivalent method for $PM_{2.5}$ are not specified explicitly in this part but, instead, shall be determined on a case-by-case basis for each such candidiate method.

APPENDIX A TO SUBPART A—REFERENCES

(1) American National Standard Quality Systems-Model for Quality Assurance in Design, Development, Production, Installation, and Servicing, ANSI/ISO/ASQC Q9001-1994. Available from American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202.

(2) American National Standard—Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs, ANSI/ASQC E41994. Available from American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202.

(3) Dimensioning and Tolerancing, ASME Y14.5M-1994. Available from the American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

(4) Mathematical Definition of Dimensioning and Tolerancing Principles, ASME Y14.5.1M-1994. Available from the American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

(5) ISO 10012, Quality Assurance Requirements for Measuring Equipment-Part 1: Meteorological confirmation system for measuring equipment):1992(E). Available from American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202.

(6) Copies of section 2.12 of the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Specific Methods, EPA/600/R-94/038b, are available from Department E (MD-77B), U.S. EPA, Research Triangle Park, NC 27711.

Subpart B—Procedures for Testing Performance Characteristics of Automated Methods SO_2, CO, O_3, and NO_2

§ 53.20 General provisions.

(a) The test procedures given in this subpart shall be used to test the performance of candidate automated methods against the performance specifications given in table B–1. A test analyzer representative of the candidate automated method must exhibit performance better than, or equal to, the specified value for each such specification (except Range) to satisfy the requirements of this subpart. Except as provided in paragraph (b) of this section, the range of the candidate method must be the range specified in table B–1 to satisfy the requirements of this subpart.

(b) For a candidate method having more than one selectable range, one range must be that specified in table B–1 and a test analyzer representative of the method must pass the tests required by this subpart while operated in that range. The tests may be repeated for a broader range (i.e., one extending to higher concentrations) than that specified in table B–1 provided that the range does not extend to concentrations more than two times the upper range limit specified in table B–1. If the application is for a reference method determination, the tests may be repeated for a narrower range (one extending to lower concentrations) than that specified in table B–1.

If the tests are conducted or passed only for the specified range, any reference or equivalent method determination with respect to the method will be limited to that range. If the tests are passed for both the specified range and a broader range (or ranges), any such determination will include the broader range(s) as well as the specified range, provided that the tests required by subpart C of this part (if applicable) are met for the broader range(s). If the tests are passed for both the specified range and a narrower range, a reference method determination for the method will include the narrower range as well as the specified range. Appropriate test data shall be submitted for each range sought to be included in a reference or equivalent method determination under this paragraph (b).

(c) For each performance specification (except Range), the test procedure shall be initially repeated seven (7) times to yield 7 test results. Each result shall be compared with the corresponding specification in table B–1; a value higher than or outside that specified constitutes a failure. These 7 results for each parameter shall be interpreted as follows:

(1) Zero (0) failures: Candidate method passes the performance parameter.

(2) Three (3) or more failures: Candidate method fails the performance parameter.

(3) One (1) or two (2) failures: Repeat the test procedures for the parameter eight (8) additional times yielding a total of fifteen (15) test results. The combined total of 15 test results shall then be interpreted as follows:

(i) One (1) or two (2) failures: Candidate method passes the performance parameter.

(ii) Three (3) or more failures: Candidate method fails the performance parameter.

TABLE B–1—PERFORMANCE SPECIFICATIONS FOR AUTOMATED METHODS

Performance parameter	Units[1]	Sulfur dioxide	Photochemical oxidants	Carbon monoxide	Nitrogen dioxide	Definitions and test procedures
1. Range	Parts per million	0–0.5	0–0.5	0–50	0–0.5	Sec. 53.23(a).
2. Noise	do	.005	.005	.50	.005	Sec. 53.23(b).
3. Lower detectable limit	Parts per million	.01	.01	1.0	.01	Sec. 53.23(c).
4. Interference equivalent						Sec. 53.23(d).
Each interferant	Parts per million	±.02	±.02	±1.0	±0.02	
Total interferant	do	.06	.06	1.5	.04	
5. Zero drift, 12 and 24 hour	do	±.02	±.02	±1.0	±.02	Sec. 52.23(e).
6. Span drift, 24 hour						Do.
20 percent of upper range limit	Percent	±20.0	±20.0	±10.0	±20.0	
80 percent of upper range limit	do	±5.0	±5.0	±2.5	±5.0	
7. Lag time	Minutes	20	20	10	20	Do.
8. Rise time	do	15	15	5	15	Do.
9. Fall time	do	15	15	5	15	Do.
10. Precision						Do.
20 percent of upper range limit	Parts per million	.01	.01	.5	.02	
80 percent of upper range limit	do	.015	.01	.5	.03	

[1] To convert from parts per million to μ g/m^3 at 25 °C and 760 mm Hg, multiply by M/0.02447, where *M* is the molecular weight of the gas.

(d) The tests for *zero drift, span drift, lag time, rise time, fall time,* and *precision* shall be combined into a single sequential procedure to be conducted at various line voltages and ambient temperatures specified in §53.23(e). The tests for *noise, lower detectable limit,* and *interference equivalents* shall be made at any temperature between 20 °C. and 30 °C. and at any normal line voltage between 105 and 125 volts, and shall be conducted such that not more than three (3) test results for each parameter are obtained per 24 hours.

(e) All response readings to be recorded shall first be converted to concentration units according to the calibration curve constructed in accordance with §53.21(b).

(f) All recorder chart tracings, records, test data and other documentation obtained from or pertinent to these tests shall be identified, dated, signed by the analyst performing the test, and submitted.

NOTE: Suggested formats for reporting the test results and calculations are provided in Figures B–2, B–3, B–4, B–5, and B–6 in appendix A. Symbols and abbreviations used in this subpart are listed in table B–5, appendix A.

[40 FR 7049, Feb. 18, 1975, as amended at 40 FR 18168, Apr. 25, 1975; 41 FR 52694, Dec. 1, 1976]

§53.21 Test conditions.

(a) *Set-up and start-up* of the test analyzer shall be in strict accordance with the operating instructions specified in the manual referred to in §53.4(b)(3).

Allow adequate warm-up or stabilization time as indicated in the operating instructions before beginning the tests. If the candidate method does not include an integral strip chart recorder, connect the output signal of the test analyzer to a suitable strip chart recorder of the servo, null-balance type. This recorder shall have a chart width of at least 25 centimeters, chart speeds up to 10 cm per hour, a response time of 1 second or less, a deadband of not more than 0.25 percent of full scale, and capability either of reading measurements at least 5 percent below zero or of offsetting the zero by at least 5 percent.

NOTE: Other data acquisition components may be used along with the chart recorder during conduct of these tests. Use of the chart recorder is intended only to facilitate evaluation of data submitted.

(b) *Calibration* of the test analyzer shall be as indicated in the manual referred to in § 53.4(b)(3) and as follows: If the chart recorder does not have below zero capability, adjust either the controls of the test analyzer or the chart recorder to obtain a +5% offset zero reading on the recorder chart to facilitate observing negative response or drift. If the candidate method is not capable of negative response, the test analyzer (not recorder) shall be operated with an offset zero. Construct and submit a calibration curve showing a plot of recorder scale readings (ordinate) against pollutant concentrations (abscissa). A plot of output units (volts, millivolts, milliamps, etc.) against pollutant concentrations shall also be shown for methods not including an integral chart recorder. All such plots shall consist of at least seven (7) approximately equally spaced, identifiable points, including 0 and 90±5 percent of full scale.

(c) Once the test analyzer has been set up and calibrated and the tests started, manual adjustment or normal periodic maintenance is permitted only every 3 days. Automatic adjustments which the test analyzer performs by itself are permitted at any time. The submitted records shall show clearly when any manual adjustment or periodic maintenance was made and describe the operations performed.

(d) If the test analyzer should malfunction during any of the performance tests, the tests for that parameter shall be repeated. A detailed explanation of the malfunction, remedial action taken, and whether recalibration was necessary (along with all pertinent records and charts) shall be submitted. If more than one malfunction occurs, all performance test procedures for all parameters shall be repeated.

(e) Tests for all performance parameters shall be completed on the same test analyzer, except that use of multiple test analyzers to accelerate testing will be permitted when alternate ranges of a multi-range candidate method are being tested.

§ 53.22 Generation of test atmospheres.

(a) Table B–2 specifies preferred methods for generating test atmospheres and suggested methods of verifying the concentrations. Only one means of establishing the concentration of a test atmosphere is normally required. If the method of generation can produce reproducible concentrations, verification is optional. If the method of generation is not reproducible, then establishment of the concentration by some verification method is required. However, when a method of generation other than that given in table B–2 is used, the test concentration shall be verified.

(b) The test atmosphere delivery system shall be designed and constructed so as not to significantly alter the test atmosphere composition or concentration during the period of the test. The delivery system shall be fabricated from borosilicate glass or FEP Teflon.

(c) The output of the test atmosphere generation system shall be sufficiently stable to obtain stable response during the required tests. If a permeation device is used for generation of a test atmosphere, the device, as well as the air passing over it, shall be controlled to ±0.1 °C.

(d) All diluent air shall be zero air free of contaminants likely to cause a detectable response on the test analyzer.

TABLE B–2—TEST ATMOSPHERES

Test gas	Generation	Verification
Ammonia	Permeation device. Similar to system described in references 1 and 2.	Indophenol method, reference 3.
Carbon dioxide	Cylinder of zero air or nitrogen containing CO_2 as required to obtain the concentration specified in table B–3.	Use NBS-certified standards whenever possible. If NBS standards are not available, obtain 2 standards from independent sources which agree within 2 percent; or obtain one standard and submit it to an independent laboratory for analysis which must agree within 2 percent of the supplier's nominal analysis.
Carbon monoxide.	Cylinder of zero air or nitrogen containing CO as required to obtain the concentration specified in table B–3.	Do.
Ethane	Cylinder of zero air or nitrogen containing ethane as required to obtain the concentration specified in table B–3.	Do.
Ethylene	Cylinder of prepurified nitrogen containing ethylene as required to obtain the concentration specified in table B–3.	Do.
Hydrogen chloride.	Cylinder[1] of prepurified nitrogen containing approximately 100 p/m of gaseous HCl. Dilute with zero air to concentration specified in table B–3.	Collect samples in bubbler containing distilled water and analyze by the mercuric thiocyanate method, ASTM (D512), p. 29, reference 4.
Hydrogen sulfide.	Permeation device system described in references 1 and 2.	Tentative method of analysis for H_2S content of the atmosphere, p. 426, reference 5.
Methane	Cylinder of zero air containing methane as required to obtain the concentration specified in table B–3.	Use NBS-certified standards whenever possible. If NBS standards are not available, obtain 2 standards from independent sources which agree within 2 percent; or obtain one standard and submit it to an independent laboratory for an analysis which must agree within 2 percent of the supplier's nominal analysis.
Nitric oxide	Cylinder[1] of prepurified nitrogen containing approximately 100 p/m NO. Dilute with zero air to required concentration.	Gas-phase titration as described in reference 6, section 7.1.
Nitrogen dioxide.	1. Gas phase titration as described in reference 6 2. Permeation device, similar to system described in references 1 and 2.	1. Use an NO_2 analyzer calibrated with a gravimetrically calibrated permeation device. 2. Use an NO_2 analyzer calibrated by gas-phase titration as described in reference 6.
Ozone	Calibrated ozone generator as described in reference 7, appendix D.	Use an ozone analyzer calibrated by gas-phase titration as described in reference 6.
Sulfur dioxide	Permeation device Similar to system described in reference method for SO_2, reference 7, appendix A.	P-rosaniline method. Reference 7, appendix A.
Water	Pass zero air through distilled water at a fixed known temperature between 20° and 30 °C. such that the air stream becomes saturated. Dilute with zero air to concentration specified in table B–3.	Measure relative humidity by means of a dew-point indicator, calibrated electrolytic or piezo electric hygrometer, or wet/dry bulb thermometer.
Xylene	Cylinder of prepurified nitrogen containing 100 p/m xylene. Dilute with zero air to concentration specified in table B–3.	Use NBS-certified standards whenever possible. If NBS standards are not available, obtain 2 standards from independent sources which agree within 2 percent; or obtain one standard and submit it to an independent laboratory for an analysis which must agree within 2 percent of the supplier's nominal analysis.
Zero air	1. Ambient air purified by appropriate scrubbers or other devices such that it is free of contaminants likely to cause a detectable response on the analyzer. 2. Cylinder of compressed zero air certified by the supplier or an independent laboratory to be free of contaminants likely to cause a detectable response on the analyzer.	

[1] Use stainless steel pressure regulator dedicated to the pollutant measured.

Reference 1. O'Keeffe, A. E., and Ortaman, G. C. ''Primary Standards for Trace Gas Analysis,'' *Anal. Chem.* 38, 760 (1966).

Reference 2. Scaringelli, F. P., A. E., Rosenberg, E., and Bell, J. P., ''Primary Standards for Trace Gas Analysis.'' *Anal. Chem.* 42, 871 (1970).

Reference 3. ''Tentative Method of Analysis for Ammonia in the Atmosphere (Indophenol Method)'', *Health Lab Sciences,* vol. 10, No. 2, 115–118, April 1973.

Reference 4. *1973 Annual Book of ASTM Standards,* American Society for Testing and Materials, 1916 Race St., Philadelphia, PA.

Reference 5. *Methods for Air Sampling and Analysis,* Intersociety Committee, 1972, American Public Health Association, 1015.

Reference 6. *Federal Register,* vol. 38, No. 110, Tentative Method for the Continuous Measurement of Nitrogen Dioxide (Chemiluminescent) addenda C. (June 8, 1973).

Reference 7. *Federal Register,* vol. 36, No. 228, National Primary and Secondary Ambient Air Quality Standards, Nov. 25, 1971.

(e) The concentration of each test atmosphere shall be established and/or verified before or during each series of tests. Samples for verifying test concentrations shall be collected from the test atmosphere delivery system as close as possible to the sample intake port of the test analyzer.

(f) The accuracy of all flow measurements used to calculate test atmosphere concentrations shall be documented and referenced to a primary standard (such as a spirometer, bubble meter, etc.). Any corrections shall be clearly shown. All flow measurements given in volume units shall be standardized to 25 °C. and 760 mm Hg.

(g) Schematic drawings and other information showing complete procedural details of the test atmosphere generation, verification, and delivery system shall be provided. All pertinent calculations shall be clearly indicated.

[40 FR 7049, Feb. 18, 1975, as amended at 40 FR 18168, Apr. 25, 1975]

§ 53.23 Test procedures.

(a) *Range*—(1) *Technical definition*. Nominal minimum and maximum concentrations which a method is capable of measuring.

NOTE: The nominal range is specified at the lower and upper range limits in concentration units, for example, 0–0.5 p/m.

(2) *Test procedure.* Submit a suitable calibration curve, as specified in § 53.21(b), showing the test analyzer's response over at least 95 percent of the required range.

NOTE: A single calibration curve will normally suffice.

(b) *Noise*—(1) *Technical definition*. Spontaneous, short duration deviations in output, about the mean output, which are not caused by input concentration changes. Noise is determined as the standard deviation about the mean and is expressed in concentration units.

(2) *Test procedure.* (i) Allow sufficient time for the test analyzer to warm up and stabilize. Determine at two concentrations, first using zero air and then a pollutant test gas concentration as indicated below. The noise specification in table B–1 shall apply to both of these tests.

(ii) Connect an integrating-type digital meter (DM) suitable for the test analyzer's output and accurate to three significant digits, to measure the analyzer's output signal.

NOTE: Use of a chart recorder in addition to the DM is optional.

(iii) Measure zero air for 60 minutes. During this 60-minute interval, record twenty-five (25) readings at 2-minute intervals. (See Figure B–2 in appendix A.)

(iv) Convert each DM reading to concentration units (p/m) by reference to the test analyzer's calibration curve as determined in § 53.21(b). Label the converted DM readings r_1, r_2, r_3 . . . r_i . . . r_{25}.

(v) Calculate the standard deviation, S, as follows:

$$S=\sqrt{\frac{\sum_{i=1}^{25}\left(r_i\right)^2-\frac{1}{25}\left(\sum_{i=1}^{25} r_i\right)^2}{24}}\,(p/m)$$

where i indicates the i-th DM reading in ppm.

(vi) Let S at 0 ppm be identified as S_o; compare S_o to the noise specification given in table B–1.

(vii) Repeat steps (iii) through (vi) of this section using a pollutant test atmosphere concentration of 80±5 percent of the upper range limit (URL) instead of zero gas, and let S at 80 percent of the URL be identified as $S_{80.}$ Compare S_{80} to the noise specification given in table B–1.

(viii) Both S_0 and S_{80} must be less than or equal to the specification for noise to pass the test for the noise parameter.

(c) *Lower detectable limit*—(1) *Technical definition.* The minimum pollutant concentration which produces a signal of twice the noise level.

(2) *Test procedure.* (i) Allow sufficient time for the test analyzer to warm up and stabilize. Measure zero air and record the stable reading in ppm as $B_{Z.}$ (See Figure B–3 in appendix A.)

(ii) Generate and measure a pollutant test atmosphere concentration equal to the value for the lower detectable limit specified in table B–1.

NOTE: If necessary, the test atmosphere concentration may be generated or verified at a higher concentration, then accurately diluted with zero air to the final required concentration.

(iii) Record the test analyzer's stable indicated reading, in ppm, as B_L.

(iv) Determine the Lower Detectable Limit (LDL) as LDL = $B_L - B_Z$. Compare this LDL value with the noise level, S_0, determined in § 53.23(b), for 0 concentration test atmosphere. LDL must be equal to or higher than $2S_0$ to pass this test.

(d) *Interference equivalent*—(1) *Technical definition.* Positive or negative response caused by a substance other than the one being measured.

(2) *Test procedure.* The test analyzer shall be tested for all substances likely to cause a detectable response. The test analyzer shall be challenged, in turn, with each interfering agent specified in table B–3. In the event that there are substances likely to cause a significant interference which have not been specified in table B–3, these substances shall be tested at a concentration substantially higher than that normally found in the ambient air. The interference may be either positive or negative, depending on whether the test analyzer's response is increased or decreased by the presence of the interferent. Interference equivalents shall be determined by mixing each interferent, one at a time, with the pollutant at the concentrations specified in table B–3, and comparing the test analyzer's response to the response caused by the pollutant alone. Known gas-phase reactions that might occur between an interferent and the pollutant are designated by footnote 3 in table B–3. In these cases, the interference equivalent shall be determined in the absence of the pollutant.

(i) Allow sufficient time for warm-up and stabilization of the test analyzer.

(ii) For a candidate method using a prefilter or scrubber based upon a chemical reaction to derive part of its specificity, and which requires periodic service or maintenance, the test analyzer shall be ''conditioned'' prior to each interference test as follows:

TABLE B–3—INTERFERANT TEST CONCENTRATION,[1] PARTS PER MILLION

Pollutant	Analyzer type [2]	Hydrochloric acid	Ammonia	Hydrogen sulfide	Sulfur dioxide	Nitrogen dioxide	Nitric oxide	Carbon dioxide	Ethylene	Ozone	M-xylene	Water vapor	Carbon monoxide	Methane	Ethane
SO_2	Flame photometric (FPD)			0.1	[1]0.14			750				[3]20,000	50		
SO_2	Gas chromatography (FPD).			.1	[4].14			750				[3]20,000	50		
SO_2	Spectrophotometric-wet chemical (pararosaniline reaction).	0.2	[3]0.1	.1	[4].14	0.5		750		0.5					
SO_2	Electrochemical	.2	[3].1	.1	[4].14	.5	0.5		0.2	.5		[3]20,000			
SO_2	Conductivity	.2	[3].1		[4].14	.5		750							
SO_2	Spectrophotometric-gas phase.				[4].14	.5	.5			.5	0.2				
O_3	Chemiluminescent			[3].1				750		[4].08		[3]20,000			
O_3	Electrochemical		[3].1		.5	.5				[4].08		[3]20,000			
O_3	Spectrophotometric-wet chemical (potassium iodide reaction).		[3].1		.5	.5	[3].5			[4].08					
O_3	Spectrophotometric-gas phase.				.5	.5	[3].5			[4].08					
CO	Infrared							750				20,000	[4]10		
CO	Gas chromatography with flame ionization detector.											20,000	[4]10		0.5
CO	Electrochemical						.5		.2			20,000	[4]10		
CO	Catalytic combustion-thermal detection.		.1					750	.2			20,000	[4]10	5.0	.5
CO	IR fluorescence							750				20,000	[4]10		.5
CO	Mercury replacement UV photometric.								.2				[4]10		.5
NO_2	Chemiluminescent		[3].1		.5	[4].1	.5					20,000			
NO_2	Spectrophotometric-wet chemical (azo-dye reaction).				.5	[4].1	.5	750		.5					
NO_2	Electrochemical	0.2	[3].1		.5	[4].1	.5	750		.5		20,000	50		
NO_2	Spectrophotometric-gas phase.		[3].1		.5	[4].1	.5			.5		20,000	50		

[1] Concentrations of interferant listed must be prepared and controlled to ± 10 percent of the state value.
[2] Analyzer types not listed will be considered by the administrator as special cases.
[3] Do not mix with pollutant.
[4] Concentration of pollutant used for test. These pollutant concentrations must be prepared to ± 10 percent of the stated value.

(A) Service or perform the indicated maintenance on the scrubber or prefilter as directed in the manual referred to in § 53.4(b)(3).

(B) Before testing for each interferent, allow the test analyzer to sample through the scrubber a test atmosphere containing the interferent at a concentration equal to the value specified in table B–3. Sampling shall be at the normal flow rate and shall be continued for 6 continuous hours prior to testing.

(iii) Generate three test atmosphere streams as follows:

(A) Test atmosphere *P:* Pollutant concentration.

(B) Test atmosphere *I:* Interference concentration.

(C) Test atmosphere *Z:* Zero air.

(iv) Adjust the individual flow rates and the pollutant or interferent generators for the three test atmospheres as follows:

(A) The flow rates of test atmospheres *I* and *Z* shall be identical.

(B) The concentration of pollutant in test atmosphere *P* shall be adjusted such that when *P* is mixed (diluted) with either test atmosphere *I* or *Z,* the resulting concentration of pollutant shall be as specified in table B–3.

(C) The concentration of interferent in test atmosphere *I* shall be adjusted such that when *I* is mixed (diluted) with test atmosphere *P,* the resulting concentration of interferent shall be equal to the value specified in table B–3.

(D) To minimize concentration errors due to flow rate differences between *I* and *Z,* it is recommended that, when possible, the flow rate of *P* be from 10 to 20 times larger than the flow rates of *I* and *Z*.

(v) Mix test atmospheres *P* and *Z* by passing the total flow of both atmospheres through a mixing flask.

(vi) Sample and measure the mixture of test atmospheres *P* and *Z* with the test analyzer. Allow for a stable reading, and record the reading, in concentration units, as *R* (see Figure B–3).

(vii) Mix test atmospheres *P* and *I* by passing the total flow of both atmospheres through a mixing flask.

(viii) Sample and measure this mixture. Record the stable reading, in concentration units, as R_I.

(ix) Calculate the interference equivalent (*IE*) as:

$$IE = R_I - R$$

IE must be equal to or less than the specification given in table B–1 for each interferent to pass the test.

(x) Follow steps (iii) through (ix) of this section, in turn, to determine the interference equivalent for each interferent.

(xi) For those interferents which cannot be mixed with the pollutant, as indicated by footnote (3) in table B–3, adjust the concentration of test atmosphere *I* to the specified value without being mixed or diluted by the pollutant test atmosphere. Determine *IE* as follows:

(A) Sample and measure test atmosphere *Z* (zero air). Allow for a stable reading and record the reading, in concentration units, as *R*.

(B) Sample and measure the interferent test atmosphere *I*. If the test analyzer is not capable of negative readings, adjust the analyzer (not the recorder) to give an offset zero. Record the stable reading in concentration units as R_I, extrapolating the calibration curve, if necessary, to represent negative readings.

(C) Calculate $\mathrm{IE} = \mathrm{R_I} - \mathrm{R}$. *IE* must be equal to or less than the specification in table B–1 to pass the test.

(xii) Sum the absolute value of all the individual interference equivalents. This sum must be equal to or less than the total interferent specification given in table B–1 to pass the test.

(e) *Zero drift, span drift, lag time, rise time, fall time, and precision*—(1) *Technical definitions*—(i) *Zero drift:* The change in response to zero pollutant concentration, over 12- and 24-hour periods of continuous unadjusted operation.

(ii) *Span drift:* The percent change in response to an up-scale pollutant concentration over a 24-hour period of continuous unadjusted operation.

(iii) *Lag time:* The time interval between a step change in input concentration and the first observable corresponding change in response.

(iv) *Rise time:* The time interval between initial response and 95 percent of final response after a step increase in input concentration.

(v) *Fall time:* The time interval between initial response and 95 percent of final response after a step decrease in input concentration.

(vi) *Precision:* Variation about the mean of repeated measurements of the same pollutant concentration, expressed as one standard deviation about the mean.

(2) Tests for these performance parameters shall be accomplished over a period of seven (7) or more days. During this time, the line voltage supplied to the test analyzer and the ambient temperature surrounding the analyzer shall be varied from day to day. One test result for each performance parameter shall be obtained each test day, for seven (7) or fifteen (15) test days as necessary. The tests are performed sequentially in a single procedure.

(3) The 24-hour test day may begin at any clock hour. The first 12 hours out of each test day are required for testing 12-hour zero drift. Tests for the other parameters shall be conducted during the remaining 12 hours.

(4) Table B–4 specifies the line voltage and room temperature to be used for each test day. The line voltage and temperature shall be changed to the specified values at the start of each test day (i.e., at the start of the 12-hour zero test). Initial adjustments (day zero) shall be made at a line voltage of 115 volts (rms) and a room temperature of 25 °C.

(5) The tests shall be conducted in blocks consisting of 3 test days each until 7 or 15 test results have been obtained. (The final block may contain fewer than three test days.) If a test is interrupted by an occurrence other than a malfunction of the test analyzer, only the block during which the interruption occurred shall be repeated.

(6) During each block, manual adjustments to the electronics, gas, or reagent flows or periodic maintenance shall not be permitted. Automatic adjustments which the test analyzer performs by itself are permitted at any time.

(7) At least 4 hours prior to the start of the first test day of each block, the test analyzer may be adjusted and/or serviced according to the periodic maintenance procedures specified in the manual referred to in § 53.4(b)(3). If a new block is to immediately follow a previous block, such adjustments or servicing may be done immediately after completion of the day's tests for the last day of the previous block and at the voltage and temperature specified for that day, but only on test days 3, 6, 9, and 12.

NOTE: If necessary, the beginning of the test days succeeding such maintenance or adjustment may be delayed as necessary to complete the service or adjustment operation.

(8) All response readings to be recorded shall first be converted to concentration units according to the calibration curve. Whenever a test atmosphere is to be measured but a stable reading is not required, the test atmosphere shall be measured long enough to cause a change in response of at least 10% of full scale. Identify all readings and other pertinent data on the strip chart. (See Figure B–1 illustrating the pattern of the required readings.)

TABLE B–4—LINE VOLTAGE AND ROOM TEMPERATURE TEST CONDITIONS

Test day	Line voltage,[1] rms	Room temperature,[2] °C	Comments
0	115	25	Initial set-up and adjustments.
1	125	20	
2	105	20	
3	125	30	Adjustments and/or periodic maintenance permitted at end of tests.
4	105	30	
5	125	20	
6	105	20	Adjustments and/or periodic maintenance permitted at end of tests.
7	125	30	Examine test results to ascertain if further testing is required.
8	105	30	
9	125	20	Adjustments and/or periodic maintenance permitted at end of tests.
10	105	20	
11	125	30	
12	105	30	Adjustments and/or periodic maintenance permitted at end of tests.
13	125	20	

TABLE B–4—LINE VOLTAGE AND ROOM TEMPERATURE TEST CONDITIONS—Continued

Test day	Line voltage,[1] rms	Room temperature,[2] °C	Comments
14	105	20	
15	125	30	

[1] Voltage specified shall be controlled to ± 1 volt.
[2] Temperature specified shall be controlled to ± 1 °C.

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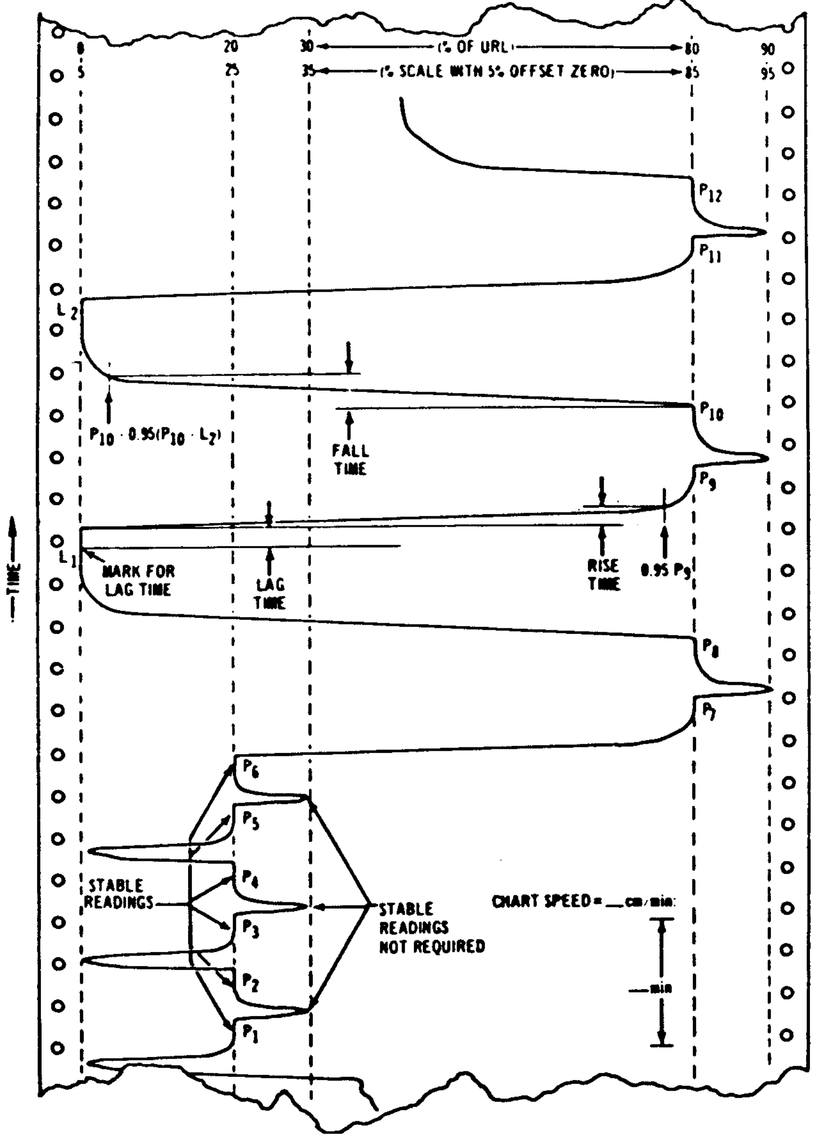

Figure B-1. Example showing the nature of the tracing obtained during the test for drift, lag time, rise time, fall time, and precision. The time scale has been greatly compressed.

(9) *Test procedure.* (i) Arrange to generate pollutant test atmospheres as follows:

Test atmosphere	Pollutant concentration (percent)
A_0	Zero air.
A_{20}	20±5 of the upper range limit.
A_{30}	30±5 of the upper range limit.

Test atmosphere	Pollutant concentration (percent)
A_{80}	80±5 of the upper range limit.
A_{90}	90±5 of the upper range limit.

Test atmospheres A_0, A_{20}, and A_{80} shall be consistent during the tests and from day to day.

(ii) For steps (xxv) through (xxxi) of this section, a chart speed of at least 10 centimeters per hour shall be used. The actual chart speed, chart speed changes, and time checks shall be clearly marked on the chart.

(iii) Allow sufficient time for test analyzer to warm up and stabilize at a line voltage of 115 volts and a room temperature of 25 °C. Recalibrate, if necessary, and adjust the zero baseline to 5 percent of chart. No further adjustments shall be made to the analyzer until the end of the tests on the third day.

(iv) Measure test atmosphere A_0 until a stable reading is obtained, and record this reading (in ppm) as Z'_n, where $n = 0$ (see Figure B–4 in appendix A).

(v) Measure test atmosphere A_{20}. Allow for a stable reading and record it as M'_n, where $n = 0$.

(vi) Measure test atmosphere A_{80}. Allow for a stable reading and record it as S'_n, where $n = 0$.

(vii) The above readings for Z'_0, M'_0, and S'_0 should be taken at least four (4) hours prior to the beginning of test day 1.

(viii) At the beginning of each test day, adjust the line voltage and room temperature to the values given in table B–4.

(ix) Measure test atmosphere A_0 continuously for at least twelve (12) continuous hours during each test day.

(x) After the 12-hour zero drift test (step ix), sample test atmosphere A_0. A stable reading is not required.

(xi) Measure test atmosphere A_{20} and record the stable reading (in ppm) as P_1. (See Figure B–4 in appendix A.)

(xii) Sample test atmosphere A_{30}; a stable reading is not required.

(xiii) Measure test atmosphere A_{20} and record the stable reading as P_2.

(xiv) Sample test atmosphere A_0; a stable reading is not required.

(xv) Measure test atmosphere A_{20} and record the stable reading as P_3.

(xvi) Sample test atmosphere A_{30}; a stable reading is not required.

(xvii) Measure test atmosphere A_{20} and record the stable reading as P_4.

(xviii) Sample test atmosphere A_0; a stable reading is not required.

(xix) Measure test atmosphere A_{20} and record the stable reading as P_5.

(xx) Sample test atmosphere A_{30}; a stable reading is not required.

(xxi) Measure test atmosphere A_{20} and record the stable reading as P_6.

(xxii) Measure test atmosphere A_{30} and record the stable reading as P_7.

(xxiii) Sample test atmosphere A_{90}; a stable reading is not required.

(xxiv) Measure test atmosphere A_{80} and record the stable reading as P_8. Increase chart speed to at least 10 centimeters per hour.

(xxv) Measure test atmosphere A_0. Record the stable reading as L_1.

(xxvi) Quickly switch the test analyzer to measure test atmosphere A_{80} and mark the recorder chart to show the exact time when the switch occurred.

(xxvii) Measure test atmosphere A_{90} and record the stable reading as P_{80}.

(xxviii) Sample test atmosphere A_{90}; a stable reading is not required.

(xxix) Measure test atmosphere A_{80} and record the stable reading as P_{10}.

(xxx) Measure test atmosphere A_0 and record the stable reading as L_2.

(xxxi) Measure test atmosphere A_{80} and record the stable reading as P_{11}.

(xxxii) Sample test atmosphere A_{90}; a stable reading is not required.

(xxxiii) Measure test atmosphere A_{80} and record the stable reading as P_{12}.

(xxxiv) Repeat steps (viii) through (xxxiii) of this section, each test day.

(xxxv) If zero and span adjustments are made after the readings are taken on test days 3, 6, 9, or 12, complete all adjustments; then measure test atmospheres A_0, A_{80}, and A_{20}. Allow for a stable reading on each, and record the readings as $Z'_n S'_n$, and M_n respectively, where n = the test day number.

(10) Determine the results of each day's tests as follows. Mark the recorder chart to show readings and determinations.

(i) *Zero drift.* (A) 12-hour. Examine the strip chart pertaining to the 12-

hour continuous zero air test. Determine the minimum (Cmin.) and maximum (Cmax.) readings (in p/m) during this period of 12 consecutive hours, extrapolating the calibration curve to negative concentration units if necessary. Determine the 12-hour zero drift ($12ZD$) as $12ZD = C_{max.} - C_{min.}$. (See Figure B–5 in appendix A.)

(B) Calculate the 24-hour zero drift ($24ZD$) for the n-th test day as $24ZD_n = Z_n - Z_{n-1}$, or $24ZD_n = Z_n - Z'_{n-1}$ if zero adjustment was made on the previous day, where $Z_n = \frac{1}{2}(L_1 + L_2)$ for L_1 and L_2 taken on the n-th test day.

(C) Compare $12ZD$ and $24ZD$ to the zero drift specification in table B–1. Both $12ZD$ and $24ZD$ must be equal to or less than the specified value to pass the test for zero drift.

(ii) *Span drift.* (A) Span drift at 20 percent of URL (MSD)

$$MSD_n = \frac{M_n - M_{n-1}}{M_{n-1}} \times 100\%$$

$$MSD_n = \frac{M_n - M'_{n-1}}{M'_{n-1}} \times 100\%$$

If span adjustment was made on the previous day, where

$$M_n = \frac{1}{6}\sum_{i=1}^{6} P_i$$

n indicates the n-th test day, and i indicates the i-th reading on the n th day.

(B) Span drift at 80 percent of URL (USD):

$$USD_n = \frac{S_n - S_{n-1}}{S_{n-1}} \times 100\%$$

or

$$USD_n = \frac{S_n - S'_{n-1}}{S'_{n-1}} \times 100\%$$

If span adjustment was made on the previous day, where

$$S_n = \frac{1}{6}\sum_{i=7}^{12} P_i$$

n indicates the n-th test day, and i indicates the i-th reading on the n-th test day.

(C) Both USD and MSD must be equal to or less than the respective specifications given in table B–1 to pass the test for span draft.

(iii) *Lag time.* Determine, from the strip chart, the elapsed time in minutes between the mark made in step (xxvi) and the first observable (two times the noise level) response. This time must be equal to or less than the time specified in table B–1 to pass the test for lag time.

(iv) *Rise time.* Calculate 95 percent of reading P_9 and determine from the recorder chart, the elapsed time between the first observable (two times noise level) response and a response equal to 95 percent of the P_9 reading. This time must be equal to or less than the rise time specified in table B–1 to pass the test for rise time.

(v) *Fall time.* Calculate five percent of $(P_{10} - L_2)$ and determine, from the strip chart, the elapsed time in minutes between the first observable decrease in response following reading P_{10} and a response equal to five percent of $(P_{10} - L_2)$. This time must be equal to or less than the fall time specification in table B–1 to pass the test for fall time.

(vi) *Precision.* Calculate precision (P_{20} and P_{80}) for each day's test as follows:

(A)

$$P_{30} = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6} \mathrm{P}_i^{\,2} - \frac{1}{6}\left(\sum_{i=1}^{6} \mathrm{P}_i\right)^2\right]}$$

(B)

$$P_{30} = \sqrt{\frac{1}{5}\left[\sum_{i=7}^{12} \mathrm{P}_i^{\,2} - \frac{1}{6}\left(\sum_{i=7}^{12} \mathrm{P}_i\right)^2\right]}$$

(C) Both P_{20} and P_{80} must be equal to or less than the specification given in table B–1 to pass the test for precision.

[40 FR 7049, Feb. 18, 1975, as amended at 41 FR 52694, Dec. 1, 1976]

APPENDIX A TO SUBPART B—OPTIONAL FORMS FOR REPORTING TEST RESULTS

TABLE B–5—SYMBOLS AND ABBREVIATIONS

B_L	Analyzer reading at specified *LDL* concentration.
B_z	Analyzer reading at 0 concentration for *LDL* test.
DM	Digital meter.
C_{max}	Maximum analyzer reading during 12*ZD* test.
C_{min}	Minimum analyzer reading during 12*ZD* test.
i	Subscript indicating the *i*-th quantity in a series.
IE	Interference equivalent.
L_1	First analyzer zero reading for 24*ZD* test.
L_2	Second analyzer zero reading for 24*ZD* test.
M_n	Average of $P_1 \ldots P_6$ for the *n*-th test day.
M'_n	Adjusted span reading at 20 percent of *URL* on the *n*-th test day.
MSD	Span drift at 20 percent of *URL.*
n	Subscript indicating the test day number.
P	Analyzer reading for precision test.
P_i	The *i*-th analyzer reading for precision test.
P_{20}	Precision at 20 percent of *URL.*
P_{80}	Precision at 80 percent of *URL.*
R	Analyzer reading of pollutant alone for *IE* test.
R_I	Analyzer reading with interferent added for *IE* test.
r_i	The *i*-th *DM* reading for noise test.
S	Standard deviation of noise readings.
S_0	Noise value (*S*) measured at 0 concentration.
S_{80}	Noise value (*S*) measured at 80 percent of *URL.*
S_n	Average of $P_7 \ldots P_{12}$ for the *n*-th test day.
S'_n	Adjusted span reading at 80 percent of *URL* on the *n*-th test day.
URL	Upper range limit.
USD	Span drift at 80 percent o
Z	Average of L_1 and L_2.
Z_n	Average of L_1 and L_2 on the *n*-th test day.
Z'_n	Adjusted zero reading on the *n*-th test day.
ZD	Zero drift.
12*ZD*	12-hour zero drift.
24*ZD*	24-hour zero drift.

Applicant ____________________ Date ____________

Test No. ____________

Analyzer ____________________ Range ____________

READING NUMBER (i)	TIME	0% of URL		80% of URL	
		DM READING	r_i, ppm	DM READING	r_i, ppm
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
$\sum_{i=1}^{25} r_i$					
$\sum_{i=1}^{25} r_i^2$					
S			$S_0 =$		$S_{80} =$

Figure B-2. Form for noise data.

Applicant ______________________________

Analyzer ______________________________ Range ______________

TEST PARAMETER		READING OR CALCULATION	TEST NUMBER														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LOWER DETECTABLE LIMIT		B_Z															
		B_L															
		$LDL = B_L - B_Z$															
INTERFERENCE EQUIVALENT	1	R_1															
		R_{11}															
		$IE_1 = R_{11} - R_1$															
	2	R_2															
		R_{12}															
		$IE_2 = R_{12} - R_2$															
	3	R_3															
		R_{13}															
		$IE_3 = R_{13} - R_3$															
	4	R_4															
		R_{14}															
		$IE_4 = R_{14} - R_4$															
	5	R_5															
		R_{15}															
		$IE_5 = R_{15} - R_5$															
	TOTAL	$IE_T = \sum_{i=1}^{\infty} \lvert IE_i \rvert$															

Figure B-3. Form for data and calculations for lower detectable limit and interference equivalent.

Applicant ______________________________

Analyzer ______________________________ Range ______________

	ANALYZER READING, ppm															
TEST DAY (n)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DATE																
P_1	▨															
P_2	▨															
P_3	▨															
P_4	▨															
P_5	▨															
P_6	▨															
$\sum_{i=1}^{6} P_i^2$	▨															
P_7	▨															
P_8	▨															
P_9	▨															
P_{10}	▨															
P_{11}	▨															
P_{12}	▨															
$\sum_{i=7}^{12} P_i^2$	▨															
L_1	▨															
L_2	▨															
Z_n'		▨	▨		▨	▨		▨	▨		▨	▨		▨	▨	▨
M_n'		▨	▨		▨	▨		▨	▨		▨	▨		▨	▨	▨
S_n'		▨	▨		▨	▨		▨	▨		▨	▨		▨	▨	▨
C_{max}	▨															
C_{min}	▨															

Figure B-4. Form recording data for drift and precision.

Applicant ____________________

Analyzer ____________________ Range ____________

TEST PARAMETER		CALCULATION	n - th TEST DAY														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Zero drift	12 hour	$12ZD = C_{max} - C_{min}$															
	24 hour	$Z = \frac{1}{2}(L_1 + L_2)$															
		$24ZD_n = Z_n - Z_{n-1}$	▨														
		$24ZD_n = Z_n - Z'_{n-1}$		▨	▨		▨	▨		▨	▨		▨	▨		▨	▨
Span drift	20% URL	$M_n = \frac{1}{6}\sum_{i=1}^{6} P_i$															
		$MSD_n = \frac{M_n - M_{n-1}}{M_{n-1}} \times 100\%$	▨														
		$MSD_n = \frac{M_n - M'_{n-1}}{M'_{n-1}} \times 100\%$		▨	▨		▨	▨		▨	▨		▨	▨		▨	▨
	80% URL	$S_n = \frac{1}{6}\sum_{i=7}^{12} P_i$															
		$USD_n = \frac{S_n - S_{n-1}}{S_{n-1}} \times 100\%$	▨														
		$USD_n = \frac{S_n - S'_{n-1}}{S'_{n-1}} \times 100\%$		▨	▨		▨	▨		▨	▨		▨	▨		▨	▨
Precision	20% URL	$P_{20} = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6} P_i^2 - \frac{1}{6}\left(\sum_{i=1}^{6} P_i\right)^2\right]}$															
	80% URL	$P_{80} = \sqrt{\frac{1}{5}\left[\sum_{i=7}^{12} P_i^2 - \frac{1}{6}\left(\sum_{i=7}^{12} P_i\right)^2\right]}$															

Figure B-5. Form for calculating zero drift, span drift and precision.

Applicant ____________ Analysts ____________

Analyzer ____________ ____________

____________ Range ____________

PERFORMANCE PARAMETER		Table B-1 spec.	TEST							TEST								No. of test failures	Pass or fail
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
NOISE, ppm	0% URL (S_0)																		
	80% URL (S_{80})																		
LDL (must be 2 × noise[a])		▨																	
INTER-FERENCE EQUIV-ALENT, ppm	IE_1																		
	IE_2																		
	IE_3																		
	IE_4																		
	IE_5																		
	TOTAL (IE_T)																		
ZERO DRIFT, ppm	12 hour (12ZD)																		
	24 hour (24ZD)																		
SPAN DRIFT, %	20% URL (MSD)																		
	80% URL (USD)																		
LAG TIME, min																			
RISE TIME, min																			
FALL TIME, min																			
PRECISION, ppm	20% URL (P_{20})																		
	80% URL (P_{80})																		

[a] Compare each test LDL reading with the corresponding noise measurements; LDL reading must exceed the 0% URL noise value by a factor of 2 to pass the test for LDL.

Figure B-6. Form for summary of test results.

[40 FR 7049, Feb. 18, 1975, as amended at 40 FR 18169, Apr. 25, 1975]

Subpart C—Procedures for Determining Comparability Between Candidate Methods and Reference Methods

SOURCE: 62 FR 38792, July 18, 1997, unless otherwise noted.

§ 53.30 General provisions.

(a) *Determination of comparability*. The test procedures prescribed in this subpart shall be used to determine if a candidate method is comparable to a reference method when both methods measure pollutant concentrations in ambient air.

(1) Comparability is shown for SO_2, CO, O_3, and NO_2 methods when the differences between:

(i) Measurements made by a candidate manual method or by a test analyzer representative of a candidate automated method.

(ii) Measurements made simultaneously by a reference method, are less than or equal to the values specified in the last column of table C–1 of this subpart.

(2) Comparability is shown for lead methods when the differences between:

(i) Measurements made by a candidate method.

(ii) Measurements made by the reference method on simultaneously collected lead samples (or the same sample, if applicable), are less than or equal to the value specified in table C–3 of this subpart.

(3) Comparability is shown for PM_{10} and $PM_{2.5}$ methods when the relationship between:

(i) Measurements made by a candidate method.

(ii) Measurements made by a reference method on simultaneously collected samples (or the same sample, if applicable) at each of two test sites, is such that the linear regression parameters (slope, intercept, and correlation coefficient) describing the relationship meet the values specified in table C–4 of this subpart.

(b) *Selection of test sites*—(1) *All methods.* Each test site shall be in a predominately urban area which can be shown to have at least moderate concentrations of various pollutants. The site shall be clearly identified and shall be justified as an appropriate test site with suitable supporting evidence such as maps, population density data, vehicular traffic data, emission inventories, pollutant measurements from previous years, concurrent pollutant measurements, and meteorological data. If approval of a proposed test site is desired prior to conducting the tests, a written request for approval of the test site or sites must be submitted prior to conducting the tests and must include the supporting and justification information required. The Administrator may exercise discretion in selecting a different site (or sites) for any additional tests the Administrator decides to conduct.

(2) *Methods for SO_2, CO, O_3, and NO_2.* All test measurements are to be made at the same test site. If necessary, the concentration of pollutant in the sampled ambient air may be augmented with artificially generated pollutant to facilitate measurements in the specified ranges described under paragraph (d)(2) of this section.

(3) *Methods for Pb.* Test measurements may be made at any number of test sites. Augmentation of pollutant concentrations is not permitted, hence an appropriate test site or sites must be selected to provide lead concentrations in the specified range.

(4) *Methods for PM_{10}.* Test measurements must be made, or derived from particulate samples collected, at not less than two test sites, each of which must be located in a geographical area characterized by ambient particulate matter that is significantly different in nature and composition from that at the other test site(s). Augmentation of pollutant concentrations is not permitted, hence appropriate test sites must be selected to provide PM_{10} concentrations in the specified range. The tests at the two sites may be conducted in different calendar seasons, if appropriate, to provide PM_{10} concentrations in the specified ranges.

(5) *Methods for $PM_{2.5}$.* Augmentation of pollutant concentrations is not permitted, hence appropriate test sites must be selected to provide $PM_{2.5}$ concentrations and $PM_{2.5}/PM_{10}$ ratios (if applicable) in the specified ranges.

(i) Where only one test site is required, as specified in table C–4 of this subpart, the site need only meet the $PM_{2.5}$ ambient concentration levels required by § 53.34(c)(3).

(ii) Where two sites are required, as specified in table C–4 of this subpart, each site must be selected to provide the ambient concentration levels required by § 53.34(c)(3). In addition, one site must be selected such that all acceptable test sample sets, as defined in § 53.34(c)(3), have a $PM_{2.5}/PM_{10}$ ratio of more than 0.75; the other site must be selected such that all acceptable test sample sets, as defined in § 53.34(c)(3), have a $PM_{2.5}/PM_{10}$ ratio of less than 0.40. At least two reference method

PM_{10} samplers shall be collocated with the candidate and reference method $PM_{2.5}$ samplers and operated simultaneously with the other samplers at each test site to measure concurrent ambient concentrations of PM_{10} to determine the $PM_{2.5}/PM_{10}$ ratio for each sample set. The $PM_{2.5}/PM_{10}$ ratio for each sample set shall be the average of the $PM_{2.5}$ concentration, as determined in § 53.34(c)(1), divided by the average PM_{10} concentration, as measured by the PM_{10} samplers. The tests at the two sites may be conducted in different calendar seasons, if appropriate, to provide $PM_{2.5}$ concentrations and $PM_{2.5}/PM_{10}$ ratios in the specified ranges.

(c) *Test atmosphere.* Ambient air sampled at an appropriate test site or sites shall be used for these tests. Simultaneous concentration measurements shall be made in each of the concentration ranges specified in tables C–1, C–3, or C–4 of this subpart, as appropriate.

(d) *Sample collection*—(1) *All methods.* All test concentration measurements or samples shall be taken in such a way that both the candidate method and the reference method receive air samples that are homogenous or as nearly identical as practical.

(2) *Methods for* SO_2, *CO*, O_3, *and* NO_2. Ambient air shall be sampled from a common intake and distribution manifold designed to deliver homogenous air samples to both methods. Precautions shall be taken in the design and construction of this manifold to minimize the removal of particulates and trace gases, and to ensure that identical samples reach the two methods. If necessary, the concentration of pollutant in the sampled ambient air may be augmented with artificially-generated pollutant. However, at all times the air sample measured by the candidate and reference methods under test shall consist of not less than 80 percent ambient air by volume. Schematic drawings, physical illustrations, descriptions, and complete details of the manifold system and the augmentation system (if used) shall be submitted.

(3) *Methods for Pb*, PM_{10} *and* $PM_{2.5}$. The ambient air intake points of all the candidate and reference method collocated samplers for lead, PM_{10} or $PM_{2.5}$ shall be positioned at the same height above the ground level, and between 2 and 4 meters apart. The samplers shall be oriented in a manner that will minimize spatial and wind directional effects on sample collection.

(4) PM_{10} *methods employing the same sampling procedure as the reference method but a different analytical method.* Candidate methods for PM_{10} which employ a sampler and sample collection procedure that are identical to the sampler and sample collection procedure specified in the reference method, but use a different analytical procedure, may be tested by analyzing common samples. The common samples shall be collected according to the sample collection procedure specified by the reference method and shall be analyzed in accordance with the analytical procedures of both the candidate method and the reference method.

(e) *Submission of test data and other information.* All recorder charts, calibration data, records, test results, procedural descriptions and details, and other documentation obtained from (or pertinent to) these tests shall be identified, dated, signed by the analyst performing the test, and submitted. For candidate methods for $PM_{2.5}$, all submitted information must meet the requirements of the ANSI/ASQC E4 Standard, sections 3.3.1, paragraphs 1 and 2 (reference 1 of appendix A of this subpart).

§ 53.31 Test conditions.

(a) *All methods.* All test measurements made or test samples collected by means of a sample manifold as specified in § 53.30(d)(2) shall be at a room temperature between 20 °C and 30 °C, and at a line voltage between 105 and 125 volts. All methods shall be calibrated as specified in paragraph (c) of this section prior to initiation of the tests.

(b) *Samplers and automated methods.* (1) Setup and start-up of the test analyzer, test sampler(s), and reference method (if applicable) shall be in strict accordance with the applicable operation manual(s). If the test analyzer does not have an integral strip chart or digital data recorder, connect the analyzer output to a suitable strip chart or digital data recorder. This recorder shall have a chart width of at least 25 centimeters, a response time of 1 second or less, a deadband of not more than 0.25 percent of full scale, and capability of either reading measurements at least 5 percent below zero or offsetting the zero by at least 5 percent. Digital data shall be recorded at appropriate time intervals such that trend plots similar to a strip chart recording may be constructed with a similar or suitable level of detail.

(2) Other data acquisition components may be used along with the chart recorder during the conduct of these tests. Use of the chart recorder is intended only to facilitate visual evaluation of data submitted.

(3) Allow adequate warmup or stabilization time as indicated in the applicable operation manual(s) before beginning the tests.

(c) *Calibration.* The reference method shall be calibrated according to the appropriate appendix to part 50 of this chapter (if it is a manual method) or according to the applicable operation manual(s) (if it is an automated method). A candidate manual method (or portion thereof) shall be calibrated, according to the applicable operation manual(s), if such calibration is a part of the method.

(d) *Range.* (1) Except as provided in paragraph (d)(2) of this section, each method shall be operated in the range specified for the reference method in the appropriate appendix to part 50 of this chapter (for manual reference methods), or specified in table B–1 of subpart B of this part (for automated reference methods).

(2) For a candidate method having more than one selectable range, one range must be that specified in table B–1 of subpart B of this part and a test analyzer representative of the method must pass the tests required by this subpart while operated on that range. The tests may be repeated for a broader range (i.e., one extending to higher concentrations) than the one specified in table B–1 of subpart B of this part, provided that the range does not extend to concentrations more than two times the upper range limit specified in table B–1 of subpart B of this part and that the test analyzer has passed the tests required by subpart B of this part (if applicable) for the broader range. If the tests required by this subpart are conducted or passed only for the range specified in table B–1 of subpart B of this part, any equivalent method determination with respect to the method will be limited to that range. If the tests are passed for both the specified range and a broader range (or ranges), any such determination will include the broader range(s) as well as the specified range. Appropriate test data shall be submitted for each range sought to be included in such a determination.

(e) *Operation of automated methods.* (1) Once the test analyzer has been set up and calibrated and tests started, manual adjustment or normal periodic maintenance as specified in the manual referred to in §53.4(b)(3) is permitted only every 3 days. Automatic adjustments which the test analyzer performs by itself are permitted at any time. The submitted records shall show clearly when manual adjustments were made and describe the operations performed.

(2) All test measurements shall be made with the same test analyzer; use of multiple test analyzers is not permitted. The test analyzer shall be operated continuously during the entire series of test measurements.

(3) If a test analyzer should malfunction during any of these tests, the entire set of measurements shall be repeated, and a detailed explanation of the malfunction, remedial action taken, and whether recalibration was necessary (along with all pertinent records and charts) shall be submitted.

§53.32 Test procedures for methods for SO_2, CO, O_3, and NO_2.

(a) Conduct the first set of simultaneous measurements with the candidate and reference methods:

(1) Table C–1 of this subpart specifies the type (1- or 24-hour) and number of measurements to be made in each of the three test concentration ranges.

(2) The pollutant concentration must fall within the specified range as measured by the reference method.

(3) The measurements shall be made in the sequence specified in table C–2 of this subpart, except for the 1-hour SO_2 measurements, which are all in the high range.

(b) For each pair of measurements, determine the difference (discrepancy) between the candidate method measurement and reference method measurement. A discrepancy which exceeds the discrepancy specified in table C–1 of this subpart constitutes a failure. Figure C–1 of this subpart contains a suggested format for reporting the test results.

(c) The results of the first set of measurements shall be interpreted as follows:

(1) Zero failures. The candidate method passes the test for comparability.

(2) Three or more failures. The candidate method fails the test for comparability.

(3) One or two failures. Conduct a second set of simultaneous measurements as specified in table C–1 of this subpart. The results of the combined total of first-set and second-set measurements shall be interpreted as follows:

(i) One or two failures. The candidate method passes the test for comparability.

(ii) Three or more failures. The candidate method fails the test for comparability.

(4) For SO_2, the 1-hour and 24-hour measurements shall be interpreted separately, and the candidate method must pass the tests for both 1- and 24-hour measurements to pass the test for comparability.

(d) A 1-hour measurement consists of the integral of the instantaneous concentration over a 60-minute continuous period divided by the time period. Integration of the instantaneous concentration may be performed by any appropriate means such as chemical, electronic, mechanical, visual judgment, or by calculating the mean of not less than 12 equally spaced instantaneous readings. Appropriate allowances or corrections shall be made in cases where significant errors could occur due to characteristic lag time or rise/fall time differences between the candidate and reference methods. Details of the means of integration and any corrections shall be submitted.

(e) A 24-hour measurement consists of the integral of the instantaneous concentration over a 24-hour continuous period divided by the time period. This integration may be performed by any appropriate means such as chemical, electronic, mechanical, or by calculating the mean of 24 sequential 1-hour measurements.

(f) For ozone and carbon monoxide, no more than six 1-hour measurements shall be made per day. For sulfur dioxide, no more than four 1-hour measurements or one 24-hour measurement shall be made per day. One-hour measurements may be made concurrently with 24-hour measurements if appropriate.

(g) For applicable methods, control or calibration checks may be performed once per day without adjusting the test analyzer or method. These checks may be used as a basis for a linear interpolation-type correction to be applied to the measurements to correct for drift. If such a correction is used, it shall be applied to all measurements made with the method, and the correction procedure shall become a part of the method.

§53.33 Test procedure for methods for lead.

(a) *Sample collection*. Collect simultaneous 24-hour samples (filters) of lead at the test site or sites with both the reference and candidate methods until at least 10 filter pairs have been obtained. If the conditions of §53.30(d)(4) apply, collect at least 10 common samples (filters) in accordance with §53.30(d)(4) and divide each to form the filter pairs.

(b) *Audit samples*. Three audit samples must be obtained from the address given in §53.4(a). The audit samples are 3/4×8-inch glass fiber strips containing known amounts of lead at the following nominal levels: 100 μg/strip; 300 μg/strip; 750 μg/strip. The true amount of lead, in total μg/strip, will be provided with each audit sample.

(c) *Filter analysis*. (1) For both the reference method samples and the audit samples, analyze each filter extract three times in accordance with the reference method analytical procedure. The analysis of replicates should not be performed sequentially, i.e., a single sample should not be analyzed three times in sequence. Calculate the indicated lead concentrations for the reference method samples in µg/m³ for each analysis of each filter. Calculate the indicated total lead amount for the audit samples in µg/strip for each analysis of each strip. Label these test results as R_{1A}, R_{1B}, R_{1C}, R_{2A}, R_{2B}, ..., Q_{1A}, Q_{1B}, Q_{1C}, ..., where R denotes results from the reference method samples; Q denotes results from the audit samples; 1, 2, 3 indicate the filter number, and A, B, C indicate the first, second, and third analysis of each filter, respectively.

(2) For the candidate method samples, analyze each sample filter or filter extract three times and calculate, in accordance with the candidate method, the indicated lead concentrates in µg/m³ for each analysis of each filter. Label these test results as C_{1A}, C_{1B}, C_{2C}, ..., where C denotes results from the candidate method. For candidate methods which provide a direct measurement of lead concentrations without a separable procedure, $C_{1A} = C_{1B} = C_{1C}$, $C_{2A} = C_{2B} = C_{2C}$, etc.

(d) *Average lead concentration*. For the reference method, calculate the average lead concentration for each filter by averaging the concentrations calculated from the three analyses:

Equation 1

$$R_{i\ ave} = \frac{R_{iA} + R_{iB} + R_{iC}}{3}$$

where:

i is the filter number.

(e) *Acceptable filter pairs*. Disregard all filter pairs for which the lead concentration as determined in the previous paragraph (d) of this section by the average of the three reference method determinations, falls outside the range of 0.5 to 4.0 µg/m³. All remaining filter pairs must be subjected to both of the following tests for precision and comparability. At least five filter pairs must be within the 0.5 to 4.0 µg/m³ range for the tests to be valid.

(f) *Test for precision*. (1) Calculate the precision (P) of the analysis (in percent) for each filter and for each method, as the maximum minus the minimum divided by the average of the three concentration values, as follows:

Equation 2

$$P_{Ri} = \frac{R_{i\ max} - R_{i\ min}}{R_{i\ ave}} \text{ x } 100\%$$

or

Equation 3

$$P_{Ci} = \frac{C_{i\ max} - C_{i\ min}}{C_{i\ ave}} \text{ x } 100\%$$

where:

i indicates the filter number.

(2) If any reference method precision value (P_{Ri}) exceeds 15 percent, the precision of the reference method analytical procedure is out of control. Corrective action must be taken to determine the source(s) of imprecision and the reference method determinations must be repeated according to paragraph (c) of this section, or the entire test procedure (starting with paragraph (a) of this section) must be repeated.

(3) If any candidate method precision value (P_{Ci}) exceeds 15 percent, the candidate method fails the precision test.

(4) The candidate method passes this test if all precision values (i.e., all P_{Ri}'s and all P_{Ci}'s) are less than 15 percent.

(g) *Test for accuracy*. (1)(i) For the audit samples calculate the average lead concentration for each strip by averaging the concentrations calculated from the three analyses:

Equation 4

$$Q_{i\ ave} = \frac{Q_{iA} + Q_{iB} + Q_{iC}}{3}$$

where:

i is audit sample number.

(ii) Calculate the percent difference (D_q) between the indicated lead concentration for each audit sample and the true lead concentration (T_q) as follows:

Equation 5

$$D_{qi} = \frac{Q_{i\ ave} - T_{qi}}{T_{qi}} \text{ x } 100\%$$

(2) If any difference value (D_{qi}) exceeds ±5 percent, the accuracy of the

reference method analytical procedure is out of control. Corrective action must be taken to determine the source of the error(s) (e.g., calibration standard discrepancies, extraction problems, etc.) and the reference method and audit sample determinations must be repeated according to paragraph (c) of this section, or the entire test procedure (starting with paragraph (a) of this section) must be repeated.

(h) *Test for comparability.* (1) For each filter pair, calculate all nine possible percent differences (D) between the reference and candidate methods, using all nine possible combinations of the three determinations (A, B, and C) for each method, as:

Equation 6

$$D_{in} = \frac{C_{ij} - R_{ik}}{R_{ik}} \text{ x } 100\%$$

where:

i is the filter number, and n numbers from 1 to 9 for the nine possible difference combinations for the three determinations for each method (j = A, B, C, candidate; k = A, B, C, reference).

(2) If none of the percent differences (D) exceeds ±20 percent, the candidate method passes the test for comparability.

(3) If one or more of the percent differences (D) exceeds ±20 percent, the candidate method fails the test for comparability.

(i) The candidate method must pass both the precision test (paragraph (f) of this section) and the comparability test (paragraph (h) of this section) to qualify for designation as an equivalent method.

§53.34 Test procedure for methods for PM_{10} and $PM_{2.5}$.

(a) *Collocated measurements.* Set up three reference method samplers collocated with three candidate method samplers or analyzers at each of the number of test sites specified in table C–4 of this subpart. At each site, obtain as many sets of simultaneous PM_{10} or $PM_{2.5}$ measurements as necessary (see paragraph (c)(3) of this section), each set consisting of three reference method and three candidate method measurements, all obtained simultaneously. For $PM_{2.5}$ candidate Class II equivalent methods, at least two collocated PM_{10} reference method samplers are also required to obtain $PM_{2.5}/PM_{10}$ ratios for each sample set. Candidate PM_{10} method measurements shall be 24-hour integrated measurements; $PM_{2.5}$ measurements may be either 24- or 48-hour integrated measurements. All collocated measurements in a sample set must cover the same 24- or 48-hour time period. For samplers, retrieve the samples promptly after sample collection and analyze each sample according to the reference method or candidate method, as appropriate, and determine the PM_{10} or $PM_{2.5}$ concentration in µg/m³. If the conditions of §53.30(d)(4) apply, collect sample sets only with the three reference method samplers. Guidance for quality assurance procedures for $PM_{2.5}$ methods is found in section 2.12 of the Quality Assurance Handbook (reference 6 of appendix A to subpart A of this part).

(b) *Sequential samplers.* For sequential samplers, the sampler shall be configured for the maximum number of sequential samples and shall be set for automatic collection of all samples sequentially such that the test samples are collected equally, to the extent possible, among all available sequential channels or utilizing the full available sequential capability.

(c) *Test for comparability and precision.* (1) For each of the measurement sets, calculate the average PM_{10} or $PM_{2.5}$ concentration obtained with the reference method samplers:

Equation 7

$$\overline{R}_j = \frac{\sum_{i=1}^{3} R_{ij}}{3}$$

where:

R denotes results from the reference method;
i is the sampler number; and
j is the set.

(2)(i) For each of the measurement sets, calculate the precision of the reference method PM_{10} or $PM_{2.5}$ measurements as:

Equation 8

$$P_j = \sqrt{\frac{\sum_{i=1}^{3} R_{ij}^2 - \frac{1}{3}\left(\sum_{i=1}^{3} R_{ij}\right)^2}{2}}$$

If the corresponding R_j is below:

80 µg/m^3 for PM_{10} methods.
40 µg/m^3 for 24-hour $PM_{2.5}$ at single test sites for Class I candidate methods.
40 µg/m^3 for 24-hour $PM_{2.5}$ at sites having $PM_{2.5}/PM_{10}$ ratios >0.75.
30 µg/m^3 for 48-hour $PM_{2.5}$ at single test sites for Class I candidate methods.
30 µg/m^3 for 48-hour $PM_{2.5}$ at sites having $PM_{2.5}/PM_{10}$ ratios >0.75.
30 µg/m^3 for 24-hour $PM_{2.5}$ at sites having $PM_{2.5}/PM_{10}$ ratios <0.40.
20 µg/m^3 for 48-hour $PM_{2.5}$ at sites having $PM_{2.5}/PM_{10}$ ratios >0.75.

(ii) Otherwise, calculate the precision of the reference method PM_{10} or $PM_{2.5}$ measurements as:

Equation 9

$$Rp_j = \frac{1}{\overline{R}_j}\sqrt{\frac{\sum_{i=1}^{3} R_{ij}^2 - \frac{1}{3}\left(\sum_{i=1}^{3} R_{ij}\right)^2}{2}} \times 100\%$$

(3) If R_j falls outside the acceptable concentration range specified in table C–4 of this subpart for any set, or if P_j RP_j as applicable, exceeds the value specified in table C–4 of this subpart for any set, that set of measurements shall be discarded. For each site, table C–4 of this subpart specifies the minimum number of sample sets required for various conditions, and § 53.30(b)(5) specifies the $PM_{2.5}/PM_{10}$ ratio requirements applicable to Class II candidate equivalent methods. Additional measurement sets shall be collected and analyzed, as necessary, to provide a minimum of 10 acceptable measurement sets for each test site. If more than 10 measurement sets are collected that meet the above criteria, all such measurement sets shall be used to demonstrate comparability.

(4) For each of the acceptable measurement sets, calculate the average PM_{10} or $PM_{2.5}$ concentration obtained with the candidate method samplers:

Equation 10

$$\overline{C}_j = \frac{\sum_{i=1}^{3} C_{ij}}{3}$$

where:

C denotes results from the candidate method;
i is the sampler number; and
j is the set.

(5) For each site, plot the average PM_{10} or $PM_{2.5}$ measurements obtained with the candidate method (R_j) against the corresponding average PM_{10} or $PM_{2.5}$ measurements obtained with the reference method (R_j). For each site, calculate and record the linear regression slope and intercept, and the correlation coefficient.

(6) If the linear regression parameters calculated under paragraph (c)(5) of this section meet the values specified in table C–4 of this subpart for all test sites, the candidate method passes the test for comparability.

[62 FR 38792, July 19, 1997; 63 FR 7714, Feb. 17, 1998]

TABLE C–1 TO SUBPART C—TEST CONCENTRATION RANGES, NUMBER OF MEASUREMENTS REQUIRED, AND MAXIMUM DISCREPANCY SPECIFICATION

Pollutant	Concentration Range Parts per Million	Simultaneous Measurements Required				Maximum Discrepancy Specification, Parts per Million
		1–hr		24–hr		
		First Set	Second Set	First Set	Second Set	
Ozone	Low 0.06 to 0.10	5	6	....	....	0.02
	Med 0.15 to 0.25	5	6	....	....	.03
	High 0.35 to 0.45	4	6	....	....	.04
	Total	14	18			
Carbon Monoxide	Low 7 to 11	5	6	....	....	1.5
	Med 20 to 30	5	6	....	....	2.0

TABLE C–1 TO SUBPART C—TEST CONCENTRATION RANGES, NUMBER OF MEASUREMENTS REQUIRED, AND MAXIMUM DISCREPANCY SPECIFICATION—Continued

Pollutant	Concentration Range Parts per Million	Simultaneous Measurements Required 1–hr First Set	Simultaneous Measurements Required 1–hr Second Set	Simultaneous Measurements Required 24–hr First Set	Simultaneous Measurements Required 24–hr Second Set	Maximum Discrepancy Specification, Parts per Million
	High 35 to 45	4	6			3.0
	Total	14	18			
Sulfur Dioxide	Low 0.02 to 0.05			3	3	0.02
	Med 0.10 to 0.15			2	3	.03
	High 0.30 to 0.50	7	8	2	2	.04
	Total	7	8	7	8	
Nitrogen Dioxide	Low 0.02 to 0.08			3	3	0.02
	Med 0.10 to 0.20			2	3	.03
	High 0.25 to 0.35			2	2	.03
	Total			7	8	

TABLE C–2 TO SUBPART C—SEQUENCE OF TEST MEASUREMENTS

Measurement	Concentration Range First Set	Concentration Range Second Set
1	Low	Medium
2	High	High
3	Medium	Low
4	High	High
5	Low	Medium
6	Medium	Low
7	Low	Medium
8	Medium	Low
9	High	High
10	Medium	Low
11	High	Medium
12	Low	High
13	Medium	Medium
14	Low	High
15		Low
16		Medium
17		Low
18		High

TABLE C–3 TO SUBPART C—TEST SPECIFICATIONS FOR LEAD METHODS

Concentration range, µg/m^3	0.5–4.0
Minimum number of 24-hr measurements	5
Maximum analytical precision, percent	5
Maximum analytical accuracy, percent	±5
Maximum difference, percent of reference method	±20

TABLE C–4 TO SUBPART C—TEST SPECIFICATIONS FOR PM_{10} AND $PM_{2.5}$ METHODS

Specification	PM_{10}	$PM_{2.5}$ Class I	$PM_{2.5}$ Class II
Acceptable concentration range (R_j), µg/m^3	30–300	10–200	10–200
Minimum number of test sites	2	1	2
Number of candidate method samplers per site	3	3	3
Number of reference method samplers per site	3	3	3
Minimum number of acceptable sample sets per site for PM_{10}:			
$R_j < 80$ µg/m^3	3		
$R_j > 80$ µg/m^3	3		
Total	10		
Minimum number of acceptable sample sets per site for $PM_{2.5}$:			

TABLE C–4 TO SUBPART C—TEST SPECIFICATIONS FOR PM_{10} AND $PM_{2.5}$ METHODS—Continued

Specification	PM_{10}	$PM_{2.5}$	
		Class I	Class II
Single test site for Class I candidate equivalent methods:			
$\bar{R}_j$ < 40 µg/m³ for 24-hr or $\bar{R}_j$ < 30 µg/m³ for 48-hr samples		3	
$\bar{R}_j$ > 40 µg/m³ for 24-hr or $\bar{R}_j$ > 30 µg/m³ for 48-hr samples		3	
Sites at which the $PM_{2.5}/PM_{10}$ ratio must be > 0.75:			
$\bar{R}_j$ < 40 µg/m³ for 24-hr or $\bar{R}_j$ < 30 µg/m³ for 48-hr samples			3
$\bar{R}_j$ > 40 µg/m³ for 24-hr or $\bar{R}_j$ > 30 µg/m³ for 48-hr samples			3
Sites at which the $PM_{2.5}/PM_{10}$ ratio must be < 0.40:			
$\bar{R}_j$ < 30 µg/m³ for 24-hr or $\bar{R}_j$ < 20 µg/m³ for 48-hr samples			3
$\bar{R}_j$ > 30 µg/m³ for 24-hr or $\bar{R}_j$ > 20 µg/m³ for 48-hr samples			3
Total, each site		10	10
Precision of replicate reference method measurements, P_j or RP_j respectively, maximum	5 µg/m³ or 7%	2 µg/m³ or 5%	2 µg/m³ or 5%
Slope of regression relationship	1±0.1	1±0.05	1±0.05
Intercept of regression relationship, µg/m³	0±5	0±1	0±1
Correlation of reference method and candidate method measurements	≥0.97	≥0.97	≥0.97

[62 FR 38792, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

FIGURE C–1 TO SUBPART C—SUGGESTED FORMAT FOR REPORTING TEST RESULTS

Candidate Method☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Reference Method☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Applicant☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

☐ First Set ☐ Second Set ☐ Type ☐ 1 Hour ☐ 24 Hour

Concentration Range		Date	Time	Concentration, ppm		Difference	Table C–1 Spec.	Pass or Fail
				Candidate	Reference			
Low ☐☐☐☐☐ ppm to ☐☐☐☐ ppm1	1							
	2							
	3							
	4							
	5							
	6							
Medium ☐☐☐☐☐ ppm to ☐☐☐☐ ppm1	1							
	2							
	3							
	4							
	5							
	6							
High ☐☐☐☐☐ ppm to ☐☐☐☐ ppm1	1							
	2							
	3							
	4							
	5							
	6							
	7							
	8							
							Total Failures:	

APPENDIX A TO SUBPART C—REFERENCES

(1) American National Standard—Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs, ANSI/ASQC E4-1994. Available from American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202.

Subpart D—Procedures for Testing Performance Characteristics of Methods for PM_{10}

SOURCE: 52 FR 24729, July 1, 1987, unless otherwise noted.

§ 53.40 General provisions.

(a) The test procedures prescribed in this subpart shall be used to test the performance of candidate methods for PM_{10} against the performance specifications given in table D–1. Except as provided in paragraph (b) of this section, a test sampler or samplers representative of the sampler described in the candidate method must exhibit performance better than, or equal to, the specified value for each performance parameter, to satisfy the requirements of this subpart.

(b) For a candidate method using a PM_{10} sampler previously approved as part of a designated PM_{10} method, only the test for precision need be conducted and passed to satisfy the requirements of this subpart. For a candidate method using a PM_{10} sampler inlet previously approved as part of a designated PM_{10} method, the tests for precision and flow rate stability must be conducted and passed to satisfy the requirements of this subpart; the tests for sampling effectiveness and 50 percent cutpoint need not be conducted if suitable rationale is provided to demonstrate that test results submitted for the previously approved method are applicable to the candidate method.

(c) The liquid particle sampling effectiveness and 50 percent cutpoint of a test sampler shall be determined in a wind tunnel using 10 particle sizes and three wind speeds as specified in table D–2. A minimum of 3 replicate measurements of sampling effectiveness shall be required for each of the 30 test conditions for a minimum of 90 test measurements.

(d) For the liquid particle sampling effectiveness parameter, a smooth curve plot shall be constructed of sampling effectiveness (percent) versus aerodynamic particle diameter (μm) for each of the three wind speeds. These plots shall be used to calculate the expected mass concentration for the test sampler, using the procedure in § 53.43(a). The candidate method passes the liquid particle sampling effectiveness test if the expected mass concentration calculated for the test sampler at each wind speed differs by no more than ±10 percent from that predicted for the ''ideal'' sampler.*

(e) For the 50 percent cutpoint parameter, the test result for each wind speed shall be reported as the particle size at which the curve specified in § 53.40(d) crosses the 50 percent effectiveness line. The candidate method passes the 50 percent cutpoint test if the test result at each wind speed falls within 10±0.5 μm.

(f) The solid particle sampling effectiveness of a test sampler shall be determined in a wind tunnel using 25 μm particles at 2 wind speeds as specified in table D–2. A minimum of three replicate measurements of sampling effectiveness for the 25 μm solid particles shall be required at both wind speeds for a minimum of 6 test measurements.

(g) For the solid particle sampling effectiveness parameter, the test result for each wind speed shall be reported as the difference between the average of the replicate sampling effectiveness measurements obtained for the 25 μm solid particles and the average of the replicate measurements obtained for the 25 μm liquid particles. The candidate method passes the solid particle sampling effectiveness test if the test result for each wind speed is less than, or equal to, 5 percent.

(h) The precision and flow rate stability of three identical test samplers shall be determined at a suitable test site by simultaneously sampling the PM_{10} concentration of the atmosphere for 10 periods of 24 hours.

(i) For the precision parameter, the test result for each of the 10 periods of 24 hours shall be calculated using the procedure in § 53.43(c). The candidate method passes the precision test if all of the test results meet the specifications in table D–1.

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*The sampling effectiveness curve for this ''ideal'' sampler is described by column 5 of table D–3 and is based on a model that approximates the penetration of particles into the human respiratory tract. Additional information on this model may be found in a document entitled, ''Particle Collection Criteria for 10 Micrometer Samplers,'' which is available from the Quality Assurance Division (MD–77), Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

(j) For the flow rate stability parameter, the test results for each of the three test samplers and for each of the 10 periods of 24 hours shall be calculated using the procedure in § 53.43(d). The candidate method passes the flow rate stability test if all of the test results meet the specifications in table D–1.

(k) All test data and other documentation obtained from or pertinent to these tests shall be identified, dated, signed by the analyst performing the test, and submitted to EPA.

TABLE D–1—PERFORMANCE SPECIFICATIONS FOR PM$_{10}$ SAMPLERS

Performance parameter	Units	Specification
1. Sampling effectiveness:		
A. Liquid particles	Percent	Such that the expected mass concentration is within ±10 percent of that predicted for the ideal sampler.
B. Solid particles	Percent	Sampling effectiveness is no more than 5 percent above that obtained for liquid particles of same size.
2. 50 Percent cutpoint	µm	10±µ.5 µm aerodynamic diameter.
3. Precision	µg/m^3 or percent	5 µg/m^3 or 7 percent for three collocated samplers.
4. Flow rate stability	Percent	Average flow rate over 24 hours within ±5 percent of initial flow rate; all measured flow rates over 24 hours within ±10 percent of initial flow rate.

§ 53.41 Test conditions.

(a) Set-up and start-up of all test samplers shall be in strict accordance with the operating instructions specified in the manual referred to in § 53.4(b)(3).

(b) If the internal surface or surfaces of the candidate method's sampler inlet on which the particles removed by the inlet are collected is a dry surface (i.e., not normally coated with oil or grease), those surfaces shall be cleaned prior to conducting wind tunnel tests with solid particles.

(c) Once the test sampler or samplers have been set up and the performance tests started, manual adjustment shall be permitted only between test points for the sampling effectiveness and 50 percent cutpoint tests or between test days for the precision and flow rate stability tests. The manual adjustments and any periodic maintenance shall be limited to only those procedures prescribed in the manual referred to in § 53.4(b)(3). The submitted records shall show clearly when any manual adjustment or periodic maintenance was made and shall describe the operations performed.

(d) If a test sampler malfunctions during any of the sampling effectiveness and 50 percent cutpoint tests, that test run shall be repeated. If a test sampler malfunctions during any of the precision and flow rate stability tests, that day's test shall be repeated. A detailed explanation of all malfunctions and the remedial actions taken shall be submitted to EPA with the application.

§ 53.42 Generation of test atmospheres for wind tunnel tests.

(a) A vibrating orifice aerosol generator shall be used to produce monodispersed liquid particles of oleic acid tagged with uranine dye and monodispersed solid particles of ammonium fluoroscein with equivalent aerodynamic diameters as specified in table D–2. The geometric standard deviation for each particle size and type generated shall not exceed 1.1 (for primary particles) and the proportion of multiplets (doublets and triplets) in a test particle atmosphere shall not exceed 10 percent. The particle delivery system shall consist of a blower system and a wind tunnel having a test section of sufficiently large cross-sectional area such that the test sampler, or portion thereof, as installed in the test section for testing, blocks no more than 15 percent of that area. To be acceptable, the blower system must be capable of achieving uniform wind speeds at the speeds specified in table D–2.

TABLE D–2—PARTICLE SIZES AND WIND SPEEDS FOR SAMPLING EFFECTIVENESS TESTS

Particle size (µm) [a]	Wind speed (km/hr)		
	2	8	24
3±0.5	/	/	/
5±0.5	/	/	/
7±0.5	/	/	/

TABLE D–2—PARTICLE SIZES AND WIND SPEEDS FOR SAMPLING EFFECTIVENESS TESTS—Continued

Particle size (µm)[a]	Wind speed (km/hr)		
	2	8	24
9±0.5	*l*	*l*	*l*
10±0.5	*l*	*l*	*l*
11±0.5	*l*	*l*	*l*
13±1.0	*l*	*l*	*l*
15±1.0	*l*	*l*	*l*
20±1.0	*l*	*l*	*l*
25±1.0	*l*	*l*/s	*l*/s

[a]&thnsp≧ Mass median aerodynamic diameter.

l = liquid particle.

s=solid particle.

Number of liquid particle test points (minimum of 3 replicates for each combination of particle size and wind speed): 90.

Number of solid particle test points (minimum of 3 replicates for each combination of particle size and wind speed): 6.

Total number of test points: 96.

(b) The size of the test particles delivered to the test section of the wind tunnel shall be established using the operating parameters of the vibrating orifice aerosol generator and shall be verified during the tests by microscopic examination of samples of the particles collected on glass slides or other suitable substrates. When sizing liquid particles on glass slides, the slides should be pretreated with an oleophobic surfactant and an appropriate flattening factor shall be used in the calculation of aerodynamic diameter. The particle size, as established by the operating parameters of the vibrating orifice aerosol generator, shall be within the tolerance specified in table D–2. The precision of the particle size verification technique shall be 0.5 µm or better, and particle size determined by the verification technique shall not differ by more than 0.5 µm or 10 percent, whichever is higher, from that established by the operating parameters of the vibrating orifice aerosol generator.

(c) The population of multiplets in a test particle atmosphere shall be determined during the tests and shall not exceed 10 percent. Solid particles shall be checked for dryness and evidence of breakage or agglomeration during the microscopic examination. If the solid particles in a test atmosphere are wet or show evidence of significant breakage or agglomeration (µ5 percent), the solid particle test atmosphere is unacceptable for purposes of these tests.

(d) The concentration of particles in the wind tunnel is not critical. However, the cross-sectional uniformity of the particle concentration in the sampling zone of the test section shall be established during the tests using isokinetic samplers. An array of not less than five evenly spaced isokinetic samplers shall be used to determine the particle concentration uniformity in the sampling zone. If the particle concentration measured by any single isokinetic sampler in the sampling zone differs by more than 10 percent from the mean concentration, the particle delivery system is unacceptable in terms of uniformity of particle concentration. The sampling zone shall be a rectangular area having a horizontal dimension not less than 1.2 times the width of the test sampler at its inlet opening and a vertical dimension not less than 25 centimeters. The sampling zone is an area in the test section of the wind tunnel that is horizontally and vertically symmetrical with respect to the test sampler inlet opening.

(e) The wind speed in the wind tunnel shall be determined during the tests using an appropriate technique capable of a precision of 5 percent or better (e.g., hot-wire anemometry). The mean wind speed in the test section of the wind tunnel during the tests shall be within 10 percent of the value specified in table D–2. The wind speed measured at any test point in the test section shall not differ by more than 10 percent from the mean wind speed in the test section. The turbulence intensity (longitudinal component and macroscale) in the test section shall be determined during the tests using an appropriate technique (e.g., hot-wire anemometry).

(f) The accuracy of all flow measurements used to calculate the test atmosphere concentrations and the test results shall be documented to be within ±2 percent, referenced to a primary standard. Any flow measurement corrections shall be clearly shown. All flow measurements shall be given in actual volumetric units.

(g) Schematic drawings of the particle delivery system (wind tunnel and blower system) and other information showing complete procedural details of the test atmosphere generation, verification, and delivery techniques shall be submitted to EPA. All pertinent calculations shall be clearly presented.

§ 53.43 Test procedures.

(a) *Sampling effectiveness*—(1) *Technical definition*. The ratio (expressed as a percentage) of the mass concentration of particles of a given size reaching the sampler filter or filters to the mass concentration of particles of the same size approaching the sampler.

(2) *Test procedure*. (i) Establish a wind speed specified in table D–2 and measure the wind speed and turbulence intensity (longitudinal component and macroscale) at a minimum of 12 test points in a cross-sectional area of the test section of the wind tunnel. The mean wind speed in the test section must be within ±10 percent of the value specified in table D–2 and the variation at any test point in the test section may not exceed 10 percent of the mean.

(ii) Generate particles of a size and type specified in table D–2 using a vibrating orifice aerosol generator. Check for the presence of satellites and adjust the generator as necessary. Calculate the aerodynamic particle size using the operating parameters of the vibrating orifice aerosol generator and record. The calculated aerodynamic diameter must be within the tolerance specified in table D–2.

(iii) Collect a sample of the particles on a glass slide or other suitable substrate at the particle injection point. If a glass slide is used, it should be pretreated with an appropriate oleophobic surfactant when collecting liquid particles. Use a microscopic technique to size a minimum of 25 primary particles in three viewing fields (do not include multiplets). Determine the geometric mean aerodynamic diameter and geometric standard deviation using the bulk density of the particle type (and an appropriate flattening factor for liquid particles if collected on a glass slide). The measured geometric mean aerodynamic diameter must be within 0.5 μm or 10 percent of the aerodynamic diameter calculated from the operating parameters of the vibrating orifice aerosol generator. The geometric standard deviation must not exceed 1.1.

(iv) Determine the population of multiplets (doublets and triplets) in the collected sample by counting a minimum of 100 particles in three viewing fields. The multiplet population of the particle test atmosphere must not exceed 10 percent.

(v) Introduce the particles into the wind tunnel and allow the particle concentration to stabilize.

(vi) Install an array of five or more evenly spaced isokinetic samplers in the sampling zone (see § 53.42(d)) of the wind tunnel. Collect particles on appropriate filters (e.g., glass fiber) over a time period such that the relative error of the measured particle concentration is less than 5 percent. Relative error is defined as (p×100%)/(X), where p is the precision of the fluorometer on the appropriate range, X is the measured concentration, and the units of p and X are the same.

(vii) Determine the quantity of material collected with each isokinetic sampler in the array using a calibrated fluorometer. Calculate and record the mass concentration for each isokinetic sampler as:

$$C_{\mathrm{iso(ij)}} = \frac{\text{mass of material collected with isokinetic sampler}}{\text{sample flow rate} \times \text{sampling time}}$$

where

i = replicate number and j = isokinetic sampler number.

(viii) Calculate and record the mean mass concentration as:

$$C_{iso(i)} = \frac{\sum_{j=1}^{n} C_{iso(ij)}}{n}$$

where
n = total number of isokinetic samplers.

(ix) Calculate and record the coefficient of variation of the mass concentration measurements as:

$$CV_{iso(i)} = \sqrt{\frac{\sum_{j=1}^{n} C^2 iso(ij) - \sum_{j=1}^{n} C_{iso(ij)}{}^2 \big/ n}{n-1}} \Big/ \overline{C}_{iso(i)}$$

If the value of $CV_{iso(i)}$ exceeds 0.10, the particle concentration uniformity is unacceptable and steps (vi) through (ix) must be repeated. If adjustment of the vibrating orifice aerosol generator or changes in the particle delivery system are necessary to achieve uniformity, steps (ii) through (ix) must be repeated. Remove the array of isokinetic samplers from the wind tunnel. NOTE: A single isokinetic sampler, operated at the same nominal flow rate as the test sampler, may be used in place of the array of isokinetic samplers for the determination of particle mass concentration used in the calculation of sampling effectiveness of the test sampler in step (xiii). In this case, the array of isokinetic samplers must be used to demonstrate particle concentration uniformity prior to the replicate measurements of sampling effectiveness.

(x) If a single isokinetic sampler is used, install the sampler in the wind tunnel with the sampler nozzle centered in the sampling zone (see § 53.42(d)). Collect particles on an appropriate filter (e.g., glass fiber) for a time period such that the relative error of the measured concentration (as defined in step (vi)) is less than 5 percent. Determine the quantity of material collected with the isokinetic sampler using a calibrated fluorometer. Calculate and record the mass concentration as $C_{iso(i)}$ as in step vii. Remove the isokinetic sampler from the wind tunnel.

(xi) Install the test sampler (or portion thereof) in the wind tunnel with the sampler inlet opening centered in the sampling zone (see § 53.42(d)). To meet the maximum blockage limit of § 53.42(a) or for convenience, part of the test sampler may be positioned external to the wind tunnel provided that neither the geometry of the sampler nor the length of any connecting tube or pipe is altered. Collect particles on an appropriate filter or filters (e.g., glass fiber) for a time period such that the relative error of the measured concentration (as defined in step (vi)) is less than 5 percent.

(xii) Determine the quantity of material collected with the test sampler using a calibrated fluorometer. Calculate and record the mass concentration as:

$$C_{sam(i)} = \frac{\text{mass of material collected with test sampler}}{\text{sample flow rate} \times \text{sampling time}}$$

where i=replicate number.

(xiii) Calculate and record the sampling effectiveness of the test sampler as:

$$E_{(i)} = \frac{C_{sam(i)}}{C_{iso(i)}} \times 100\%$$

where i = replicate number.

NOTE: If a single isokinetic sampler is used for the determination of particle mass concentration, replace $C_{iso(i)}$ with $C_{iso(i)}$.

(xiv) Remove the test sampler from the wind tunnel. Repeat steps (vi) through (xiii), as appropriate, to obtain a minimum of three replicate measurements of sampling effectiveness.

(xv) Calculate and record the average sampling effectiveness of the test sampler as:

$$\overline{E} = \frac{\sum_{i=1}^{n} E_{(i)}}{n}$$

where n=number of replicates.

(xvi) Calculate and record the coefficient of variation for the replicate sampling effectiveness measurements of the test sampler as:

$$CV_E = \sqrt{\frac{\sum_{i=1}^{n} E^2{}_{(i)} - \left(\sum_{i=1}^{n} E_{(i)}\right)^{2} \Big/ n}{n-1}} \Big/ \overline{E}$$

If the value of CV_E exceeds 0.10, the test run (steps (ii) through (xvi)) must be repeated.

(xvii) Repeat steps i through xvi for each wind speed, particle size, and particle type specified in table D–2.

(xviii) For each of the three wind speeds (nominally 2, 8, and 24 km/hr), correct the liquid particle sampling effectiveness data for the presence of multiplets (doublets and triplets) in the test particle atmospheres.

(xix) For each wind speed, plot the corrected liquid particle sampling effectiveness of the test sampler (E_{corr}) as a function of particle size (d_p) on semi-logarithmic graph paper where d_p is the particle size established by the operating parameters of the vibrating orifice aerosol generator. Construct a smooth curve through the data.

(xx) For each wind speed, calculate the expected mass concentration for the test sampler under the assumed particle size distribution and compare it to the mass concentration predicted for the ideal sampler, as follows:

(A) Extrapolate the upper and lower ends of the corrected liquid particle sampling effectiveness curve to 100 percent and 0 percent, respectively, using smooth curves. Assume that E_{corr} = 100 percent at a particle size of 1.0 µm and E_{corr} = 0 percent at a particle size of 50 µm.

(B) Determine the value of E_{corr} at each of the particle sizes specified in the first column of table D–3. Record each E_{corr} value as a decimal between 0 and 1 in the second column of table D–3.

(C) Multiply the values of E_{corr} in column 2 by the interval mass concentration values in column 3 and enter the products in column 4 of table D–3.

(D) Sum the values in column 4 and enter the total as the expected mass concentration for the test sampler at the bottom of column 4 of table D–3.

(E) Calculate and record the percent difference in expected mass concentration between the test sampler and the ideal sampler as:

$$\Delta C = \frac{C_{sam(exp)} - C_{ideal(exp)}}{C_{ideal(exp)}} \times 100\%$$

where:

$C_{sam(exp)}$ = expected mass concentration for the test sampler, µg/m^3

$C_{ideal(exp)}$ = expected mass concentration for the ideal sampler, µg/m^3 (calculated for the ideal sampler and given at the bottom of column 7 of table D–3.)

(F) The candidate method passes the liquid particle sampling effectiveness test if the Δ C value for each wind speed meets the specification in table D–1.

(xxi) For each of the two wind speeds (nominally 8 and 24 km/hr), calculate the difference between the average sampling effectiveness value for the 25 µm solid particles and the average sampling effectiveness value for the 25 µm liquid particles (uncorrected for multiplets).

(xxii) The candidate method passes the solid particle sampling effectiveness test if each such difference meets the specification in table D–1.

TABLE D–3—EXPECTED MASS CONCENTRATION FOR PM_{10} SAMPLERS

Particle size (um)	Test sampler			Ideal Sampler		
	Sampling effectiveness	Interval mass concentration (µg/m^3)	Expected mass concentration (µg/m^3)	Sampling effectiveness	Interval mass concentration (µg/m^3)	Expected mass concentration (µg/m^3)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
<1.0	1.000	62.813	62.813	1.000	62.813	62.813
1.5		9.554		0.949	9.554	9.067
02.0		2.164		0.942	2.164	2.038
02.5		1.785		0.933	1.785	1.665
03.0		2.084		0.922	2.084	1.921
03.5		2.618		0.909	2.618	2.380
04.0		3.211		0.893	3.211	2.867
04.5		3.784		0.876	3.784	3.315
05.0		4.300		0.857	4.300	3.685
05.5		4.742		0.835	4.742	3.960
06.0		5.105		0.812	5.105	4.145
06.5		5.389		0.786	5.389	4.236
07.0		5.601		0.759	5.601	4.251
07.5		5.746		0.729	5.746	4.189
08.0		5.834		0.697	5.834	4.066
08.5		5.871		0.664	5.871	3.898
09.0		5.864		0.628	5.864	3.683
09.5		5.822		0.590	5.822	3.435
10.0		5.750		0.551	5.750	3.168
10.5		5.653		0.509	5.653	2.877
11.0		8.257		0.465	8.257	3.840
12.0		10.521		0.371	10.521	3.903
13.0		9.902		0.269	9.902	2.664
14.0		9.250		0.159	9.250	1.471
15.0		8.593		0.041	8.593	0.352
16.0		7.948		0.000	7.948	0.000
17.0		7.329		0.000	7.329	0.000
18.0		9.904		0.000	9.904	0.000
20.0		11.366		0.000	11.366	0.000
22.0		9.540		0.000	9.540	0.000
24.0		7.997		0.000	7.997	0.000
26.0		6.704		0.000	6.704	0.000
28.0		5.627		0.000	5.627	0.000
30.0		7.785		0.000	7.785	0.000
35.0		7.800		0.000	7.800	0.000
40.0		5.192		0.000	5.192	0.000
45.0		4.959		0.000	4.959	0.000
		$C_{sam(exp)}$ = D			$C_{ideal(exp)}$ =	143.889

(b) *50 Percent cutpoint*—(1) *Technical definition*. The particle size for which the sampling effectiveness of the sampler is 50 percent.

(2) *Test procedure.* (i) From the corrected liquid particle sampling effectiveness curves for each of the three wind speeds, determine the particle size at which the curve crosses the 50 percent effectiveness line and record as D_{50} on the corresponding sampling effectiveness plot.

(ii) The candidate method passes the 50 percent cutpoint test if the D_{50} value at each wind speed meets the specification in table D–1.

(c) *Precision*—(1) *Technical definition*. The variation in the measured particle concentration among identical samplers under typical sampling conditions.

(2) *Test procedure.* (i) Set up three identical test samplers at the test site in strict accordance with the instructions in the manual referred to in § 53.4(b)(3). Locate the test sampler inlet openings at the same height and between 2 and 4 meters apart. The samplers shall be oriented in a manner that will minimize spatial and wind directional effects on sample collection. Perform a flow calibration for each test sampler in accordance with the instructions given in the instruction manual and/or appendix J to part 50 of this chapter. Set the operating flow rate to the value prescribed in the sampler instruction manual.

NOTE: For candidate equivalent methods, this test may be used to satisfy part of the requirements of subpart C of this chapter. In that case, three reference method samplers are also used at the test site, measurements with the candidate and reference methods are compared as specified in § 53.34, and the test site must meet the requirements of § 53.30(b).

(ii) Measure the PM_{10} concentration of the atmosphere using the three test samplers for 10 periods (test days) of 24 hours each. On each of the 10 test days, measure the initial and final flow rates of each test sampler. On three of the test days, measure the flow rate of each test sampler after 6, 12, and 18 hours of operation. All measurements of flow rate and mass collected must be made in accordance with the procedures prescribed in the sampler instruction manual and/or appendix J to part 50 of this chapter. All measurements of flow rate must be in actual volumetric units. Record the PM_{10} concentration for each sampler and each test day as $C_{(i)(j)}$ where i is the sampler number and j is the test day.

(iii) For each test day, calculate and record the average of the three measured PM_{10} concentrations as $C_{(j)}$ where j is the test day. If $C_{(j)} < 30\ \mu g/m^3$ for any test day, data from that test day are unacceptable and the tests for that day must be repeated.

(iv) Calculate and record the precision for each of the 10 test days as:

$$P_j = \sqrt{\frac{\sum_{i=1}^{3} C^2{}_{(i)(j)} - \left(\sum_{i=1}^{3} C_{(i)(j)}\right)^{2}\!\Big/3}{2}}$$

if $\overline{\mathrm{C}}$j is below 80 μg / m^3, or

$$RP_j = 100\% \times \sqrt{\frac{\sum_{i=1}^{3} C^2{}_{(i)(j)} - \left(\sum_{i=1}^{3} C_{(i)(j)}\right)^{2}\!\Big/3}{2}} \qquad \overline{C}_{(j)}$$

if $\overline{\mathrm{C}}$j is above 80 μg / m^3.

(v) The candidate method passes the precision test if all 10 P_j or RP_j values meet the specifications in table D–1.

(d) *Flow rate stability*—(1) *Technical definition*. Freedom from variation in the operating flow rate of the sampler under typical sampling conditions.

(2) *Test procedure*. (i) For each of the three test samplers and each of the 10 test days of the precision test, record each measured flow rate as $F_{(i)(j)(t)}$, where i is the sampler number, j is the test day, and t is the time of flow rate measurement (t=0, 6, 12, 18, or 24 hours).

(ii) For each sampler and for each test day, calculate and record the average flow rate as:

$$\overline{F}_{(i)(j)} = \frac{\sum_{t=0}^{24} F_{(i)(j)(t)}}{n}$$

where n = number of flow rate measurements during the 24-hour test day.

(iii) For each sampler and for each test day, calculate and record the percent difference between the average flow rate and the initial flow rate as:

$$\Delta F_{(i)(j)} = \frac{\overline{F}_{(i)(j)} - F_{(i)(j)(0)}}{F_{(i)(j)(0)}} \times 100\%$$

where $F_{(i)(j)(0)}$ is the initial flow rate (t=0).

(iv) For each sampler and for each of the 3 test days on which flow measurements were obtained at 6-hour intervals throughout the 24-hour sampling period, calculate and record the percent differences between each measured flow rate and the initial flow rate as:

$$\Delta F_{(i)(j)(t)} = \frac{F_{(i)(j)} - F_{(i)(j)(0)}}{F_{(i)(j)(0)}} \times 100\%$$

where t = 6, 12, 18, or 24 hours.

(v) The candidate method passes the flow rate stability test if all of the $\Delta F_{(i)(j)}$ and $\Delta F_{(i)(j)(t)}$ values meet the specifications in table D–1.

Subpart E—Procedures for Testing Physical (Design) and Performance Characteristics of Reference Methods and Class I Equivalent Methods for $PM_{2.5}$

SOURCE: 62 FR 38799, July 18, 1997, unless otherwise noted.

§ 53.50 General provisions.

(a) This subpart sets forth the specific tests that must be carried out and the test results, evidence, documentation, and other materials that must be provided to EPA to demonstrate that a $PM_{2.5}$ sampler associated with a candidate reference method or Class I equivalent method meets all design and performance specifications set forth in 40 CFR part 50, appendix L, as well as additional requirements specified in this subpart E. Some of these tests may also be applicable to portions of a candidate Class II equivalent method sampler, as determined under subpart F of this part. Some or all of these tests may also be applicable to a candidate Class III equivalent method sampler, as may be determined under § 53.3(a)(4) or § 53.3(b)(3).

(b) Samplers associated with candidate reference methods for $PM_{2.5}$ shall be subject to the provisions, specifications, and test procedures prescribed in §§ 53.51 through 53.58. Samplers associated with candidate Class I equivalent methods for $PM_{2.5}$ shall be subject to the provisions, specifications, and test procedures prescribed in all sections of this subpart. Samplers associated with candidate Class II equivalent methods for $PM_{2.5}$ shall be subject to the provisions, specifications, and test procedures prescribed in all applicable sections of this subpart, as specified in subpart F of this part.

(c) The provisions of § 53.51 pertain to test results and documentation required to demonstrate compliance of a candidate method sampler with the design specifications set forth in 40 CFR part 50, appendix L. The test procedures prescribed in §§ 53.52 through 53.59 pertain to performance tests required to demonstrate compliance of a candidate method sampler with the performance specifications set forth in 40 CFR part 50, appendix L, as well as additional requirements specified in this subpart E. These latter test procedures shall be used to test the performance of candidate samplers against the performance specifications and requirements specified in each procedure and summarized in table E–1 of this subpart.

(d) Test procedures prescribed in § 53.59 do not apply to candidate reference method samplers. These procedures apply primarily to candidate Class I equivalent method samplers for $PM_{2.5}$ which have a sample air flow path configuration upstream of the sample filter that is modified with respect to that specified for the reference method sampler, as set forth in 40 CFR part 50, appendix L, figures L–1 to L–29, such as might be necessary to provide for sequential sample capability. The additional tests determine the adequacy of aerosol transport through any altered components or supplemental devices that are used in a candidate sampler upstream of the sample filter. In addition to the other test procedures in this subpart, these test procedures shall be used to further test the performance of such an equivalent method sampler against the performance specifications given in the procedure and summarized in table E–1 of this subpart.

(e) A 10–day operational field test of measurement precision is required under § 53.58 for both candidate reference and equivalent method samplers. This test requires collocated operation of three candidate method samplers at a field test site. For candidate equivalent method samplers, this test may be combined and carried out concurrently with the test for comparability to the reference method specified under §53.34, which requires collocated operation of three reference method samplers and three candidate equivalent method samplers.

(f) All tests and collection of test data shall be performed in accordance with the requirements of reference 1, section 4.10.5 (ISO 9001) and reference 2, part B, section 3.3.1, paragraphs 1 and 2 and part C, section 4.6 (ANSI/ASQC E4) in appendix A of this subpart. All test data and other documentation obtained specifically from or pertinent to these tests shall be identified, dated, signed by the analyst performing the test, and submitted to EPA in accordance with subpart A of this part.

§53.51 Demonstration of compliance with design specifications and manufacturing and test requirements.

(a) *Overview.* (1) The subsequent paragraphs of this section specify certain documentation that must be submitted and tests that are required to demonstrate that samplers associated with a designated reference or equivalent method for $PM_{2.5}$ are properly manufactured to meet all applicable design and performance specifications and have been properly tested according to all applicable test requirements for such designation. Documentation is required to show that instruments and components of a $PM_{2.5}$ sampler are manufactured in an ISO 9001-registered facility under a quality system that meets ISO-9001 requirements for manufacturing quality control and testing.

(2) In addition, specific tests are required to verify that two critical features of reference method samplers impactor jet diameter and the surface finish of surfaces specified to be anodized meet the specifications of 40 CFR part 50, appendix L. A checklist is required to provide certification by an ISO-certified auditor that all performance and other required tests have been properly and appropriately conducted, based on a reasonable and appropriate sample of the actual operations or their documented records. Following designation of the method, another checklist is required, initially and annually, to provide an ISO-certified auditor's certification that the sampler manufacturing process is being implemented under an adequate and appropriate quality system.

(3) For the purposes of this section, the definitions of ISO 9001-registered facility and ISO-certified auditor are found in §53.1. An exception to the reliance by EPA on ISO-certified auditors is the requirement for the submission of the operation or instruction manual associated with the candidate method to EPA as part of the application. This manual is required under §53.4(b)(3). EPA has determined that acceptable technical judgment for review of this manual may not be assured by ISO-certified auditors, and approval of this manual will therefore be performed by EPA.

(b) *ISO registration of manufacturing facility.* (1) The applicant must submit documentation verifying that the samplers identified and sold as part of a designated $PM_{2.5}$ reference or equivalent method will be manufactured in an ISO 9001-registered facility and that the manufacturing facility is maintained in compliance with all applicable ISO 9001 requirements (reference 1 in appendix A of this subpart). The documentation shall indicate the date of the original ISO 9001 registration for the facility and shall include a copy of the most recent certification of continued ISO 9001 facility registration. If the manufacturer does not wish to initiate or complete ISO 9001 registration for the manufacturing facility, documentation must be included in the application to EPA describing an alternative method to demonstrate that the facility meets the same general requirements as required for registration to ISO-9001. In this case, the applicant must provide documentation in the application to demonstrate, by required ISO-certified auditor's inspections, that a quality system is in place which is adequate to document and monitor that the sampler system components and final assembled samplers all conform to the design, performance and other requirements specified in this part and in 40 CFR part 50, appendix L.

(2) Phase-in period. For a period of 1 year following the effective date of this

subpart, a candidate reference or equivalent method for $PM_{2.5}$ that utilizes a sampler manufactured in a facility that is not ISO 9001-registered or otherwise approved by EPA under paragraph (b)(1) of this section may be conditionally designated as a reference or equivalent method under this part. Such conditional designation will be considered on the basis of evidence submitted in association with the candidate method application showing that appropriate efforts are currently underway to seek ISO 9001 registration or alternative approval of the facility's quality system under paragraph (b)(1) of this section within the next 12 months. Such conditional designation shall expire 1 year after the date of the FEDERAL REGISTER notice of the conditional designation unless documentation verifying successful ISO 9001 registration for the facility or other EPA-acceptable quality system review and approval process of the production facility that will manufacture the samplers is submitted at least 30 days prior to the expiration date.

(c) *Sampler manufacturing quality control.* The manufacturer must ensure that all components used in the manufacture of $PM_{2.5}$ samplers to be sold as part of a reference or equivalent method and that are specified by design in 40 CFR part 50, appendix L, are fabricated or manufactured exactly as specified. If the manufacturer's quality records show that its quality control (QC) and quality assurance (QA) system of standard process control inspections (of a set number and frequency of testing that is less than 100 percent) complies with the applicable QA provisions of section 4 of reference 4 in appendix A of this subpart and prevents nonconformances, 100 percent testing shall not be required until that conclusion is disproved by customer return or other independent manufacturer or customer test records. If problems are uncovered, inspection to verify conformance to the drawings, specifications, and tolerances shall be performed. Refer also to paragraph (e) of this section—final assembly and inspection requirements.

(d) *Specific tests and supporting documentation required to verify conformance to critical component specifications*—(1) *Verification of $PM_{2.5}$ impactor jet diameter.* The diameter of the jet of each impactor manufactured for a $PM_{2.5}$ sampler under the impactor design specifications set forth in 40 CFR part 50, appendix L, shall be verified against the tolerance specified on the drawing, using standard, NIST-traceable ZZ go/no go plug gages. This test shall be a final check of the jet diameter following all fabrication operations, and a record shall be kept of this final check. The manufacturer shall submit evidence that this procedure is incorporated into the manufacturing procedure, that the test is or will be routinely implemented, and that an appropriate procedure is in place for the disposition of units that fail this tolerance test.

(2) *Verification of surface finish.* The anodization process used to treat surfaces specified to be anodized shall be verified by testing treated specimen surfaces for weight and corrosion resistance to ensure that the coating obtained conforms to the coating specification. The specimen surfaces shall be finished in accordance with military standard specification 8625F, Type II, Class I (reference 4 in appendix A of this subpart) in the same way the sampler surfaces are finished, and tested, prior to sealing, as specified in section 4.5.2 of reference 4 in appendix A of this subpart.

(e) *Final assembly and inspection requirements.* Each sampler shall be tested after manufacture and before delivery to the final user. Each manufacturer shall document its post-manufacturing test procedures. As a minimum, each test shall consist of the following: Tests of the overall integrity of the sampler, including leak tests; calibration or verification of the calibration of the flow measurement device, barometric pressure sensor, and temperature sensors; and operation of the sampler with a filter in place over a period of at least 48 hours. The results of each test shall be suitably documented and shall be subject to review by an ISO-certified auditor.

(f) *Manufacturer's audit checklists.* Manufacturers shall require an ISO-certified auditor to sign and date a statement indicating that the auditor is aware of the appropriate manufacturing specifications contained in 40 CFR part 50, appendix L, and the test or verification requirements in this subpart. Manufacturers shall also require an ISO-certified auditor to complete the checklists, shown in figures E–1 and E–2 of this subpart, which describe the manufacturer's ability to meet the requirements of the standard for both designation testing and product manufacture.

(1) *Designation testing checklist.* The completed statement and checklist as shown in figure E–1 of this subpart shall be submitted with the application for reference or equivalent method determination.

(2) *Product manufacturing checklist.* Manufacturers shall require an ISO-certified auditor to complete a Product Manufacturing Checklist (figure E–2 of this subpart), which evaluates the manufacturer on its ability to meet the requirements of the standard in maintaining quality control in the production of reference or equivalent devices. The initial completed checklist shall be submitted with the application for reference or equivalent method determination. Also, this checklist (figure E–2 of this subpart) must be completed and submitted annually to retain a reference or equivalent method designation for a $PM_{2.5}$ method.

(3) *Phase-in period.* If the conditions of paragraph (b)(2) of this section apply, a candidate reference or equivalent method for $PM_{2.5}$ may be conditionally designated as a reference or equivalent method under this part 53 without the submission of the checklists described in paragraphs (f)(1) and (f)(2) of this section. Such conditional designation shall expire 1 year after the date of the FEDERAL REGISTER notice of the conditional designation unless the checklists are submitted at least 30 days prior to the expiration date.

[62 FR 38799, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

§ 53.52 Leak check test.

(a) *Overview.* In section 7.4.6 of 40 CFR part 50, appendix L, the sampler is required to include the facility, including components, instruments, operator controls, a written procedure, and other capabilities as necessary, to allow the operator to carry out a leak test of the sampler at a field monitoring site without additional equipment. This test procedure is intended to test the adequacy and effectiveness of the sampler's leak check facility. Because of the variety of potential sampler configurations and leak check procedures possible, some adaptation of this procedure may be necessary to accommodate the specific sampler under test. The test conditions and performance specifications associated with this test are summarized in table E–1 of this subpart. The candidate test sampler must meet all test parameters and test specifications to successfully pass this test.

(b) *Technical definitions.* (1) External leakage includes the total flow rate of external ambient air which enters the sampler other than through the sampler inlet and which passes through any one or more of the impactor, filter, or flow rate measurement components.

(2) Internal leakage is the total sample air flow rate that passes through the filter holder assembly without passing through the sample filter.

(c) *Required test equipment.* (1) Flow rate measurement device, range 70 mL/min to 130 mL/min, 2 percent certified accuracy, NIST-traceable.

(2) Flow rate measurement adaptor (40 CFR part 50, appendix L, figure L-30) or equivalent adaptor to facilitate measurement of sampler flow rate at the top of the downtube.

(3) Impermeable membrane or disk, 47 mm nominal diameter.

(4) Means, such as a micro-valve, of providing a simulated leak flow rate through the sampler of approximately 80 mL/min under the conditions specified for the leak check in the sampler's leak check procedure.

(5) Teflon sample filter, as specified in section 6 of 40 CFR part 50, appendix L.

(d) *Calibration of test measurement instruments.* Submit documentation showing evidence of appropriately recent calibration, certification of calibration accuracy, and NIST-traceability (if required) of all measurement instruments used in the tests. The accuracy of flow rate meters shall be verified at the highest and lowest pressures and temperatures used in the tests and shall be checked at zero and one or more non-zero flow rates within 7 days of use for this test.

(e) *Test setup.* (1) The test sampler shall be set up for testing as described in the sampler's operation or instruction manual referred to in § 53.4(b)(3). The sampler shall be installed upright and set up in its normal configuration for collecting $PM_{2.5}$ samples, except that the sample air inlet shall be removed and the flow rate measurement adaptor shall be installed on the sampler's downtube.

(2) The flow rate control device shall be set up to provide a constant, controlled flow rate of 80 mL/min into the sampler downtube under the conditions specified for the leak check in the sampler's leak check procedure.

(3) The flow rate measurement device shall be set up to measure the controlled flow rate of 80 mL/min into the sampler downtube under the conditions specified for the leak check in the sampler's leak check procedure.

(f) *Procedure.* (1) Install the impermeable membrane in a filter cassette and install the cassette into the sampler. Carry out the internal leak check procedure as described in the sampler's operation/instruction manual and verify that the leak check acceptance criterion specified in table E–1 of this subpart is met.

(2) Replace the impermeable membrane with a Teflon filter and install the cassette in the sampler. Remove the inlet from the sampler and install the flow measurement adaptor on the sampler's downtube. Close the valve of the adaptor to seal the flow system. Conduct the external leak check procedure as described in the sampler's operation/instruction manual and verify that the leak check acceptance criteria specified in table E–1 of this subpart are met.

(3) Arrange the flow control device, flow rate measurement device, and other apparatus as necessary to provide a simulated leak flow rate of 80 mL/min into the test sampler through the downtube during the specified external leak check procedure. Carry out the external leak check procedure as described in the sampler's operation/instruction manual but with the simulated leak of 80 mL/min.

(g) *Test results.* The requirements for successful passage of this test are:

(1) That the leak check procedure indicates no significant external or internal leaks in the test sampler when no simulated leaks are introduced.

(2) That the leak check procedure properly identifies the occurrence of the simulated external leak of 80 mL/min.

§ 53.53 Test for flow rate accuracy, regulation, measurement accuracy, and cut-off.

(a) *Overview.* This test procedure is designed to evaluate a candidate sampler's flow rate accuracy with respect to the design flow rate, flow rate regulation, flow rate measurement accuracy, coefficient of variability measurement accuracy, and the flow rate cut-off function. The tests for the first four parameters shall be conducted over a 6-hour time period during which reference flow measurements are made at intervals not to exceed 5 minutes. The flow rate cut-off test, conducted separately, is intended to verify that the sampler carries out the required automatic sample flow rate cut-off function properly in the event of a low-flow condition. The test conditions and performance specifications associated with this test are summarized in table E–1 of this subpart. The candidate test sampler must meet all test parameters and test specifications to successfully pass this test.

(b) *Technical definitions.* (1) Sample flow rate means the quantitative volumetric flow rate of the air stream caused by the sampler to enter the sampler inlet and pass through the sample filter, measured in actual volume units at the temperature and pressure of the air as it enters the inlet.

(2) The flow rate cut-off function requires the sampler to automatically stop sample flow and terminate the current sample collection if the sample flow rate deviates by more than the variation limits specified in table E–1 of this subpart (±10 percent from the nominal sample flow rate) for more than 60 seconds during a sample collection period. The sampler is also required to properly notify the operator

with a flag warning indication of the out-of-specification flow rate condition and if the flow rate cut-off results in an elapsed sample collection time of less than 23 hours.

(c) *Required test equipment.* (1) Flow rate meter, suitable for measuring and recording the actual volumetric sample flow rate at the sampler downtube, with a minimum range of 10 to 25 L/min, 2 percent certified, NIST-traceable accuracy. Optional capability for continuous (analog) recording capability or digital recording at intervals not to exceed 30 seconds is recommended. While a flow meter which provides a direct indication of volumetric flow rate is preferred for this test, an alternative certified flow measurement device may be used as long as appropriate volumetric flow rate corrections are made based on measurements of actual ambient temperature and pressure conditions.

(2) Ambient air temperature sensor, with a resolution of 0.1 °C and certified to be accurate to within 0.5 °C (if needed). If the certified flow meter does not provide direct volumetric flow rate readings, ambient air temperature measurements must be made using continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes.

(3) Barometer, range 600 mm Hg to 800 mm Hg, certified accurate to 2 mm Hg (if needed). If the certified flow meter does not provide direct volumetric flow rate readings, ambient pressure measurements must be made using continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes.

(4) Flow measurement adaptor (40 CFR part 50, appendix L, figure L-30) or equivalent adaptor to facilitate measurement of sample flow rate at the sampler downtube.

(5) Valve or other means to restrict or reduce the sample flow rate to a value at least 10 percent below the design flow rate (16.67 L/min). If appropriate, the valve of the flow measurement adaptor may be used for this purpose.

(6) Means for creating an additional pressure drop of 55 mm Hg in the sampler to simulate a heavily loaded filter, such as an orifice or flow restrictive plate installed in the filter holder or a valve or other flow restrictor temporarily installed in the flow path near the filter.

(7) Teflon sample filter, as specified in section 6 of 40 CFR part 50, appendix L (if required).

(d) *Calibration of test measurement instruments.* Submit documentation showing evidence of appropriately recent calibration, certification of calibration accuracy, and NIST-traceability (if required) of all measurement instruments used in the tests. The accuracy of flow-rate meters shall be verified at the highest and lowest pressures and temperatures used in the tests and shall be checked at zero and at least one flow rate within ±3 percent of 16.7 L/min within 7 days prior to use for this test. Where an instrument's measurements are to be recorded with an analog recording device, the accuracy of the entire instrument-recorder system shall be calibrated or verified.

(e) *Test setup.* (1) Setup of the sampler shall be as required in this paragraph (e) and otherwise as described in the sampler's operation or instruction manual referred to in § 53.4(b)(3). The sampler shall be installed upright and set up in its normal configuration for collecting $PM_{2.5}$ samples. A sample filter and (or) the device for creating an additional 55 mm Hg pressure drop shall be installed for the duration of these tests. The sampler's ambient temperature, ambient pressure, and flow rate measurement systems shall all be calibrated per the sampler's operation or instruction manual within 7 days prior to this test.

(2) The inlet of the candidate sampler shall be removed and the flow measurement adaptor installed on the sampler's downtube. A leak check as described in the sampler's operation or instruction manual shall be conducted and must be properly passed before other tests are carried out.

(3) The inlet of the flow measurement adaptor shall be connected to the outlet of the flow rate meter.

(4) For the flow rate cut-off test, the valve or means for reducing sampler flow rate shall be installed between the flow measurement adaptor and the downtube or in another location within the sampler such that the sampler flow

rate can be manually restricted during the test.

(f) *Procedure.* (1) Set up the sampler as specified in paragraph (e) of this section and otherwise prepare the sampler for normal sample collection operation as directed in the sampler's operation or instruction manual. Set the sampler to automatically start a 6-hour sample collection period at a convenient time.

(2) During the 6-hour operational flow rate portion of the test, measure and record the sample flow rate with the flow rate meter at intervals not to exceed 5 minutes. If ambient temperature and pressure corrections are necessary to calculate volumetric flow rate, ambient temperature and pressure shall be measured at the same frequency as that of the certified flow rate measurements. Note and record the actual start and stop times for the 6-hour flow rate test period.

(3) Following completion of the 6-hour flow rate test period, install the flow rate reduction device and change the sampler flow rate recording frequency to intervals of not more than 30 seconds. Reset the sampler to start a new sample collection period. Manually restrict the sampler flow rate such that the sampler flow rate is decreased slowly over several minutes to a flow rate slightly less than the flow rate cut-off value (15.0 L/min). Maintain this flow rate for at least 2.0 minutes or until the sampler stops the sample flow automatically. Manually terminate the sample period, if the sampler has not terminated it automatically.

(g) *Test results.* At the completion of the test, validate the test conditions and determine the test results as follows:

(1) *Mean sample flow rate.* (i) From the certified measurements (Q_{ref}) of the test sampler flow rate obtained by use of the flow rate meter, tabulate each flow rate measurement in units of L/min. If ambient temperature and pressure corrections are necessary to calculate volumetric flow rate, each measured flow rate shall be corrected using its corresponding temperature and pressure measurement values. Calculate the mean flow rate for the sample period ($Q_{ref,ave}$) as follows:

Equation 1

$$Q_{ref,ave} = \frac{\sum_{i=1}^{n} Q_{ref,i}}{n}$$

where:

n equals the number of discrete certified flow rate measurements over the 6-hour test period.

(ii)(A) Calculate the percent difference between this mean flow rate value and the design value of 16.67 L/min, as follows:

Equation 2

$$\%\ \text{Difference} = \frac{Q_{ref,ave} - 16.67}{16.67} \text{ x } 100\%$$

(B) To successfully pass the mean flow rate test, the percent difference calculated in Equation 2 of this paragraph (g)(1)(ii) must be within ±5 percent.

(2) *Sample flow rate regulation.* (i) From the certified measurements of the test sampler flow rate, calculate the sample coefficient of variation (CV) of the discrete measurements as follows:

Equation 3

$$\%CV_{ref} = \frac{1}{Q_{ref,ave}} \text{ x} \sqrt{\frac{\sum_{i=1}^{n} Q_{ref,i}^{2} - \frac{1}{n}\left(\sum_{i-1}^{n} Q_{ref,i}\right)^{2}}{n-1}} \text{ x } 100\%$$

(ii) To successfully pass the flow rate regulation test, the calculated coefficient of variation for the certified flow rates must not exceed 2 percent.

(3) *Flow rate measurement accuracy.* (i) Using the mean volumetric flow rate reported by the candidate test sampler at the completion of the 6-hour test period ($Q_{ind,ave}$), determine the accuracy of the reported mean flow rate as:

Equation 4

$$\%\ \text{Difference} = \frac{|Q_{ind,ave} - Q_{ref,ave}|}{Q_{ref,ave}} \text{ x } 100\%$$

(ii) To successfully pass the flow rate measurement accuracy test, the percent difference calculated in Equation

4 of this paragraph (g)(3) shall not exceed 2 percent.

(4) *Flow rate coefficient of variation measurement accuracy.* (i) Using the flow rate coefficient of variation indicated by the candidate test sampler at the completion of the 6-hour test ($\%CV_{ind}$), determine the accuracy of this reported coefficient of variation as:

Equation 5

$$\text{Difference}\,(\%) = |\%CV_{ind} - \%CV_{ref}|$$

(ii) To successfully pass the flow rate CV measurement accuracy test, the absolute difference in values calculated in Equation 5 of this paragraph (g)(4) must not exceed 0.3 (CV%).

(5) *Flow rate cut-off.* (i) Inspect the measurements of the sample flow rate during the flow rate cut-off test and determine the time at which the sample flow rate decreased to a value less than the cut-off value specified in table E–1 of this subpart. To pass this test, the sampler must have automatically stopped the sample flow at least 30 seconds but not more than 90 seconds after the time at which the sampler flow rate was determined to have decreased to a value less than the cut-off value.

(ii) At the completion of the flow rate cut-off test, download the archived data from the test sampler and verify that the sampler's required Flow-out-of-spec and Incorrect sample period flag indicators are properly set.

§53.54 Test for proper sampler operation following power interruptions.

(a) *Overview.* (1) This test procedure is designed to test certain performance parameters of the candidate sampler during a test period in which power interruptions of various duration occur. The performance parameters tested are:

(i) Proper flow rate performance of the sampler.

(ii) Accuracy of the sampler's average flow rate, CV, and sample volume measurements.

(iii) Accuracy of the sampler's reported elapsed sampling time.

(iv) Accuracy of the reported time and duration of power interruptions.

(2) This test shall be conducted during operation of the test sampler over a continuous 6-hour test period during which the sampler's flow rate shall be measured and recorded at intervals not to exceed 5 minutes. The performance parameters tested under this procedure, the corresponding minimum performance specifications, and the applicable test conditions are summarized in table E–1 of this subpart. Each performance parameter tested, as described or determined in the test procedure, must meet or exceed the associated performance specification to successfully pass this test.

(b) *Required test equipment.* (1) Flow rate meter, suitable for measuring and recording the actual volumetric sample flow rate at the sampler downtube, with a minimum range of 10 to 25 L/min, 2 percent certified, NIST-traceable accuracy. Optional capability for continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes is recommended. While a flow meter which provides a direct indication of volumetric flow rate is preferred for this test, an alternative certified flow measurement device may be used as long as appropriate volumetric flow rate corrections are made based on measurements of actual ambient temperature and pressure conditions.

(2) Ambient air temperature sensor (if needed for volumetric corrections to flow rate measurements), with a resolution of 0.1 °C, certified accurate to within 0.5 °C, and continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes.

(3) Barometer (if needed for volumetric corrections to flow rate measurements), range 600 mm Hg to 800 mm Hg, certified accurate to 2 mm Hg, with continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes.

(4) Flow measurement adaptor (40 CFR part 50, appendix L, figure L-30) or equivalent adaptor to facilitate measurement of sample flow rate at the sampler downtube.

(5) Means for creating an additional pressure drop of 55 mm Hg in the sampler to simulate a heavily loaded filter, such as an orifice or flow restrictive

plate installed in the filter holder or a valve or other flow restrictor temporarily installed in the flow path near the filter.

(6) Teflon sample filter, as specified in section 6 of 40 CFR part 50, appendix L (if required).

(7) Time measurement system, accurate to within 10 seconds per day.

(c) *Calibration of test measurement instruments.* Submit documentation showing evidence of appropriately recent calibration, certification of calibration accuracy, and NIST-traceability (if required) of all measurement instruments used in the tests. The accuracy of flow rate meters shall be verified at the highest and lowest pressures and temperatures used in the tests and shall be checked at zero and at least one flow rate within ±3 percent of 16.7 L/min within 7 days prior to use for this test. Where an instrument's measurements are to be recorded with an analog recording device, the accuracy of the entire instrument-recorder system shall be calibrated or verified.

(d) *Test setup.* (1) Setup of the sampler shall be performed as required in this paragraph (d) and otherwise as described in the sampler's operation or instruction manual referred to in § 53.4(b)(3). The sampler shall be installed upright and set up in its normal configuration for collecting $PM_{2.5}$ samples. A sample filter and (or) the device for creating an additional 55 mm Hg pressure drop shall be installed for the duration of these tests. The sampler's ambient temperature, ambient pressure, and flow measurement systems shall all be calibrated per the sampler's operating manual within 7 days prior to this test.

(2) The inlet of the candidate sampler shall be removed and the flow measurement adaptor installed on the sample downtube. A leak check as described in the sampler's operation or instruction manual shall be conducted and must be properly passed before other tests are carried out.

(3) The inlet of the flow measurement adaptor shall be connected to the outlet of the flow rate meter.

(e) *Procedure.* (1) Set up the sampler as specified in paragraph (d) of this section and otherwise prepare the sampler for normal sample collection operation as directed in the sampler's operation or instruction manual. Set the sampler to automatically start a 6-hour sample collection period at a convenient time.

(2) During the entire 6-hour operational flow rate portion of the test, measure and record the sample flow rate with the flow rate meter at intervals not to exceed 5 minutes. If ambient temperature and pressure corrections are necessary to calculate volumetric flow rate, ambient temperature and pressure shall be measured at the same frequency as that of the certified flow rate measurements. Note and record the actual start and stop times for the 6-hour flow rate test period.

(3) During the 6-hour test period, interrupt the AC line electrical power to the sampler 5 times, with durations of 20 seconds, 40 seconds, 2 minutes, 7 minutes, and 20 minutes (respectively), with not less than 10 minutes of normal electrical power supplied between each power interruption. Record the hour and minute and duration of each power interruption.

(4) At the end of the test, terminate the sample period (if not automatically terminated by the sampler) and download all archived instrument data from the test sampler.

(f) *Test results.* At the completion of the sampling period, validate the test conditions and determine the test results as follows:

(1) *Mean sample flow rate.* (i) From the certified measurements (Q_{ref}) of the test sampler flow rate, tabulate each flow rate measurement in units of L/min. If ambient temperature and pressure corrections are necessary to calculate volumetric flow rate, each measured flow rate shall be corrected using its corresponding temperature and pressure measurement values. Calculate the mean flow rate for the sample period ($Q_{ref,ave}$) as follows:

Equation 6

$$Q_{ref,ave} = \frac{\sum_{i=1}^{n} Q_{ref,i}}{n}$$

where:

n equals the number of discrete certified flow rate measurements over the 6-hour test period, excluding flow rate values obtained during periods of power interruption.

(ii)(A) Calculate the percent difference between this mean flow rate value and the design value of 16.67 L/min, as follows:

Equation 7

$$\% \text{ Difference} = \frac{Q_{ref,ave} - 16.67}{16.67} \text{ x } 100\%$$

(B) To successfully pass this test, the percent difference calculated in Equation 7 of this paragraph (f)(1)(ii) must be within ±5 percent.

(2) *Sample flow rate regulation.* (i) From the certified measurements of the test sampler flow rate, calculate the sample coefficient of variation of the discrete measurements as follows:

Equation 8

$$\%CV_{ref} = \frac{1}{Q_{ref,ave}} \text{ x} \sqrt{\frac{\sum_{i=1}^{n} Q_{ref,i}^2 - \frac{1}{n}\left(\sum_{i-1}^{n} Q_{ref,i}\right)^2}{n-1}} \text{ x } 100\%$$

(ii) To successfully pass this test, the calculated coefficient of variation for the certified flow rates must not exceed 2 percent.

(3) *Flow rate measurement accuracy.* (i) Using the mean volumetric flow rate reported by the candidate test sampler at the completion of the 6-hour test ($Q_{ind,ave}$), determine the accuracy of the reported mean flow rate as:

Equation 9

$$\% \text{ Difference} = \frac{|Q_{ind,ave} - Q_{ref,ave}|}{Q_{ref,ave}} \text{ x } 100\%$$

(ii) To successfully pass this test, the percent difference calculated in Equation 9 of this paragraph (f)(3) shall not exceed 2 percent.

(4) *Flow rate CV measurement accuracy.* (i) Using the flow rate coefficient of variation indicated by the candidate test sampler at the completion of the 6-hour test ($\%CV_{ind}$), determine the accuracy of the reported coefficient of variation as:

Equation 10

$$\text{Difference } (\%) = |\%CV_{ind} - \%CV_{ref}|$$

(ii) To successfully pass this test, the absolute difference in values calculated in Equation 10 of this paragraph (f)(4) must not exceed 0.3 (CV%).

(5) Verify that the sampler properly provided a record and visual display of the correct year, month, day-of-month, hour, and minute with an accuracy of ±2 minutes, of the start of each power interruption of duration greater than 60 seconds.

(6) Calculate the actual elapsed sample time, excluding the periods of electrical power interruption. Verify that the elapsed sample time reported by the sampler is accurate to within ±20 seconds for the 6-hour test run.

(7) Calculate the sample volume as $Q_{ref.ave}$ multiplied by the sample time, excluding periods of power interruption. Verify that the sample volume reported by the sampler is within 2 percent of the calculated sample volume to successfully pass this test.

(8) Inspect the downloaded instrument data from the test sampler and verify that all data are consistent with normal operation of the sampler.

[62 FR 38799, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

§53.55 Test for effect of variations in power line voltage and ambient temperature.

(a) *Overview.* (1) This test procedure is a combined procedure to test various performance parameters under variations in power line voltage and ambient temperature. Tests shall be conducted in a temperature controlled environment over four 6-hour time periods during which reference temperature and flow rate measurements shall be made at intervals not to exceed 5 minutes. Specific parameters to be evaluated at line voltages of 105 and 125 volts and temperatures of −20 °C and =40 °C are as follows:

(i) Sample flow rate.

(ii) Flow rate regulation.

(iii) Flow rate measurement accuracy.

(iv) Coefficient of variability measurement accuracy.

(v) Ambient air temperature measurement accuracy.

(vi) Proper operation of the sampler when exposed to power line voltage and ambient temperature extremes.

(2) The performance parameters tested under this procedure, the corresponding minimum performance specifications, and the applicable test conditions are summarized in table E–1 of this subpart. Each performance parameter tested, as described or determined in the test procedure, must meet or exceed the associated performance specification given. The candidate sampler must meet all specifications for the associated $PM_{2.5}$ method to pass this test procedure.

(b) *Technical definition.* Sample flow rate means the quantitative volumetric flow rate of the air stream caused by the sampler to enter the sampler inlet and pass through the sample filter, measured in actual volume units at the temperature and pressure of the air as it enters the inlet.

(c) *Required test equipment.* (1) Environmental chamber or other temperature-controlled environment or environments, capable of obtaining and maintaining temperatures at −20 °C and =40 °C as required for the test with an accuracy of ±2 °C. The test environment(s) must be capable of maintaining these temperatures within the specified limits continuously with the additional heat load of the operating test sampler in the environment. Henceforth, where the test procedures specify a test or environmental ‘‘chamber,’’ an alternative temperature-controlled environmental area or areas may be substituted, provided the required test temperatures and all other test requirements are met.

(2) Variable voltage AC power transformer, range 100 Vac to 130 Vac, with sufficient current capacity to operate the test sampler continuously under the test conditions.

(3) Flow rate meter, suitable for measuring and recording the actual volumetric sample flow rate at the sampler downtube, with a minimum range of 10 to 25 actual L/min, 2 percent certified, NIST-traceable accuracy. Optional capability for continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes is recommended. While a flow meter which provides a direct indication of volumetric flow rate is preferred for this test, an alternative certified flow measurement device may be used as long as appropriate volumetric flow rate corrections are made based on measurements of actual ambient temperature and pressure conditions.

(4) Ambient air temperature recorder, range −30 °C to =50 °C, with a resolution of 0.1 °C and certified accurate to within 0.5 °C. Ambient air temperature measurements must be made using continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes.

(5) Barometer, range 600 mm Hg to 800 mm Hg, certified accurate to 2 mm Hg. If the certified flow rate meter does not provide direct volumetric flow rate readings, ambient pressure measurements must be made using continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes.

(6) Flow measurement adaptor (40 CFR part 50, appendix L, figure L-30) or equivalent adaptor to facilitate measurement of sampler flow rate at the sampler downtube.

(7) Means for creating an additional pressure drop of 55 mm Hg in the sampler to simulate a heavily loaded filter, such as an orifice or flow restrictive plate installed in the filter holder or a valve or other flow restrictor temporarily installed in the flow path near the filter.

(8) AC RMS voltmeter, accurate to 1.0 volt.

(9) Teflon sample filter, as specified in section 6 of 40 CFR part 50, appendix L (if required).

(d) *Calibration of test measurement instruments.* Submit documentation showing evidence of appropriately recent calibration, certification of calibration accuracy, and NIST-traceability (if required) of all measurement instruments used in the tests. The accuracy of flow rate meters shall be verified at the highest and lowest pressures and temperatures used in the tests and shall be checked at zero and at least one flow rate within ±3 percent of 16.7 L/min within 7 days prior to use for this test. Where an instrument's measurements are to be recorded with an analog recording device, the accuracy of the entire instrument-recorder system shall be calibrated or verified.

(e) *Test setup.* (1) Setup of the sampler shall be performed as required in this paragraph (e) and otherwise as described in the sampler's operation or instruction manual referred to in §53.4(b)(3). The sampler shall be installed upright and set up in the temperature-controlled chamber in its normal configuration for collecting $PM_{2.5}$ samples. A sample filter and (or) the device for creating an additional 55 mm Hg pressure drop shall be installed for the duration of these tests. The sampler's ambient temperature, ambient pressure, and flow measurement systems shall all be calibrated per the sampler's operating manual within 7 days prior to this test.

(2) The inlet of the candidate sampler shall be removed and the flow measurement adaptor installed on the sampler's downtube. A leak check as described in the sampler's operation or instruction manual shall be conducted and must be properly passed before other tests are carried out.

(3) The inlet of the flow measurement adaptor shall be connected to the outlet of the flow rate meter.

(4) The ambient air temperature recorder shall be installed in the test chamber such that it will accurately measure the temperature of the air in the vicinity of the candidate sampler without being unduly affected by the chamber's air temperature control system.

(f) *Procedure.* (1) Set up the sampler as specified in paragraph (e) of this section and otherwise prepare the sampler for normal sample collection operation as directed in the sampler's operation or instruction manual.

(2) The test shall consist of four test runs, one at each of the following conditions of chamber temperature and electrical power line voltage (respectively):

(i) −20 °C ±2 °C and 105 ±1 Vac.

(ii) −20 °C ±2 °C and 125 ±1 Vac.

(iii) =40 °C ±2 °C and 105 ±1 Vac.

(iv) =40 °C ±2 °C and 125 ±1 Vac.

(3) For each of the four test runs, set the selected chamber temperature and power line voltage for the test run. Upon achieving each temperature setpoint in the chamber, the candidate sampler and flow meter shall be thermally equilibrated for a period of at least 2 hours prior to the test run. Following the thermal conditioning time, set the sampler to automatically start a 6-hour sample collection period at a convenient time.

(4) During each 6-hour test period:

(i) Measure and record the sample flow rate with the flow rate meter at intervals not to exceed 5 minutes. If ambient temperature and pressure corrections are necessary to calculate volumetric flow rate, ambient temperature and pressure shall be measured at the same frequency as that of the certified flow rate measurements. Note and record the actual start and stop times for the 6-hour flow rate test period.

(ii) Determine and record the ambient (chamber) temperature indicated by the sampler and the corresponding ambient (chamber) temperature measured by the ambient temperature recorder specified in paragraph (c)(4) of this section at intervals not to exceed 5 minutes.

(iii) Measure the power line voltage to the sampler at intervals not greater than 1 hour.

(5) At the end of each test run, terminate the sample period (if not automatically terminated by the sampler) and download all archived instrument data from the test sampler.

(g) *Test results.* For each of the four test runs, examine the chamber temperature measurements and the power line voltage measurements. Verify that the temperature and line voltage met the requirements specified in paragraph (f) of this section at all times during the test run. If not, the test run is not valid and must be repeated. Determine the test results as follows:

(1) *Mean sample flow rate.* (i) From the certified measurements (Q_{ref}) of the test sampler flow rate, tabulate each flow rate measurement in units of L/min. If ambient temperature and pressure corrections are necessary to calculate volumetric flow rate, each measured flow rate shall be corrected using its corresponding temperature

and pressure measurement values. Calculate the mean flow rate for each sample period ($Q_{ref,ave}$) as follows:

Equation 11

$$Q_{ref,ave} = \frac{\sum_{i=1}^{n} Q_{ref,i}}{n}$$

where:

n equals the number of discrete certified flow rate measurements over each 6-hour test period.

(ii)(A) Calculate the percent difference between this mean flow rate value and the design value of 16.67 L/min, as follows:

Equation 12

$$\%\ \text{Difference} = \frac{Q_{ref,ave} - 16.67}{16.67} \text{ x } 100\%$$

(B) To successfully pass this test, the percent difference calculated in Equation 12 of this paragraph (g)(1)(ii) must be within ±5 percent for each test run.

(2) *Sample flow rate regulation.* (i) From the certified measurements of the test sampler flow rate, calculate the sample coefficient of variation of the discrete measurements as follows:

Equation 13

$$\%CV_{ref} = \frac{1}{Q_{ref,ave}} \text{ x } \sqrt{\frac{\sum_{i=1}^{n} Q_{ref,i}^{2} - \frac{1}{n}\left(\sum_{i-1}^{n} Q_{ref,i}\right)^{2}}{n-1}} \text{ x } 100\%$$

(ii) To successfully pass this test, the calculated coefficient of variation for the certified flow rates must not exceed 2 percent.

(3) *Flow rate measurement accuracy.* (i) Using the mean volumetric flow rate reported by the candidate test sampler at the completion of each 6-hour test ($Q_{ind,ave}$), determine the accuracy of the reported mean flow rate as:

Equation 14

$$\%\ \text{Difference} = \frac{|Q_{ind,ave} - Q_{ref,ave}|}{Q_{ref,ave}} \text{ x } 100\%$$

(ii) To successfully pass this test, the percent difference calculated in Equation 14 of this paragraph (g)(3) shall not exceed 2 percent for each test run.

(4) *Flow rate coefficient of variation measurement accuracy.* (i) Using the flow rate coefficient of variation indicated by the candidate test sampler ($\%CV_{ind}$), determine the accuracy of the reported coefficient of variation as:

Equation 15

$$\text{Difference}\ \% = |\%CV_{ind} - \%CV_{ref}|$$

(ii) To successfully pass this test, the absolute difference calculated in Equation 15 of this paragraph (g)(4) must not exceed 0.3 (CV%) for each test run.

(5) *Ambient temperature measurement accuracy.* (i) Calculate the absolute value of the difference between the mean ambient air temperature indicated by the test sampler and the mean ambient (chamber) air temperature measured with the ambient air temperature recorder as:

Equation 16

$$T_{diff} = |T_{ind,ave} - T_{ref,ave}|$$

where:

$T_{ind,ave}$ = mean ambient air temperature indicated by the test sampler, °C; and

$_{ref,ave}$ = mean ambient air temperature measured by the reference temperature instrument, °C.

(ii) The calculated temperature difference must be less than 2 °C for each test run.

(6) *Sampler functionality.* To pass the sampler functionality test, the following two conditions must both be met for each test run:

(i) The sampler must not shutdown during any portion of the 6-hour test.

(ii) An inspection of the downloaded data from the test sampler verifies that all the data are consistent with normal operation of the sampler.

§ 53.56 Test for effect of variations in ambient pressure.

(a) *Overview.* (1) This test procedure is designed to test various sampler performance parameters under variations in ambient (barometric) pressure. Tests shall be conducted in a pressure-controlled environment over two 6-hour time periods during which reference pressure and flow rate measurements shall be made at intervals not to exceed 5 minutes. Specific parameters to be evaluated at operating pressures of 600 and 800 mm Hg are as follows:

(i) Sample flow rate.

(ii) Flow rate regulation.

(iii) Flow rate measurement accuracy.

(iv) Coefficient of variability measurement accuracy.

(v) Ambient pressure measurement accuracy.

(vi) Proper operation of the sampler when exposed to ambient pressure extremes.

(2) The performance parameters tested under this procedure, the corresponding minimum performance specifications, and the applicable test conditions are summarized in table E–1 of this subpart. Each performance parameter tested, as described or determined in the test procedure, must meet or exceed the associated performance specification given. The candidate sampler must meet all specifications for the associated $PM_{2.5}$ method to pass this test procedure.

(b) *Technical definition.* Sample flow rate means the quantitative volumetric flow rate of the air stream caused by the sampler to enter the sampler inlet and pass through the sample filter, measured in actual volume units at the temperature and pressure of the air as it enters the inlet.

(c) *Required test equipment.* (1) Hypobaric chamber or other pressure-controlled environment or environments, capable of obtaining and maintaining pressures at 600 mm Hg and 800 mm Hg required for the test with an accuracy of 5 mm Hg. Henceforth, where the test procedures specify a test or environmental chamber, an alternative pressure-controlled environmental area or areas may be substituted, provided the test pressure requirements are met. Means for simulating ambient pressure using a closed-loop sample air system may also be approved for this test; such a proposed method for simulating the test pressure conditions may be described and submitted to EPA at the address given in § 53.4(a) prior to conducting the test for a specific individual determination of acceptability.

(2) Flow rate meter, suitable for measuring and recording the actual volumetric sampler flow rate at the sampler downtube, with a minimum range of 10 to 25 L/min, 2 percent certified, NIST-traceable accuracy. Optional capability for continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes is recommended. While a flow meter which provides a direct indication of volumetric flow rate is preferred for this test, an alternative certified flow measurement device may be used as long as appropriate volumetric flow rate corrections are made based on measurements of actual ambient temperature and pressure conditions.

(3) Ambient air temperature recorder (if needed for volumetric corrections to flow rate measurements) with a range −30 °C to =50 °C, certified accurate to within 0.5 °C. If the certified flow meter does not provide direct volumetric flow rate readings, ambient temperature measurements must be made using continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes.

(4) Barometer, range 600 mm Hg to 800 mm Hg, certified accurate to 2 mm Hg. Ambient air pressure measurements must be made using continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes.

(5) Flow measurement adaptor (40 CFR part 50, appendix L, figure L–30) or equivalent adaptor to facilitate measurement of sampler flow rate at the sampler downtube.

(6) Means for creating an additional pressure drop of 55 mm Hg in the sampler to simulate a heavily loaded filter, such as an orifice or flow restrictive plate installed in the filter holder or a valve or other flow restrictor temporarily installed in the flow path near the filter.

(7) Teflon sample filter, as specified in section 6 of 40 CFR part 50, appendix L (if required).

(d) *Calibration of test measurement instruments.* Submit documentation showing evidence of appropriately recent calibration, certification of calibration accuracy, and NIST-traceability (if required) of all measurement instruments used in the tests.

The accuracy of flow rate meters shall be verified at the highest and lowest pressures and temperatures used in the tests and shall be checked at zero and at least one flow rate within ±3 percent of 16.7 L/min within 7 days prior to use for this test. Where an instrument's measurements are to be recorded with an analog recording device, the accuracy of the entire instrument-recorder system shall be calibrated or verified.

(e) *Test setup.* (1) Setup of the sampler shall be performed as required in this paragraph (e) and otherwise as described in the sampler's operation or instruction manual referred to in § 53.4(b)(3). The sampler shall be installed upright and set up in the pressure-controlled chamber in its normal configuration for collecting $PM_{2.5}$ samples. A sample filter and (or) the device for creating an additional 55 mm Hg pressure drop shall be installed for the duration of these tests. The sampler's ambient temperature, ambient pressure, and flow measurement systems shall all be calibrated per the sampler's operating manual within 7 days prior to this test.

(2) The inlet of the candidate sampler shall be removed and the flow measurement adaptor installed on the sampler's downtube. A leak check as described in the sampler's operation or instruction manual shall be conducted and must be properly passed before other tests are carried out.

(3) The inlet of the flow measurement adaptor shall be connected to the outlet of the flow rate meter.

(4) The barometer shall be installed in the test chamber such that it will accurately measure the air pressure to which the candidate sampler is subjected.

(f) *Procedure.* (1) Set up the sampler as specified in paragraph (e) of this section and otherwise prepare the sampler for normal sample collection operation as directed in the sampler's operation or instruction manual.

(2) The test shall consist of two test runs, one at each of the following conditions of chamber pressure:

(i) 600 mm Hg.

(ii) 800 mm Hg.

(3) For each of the two test runs, set the selected chamber pressure for the test run. Upon achieving each pressure setpoint in the chamber, the candidate sampler shall be pressure-equilibrated for a period of at least 30 minutes prior to the test run. Following the conditioning time, set the sampler to automatically start a 6-hour sample collection period at a convenient time.

(4) During each 6-hour test period:

(i) Measure and record the sample flow rate with the flow rate meter at intervals not to exceed 5 minutes. If ambient temperature and pressure corrections are necessary to calculate volumetric flow rate, ambient temperature and pressure shall be measured at the same frequency as that of the certified flow rate measurements. Note and record the actual start and stop times for the 6-hour flow rate test period.

(ii) Determine and record the ambient (chamber) pressure indicated by the sampler and the corresponding ambient (chamber) pressure measured by the barometer specified in paragraph (c)(4) of this section at intervals not to exceed 5 minutes.

(5) At the end of each test period, terminate the sample period (if not automatically terminated by the sampler) and download all archived instrument data for the test run from the test sampler.

(g) *Test results.* For each of the two test runs, examine the chamber pressure measurements. Verify that the pressure met the requirements specified in paragraph (f) of this section at all times during the test. If not, the test run is not valid and must be repeated. Determine the test results as follows:

(1) *Mean sample flow rate.* (i) From the certified measurements (Q_{ref}) of the test sampler flow rate, tabulate each flow rate measurement in units of L/min. If ambient temperature and pressure corrections are necessary to calculate volumetric flow rate, each measured flow rate shall be corrected using its corresponding temperature and pressure measurement values. Calculate the mean flow rate for the sample period ($Q_{ref,ave}$) as follows:

Equation 17

$$Q_{ref,ave} = \frac{\sum_{i=1}^{n} Q_{ref,i}}{n}$$

where:

n equals the number of discrete certified flow measurements over the 6-hour test period.

(ii)(A) Calculate the percent difference between this mean flow rate value and the design value of 16.67 L/min, as follows:

Equation 18

$$\%\ \text{Difference} = \frac{Q_{ref,ave} - 16.67}{16.67} \text{ x } 100\%$$

(B) To successfully pass this test, the percent difference calculated in Equation 18 of this paragraph (g)(1) must be within ±5 percent for each test run.

(2) *Sample flow rate regulation.* (i) From the certified measurements of the test sampler flow rate, calculate the sample coefficient of variation of the discrete measurements as follows:

Equation 19

$$\%CV_{ref} = \frac{1}{Q_{ref,ave}} \text{ x} \sqrt{\frac{\sum_{i=1}^{n} Q_{ref,i}^{2} - \frac{1}{n}\left(\sum_{i-1}^{n} Q_{ref,i}\right)^{2}}{n-1}} \text{ x } 100\%$$

(ii) To successfully pass this test, the calculated coefficient of variation for the certified flow rates must not exceed 2 percent.

(3) *Flow rate measurement accuracy.* (i) Using the mean volumetric flow rate reported by the candidate test sampler at the completion of each 6-hour test ($Q_{ind,ave}$), determine the accuracy of the reported mean flow rate as:

Equation 20

$$\%\ \text{Difference} = \frac{|Q_{ind,ave} - Q_{ref,ave}|}{Q_{ref,ave}} \text{ x } 100\%$$

(ii) To successfully pass this test, the percent difference calculated in Equation 20 of this paragraph (g)(3) shall not exceed 2 percent for each test run.

(4) *Flow rate CV measurement accuracy.* (i) Using the flow rate coefficient of variation indicated by the candidate test sampler at the completion of the 6-hour test ($\%CV_{ind}$), determine the accuracy of the reported coefficient of variation as:

Equation 21

$$\text{Difference}\ (\%) = |\%CV_{ind} - \%CV_{ref}|$$

(ii) To successfully pass this test, the absolute difference in values calculated in Equation 21 of this paragraph (g)(4) must not exceed 0.3 (CV%) for each test run.

(5) *Ambient pressure measurement accuracy.* (i) Calculate the absolute difference between the mean ambient air pressure indicated by the test sampler and the ambient (chamber) air pressure measured with the reference barometer as:

Equation 22

$$P_{diff} = |P_{ind,ave} - P_{ref,ave}|$$

where:

$P_{ind,ave}$ = mean ambient pressure indicated by the test sampler, mm Hg; and

$P_{ref,ave}$ = mean barometric pressure measured by the reference barometer, mm Hg.

(ii) The calculated pressure difference must be less than 10 mm Hg for each test run to pass the test.

(6) *Sampler functionality.* To pass the sampler functionality test, the following two conditions must both be met for each test run:

(i) The sampler must not shut down during any part of the 6-hour tests; and

(ii) An inspection of the downloaded data from the test sampler verifies that all the data are consistent with normal operation of the sampler.

[62 FR 38799, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

§53.57 Test for filter temperature control during sampling and post-sampling periods.

(a) *Overview.* This test is intended to measure the candidate sampler's ability to prevent excessive overheating of the $PM_{2.5}$ sample collection filter (or filters) under conditions of elevated solar insolation. The test evaluates radiative effects on filter temperature during a 4-hour period of active sampling as well as during a subsequent 4-hour non-sampling time period prior to filter retrieval. Tests shall be conducted in an environmental chamber which provides the proper radiant wavelengths and energies to adequately simulate the sun's radiant effects under clear conditions at sea level. For additional guidance on conducting solar radiative tests under controlled conditions, consult military standard specification 810-E (reference 6 in appendix A of this subpart). The performance parameters tested under this procedure, the corresponding minimum performance specifications, and the applicable test conditions are summarized in table E–1 of this subpart. Each performance parameter tested, as described or determined in the test procedure, must meet or exceed the associated performance specification to successfully pass this test.

(b) *Technical definition.* Filter temperature control during sampling is the ability of a sampler to maintain the temperature of the particulate matter sample filter within the specified deviation (5 °C) from ambient temperature during any active sampling period. Post-sampling temperature control is the ability of a sampler to maintain the temperature of the particulate matter sample filter within the specified deviation from ambient temperature during the period from the end of active sample collection of the PM$_{2.5}$ sample by the sampler until the filter is retrieved from the sampler for laboratory analysis.

(c) *Required test equipment.* (1) Environmental chamber providing the means, such as a bank of solar-spectrum lamps, for generating or simulating thermal radiation in approximate spectral content and intensity equivalent to solar insolation of 1000 ±50 W/m^2 inside the environmental chamber. To properly simulate the sun's radiative effects on the sampler, the solar bank must provide the spectral energy distribution and permitted tolerances specified in table E–2 of this subpart. The solar radiation source area shall be such that the width of the candidate sampler shall not exceed one-half the dimensions of the solar bank. The solar bank shall be located a minimum of 76 cm (30 inches) from any surface of the candidate sampler. To meet requirements of the solar radiation tests, the chamber's internal volume shall be a minimum of 10 times that of the volume of the candidate sampler. Air velocity in the region of the sampler must be maintained continuously during the radiative tests at 2.0 ±0.5 m/sec.

(2) Ambient air temperature recorder, range −30 °C to =50 °C, with a resolution of 0.1 °C and certified accurate to within 0.5 °C. Ambient air temperature measurements must be made using continuous (analog) recording capability or digital recording at intervals not to exceed 5 minutes.

(3) Flow measurement adaptor (40 CFR part 50, appendix L, figure L-30) or equivalent adaptor to facilitate measurement of sampler flow rate at the sampler downtube.

(4) Miniature temperature sensor(s), capable of being installed in the sampler without introducing air leakage and capable of measuring the sample air temperature within 1 cm of the center of the filter, downstream of the filter; with a resolution of 0.1 °C, certified accurate to within 0.5 °C, NIST-traceable, with continuous (analog) recording capability or digital recording at intervals of not more than 5 minutes.

(5) Solar radiometer, to measure the intensity of the simulated solar radiation in the test environment, range of 0 to approximately 1500 W/m$^{2.}$ Optional capability for continuous (analog) recording or digital recording at intervals not to exceed 5 minutes is recommended.

(6) Sample filter or filters, as specified in section 6 of 40 CFR part 50, appendix L.

(d) *Calibration of test measurement instruments.* Submit documentation showing evidence of appropriately recent calibration, certification of calibration accuracy, and NIST-traceability (if required) of all measurement instruments used in the tests. The accuracy of flow rate meters shall be verified at the highest and lowest pressures and temperatures used in the tests and shall be checked at zero and at least one flow rate within ±3 percent of 16.7 L/min within 7 days prior to use for this test. Where an instrument's measurements are to be recorded with an analog recording device, the accuracy of the entire instrument-recorder system shall be calibrated or verified.

(e) *Test setup.* (1) Setup of the sampler shall be performed as required in this paragraph (e) and otherwise as described in the sampler's operation or instruction manual referred to in § 53.4(b)(3). The sampler shall be installed upright and set up in the solar radiation environmental chamber in its normal configuration for collecting $PM_{2.5}$ samples (with the inlet installed). The sampler's ambient and filter temperature measurement systems shall be calibrated per the sampler's operating manual within 7 days prior to this test. A sample filter shall be installed for the duration of this test. For sequential samplers, a sample filter shall also be installed in each available sequential channel or station intended for collection of a sequential sample (or at least 5 additional filters for magazine-type sequential samplers) as directed by the sampler's operation or instruction manual.

(2) The miniature temperature sensor shall be temporarily installed in the test sampler such that it accurately measures the air temperature 1 cm from the center of the filter on the downstream side of the filter. The sensor shall be installed such that no external or internal air leakage is created by the sensor installation. The sensor's dimensions and installation shall be selected to minimize temperature measurement uncertainties due to thermal conduction along the sensor mounting structure or sensor conductors. For sequential samplers, similar temperature sensors shall also be temporarily installed in the test sampler to monitor the temperature 1 cm from the center of each filter stored in the sampler for sequential sample operation.

(3) The solar radiant energy source shall be installed in the test chamber such that the entire test sampler is irradiated in a manner similar to the way it would be irradiated by solar radiation if it were located outdoors in an open area on a sunny day, with the radiation arriving at an angle of between 30° and 45° from vertical. The intensity of the radiation received by all sampler surfaces that receive direct radiation shall average 1000 ±50 W/m^2, measured in a plane perpendicular to the incident radiation. The incident radiation shall be oriented with respect to the sampler such that the area of the sampler's ambient temperature sensor (or temperature shield) receives full, direct radiation as it would or could during normal outdoor installation. Also, the temperature sensor must not be shielded or shaded from the radiation by a sampler part in a way that would not occur at other normal insolation angles or directions.

(4) The solar radiometer shall be installed in a location where it measures thermal radiation that is generally representative of the average thermal radiation intensity that the upper portion of the sampler and sampler inlet receive. The solar radiometer shall be oriented so that it measures the radiation in a plane perpendicular to its angle of incidence.

(5) The ambient air temperature recorder shall be installed in the test chamber such that it will accurately measure the temperature of the air in the chamber without being unduly affected by the chamber's air temperature control system or by the radiant energy from the solar radiation source that may be present inside the test chamber.

(f) *Procedure.* (1) Set up the sampler as specified in paragraph (e) of this section and otherwise prepare the sampler for normal sample collection operation as directed in the sampler's operation or instruction manual.

(2) Remove the inlet of the candidate test sampler and install the flow measurement adaptor on the sampler's downtube. Conduct a leak check as described in the sampler's operation or instruction manual. The leak test must be properly passed before other tests are carried out.

(3) Remove the flow measurement adaptor from the downtube and re-install the sampling inlet.

(4) Activate the solar radiation source and verify that the resulting energy distribution prescribed in table E–2 of this subpart is achieved.

(5) Program the test sampler to conduct a single sampling run of 4 continuous hours. During the 4-hour sampling run, measure and record the radiant flux, ambient temperature, and filter temperature (all filter temperatures for sequential samplers) at intervals not to exceed 5 minutes.

(6) At the completion of the 4-hour sampling phase, terminate the sample period, if not terminated automatically by the sampler. Continue to measure and record the radiant flux, ambient temperature, and filter temperature or temperatures for 4 additional hours at intervals not to exceed 5 minutes. At the completion of the 4-hour post-sampling period, discontinue the measurements and turn off the solar source.

(7) Download all archived sampler data from the test run.

(g) *Test results.* Chamber radiant flux control. Examine the continuous record of the chamber radiant flux and verify that the flux met the requirements specified in table E–2 of this subpart at all times during the test. If not, the entire test is not valid and must be repeated.

(1) *Filter temperature measurement accuracy.* (i) For each 4-hour test period, calculate the absolute value of the difference between the mean filter temperature indicated by the sampler (active filter) and the mean filter temperature measured by the reference temperature sensor installed within 1 cm downstream of the (active) filter as:

Equation 23

$$T_{diff,filter} = |T_{ind,filter} - T_{ref,filter}|$$

where:

$T_{ind,filter}$ = mean filter temperature indicated by the test sampler, °C; and

$T_{ref,filter}$ = mean filter temperature measured by the reference temperature sensor, °C.

(ii) To successfully pass the indicated filter temperature accuracy test, the calculated difference between the measured means ($T_{diff,filter}$) must not exceed 2 °C for each 4-hour test period.

(2) *Ambient temperature measurement accuracy.* (i) For each 4-hour test period, calculate the absolute value of the difference between the mean ambient air temperature indicated by the test sampler and the mean ambient air temperature measured by the reference ambient air temperature recorder as:

Equation 24

$$T_{diff,ambient} = |T_{ind,ambient} - T_{ref,ambient}|$$

where:

$T_{ind,ambient}$ = mean ambient air temperature indicated by the test sampler, °C; and

$T_{ref,ambient}$ = mean ambient air temperature measured by the reference ambient air temperature recorder, °C.

(ii) To successfully pass the indicated ambient temperature accuracy test, the calculated difference between the measured means ($T_{diff,ambient}$) must not exceed 2 °C for each 4-hour test period.

(3) *Filter temperature control accuracy.* (i) For each temperature measurement interval over each 4-hour test period, calculate the difference between the filter temperature indicated by the reference temperature sensor and the ambient temperature indicated by the test sampler as:

Equation 25

$$T_{diff} = T_{ref,filter} - T_{ind,ambient}$$

(ii) Tabulate and inspect the calculated differences as a function of time. To successfully pass the indicated filter temperature control test, the calculated difference between the measured values must not exceed 5 °C for any consecutive intervals covering more than a 30–minute time period.

(iii) For sequential samplers, repeat the test calculations for each of the stored sequential sample filters. All stored filters must also meet the 5 °C temperature control test.

[62 FR 38799, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

§ 53.58 Operational field precision and blank test.

(a) *Overview.* This test is intended to determine the operational precision of the candidate sampler during a minimum of 10 days of field operation, using three collocated test samplers. Measurements of $PM_{2.5}$ are made at a test site with all of the samplers and then compared to determine replicate precision. Candidate sequential samplers are also subject to a test for possible deposition of particulate matter on inactive filters during a period of storage in the sampler. This procedure is applicable to both reference and equivalent methods. In the case of equivalent methods, this test may be combined and conducted concurrently with the comparability test for equivalent methods (described in subpart C of this part), using three reference method samplers collocated with three candidate equivalent method samplers and meeting the applicable site and other requirements of subpart C of this part.

(b) *Technical definition.* (1) Field precision is defined as the standard deviation or relative standard deviation of a set of $PM_{2.5}$ measurements obtained concurrently with three or more collocated samplers in actual ambient air field operation.

(2) Storage deposition is defined as the mass of material inadvertently deposited on a sample filter that is stored in a sequential sampler either prior to or subsequent to the active sample collection period.

(c) *Test site.* Any outdoor test site having $PM_{2.5}$ concentrations that are reasonably uniform over the test area and that meet the minimum level requirement of paragraph (g)(2) of this section is acceptable for this test.

(d) *Required facilities and equipment.* (1) An appropriate test site and suitable electrical power to accommodate three test samplers are required.

(2) Teflon sample filters, as specified in section 6 of 40 CFR part 50, appendix L, conditioned and preweighed as required by section 8 of 40 CFR part 50, appendix L, as needed for the test samples.

(e) *Test setup.* (1) Three identical test samplers shall be installed at the test site in their normal configuration for collecting $PM_{2.5}$ samples in accordance with the instructions in the associated manual referred to in § 53.4(b)(3) and should be in accordance with applicable supplemental guidance provided in reference 3 in appendix A of this subpart. The test samplers' inlet openings shall be located at the same height above ground and between 2 and 4 meters apart horizontally. The samplers shall be arranged or oriented in a manner that will minimize the spatial and wind directional effects on sample collection of one sampler on any other sampler.

(2) Each test sampler shall be successfully leak checked, calibrated, and set up for normal operation in accordance with the instruction manual and with any applicable supplemental guidance provided in reference 3 in appendix A of this subpart.

(f) *Test procedure.* (1) Install a conditioned, preweighed filter in each test sampler and otherwise prepare each sampler for normal sample collection. Set identical sample collection start and stop times for each sampler. For sequential samplers, install a conditioned, preweighed specified filter in each available channel or station intended for automatic sequential sample filter collection (or at least 5 additional filters for magazine-type sequential samplers), as directed by the sampler's operation or instruction manual. Since the inactive sequential channels are used for the storage deposition part of the test, they may not be used to collect the active $PM_{2.5}$ test samples.

(2) Collect either a 24-hour or a 48-hour atmospheric $PM_{2.5}$ sample simultaneously with each of the three test samplers.

(3) Following sample collection, retrieve the collected sample from each sampler. For sequential samplers, retrieve the additional stored (blank, unsampled) filters after at least 5 days (120 hours) storage in the sampler if the active samples are 24-hour samples, or after at least 10 days (240 hours) if the active samples are 48-hour samples.

(4) Determine the measured $PM_{2.5}$ mass concentration for each sample in accordance with the applicable procedures prescribed for the candidate method in appendix L, 40 CFR part 50 of this chapter, in the associated manual referred to in § 53.4(b)(3) and in accordance with supplemental guidance in reference 2 in appendix A of this subpart. For sequential samplers, also similarly determine the storage deposition as the net weight gain of each blank, unsampled filter after the 5–day (or 10–day) period of storage in the sampler.

(5) Repeat this procedure to obtain a total of 10 sets of any combination of

24-hour or 48-hour $PM_{2.5}$ measurements over 10 test periods. For sequential samplers, repeat the 5–day (or 10–day) storage test of additional blank filters once for a total of two sets of blank filters.

(g) *Calculations.* (1) Record the $PM_{2.5}$ concentration for each test sampler for each test period as $C_{i,j}$, where i is the sampler number (i = 1,2,3) and j is the test period (j = 1,2, . . . 10).

(2)(i) For each test period, calculate and record the average of the three measured $PM_{2.5}$ concentrations as C_j where j is the test period:

Equation 26

$$C_{ave,j} = \frac{1}{3} x \sum_{i=1}^{3} C_{i,j}$$

(ii) If $C_{ave,j} < 10\ \mu g/m^3$ for any test period, data from that test period are unacceptable, and an additional sample collection set must be obtained to replace the unacceptable data.

(3)(i) Calculate and record the precision for each of the 10 test days as:

Equation 27

$$P_j = \sqrt{\frac{\sum_{i=1}^{3} C_{i,j}^2 - \frac{1}{3}\left(\sum_{i=1}^{3} C_{i,j}\right)^2}{2}}$$

(ii) If $C_{ave,j}$ is below 40 $\mu g/m^3$ for 24-hour measurements or below 30 $\mu g/m^3$ for 48-hour measurements; or

Equation 28

$$RP_j = 100\%\ x\ \frac{1}{C_{ave,j}} \sqrt{\frac{\sum_{i=1}^{3} C_{i,j}^2 - \frac{1}{3}\left(\sum_{i=1}^{3} C_{i,j}\right)^2}{2}}$$

(iii) If $C_{ave,j}$ is above 40 $\mu g/m^3$ for 24-hour measurements or above 30 $\mu g/m^3$ for 48-hour measurements.

(h) *Test results.* (1) The candidate method passes the precision test if all 10 P_j or RP_j values meet the specifications in table E–1 of this subpart.

(2) The candidate sequential sampler passes the blank filter storage deposition test if the average net storage deposition weight gain of each set of blank filters (total of the net weight gain of each blank filter divided by the number of filters in the set) from each test sampler (six sets in all) is less than 50 μg.

§ 53.59 Aerosol transport test for Class I equivalent method samplers.

(a) *Overview.* This test is intended to verify adequate aerosol transport through any modified or air flow splitting components that may be used in a Class I candidate equivalent method sampler such as may be necessary to achieve sequential sampling capability. This test is applicable to all Class I candidate samplers in which the aerosol flow path (the flow path through which sample air passes upstream of sample collection filter) differs from that specified for reference method samplers as specified in 40 CFR part 50, appendix L. The test requirements and performance specifications for this test are summarized in table E–1 of this subpart.

(b) *Technical definitions.* (1) Aerosol transport is the percentage of a laboratory challenge aerosol which penetrates to the active sample filter of the candidate equivalent method sampler.

(2) The active sample filter is the exclusive filter through which sample air is flowing during performance of this test.

(3) A no-flow filter is a sample filter through which no sample air is intended to flow during performance of this test.

(4) A channel is any of two or more flow paths that the aerosol may take, only one of which may be active at a time.

(5) An added component is any physical part of the sampler which is different in some way from that specified for a reference method sampler in 40 CFR part 50, appendix L, such as a device or means to allow or cause the aerosol to be routed to one of several channels.

(c) *Required facilities and test equipment.* (1) Aerosol generation system, as specified in § 53.62(c)(2).

(2) Aerosol delivery system, as specified in § 53.64(c)(2).

(3) Particle size verification equipment, as specified in § 53.62(c)(3).

(4) Fluorometer, as specified in § 53.62(c)(7).

(5) Candidate test sampler, with the inlet and impactor or impactors removed, and with all internal surfaces of added components electroless nickel coated as specified in § 53.64(d)(2).

(6) Filters that are appropriate for use with fluorometric methods (e.g., glass fiber).

(d) *Calibration of test measurement instruments.* Submit documentation showing evidence of appropriately recent calibration, certification of calibration accuracy, and NIST-traceability (if required) of all measurement instruments used in the tests. The accuracy of flow rate meters shall be verified at the highest and lowest pressures and temperatures used in the tests and shall be checked at zero and at least one flow rate within ±3 percent of 16.7 L/min within 7 days prior to use for this test. Where an instrument's measurements are to be recorded with an analog recording device, the accuracy of the entire instrument-recorder system shall be calibrated or verified.

(e) *Test setup.* (1) The candidate test sampler shall have its inlet and impactor or impactors removed. The lower end of the down tube shall be reconnected to the filter holder, using an extension of the downtube, if necessary. If the candidate sampler has a separate impactor for each channel, then for this test, the filter holder assemblies must be connected to the physical location on the sampler where the impactors would normally connect.

(2) The test particle delivery system shall be connected to the sampler downtube so that the test aerosol is introduced at the top of the downtube.

(f) *Test procedure.* (1) All surfaces of the added or modified component or components which come in contact with the aerosol flow shall be thoroughly washed with 0.01 N NaOH and then dried.

(2) Generate aerosol. (i) Generate aerosol composed of oleic acid with a uranine fluorometric tag of 3 ±0.25 µm aerodynamic diameter using a vibrating orifice aerosol generator according to conventions specified in § 53.61(g).

(ii) Check for the presence of satellites and adjust the generator to minimize their production.

(iii) Calculate the aerodynamic particle size using the operating parameters of the vibrating orifice aerosol generator. The calculated aerodynamic diameter must be 3 ±0.25 µm aerodynamic diameter.

(3) Verify the particle size according to procedures specified in § 53.62(d)(4)(i).

(4) Collect particles on filters for a time period such that the relative error of the resulting measured fluorometric concentration for the active filter is less than 5 percent.

(5) Determine the quantity of material collected on the active filter using a calibrated fluorometer. Record the mass of fluorometric material for the active filter as $M_{active\ (i)}$ where i = the active channel number.

(6) Determine the quantity of material collected on each no-flow filter using a calibrated fluorometer. Record the mass of fluorometric material on each no-flow filter as $M_{no\text{-}flow.}$

(7) Using 0.01 N NaOH, wash the surfaces of the added component or components which contact the aerosol flow. Determine the quantity of material collected using a calibrated fluorometer. Record the mass of fluorometric material collected in the wash as $M_{wash.}$

(8) Calculate the aerosol transport as:

Equation 29

$$T_{(i)} = \frac{M_{active}}{M_{active+} M_{wash+} \sum M_{no\text{-}flow}} \text{ x } 100\%$$

where:

i = the active channel number.

(9) Repeat paragraphs (f)(1) through (8) of this section for each channel, making each channel in turn the exclusive active channel.

(g) *Test results.* The candidate Class I sampler passes the aerosol transport test if $T_{(i)}$ is at least 97 percent for each channel.

TABLE E–1 TO SUBPART E—SUMMARY OF TEST REQUIREMENTS FOR REFERENCE AND CLASS I EQUIVALENT METHODS FOR PM$_{2.5}$

Subpart E Procedure	Performance Test	Performance Specification	Test Conditions	Part 50, Appendix L Reference
§ 53.52 Sampler leak check test.	Sampler leak check facility	External leakage: 80 mL/min, max Internal leakage: 80 mL/min, max	Controlled leak flow rate of 80 mL/min	Sec. 7.4.6
§ 53.53 Base flow rate test.	Sample flow rate: 1. Mean 2. Regulation 3. Meas. accuracy 4. CV accuracy 5. Cut-off	1. 16.67 ±5%, L/min 2. 2%, max 3. 2%, max 4. 0.3%, max 5. Flow rate cut-off if flow rate deviates more than 10% from design flow rate for >60±30 seconds	(a) 6-hour normal operational test plus flow rate cut-off test (b) Nominal conditions (c) Additional 55 mm Hg pressure drop to simulate loaded filter (d) Variable flow restriction used for cut-off test	Sec. 7.4.1 Sec. 7.4.2 Sec. 7.4.3 Sec. 7.4.4 Sec. 7.4.5
§ 53.54 Power interruption test.	Sample flow rate: 1. Mean 2. Regulation 3. Meas. accuracy 4. CV accuracy 5. Occurrence time of power interruptions 6. Elapsed sample time 7. Sample volume	1. 16.67±5%, L/min 2. 2%, max 3. 2%, max 4. 0.3%, max 5. ±2 min if >60 seconds 6. ±20 seconds 7. ±2%, max	(a) 6-hour normal operational test (b) Nominal conditions (c) Additional 55 mm Hg pressure drop to simulate loaded filter (d) 6 power interruptions of various durations	Sec. 7.4.1 Sec. 7.4.2 Sec. 7.4.3 Sec. 7.4.5 Sec. 7.4.12 Sec. 7.4.13 Sec. 7.4.15.4 Sec. 7.4.15.5
§ 53.55 Temperature and line voltage effect test.	Sample flow rate: 1. Mean 2. Regulation 3. Meas. accuracy 4. CV accuracy 5. Temperature meas. accuracy 6. Proper operation	1. 16.67±5%, L/min 2. 2 %, max 3. 2 %, max 4. 0.3 %, max 5. 2 °C	(a) 6-hour normal operational test (b) Nominal conditions (c) Additional 55 mm Hg pressure drop to simulate loaded filter (d) Ambient temperature at −20 and +40 °C (e) Line voltage: 105 Vac to 125 Vac	Sec. 7.4.1 Sec. 7.4.2 Sec. 7.4.3 Sec. 7.4.5 Sec. 7.4.8 Sec. 7.4.15.1
§ 53.56 Barometric pressure effect test.	Sample flow rate: 1. Mean 2. Regulation 3. Meas. accuracy 4. CV accuracy 5. Pressure meas. accuracy 6. Proper operation	1. 16.67±5%, L/min 2. 2%, max 3. 2%, max 4. 0.3%, max 5. 10 mm Hg	(a) 6-hour normal operational test (b) Nominal conditions (c) Additional 55 mm Hg pressure drop to simulate loaded filter (d) Barometric pressure at 600 and 800 mm Hg.	Sec. 7.4.1 Sec. 7.4.2 Sec. 7.4.3 Sec. 7.4.5 Sec. 7.4.9
§ 53.57 Filter temperature control test.	1. Filter temp meas. accuracy 2. Ambient temp. meas. accuracy 3. Filter temp control accuracy, sampling and non-sampling	1. 2 °C 2. 2 °C 3. Not more than 5 °C above ambient temp. for more than 30 min	(a) 4-hour simulated solar radiation, sampling (b) 4-hour simulated solar radiation, non-sampling (c) Solar flux of 1000±50W/m^2	Sec. 7.4.8 Sec. 7.4.10 Sec. 7.4.11
§ 53.58 Field precision test.	1. Measurement precision 2. Storage deposition test for sequential samplers	1. P_j <2 μg/m^3 for conc. <40 μg/m^3 (24-hr) or <30 μg/m^3 (48-hr); or RP$_j$ < 5% for conc. >40 μg/m3 (24-hr) or >30 μg/m3 (48-hr) 2. 50 μg, max weight gain	(a) 3 collocated samplers at 1 site for at least 10 days (b) PM$_{2.5}$ conc.≥10 μg/m^3 (c) 24- or 48-hour samples (d) 5- or 10-day storage period for inactive stored filters	Sec. 5.1 Sec. 7.3.5 Sec. 8 Sec. 9 Sec. 10

Subpart E Procedure	Performance Test	Performance Specification	Test Conditions	Part 50, Appendix L Reference
The Following Requirement is Applicable to Candidate Equivalent Methods Only				
§ 53.59 Aerosol transport test.	Aerosol transport	97%, min, for all channels	Determine aerosol transport through any new or modified components with respect to the reference method sampler before the filter for each channel.	

[62 FR 38799, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

TABLE E–2 TO SUBPART E—SPECTRAL ENERGY DISTRIBUTION AND PERMITTED TOLERANCE FOR CONDUCTING RADIATIVE TESTS

Characteristic	Spectral Region			
	Ultraviolet		Visible	Infrared
Bandwidth (μm)	0.28 to 0.32	0.32 to 0.40	0.40 to 0.78	0.78 to 3.00
Irradiance (W/m^2)	5	56	450 to 550	439
Allowed Tolerance	± 35%	±25%	± 10%	±10%

[62 FR 38799, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

FIGURE E–1 TO SUBPART E—DESIGNATION TESTING CHECKLIST

DESIGNATION TESTING CHECKLIST

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Compliance Status: Y = Yes N = No NA = Not applicable/Not available				Verification Comments (Includes documentation of who, what, where, when, why) (Doc. #, Rev. #, Rev. Date)
Verification			Verified by Direct Observation of Process or of Documented Evidence: Performance, Design or Application Spec. Corresponding to Sections of 40 CFR Part 53 or 40 CFR Part 50, Appendix L	
Y	N	NA		
			Performance Specification Tests Sample flow rate coefficient of variation (§ 53.53) (L–7.4.3)	
			Filter temperature control (sampling) (§ 53.57) (L–7.4.10)	
			Elapsed sample time accuracy (§ 53.54) (L–7.4.13)	
			Filter temperature control (post sampling) (§ 53.57) (L–7.4.10)	
			Application Specification Tests	
			Field Precision (§ 53.58) (L–5.1)	
			Meets all Appendix L requirements (part 53, subpart A, § 53.2(a)(3)) (part 53, subpart E, § 53.51(a),(d))	
			Filter Weighing (L–8)	
			Field Sampling Procedure (§ 53.30, .31, .34)	
			Design Specification Tests	
			Filter (L–6)	
			Range of Operational Conditions (L–7.4.7)	
The Following Requirements Apply Only to Class I Candidate Equivalent Methods				
			Aerosol Transport (§ 53.59)	

FIGURE E–2 TO SUBPART E—PRODUCT MANUFACTURING CHECKLIST

PRODUCT MANUFACTURING CHECKLIST

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Auditee Auditor signature Date

Compliance Status: Y = Yes N = No NA = Not applicable/Not available				Verification Comments (Includes documentation of who, what, where, when, why) (Doc. #, Rev. #, Rev. Date)
Verification			Verified by Direct Observation of Process or of Documented Evidence: Performance, Design or Application Spec. Corresponding to Sections of 40 CFR Part 53 or 40 CFR Part 50, Appendix L	
Y	N	NA		
			Performance Specification Tests	
			Assembled operational performance (Burn-in test) (§ 53.53)	
			Sample flow rate (§ 53.53) (L–7.4.1, L–7.4.2)	
			Sample flow rate regulation (§ 53.53) (L–7.4.3)	
			Flow rate and average flow rate measurement accuracy (§ 53.53) (L–7.4.5)	
			Ambient air temperature measurement accuracy (§ 53.55) (L–7.4.8)	
			Ambient barometric pressure measurement accuracy (§ 53.56) (L–7.4.9)	
			Sample flow rate cut-off (§ 53.53) (L–7.4.4)	
			Sampler leak check facility (§ 53.52) (L–7.4.6)	
			Application Specification Tests	
			Flow rate calibration transfer standard (L-9.2)	
			Operational /Instructional manual (L-7.4.18)	
			Design Specification Tests	
			Impactor (jet width) (§ 53.51(d)(1)) (L-7.3.4.1)	
			Surface finish (§ 53.51(d)(2)) (L-7.3.7)	

APPENDIX A TO SUBPART E—REFERENCES

(1) Quality systems—Model for quality assurance in design, development, production, installation and servicing, ISO 9001. July 1994. Available from American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202.

(2) American National Standard—Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs. ANSI/ASQC E4-1994. January 1995. Available from American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202.

(3) Copies of section 2.12 of the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Specific Methods, EPA/600/R-94/038b, are available from Department E (MD-77B), U.S. EPA, Research Triangle Park, NC 27711.

(4) Military standard specification (mil. spec.) 8625F, Type II, Class 1 as listed in Department of Defense Index of Specifications and Standards (DODISS), available from DODSSP-Customer Service, Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 1911-5094.

(5) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements. Revised March, 1995. EPA-600/R-94-038d. Available from U.S. EPA, ORD Publications Office, Center for Environmental Research Information (CERI), 26 West Martin Luther King Drive, Cincinnati, Ohio 45268-1072 (513-569-7562).

(6) Military standard specification (mil. spec.) 810-E as listed in Department of Defense Index of Specifications and Standards (DODISS), available from DODSSP-Customer Service, Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 1911-5094.

Subpart F—Procedures for Testing Performance Characteristics of Class II Equivalent Methods for $PM_{2.5}$

SOURCE: 62 FR 38814, July 18, 1997, unless otherwise noted.

§ 53.60 General provisions.

(a) This subpart sets forth the specific requirements that a $PM_{2.5}$ sampler associated with a candidate Class II equivalent method must meet to be designated as an equivalent method for $PM_{2.5}$. This subpart also sets forth the explicit test procedures that must be carried out and the test results, evidence, documentation, and other materials that must be provided to EPA to demonstrate that a sampler meets all specified requirements for designation as an equivalent method.

(b) A candidate method described in an application for a reference or equivalent method application submitted under § 53.4 shall be determined by the EPA to be a Class II candidate equivalent method on the basis of the definition of a Class II equivalent method given in § 53.1.

(c) Any sampler associated with a Class II candidate equivalent method (Class II sampler) must meet all requirements for reference method samplers and Class I equivalent method samplers specified in subpart E of this part, as appropriate. In addition, a Class II sampler must meet the additional requirements as specified in paragraph (d) of this section.

(d) Except as provided in paragraphs (d) (1), (2), and (3) of this section, all Class II samplers are subject to the additional tests and performance requirements specified in § 53.62 (full wind tunnel test), § 53.65 (loading test), and § 53.66 (volatility test). Alternative tests and performance requirements, as described in paragraphs (d)(1), (2), and (3) of this section, are optionally available for certain Class II samplers which meet the requirements for reference method or Class I samplers given in 40 CFR part 50, appendix L, and in subpart E of this part, except for specific deviations of the inlet, fractionator, or filter.

(1) *Inlet deviation.* A sampler which has been determined to be a Class II sampler solely because the design or construction of its inlet deviates from the design or construction of the inlet specified in 40 CFR part 50, appendix L, for reference method samplers shall not be subject to the requirements of § 53.62 (full wind tunnel test), provided that it meets all requirements of § 53.63 (wind tunnel inlet aspiration test), § 53.65 (loading test), and § 53.66 (volatility test).

(2) *Fractionator deviation.* A sampler which has been determined to be a Class II sampler solely because the design or construction of its particle size fractionator deviates from the design or construction of the particle size fractionator specified in 40 CFR part 50, appendix L for reference method samplers shall not be subject to the requirements of § 53.62 (full wind tunnel test), provided that it meets all requirements of § 53.64 (static fractionator test), § 53.65 (loading test), and § 53.66 (volatility test).

(3) *Filter size deviation.* A sampler which has been determined to be a Class II sampler solely because its effective filtration area deviates from that of the reference method filter specified in 40 CFR part 50, appendix L, for reference method samplers shall not be subject to the requirements of § 53.62 (full wind tunnel test) nor § 53.65 (loading test), provided it meets all requirements of § 53.66 (volatility test).

(e) *The test specifications and acceptance criteria for each test are summarized in table F–1 of this subpart.* The candidate sampler must demonstrate performance that meets the acceptance criteria for each applicable test to be designated as an equivalent method.

(f) *Overview of various test procedures for Class II samplers*—(1) *Full wind tunnel test.* This test procedure is designed to ensure that the candidate sampler's effectiveness (aspiration of an ambient aerosol and penetration of the sub 2.5-micron fraction to its sample filter) will be comparable to that of a reference method sampler. The candidate sampler is challenged at wind speeds of 2 and 24 km/hr with monodisperse aerosols of the size specified in table F–2 of this subpart. The experimental test results are then integrated with three idealized ambient distributions (typical, fine, and coarse) to yield the expected mass concentration measurement for each. The acceptance criteria are based on the results of this numerical analysis and the particle diameter for which the sampler effectiveness is 50 percent.

(2) *Wind tunnel inlet aspiration test.* The wind tunnel inlet aspiration test directly compares the inlet of the candidate sampler to the inlet of a reference method sampler with the single-sized, liquid, monodisperse challenge aerosol specified in table F–2 of this subpart at wind speeds of 2 km/hr and 24 km/hr. The acceptance criteria, presented in table F–1 of this subpart, is based on the relative aspiration between the candidate inlet and the reference method inlet.

(3) *Static fractionator test.* The static fractionator test determines the effectiveness of the candidate sampler's 2.5-micron fractionator under static conditions for aerosols of the size specified in table F–2 of this subpart. The numerical analysis procedures and acceptance criteria are identical to those in the full wind tunnel test.

(4) *Loading test.* The loading test is conducted to ensure that the performance of a candidate sampler is not significantly affected by the amount of particulate deposited on its interior surfaces between periodic cleanings. The candidate sampler is artificially loaded by sampling a test environment containing aerosolized, standard test dust. The duration of the loading phase is dependent on both the time between cleaning as specified by the candidate method and the aerosol mass concentration in the test environment. After loading, the candidate's performance must then be evaluated by § 53.62 (full wind tunnel evaluation), § 53.64 (wind tunnel inlet aspiration test), or § 53.64 (static fractionator test). If the results of the appropriate test meet the criteria presented in table F–1 of this subpart, then the candidate sampler passes the loading test under the condition that it be cleaned at least as often as the cleaning frequency proposed by the candidate method and that has been demonstrated to be acceptable by this test.

(5) *Volatility test.* The volatility test challenges the candidate sampler with a polydisperse, semi-volatile liquid aerosol. This aerosol is simultaneously sampled by the candidate method sampler and a reference method sampler for a specified time period. Clean air is then passed through the samplers during a blow-off time period. Residual mass is then calculated as the weight of the filter after the blow-off phase is subtracted from the initial weight of the filter. Acceptance criteria are based on a comparison of the residual mass measured by the candidate sampler (corrected for flow rate variations from that of the reference method) to the residual mass measured by the reference method sampler for several specified clean air sampling time periods.

(g) *Test data.* All test data and other documentation obtained from or pertinent to these tests shall be identified, dated, signed by the analyst performing the test, and submitted to EPA as part of the equivalent method application. Schematic drawings of each particle delivery system and other information showing complete procedural details of the test atmosphere generation, verification, and delivery techniques for each test performed shall be submitted to EPA. All pertinent calculations shall be clearly presented. In addition, manufacturers are required to submit as part of the application, a Designation Testing Checklist (Figure F–1 of this subpart) which has been completed and signed by an ISO-certified auditor.

§ 53.61 Test conditions for $PM_{2.5}$ reference method equivalency.

(a) *Sampler surface preparation.* Internal surfaces of the candidate sampler shall be cleaned and dried prior to performing any Class II sampler test in this subpart. The internal collection surfaces of the sampler shall then be prepared in strict accordance with the operating instructions specified in the sampler's operating manual referred to in section 7.4.18 of 40 CFR part 50, appendix L.

(b) *Sampler setup.* Set up and start up of all test samplers shall be in strict accordance with the operating instructions specified in the manual referred to in section 7.4.18 of 40 CFR part 50, appendix L, unless otherwise specified within this subpart.

(c) *Sampler adjustments.* Once the test sampler or samplers have been set up and the performance tests started, manual adjustment shall be permitted only between test points for all applicable tests. Manual adjustments and any periodic maintenance shall be limited to only those procedures prescribed in the manual referred to in section 7.4.18 of 40 CFR part 50, appendix L. The submitted records shall clearly indicate when any manual adjustment or periodic maintenance was made and shall describe the operations performed.

(d) *Sampler malfunctions.* If a test sampler malfunctions during any of the applicable tests, that test run shall be repeated. A detailed explanation of all malfunctions and the remedial actions taken shall be submitted as part of the equivalent method application.

(e) *Particle concentration measurements.* All measurements of particle concentration must be made such that the relative error in measurement is less than 5.0 percent. Relative error is defined as (s × 100 percent)/(X), where s is the sample standard deviation of the particle concentration detector, X is the measured concentration, and the units of s and X are identical.

(f) *Operation of test measurement equipment.* All test measurement equipment shall be set up, calibrated, and maintained by qualified personnel according to the manufacturer's instructions. All appropriate calibration information and manuals for this equipment shall be kept on file.

(g) *Vibrating orifice aerosol generator conventions.* This section prescribes conventions regarding the use of the vibrating orifice aerosol generator (VOAG) for the size-selective performance tests outlined in §§53.62, 53.63, 53.64, and 53.65.

(1) *Particle aerodynamic diameter.* The VOAG produces near-monodisperse droplets through the controlled breakup of a liquid jet. When the liquid solution consists of a non-volatile solute dissolved in a volatile solvent, the droplets dry to form particles of near-monodisperse size.

(i) The physical diameter of a generated spherical particle can be calculated from the operating parameters of the VOAG as:

Equation 1

$$D_p = \left(\frac{6\ \mathrm{Q}\ \mathrm{C}_{vol}}{\pi\ \mathrm{f}} \right)^{1/3}$$

where:

D_p = particle physical diameter, µm;

Q = liquid volumetric flow rate, μm^3/sec;

C_{vol} = volume concentration (particle volume produced per drop volume), dimensionless; and

f = frequency of applied vibrational signal, 1/sec.

(ii) A given particle's aerodynamic behavior is a function of its physical particle size, particle shape, and density. Aerodynamic diameter is defined as the diameter of a unit density (ρ_o = 1g/cm^3) sphere having the same settling velocity as the particle under consideration. For converting a spherical particle of known density to aerodynamic diameter, the governing relationship is:

Equation 2

$$D_{ae} = \frac{\sqrt{\rho_p}\sqrt{C_{D_p}}\,D_p}{\sqrt{\rho_o}\sqrt{C_{D_{ae}}}}$$

where:

D_{ae} = particle aerodynamic diameter, µm;

ρ_p = particle density, g/cm^3;

ρ_o = aerodynamic particle density = 1 g/cm^3;

C_{Dp} = Cunningham's slip correction factor for physical particle diameter, dimensionless; and

C_{Dae} = Cunningham's slip correction factor for aerodynamic particle diameter, dimensionless.

(iii) At room temperature and standard pressure, the Cunningham's slip correction factor is solely a function of particle diameter:

Equation 3

$$C_{Dae} = 1 + \frac{0.1659}{D_{ae}} + \frac{0.053}{D_{ae}}\ \exp\left(-8.33\ \mathrm{D}_{ae}\right)$$

or

Equation 4

$$C_{D_p} = 1 + \frac{0.1659}{D_p} + \frac{0.053}{D_p} \exp\left(-8.33\ D_p\right)$$

(iv) Since the slip correction factor is itself a function of particle diameter, the aerodynamic diameter in equation 2 of paragraph (g)(1)(ii) of this section cannot be solved directly but must be determined by iteration.

(2) *Solid particle generation*. (i) Solid particle tests performed in this subpart shall be conducted using particles composed of ammonium fluorescein. For use in the VOAG, liquid solutions of known volumetric concentration can be prepared by diluting fluorescein powder ($C_20H_{12}O_5$, FW = 332.31, CAS 2321-07-5) with aqueous ammonia. Guidelines for preparation of fluorescein solutions of the desired volume concentration (C_{vol}) are presented by Vanderpool and Rubow (1988) (Reference 2 in appendix A of this subpart). For purposes of converting particle physical diameter to aerodynamic diameter, an ammonium fluorescein density of 1.35 g/cm^3 shall be used.

(ii) Mass deposits of ammonium fluorescein shall be extracted and analyzed using solutions of 0.01 N ammonium hydroxide.

(3) *Liquid particle generation*. (i) Tests prescribed in § 53.63 for inlet aspiration require the use of liquid particle tests composed of oleic acid tagged with uranine to enable subsequent fluorometric quantitation of collected aerosol mass deposits. Oleic acid ($C_{18}H_{34}O_2$, FW = 282.47, CAS 112-80-1) has a density of 0.8935 g/cm^3. Because the viscosity of oleic acid is relatively high, significant errors can occur when dispensing oleic acid using volumetric pipettes. For this reason, it is recommended that oleic acid solutions be prepared by quantifying dispensed oleic acid gravimetrically. The volume of oleic acid dispensed can then be calculated simply by dividing the dispensed mass by the oleic acid density.

(ii) Oleic acid solutions tagged with uranine shall be prepared as follows. A known mass of oleic acid shall first be diluted using absolute ethanol. The desired mass of the uranine tag should then be diluted in a separate container using absolute ethanol. Uranine ($C_{20}H_{10}O_5Na_2$, FW = 376.3, CAS 518-47-8) is the disodium salt of fluorescein and has a density of 1.53 g/cm^3. In preparing uranine tagged oleic acid particles, the uranine content shall not exceed 20 percent on a mass basis. Once both oleic acid and uranine solutions are properly prepared, they can then be combined and diluted to final volume using absolute ethanol.

(iii) Calculation of the physical diameter of the particles produced by the VOAG requires knowledge of the liquid solution's volume concentration (C_{vol}). Because uranine is essentially insoluble in oleic acid, the total particle volume is the sum of the oleic acid volume and the uranine volume. The volume concentration of the liquid solution shall be calculated as:

Equation 5

$$C_{vol} = \frac{V_u + V_{oleic}}{V_{sol}} = \frac{\left(M_u/\rho_u\right) + \left(M_{oleic}/\rho_{oleic}\right)}{V_{sol}}$$

where:

V_u = uranine volume, ml;
V_{oleic} = oleic acid volume, ml;
V_{sol} = total solution volume, ml;
M_u = uranine mass, g;
ρ_u = uranine density, g/cm^3;
M_{oleic} = oleic acid mass, g; and
ρ_{oleic} = oleic acid density, g/cm^3.

(iv) For purposes of converting the particles' physical diameter to aerodynamic diameter, the density of the generated particles shall be calculated as:

Equation 6

$$\rho_p = \frac{M_u + M_{oleic}}{\left(M_u/\rho_u\right) + \left(M_{oleic}/\rho_{oleic}\right)}$$

(v) Mass deposits of oleic acid shall be extracted and analyzed using solutions of 0.01 N sodium hydroxide.

[62 FR 38814, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

§ 53.62 Test procedure: Full wind tunnel test.

(a) *Overview*. The full wind tunnel test evaluates the effectiveness of the candidate sampler at 2 km/hr and 24 km/hr for aerosols of the size specified in table F–2 of this subpart (under the heading, ‘‘Full Wind Tunnel Test’’). For each wind speed, a smooth curve is fit to the effectiveness data and corrected for the presence of multiplets in the wind tunnel calibration aerosol. The cutpoint diameter (D_{p50}) at each wind speed is then determined from the corrected effectiveness curves. The two resultant penetration curves are then each numerically integrated with three idealized ambient particle size distributions to provide six estimates of measured mass concentration. Critical parameters for these idealized distributions are presented in table F–3 of this subpart.

(b) *Technical definitions.* Effectiveness is the ratio (expressed as a percentage) of the mass concentration of particles of a specific size reaching the sampler filter or filters to the mass concentration of particles of the same size approaching the sampler.

(c) *Facilities and equipment required*—(1) *Wind tunnel.* The particle delivery system shall consist of a blower system and a wind tunnel having a test section of sufficiently large cross-sectional area such that the test sampler, or portion thereof, as installed in the test section for testing, blocks no more than 15 percent of the test section area. The wind tunnel blower system must be capable of maintaining uniform wind speeds at the 2 km/hr and 24 km/hr in the test section.

(2) *Aerosol generation system.* A vibrating orifice aerosol generator shall be used to produce monodisperse solid particles of ammonium fluorescein with equivalent aerodynamic diameters as specified in table F–2 of this subpart. The geometric standard deviation for each particle size generated shall not exceed 1.1 (for primary particles) and the proportion of multiplets (doublets and triplets) in all test particle atmosphere shall not exceed 10 percent of the particle population. The aerodynamic particle diameter, as established by the operating parameters of the vibrating orifice aerosol generator, shall be within the tolerance specified in table F–2 of this subpart.

(3) *Particle size verification equipment.* The size of the test particles shall be verified during this test by use of a suitable instrument (e.g., scanning electron microscope, optical particle sizer, time-of-flight apparatus). The instrument must be capable of measuring solid and liquid test particles with a size resolution of 0.1 µm or less. The accuracy of the particle size verification technique shall be 0.15 µm or better.

(4) *Wind speed measurement.* The wind speed in the wind tunnel shall be determined during the tests using an appropriate technique capable of a precision of 2 percent and an accuracy of 5 percent or better (e.g., hot-wire anemometry). For the wind speeds specified in table F–2 of this subpart, the wind speed shall be measured at a minimum of 12 test points in a cross-sectional area of the test section of the wind tunnel. The mean wind speed in the test section must be within ±10 percent of the value specified in table F–2 of this subpart, and the variation at any test point in the test section may not exceed 10 percent of the measured mean.

(5) *Aerosol rake.* The cross-sectional uniformity of the particle concentration in the sampling zone of the test section shall be established during the tests using an array of isokinetic samplers, referred to as a rake. Not less than five evenly spaced isokinetic samplers shall be used to determine the particle concentration spatial uniformity in the sampling zone. The sampling zone shall be a rectangular area having a horizontal dimension not less than 1.2 times the width of the test sampler at its inlet opening and a vertical dimension not less than 25 centimeters.

(6) *Total aerosol isokinetic sampler.* After cross-sectional uniformity has been confirmed, a single isokinetic sampler may be used in place of the array of isokinetic samplers for the determination of particle mass concentration used in the calculation of sampling effectiveness of the test sampler in paragraph (d)(5) of this section. In this case, the array of isokinetic samplers must be used to demonstrate particle concentration uniformity prior to the replicate measurements of sampling effectiveness.

(7) *Fluorometer.* A fluorometer used for quantifying extracted aerosol mass deposits shall be set up, maintained,

and calibrated according to the manufacturer's instructions. A series of calibration standards shall be prepared to encompass the minimum and maximum concentrations measured during size-selective tests. Prior to each calibration and measurement, the fluorometer shall be zeroed using an aliquot of the same solvent used for extracting aerosol mass deposits.

(8) *Sampler flow rate measurements.* All flow rate measurements used to calculate the test atmosphere concentrations and the test results must be accurate to within ±2 percent, referenced to a NIST-traceable primary standard. Any necessary flow rate measurement corrections shall be clearly documented. All flow rate measurements shall be performed and reported in actual volumetric units.

(d) *Test procedures*—(1) *Establish and verify wind speed.* (i) Establish a wind speed specified in table F–2 of this subpart.

(ii) Measure the wind speed at a minimum of 12 test points in a cross-sectional area of the test section of the wind tunnel using a device as described in paragraph (c)(4) of this section.

(iii) Verify that the mean wind speed in the test section of the wind tunnel during the tests is within 10 percent of the value specified in table F–2 of this subpart. The wind speed measured at any test point in the test section shall not differ by more than 10 percent from the mean wind speed in the test section.

(2) *Generate aerosol.* (i) Generate particles of a size specified in table F–2 of this subpart using a vibrating orifice aerosol generator.

(ii) Check for the presence of satellites and adjust the generator as necessary.

(iii) Calculate the physical particle size using the operating parameters of the vibrating orifice aerosol generator and record.

(iv) Determine the particle's aerodynamic diameter from the calculated physical diameter and the known density of the generated particle. The calculated aerodynamic diameter must be within the tolerance specified in table F–2 of this subpart.

(3) *Introduce particles into the wind tunnel.* Introduce the generated particles into the wind tunnel and allow the particle concentration to stabilize.

(4) *Verify the quality of the test aerosol.* (i) Extract a representative sample of the aerosol from the sampling test zone and measure the size distribution of the collected particles using an appropriate sizing technique. If the measurement technique does not provide a direct measure of aerodynamic diameter, the geometric mean aerodynamic diameter of the challenge aerosol must be calculated using the known density of the particle and the measured mean physical diameter. The determined geometric mean aerodynamic diameter of the test aerosol must be within 0.15 µm of the aerodynamic diameter calculated from the operating parameters of the vibrating orifice aerosol generator. The geometric standard deviation of the primary particles must not exceed 1.1.

(ii) Determine the population of multiplets in the collected sample. The multiplet population of the particle test atmosphere must not exceed 10 percent of the total particle population.

(5) *Aerosol uniformity and concentration measurement.* (i) Install an array of five or more evenly spaced isokinetic samplers in the sampling zone (paragraph (c)(5) of this section). Collect particles on appropriate filters over a time period such that the relative error of the measured particle concentration is less than 5.0 percent.

(ii) Determine the quantity of material collected with each isokinetic sampler in the array using a calibrated fluorometer. Calculate and record the mass concentration for each isokinetic sampler as:

Equation 7

$$C_{iso(ij)} = \frac{M_{iso(ij)}}{Q_{(ij)} \times t_{(ij)}}$$

where:

i = replicate number;

j = isokinetic sampler number;

M_{iso} = mass of material collected with the isokinetic sampler;

Q = isokinetic sampler volumetric flow rate; and

t = sampling time.

(iii) Calculate and record the mean mass concentration as:

Equation 8

$$\overline{C}_{iso(i)} = \frac{\sum_{j=1}^{n} C_{iso(ij)}}{n}$$

where:

i = replicate number;
j = isokinetic sampler number; and
n = total number of isokinetic samplers.

(iv) Precision calculation. (A) Calculate the coefficient of variation of the mass concentration measurements as:

Equation 9

$$CV_{iso(i)} = \frac{\sqrt{\sum_{j=1}^{n} C_{iso(ij)}^{2} - \frac{1}{n}\left(\sum_{j=1}^{n} C_{iso(ij)}\right)^{2}}}{n-1} / \overline{C}_{iso(i)} \times 100\%$$

where:

i = replicate number;
j = isokinetic sampler number; and
n = total number of isokinetic samplers.

(B) If the value of $CV_{iso(i)}$ for any replicate exceeds 10 percent, the particle concentration uniformity is unacceptable and step 5 must be repeated. If adjustment of the vibrating orifice aerosol generator or changes in the particle delivery system are necessary to achieve uniformity, steps 1 through 5 must be repeated. When an acceptable aerosol spatial uniformity is achieved, remove the array of isokinetic samplers from the wind tunnel.

(6) *Alternative measure of wind tunnel total concentration.* If a single isokinetic sampler is used to determine the mean aerosol concentration in the wind tunnel, install the sampler in the wind tunnel with the sampler nozzle centered in the sampling zone (paragraph (c)(6) of this section).

(i) Collect particles on an appropriate filter over a time period such that the relative error of the measured concentration is less than 5.0 percent.

(ii) Determine the quantity of material collected with the isokinetic sampler using a calibrated fluorometer.

(iii) Calculate and record the mass concentration as $C_{iso(i)}$ as in paragraph (d)(5)(ii) of this section.

(iv) Remove the isokinetic sampler from the wind tunnel.

(7) *Measure the aerosol with the candidate sampler.* (i) Install the test sampler (or portion thereof) in the wind tunnel with the sampler inlet opening centered in the sampling zone. To meet the maximum blockage limit of paragraph (c)(1) of this section or for convenience, part of the test sampler may be positioned external to the wind tunnel provided that neither the geometry of the sampler nor the length of any connecting tube or pipe is altered. Collect particles for a time period such that the relative error of the measured concentration is less than 5.0 percent.

(ii) Remove the test sampler from the wind tunnel.

(iii) Determine the quantity of material collected with the test sampler using a calibrated fluorometer. Calculate and record the mass concentration for each replicate as:

Equation 10

$$C_{cand(i)} = \frac{M_{cand(i)}}{Q_{(i)} \times t_{(i)}}$$

where:

i = replicate number;
M_{cand} = mass of material collected with the candidate sampler;
Q = candidate sampler volumetric flow rate; and
t = sampling time.

(iv)(A) Calculate and record the sampling effectiveness of the candidate sampler as:

Equation 11

$$E_{(i)} = \frac{C_{cand(i)}}{\overline{C}_{iso(i)}} \times 100\%$$

where:

i = replicate number.

(B) If a single isokinetic sampler is used for the determination of particle mass concentration, replace $C_{iso(i)}$ with C_{iso}.

(8) *Replicate measurements and calculation of mean sampling effectiveness.* (i) Repeat steps in paragraphs (d)(5) through (d)(7) of this section, as appropriate, to obtain a minimum of three

valid replicate measurements of sampling effectiveness.

(ii) Calculate and record the average sampling effectiveness of the test sampler for the particle size as:

Equation 12

$$\overline{E} = \frac{\sum_{i=1}^{n} E_{(i)}}{n}$$

where:

i = replicate number; and
n = number of replicates.

(iii) Sampling effectiveness precision. (A) Calculate and record the coefficient of variation for the replicate sampling effectiveness measurements of the test sampler as:

Equation 13

$$CV_E = \frac{\sqrt{\sum_{i=1}^{n} E_{(i)}^2 - \frac{1}{n}\left(\sum_{i=1}^{n} E_{(i)}\right)^2}}{n-1} \frac{1}{\overline{E}} \times 100\%$$

where:

i = replicate number, and
n = number of replicates.

(B) If the value of CV_E exceeds 10 percent, the test run (steps in paragraphs (d)(2) through (d)(8) of this section) must be repeated until an acceptable value is obtained.

(9) Repeat steps in paragraphs (d)(2) through (d)(8) of this section until the sampling effectiveness has been measured for all particle sizes specified in table F–2 of this subpart.

(10) Repeat steps in paragraphs (d)(1) through (d)(9) of this section until tests have been successfully conducted for both wind speeds of 2 km/hr and 24 km/hr.

(e) *Calculations*—(1) *Graphical treatment of effectiveness data.* For each wind speed given in table F–2 of this subpart, plot the particle average sampling effectiveness of the candidate sampler as a function of aerodynamic particle diameter (D_{ae}) on semi-logarithmic graph paper where the aerodynamic particle diameter is the particle size established by the parameters of the VOAG in conjunction with the known particle density. Construct a best-fit, smooth curve through the data by extrapolating the sampling effectiveness curve through 100 percent at an aerodynamic particle size of 0.5 µm and 0 percent at an aerodynamic particle size of 10 µm. Correction for the presence of multiplets shall be performed using the techniques presented by Marple, et al (1987). This multiplet-corrected effectiveness curve shall be used for all remaining calculations in this paragraph (e).

(2) *Cutpoint determination.* For each wind speed determine the sampler Dp_{50} cutpoint defined as the aerodynamic particle size corresponding to 50 percent effectiveness from the multiplet corrected smooth curve.

(3) *Expected mass concentration calculation.* For each wind speed, calculate the estimated mass concentration measurement for the test sampler under each particle size distribution (Tables F–4, F–5, and F–6 of this subpart) and compare it to the mass concentration predicted for the reference sampler as follows:

(i) Determine the value of corrected effectiveness using the best-fit, multiplet-corrected curve at each of the particle sizes specified in the first column of table F–4 of this subpart. Record each corrected effectiveness value as a decimal between 0 and 1 in column 2 of table F–4 of this subpart.

(ii) Calculate the interval estimated mass concentration measurement by multiplying the values of corrected effectiveness in column 2 by the interval mass concentration values in column 3 and enter the products in column 4 of table F–4 of this subpart.

(iii) Calculate the estimated mass concentration measurement by summing the values in column 4 and entering the total as the estimated mass concentration measurement for the test sampler at the bottom of column 4 of table F–4 of this subpart.

(iv) Calculate the estimated mass concentration ratio between the candidate method and the reference method as:

Equation 14

$$R_c = \frac{C_{cand(est)}}{C_{ref(est)}} \times 100\%$$

where:

$C_{cand(est)}$ = estimated mass concentration measurement for the test sampler, µg/m^3; and

$C_{ref(est)}$ = estimated mass concentration measurement for the reference sampler, µg/m^3 (calculated for the reference sampler and specified at the bottom of column 7 of table F–4 of this subpart).

(v) Repeat steps in paragraphs (e) (1) through (e)(3) of this section for tables F–5 and F–6 of this subpart.

(f) *Evaluation of test results.* The candidate method passes the wind tunnel effectiveness test if the R_c value for each wind speed meets the specification in table F–1 of this subpart for each of the three particle size distributions.

§ 53.63 Test procedure: Wind tunnel inlet aspiration test.

(a) *Overview.* This test applies to a candidate sampler which differs from the reference method sampler only with respect to the design of the inlet. The purpose of this test is to ensure that the aspiration of a Class II candidate sampler is such that it representatively extracts an ambient aerosol at elevated wind speeds. This wind tunnel test uses a single-sized, liquid aerosol in conjunction with wind speeds of 2 km/hr and 24 km/hr. The test atmosphere concentration is alternately measured with the candidate sampler and a reference method device, both of which are operated without the 2.5-micron fractionation device installed. The test conditions are summarized in table F–2 of this subpart (under the heading of ‘‘wind tunnel inlet aspiration test’’). The candidate sampler must meet or exceed the acceptance criteria given in table F–1 of this subpart.

(b) *Technical definition.* Relative aspiration is the ratio (expressed as a percentage) of the aerosol mass concentration measured by the candidate sampler to that measured by a reference method sampler.

(c) *Facilities and equipment required.* The facilities and equipment are identical to those required for the full wind tunnel test (§ 53.62(c)).

(d) *Setup.* The candidate and reference method samplers shall be operated with the $PM_{2.5}$ fractionation device removed from the flow path throughout this entire test procedure. Modifications to accommodate this requirement shall be limited to removal of the fractionator and insertion of the filter holder directly into the downtube of the inlet.

(e) *Test procedure*—(1) *Establish the wind tunnel test atmosphere.* Follow the procedures in § 53.62(d)(1) through (d)(4) to establish a test atmosphere for one of the two wind speeds specified in table F–2 of this subpart.

(2) *Measure the aerosol concentration with the reference sampler.* (i) Install the reference sampler (or portion thereof) in the wind tunnel with the sampler inlet opening centered in the sampling zone. To meet the maximum blockage limit of § 53.62(c)(1) or for convenience, part of the test sampler may be positioned external to the wind tunnel provided that neither the geometry of the sampler nor the length of any connecting tube or pipe is altered. Collect particles for a time period such that the relative error of the measured concentration is less than 5.0 percent.

(ii) Determine the quantity of material collected with the reference method sampler using a calibrated fluorometer. Calculate and record the mass concentration as:

Equation 15

$$C_{ref(i)} = \frac{M_{ref(i)}}{Q_{(i)} \times t_{(i)}}$$

where:

i = replicate number;

M_{ref} = mass of material collected with the reference method sampler;

Q = reference method sampler volumetric flow rate; and

t = sampling time.

(iii) Remove the reference method sampler from the tunnel.

(3) *Measure the aerosol concentration with the candidate sampler.* (i) Install the candidate sampler (or portion thereof) in the wind tunnel with the sampler inlet centered in the sampling zone. To meet the maximum blockage limit of § 53.62(c)(1) or for convenience, part of the test sampler may be positioned external to the wind tunnel provided that neither the geometry of the sampler nor the length of any connecting tube or pipe is altered. Collect

particles for a time period such that the relative error of the measured concentration is less than 5.0 percent.

(ii) Determine the quantity of material collected with the candidate sampler using a calibrated fluorometer. Calculate and record the mass concentration as:

Equation 16

$$C_{cand(i)} = \frac{M_{cand(i)}}{Q_{(i)} \times t_{(i)}}$$

where:

i = replicate number;
M_{cand} = mass of material collected with the candidate sampler;
Q = candidate sampler volumetric flow rate; and
t = sampling time.

(iii) Remove the candidate sampler from the wind tunnel.

(4) Repeat steps in paragraphs (d) (2) and (d)(3) of this section. Alternately measure the tunnel concentration with the reference sampler and the candidate sampler until four reference sampler and three candidate sampler measurements of the wind tunnel concentration are obtained.

(5) *Calculations.* (i) Calculate and record aspiration ratio for each candidate sampler run as:

Equation 17

$$A_{(i)} = \frac{C_{cand(i)}}{\left(C_{ref(i)} + C_{ref(i+1)}\right) \times \frac{1}{2}}$$

where:

i = replicate number.

(ii) Calculate and record the mean aspiration ratio as:

Equation 18

$$\overline{A} = \frac{\sum_{i=1}^{n} A_{(i)}}{n}$$

where:

i = replicate number; and
n = total number of measurements of aspiration ratio.

(iii) Precision of the aspiration ratio. (A) Calculate and record the precision of the aspiration ratio measurements as the coefficient of variation as:

Equation 19

$$CV_A = \frac{\sqrt{\sum_{i=1}^{n} A_{(i)}^2 - \frac{1}{n}\left(\sum_{i=1}^{n} A_{(i)}\right)^2}}{n-1} / \overline{A}_{(i)} \times 100\%$$

where:

i = replicate number; and
n = total number of measurements of aspiration ratio.

(B) If the value of CV_A exceeds 10 percent, the entire test procedure must be repeated.

(f) *Evaluation of test results.* The candidate method passes the inlet aspiration test if all values of A meet the acceptance criteria specified in table F–1 of this subpart.

§ 53.64 Test procedure: Static fractionator test.

(a) *Overview.* This test applies only to those candidate methods in which the sole deviation from the reference method is in the design of the 2.5-micron fractionation device. The purpose of this test is to ensure that the fractionation characteristics of the candidate fractionator are acceptably similar to that of the reference method sampler. It is recognized that various methodologies exist for quantifying fractionator effectiveness. The following commonly-employed techniques are provided for purposes of guidance. Other methodologies for determining sampler effectiveness may be used contingent upon prior approval by the Agency.

(1) *Wash-off method.* Effectiveness is determined by measuring the aerosol mass deposited on the candidate sampler's after filter versus the aerosol mass deposited in the fractionator. The material deposited in the fractionator is recovered by washing its internal surfaces. For these wash-off tests, a fluorometer must be used to quantitate the aerosol concentration. Note that if this technique is chosen, the candidate must be reloaded with coarse aerosol prior to each test point when reevaluating the curve as specified in the loading test.

(2) *Static chamber method.* Effectiveness is determined by measuring the aerosol mass concentration sampled by the candidate sampler's after filter versus that which exists in a static chamber. A calibrated fluorometer shall be used to quantify the collected aerosol deposits. The aerosol concentration is calculated as the measured aerosol mass divided by the sampled air volume.

(3) *Divided flow method.* Effectiveness is determined by comparing the aerosol concentration upstream of the candidate sampler's fractionator versus that concentration which exists downstream of the candidate fractionator. These tests may utilize either fluorometry or a real-time aerosol measuring device to determine the aerosol concentration.

(b) *Technical definition.* Effectiveness under static conditions is the ratio (expressed as a percentage) of the mass concentration of particles of a given size reaching the sampler filter to the mass concentration of particles of the same size existing in the test atmosphere.

(c) *Facilities and equipment required*—(1) *Aerosol generation.* Methods for generating aerosols shall be identical to those prescribed in § 53.62(c)(2).

(2) *Particle delivery system.* Acceptable apparatus for delivering the generated aerosols to the candidate fractionator is dependent on the effectiveness measurement methodology and shall be defined as follows:

(i) *Wash-off test apparatus.* The aerosol may be delivered to the candidate fractionator through direct piping (with or without an in-line mixing chamber). Validation particle size and quality shall be conducted at a point directly upstream of the fractionator.

(ii) *Static chamber test apparatus.* The aerosol shall be introduced into a chamber and sufficiently mixed such that the aerosol concentration within the chamber is spatially uniform. The chamber must be of sufficient size to house at least four total filter samplers in addition to the inlet of the candidate method size fractionator. Validation of particle size and quality shall be conducted on representative aerosol samples extracted from the chamber.

(iii) *Divided flow test apparatus.* The apparatus shall allow the aerosol concentration to be measured upstream and downstream of the fractionator. The aerosol shall be delivered to a manifold with two symmetrical branching legs. One of the legs, referred to as the bypass leg, shall allow the challenge aerosol to pass unfractionated to the detector. The other leg shall accommodate the fractionation device.

(3) *Particle concentration measurement*—(i) *Fluorometry.* Refer to § 53.62(c)(7).

(ii) *Number concentration measurement.* A number counting particle sizer may be used in conjunction with the divided flow test apparatus in lieu of fluorometric measurement. This device must have a minimum range of 1 to 10 μm, a resolution of 0.1 μm, and an accuracy of 0.15 μm such that primary particles may be distinguished from multiplets for all test aerosols. The measurement of number concentration shall be accomplished by integrating the primary particle peak.

(d) *Setup*—(1) *Remove the inlet and downtube from the candidate fractionator.* All tests procedures shall be conducted with the inlet and downtube removed from the candidate sampler.

(2) *Surface treatment of the fractionator.* Rinsing aluminum surfaces with alkaline solutions has been found to adversely affect subsequent fluorometric quantitation of aerosol mass deposits. If wash-off tests are to be used for quantifying aerosol penetration, internal surfaces of the fractionator must first be plated with electroless nickel. Specifications for this plating are specified in Society of Automotive Engineers Aerospace Material Specification (SAE AMS) 2404C, Electroless Nickel Plating (Reference 3 in appendix A of subpart F).

(e) *Test procedure: Wash-off method*—(1) *Clean the candidate sampler.* Note: The procedures in this step may be omitted if this test is being used to evaluate the fractionator after being loaded as specified in § 53.65.

(i) Clean and dry the internal surfaces of the candidate sampler.

(ii) Prepare the internal fractionator surfaces in strict accordance with the operating instructions specified in the sampler's operating manual referred to in section 7.4.18 of 40 CFR part 50, appendix L.

(2) *Generate aerosol.* Follow the procedures for aerosol generation prescribed in § 53.62(d)(2).

(3) *Verify the quality of the test aerosol.* Follow the procedures for verification of test aerosol size and quality prescribed in § 53.62(d)(4).

(4) *Determine effectiveness for the particle size being produced.* (i) Collect particles downstream of the fractionator on an appropriate filter over a time period such that the relative error of the fluorometric measurement is less than 5.0 percent.

(ii) Determine the quantity of material collected on the after filter of the candidate method using a calibrated fluorometer. Calculate and record the aerosol mass concentration for the sampler filter as:

Equation 20

$$C_{cand(i)} = \frac{M_{cand(i)}}{Q_{(i)} \times t_{(i)}}$$

where:

i = replicate number;

M_{cand} = mass of material collected with the candidate sampler;

Q = candidate sampler volumetric flowrate; and

t = sampling time.

(iii) Wash all interior surfaces upstream of the filter and determine the quantity of material collected using a calibrated fluorometer. Calculate and record the fluorometric mass concentration of the sampler wash as:

Equation 21

$$C_{wash(i)} = \frac{M_{wash(i)}}{Q_{(i)} \times t_{(i)}}$$

where:

i = replicate number;

M_{wash} = mass of material washed from the interior surfaces of the fractionator;

Q = candidate sampler volumetric flowrate; and

t = sampling time.

(iv) Calculate and record the sampling effectiveness of the test sampler for this particle size as:

Equation 22

$$E_{(i)} = \frac{C_{wash(i)}}{C_{cand(i)} + C_{wash(i)}} \times 100\%$$

where:

i = replicate number.

(v) Repeat steps in paragraphs (e)(4) of this section, as appropriate, to obtain a minimum of three replicate measurements of sampling effectiveness. Note: The procedures for loading the candidate in § 53.65 must be repeated between repetitions if this test is being used to evaluate the fractionator after being loaded as specified in § 53.65.

(vi) Calculate and record the average sampling effectiveness of the test sampler as:

Equation 23

$$\overline{E} = \frac{\sum_{i=1}^{n} E_{(i)}}{n}$$

where:

i = replicate number; and

n = number of replicates.

(vii)(A) Calculate and record the coefficient of variation for the replicate sampling effectiveness measurements of the test sampler as:

Equation 24

$$CV_E = \frac{\sqrt{\sum_{i=1}^{n} E_{(i)}^2 - \frac{1}{n}\left(\sum_{i=1}^{n} E_{(i)}\right)^2}}{n-1} \times \frac{1}{\overline{E}} \times 100\%$$

where:

i = replicate number; and

n = total number of measurements.

(B) If the value of CV_E exceeds 10 percent, then steps in paragraphs (e) (2) through (e)(4) of this section must be repeated.

(5) Repeat steps in paragraphs (e) (1) through (e)(4) of this section for each particle size specified in table F–2 of this subpart.

(f) *Test procedure: Static chamber method*—(1) *Generate aerosol.* Follow the procedures for aerosol generation prescribed in § 53.62(d)(2).

(2) *Verify the quality of the test aerosol.* Follow the procedures for verification of test aerosol size and quality prescribed in § 53.62(d)(4).

(3) *Introduce particles into chamber.* Introduce the particles into the static chamber and allow the particle concentration to stabilize.

(4) *Install and operate the candidate sampler's fractionator and its after-filter and at least four total filters.* (i) Install the fractionator and an array of four or more equally spaced total filter samplers such that the total filters surround and are in the same plane as the inlet of the fractionator.

(ii) Simultaneously collect particles onto appropriate filters with the total filter samplers and the fractionator for a time period such that the relative error of the measured concentration is less than 5.0 percent.

(5) *Calculate the aerosol spatial uniformity in the chamber.* (i) Determine the quantity of material collected with each total filter sampler in the array using a calibrated fluorometer. Calculate and record the mass concentration for each total filter sampler as:

Equation 25

$$C_{total(ij)} = \frac{M_{total(ij)}}{Q_{(ij)} \times t_{(ij)}}$$

where:

i = replicate number;
j = total filter sampler number;
M_{total} = mass of material collected with the total filter sampler;
Q = total filter sampler volumetric flowrate; and
t = sample time.

(ii) Calculate and record the mean mass concentration as:

Equation 26

$$\overline{C}_{total(i)} = \frac{\sum_{j=1}^{n} C_{total(ij)}}{n}$$

where:

n = total number of samplers;
i = replicate number; and
j = filter sampler number.

(iii) (A) Calculate and record the coefficient of variation of the total mass concentration as:

Equation 27

$$CV_{total} = \frac{\sqrt{\sum_{j=1}^{n} C^2_{total(ij)} - \frac{1}{n}\left(\sum_{j=1}^{n} C_{total(ij)}\right)^2}}{n-1} \times \frac{1}{\overline{C}_{total(i)}} \times 100\%$$

where:

i = replicate number;
j = total filter sampler number; and
n = number of total filter samplers.

(B) If the value of CV_{total} exceeds 10 percent, then the particle concentration uniformity is unacceptable, alterations to the static chamber test apparatus must be made, and steps in paragraphs (f)(1) through (f)(5) of this section must be repeated.

(6) *Determine the effectiveness of the candidate sampler.* (i) Determine the quantity of material collected on the candidate sampler's after filter using a calibrated fluorometer. Calculate and record the mass concentration for the candidate sampler as:

Equation 28

$$C_{cand(i)} = \frac{M_{cand(i)}}{Q_{(i)} \times t_{(i)}}$$

where:

i = replicate number;
M_{cand} = mass of material collected with the candidate sampler;
Q = candidate sampler volumetric flowrate; and
t = sample time.

(ii) Calculate and record the sampling effectiveness of the candidate sampler as:

Equation 29

$$E_{(i)} = \frac{C_{cand(i)}}{\overline{C}_{total(i)}} \times 100\%$$

where:

i = replicate number.

(iii) Repeat step in paragraph (f)(4) through (f)(6) of this section, as appropriate, to obtain a minimum of three replicate measurements of sampling effectiveness.

(iv) Calculate and record the average sampling effectiveness of the test sampler as:

Equation 30

$$\overline{E} = \frac{\sum_{i=1}^{n} E_{(i)}}{n}$$

where:

i= replicate number.

(v)(A) Calculate and record the coefficient of variation for the replicate sampling effectiveness measurements of the test sampler as:

Equation 31

$$CV_E = \frac{\sqrt{\sum_{i=1}^{n} E_{(i)}^2 - \frac{1}{n}\left(\sum_{i=1}^{n} E_{(i)}\right)^2}}{n-1} \times \frac{1}{\overline{E}} \times 100\%$$

where:

i = replicate number; and

n = number of measurements of effectiveness.

(B) If the value of CV_E exceeds 10 percent, then the test run (steps in paragraphs (f)(2) through (f)(6) of this section) is unacceptable and must be repeated.

(7) Repeat steps in paragraphs (f)(1) through (f)(6) of this section for each particle size specified in table F–2 of this subpart.

(g) *Test procedure: Divided flow method*—(1) *Generate calibration aerosol.* Follow the procedures for aerosol generation prescribed in § 53.62(d)(2).

(2) *Verify the quality of the calibration aerosol.* Follow the procedures for verification of calibration aerosol size and quality prescribed in § 53.62(d)(4).

(3) *Introduce aerosol.* Introduce the calibration aerosol into the static chamber and allow the particle concentration to stabilize.

(4) *Validate that transport is equal for the divided flow option.* (i) With fluorometry as a detector:

(A) Install a total filter on each leg of the divided flow apparatus.

(B) Collect particles simultaneously through both legs at 16.7 L/min onto an appropriate filter for a time period such that the relative error of the measured concentration is less than 5.0 percent.

(C) Determine the quantity of material collected on each filter using a calibrated fluorometer. Calculate and record the mass concentration measured in each leg as:

Equation 32

$$C_{(i)} = \frac{M_{(i)}}{Q_{(i)} \times t_{(i)}}$$

where:

i = replicate number,

M = mass of material collected with the total filter; and

Q = candidate sampler volumetric flowrate.

(D) Repeat steps in paragraphs (g)(4)(i)(A) through (g)(4)(i)(C) of this section until a minimum of three replicate measurements are performed.

(ii) With an aerosol number counting device as a detector:

(A) Remove all flow obstructions from the flow paths of the two legs.

(B) Quantify the aerosol concentration of the primary particles in each leg of the apparatus.

(C) Repeat steps in paragraphs (g)(4)(ii)(A) through (g)(4)(ii)(B) of this section until a minimum of three replicate measurements are performed.

(iii) (A) Calculate the mean concentration and coefficient of variation as:

Equation 33

$$\overline{C}=\frac{\sum_{i=1}^{n}C_{(i)}}{n}$$

Equation 34

$$CV=\frac{\sqrt{\sum_{i=1}^{n}C_{(i)}^{2}-\frac{1}{n}\left(\sum_{i=1}^{n}C_{(i)}\right)^{2}}}{n-1}\times\frac{1}{\overline{C}}\times 100\%$$

where:

i = replicate number; and
n = number of replicates.

(B) If the measured mean concentrations through the two legs do not agree within 5 percent, then adjustments may be made in the setup, and this step must be repeated.

(5) *Determine effectiveness.* Determine the sampling effectiveness of the test sampler with the inlet removed by one of the following procedures:

(i) With fluorometry as a detector:

(A) Prepare the divided flow apparatus for particle collection. Install a total filter into the bypass leg of the divided flow apparatus. Install the particle size fractionator with a total filter placed immediately downstream of it into the other leg.

(B) Collect particles simultaneously through both legs at 16.7 L/min onto appropriate filters for a time period such that the relative error of the measured concentration is less than 5.0 percent.

(C) Determine the quantity of material collected on each filter using a calibrated fluorometer. Calculate and record the mass concentration measured by the total filter and that measured after penetrating through the candidate fractionator as follows:

Equation 35

$$C_{total_{(i)}}=\frac{M_{total(i)}}{Q_{(i)}\times t_{(i)}}$$

Equation 36

$$C_{cand_{(i)}}=\frac{M_{cand(i)}}{Q_{(i)}\times t_{(i)}}$$

where:

i = replicate number.

(ii) With a number counting device as a detector:

(A) Install the particle size fractionator into one of the legs of the divided flow apparatus.

(B) Quantify and record the aerosol number concentration of the primary particles passing through the fractionator as $C_{cand(i)}$.

(C) Divert the flow from the leg containing the candidate fractionator to the bypass leg. Allow sufficient time for the aerosol concentration to stabilize.

(D) Quantify and record the aerosol number concentration of the primary particles passing through the bypass leg as $C_{total(i)}$.

(iii) Calculate and record sampling effectiveness of the candidate sampler as:

Equation 37

$$E_{(i)}=\frac{C_{cand(i)}}{\overline{C}_{total(i)}}\times 100\%$$

where:

i = replicate number.

(6) Repeat step in paragraph (g)(5) of this section, as appropriate, to obtain a minimum of three replicate measurements of sampling effectiveness.

(7) *Calculate the mean and coefficient of variation for replicate measurements of effectiveness.* (i) Calculate and record the mean sampling effectiveness of the candidate sampler as:

Equation 38

$$\overline{E}=\frac{\sum_{i=1}^{n}E_{(i)}}{n}$$

where:

i = replicate number.

(ii)(A) Calculate and record the coefficient of variation for the replicate sampling effectiveness measurements of the candidate sampler as:

Equation 39

$$CV_E = \frac{\sqrt{\sum_{i=1}^{n} E_{(i)}^2 - \frac{1}{n}\left(\sum_{i=1}^{n} E_{(i)}\right)^2}}{n-1} \times \frac{1}{\overline{E}} \times 100\%$$

where:

i = replicate number; and
n = number of replicates.

(B) If the coefficient of variation is not less than 10 percent, then the test run must be repeated (steps in paragraphs (g)(1) through (g)(7) of this section).

(8) Repeat steps in paragraphs (g)(1) through (g)(7) of this section for each particle size specified in table F–2 of this subpart.

(h) *Calculations*—(1) *Treatment of multiplets.* For all measurements made by fluorometric analysis, data shall be corrected for the presence of multiplets as described in § 53.62(f)(1). Data collected using a real-time device (as described in paragraph (c)(3)(ii)) of this section will not require multiplet correction.

(2) *Cutpoint determination.* For each wind speed determine the sampler Dp_{50} cutpoint defined as the aerodynamic particle size corresponding to 50 percent effectiveness from the multiplet corrected smooth curve.

(3) *Graphical analysis and numerical integration with ambient distributions.* Follow the steps outlined in § 53.62 (e)(3) through (e)(4) to calculate the estimated concentration measurement ratio between the candidate sampler and a reference method sampler.

(i) *Test evaluation.* The candidate method passes the static fractionator test if the values of Rc and Dp_{50} for each distribution meets the specifications in table F–1 of this subpart.

[62 FR 38814, July 18, 1997; 63 FR 7714, Feb. 17, 1998]

§ 53.65 Test procedure: Loading test.

(a) *Overview.* (1) The loading tests are designed to quantify any appreciable changes in a candidate method sampler's performance as a function of coarse aerosol collection. The candidate sampler is exposed to a mass of coarse aerosol equivalent to sampling a mass concentration of 150 μg/m^3 over the time period that the manufacturer has specified between periodic cleaning. After loading, the candidate sampler is then evaluated by performing the test in § 53.62 (full wind tunnel test), § 53.63 (wind tunnel inlet aspiration test), or § 53.64 (static fractionator test). If the acceptance criteria are met for this evaluation test, then the candidate sampler is approved for multiday sampling with the periodic maintenance schedule as specified by the candidate method. For example, if the candidate sampler passes the reevaluation tests following loading with an aerosol mass equivalent to sampling a 150 μg/m^3 aerosol continuously for 7 days, then the sampler is approved for 7 day field operation before cleaning is required.

(2) [Reserved]

(b) *Technical definition.* Effectiveness after loading is the ratio (expressed as a percentage) of the mass concentration of particles of a given size reaching the sampler filter to the mass concentration of particles of the same size approaching the sampler.

(c) *Facilities and equipment required*—(1) *Particle delivery system.* The particle delivery system shall consist of a static chamber or a low velocity wind tunnel having a sufficiently large cross-sectional area such that the test sampler, or portion thereof, may be installed in the test section. At a minimum, the system must have a sufficiently large cross section to house the candidate sampler inlet as well as a collocated isokinetic nozzle for measuring total aerosol concentration. The mean velocity in the test section of the static chamber or wind tunnel shall not exceed 2 km/hr.

(2) *Aerosol generation equipment.* For purposes of these tests, the test aerosol shall be produced from commercially available, bulk Arizona road dust. To provide direct interlaboratory comparability of sampler loading characteristics, the bulk dust is specified as 0-10 μm ATD available from Powder Technology Incorporated (Burnsville, MN). A fluidized bed aerosol generator, Wright dust feeder, or sonic nozzle shall be used to efficiently

deagglomerate the bulk test dust and transform it into an aerosol cloud. Other dust generators may be used contingent upon prior approval by the Agency.

(3) *Isokinetic sampler.* Mean aerosol concentration within the static chamber or wind tunnel shall be established using a single isokinetic sampler containing a preweighed high-efficiency total filter.

(4) *Analytic balance.* An analytical balance shall be used to determine the weight of the total filter in the isokinetic sampler. The precision and accuracy of this device shall be such that the relative measurement error is less than 5.0 percent for the difference between the initial and final weight of the total filter. The identical analytic balance shall be used to perform both initial and final weighing of the total filter.

(d) *Test procedure.* (1) Calculate and record the target time weighted concentration of Arizona road dust which is equivalent to exposing the sampler to an environment of 150 µg/m³ over the time between cleaning specified by the candidate sampler's operations manual as:

Equation 40

$$\text{Target TWC} = 150\,\mu g/m^3 \times t$$

where:

t = the number of hours specified by the candidate method prior to periodic cleaning.

(2) Clean the candidate sampler. (i) Clean and dry the internal surfaces of the candidate sampler.

(ii) Prepare the internal surfaces in strict accordance with the operating manual referred to in section 7.4.18 of 40 CFR part 50, appendix L.

(3) Determine the preweight of the filter that shall be used in the isokinetic sampler. Record this value as InitWt.

(4) Install the candidate sampler's inlet and the isokinetic sampler within the test chamber or wind tunnel.

(5) Generate a dust cloud. (i) Generate a dust cloud composed of Arizona test dust.

(ii) Introduce the dust cloud into the chamber.

(iii) Allow sufficient time for the particle concentration to become steady within the chamber.

(6) Sample aerosol with a total filter and the candidate sampler. (i) Sample the aerosol for a time sufficient to produce an equivalent TWC equal to that of the target TWC ±15 percent.

(ii) Record the sampling time as t.

(7) Determine the time weighted concentration. (i) Determine the postweight of the isokinetic sampler's total filter.

(ii) Record this value as FinalWt.

(iii) Calculate and record the TWC as:

Equation 41

$$TWC = \frac{(FinalWt - InitWt) \times t}{Q}$$

where:

Q = the flow rate of the candidate method.

(iv) If the value of TWC deviates from the target TWC ±15 percent, then the loaded mass is unacceptable and the entire test procedure must be repeated.

(8) Determine the candidate sampler's effectiveness after loading. The candidate sampler's effectiveness as a function of particle aerodynamic diameter must then be evaluated by performing the test in §53.62 (full wind tunnel test). A sampler which fits the category of inlet deviation in §53.60(e)(1) may opt to perform the test in §53.63 (inlet aspiration test) in lieu of the full wind tunnel test. A sampler which fits the category of fractionator deviation in §53.60(e)(2) may opt to perform the test in §53.64 (static fractionator test) in lieu of the full wind tunnel test.

(e) *Test results.* If the candidate sampler meets the acceptance criteria for the evaluation test performed in paragraph (d)(8) of this section, then the candidate sampler passes this test with the stipulation that the sampling train be cleaned as directed by and as frequently as that specified by the candidate sampler's operations manual.

§53.66 Test procedure: Volatility test.

(a) *Overview.* This test is designed to ensure that the candidate method's losses due to volatility when sampling semi-volatile ambient aerosol will be comparable to that of a federal reference method sampler. This is accomplished by challenging the candidate sampler with a polydisperse, semi-volatile liquid aerosol in three distinct phases. During phase A of this test, the aerosol is elevated to a steady-state, test-specified mass concentration and the sample filters are conditioned and preweighed. In phase B, the challenge aerosol is simultaneously sampled by the candidate method sampler and a reference method sampler onto the preweighed filters for a specified time period. In phase C (the blow-off phase), aerosol and aerosol-vapor free air is sampled by the samplers for an additional time period to partially volatilize the aerosol on the filters. The candidate sampler passes the volatility test if the acceptance criteria presented in table F–1 of this subpart are met or exceeded.

(b) *Technical definitions.* (1) Residual mass (RM) is defined as the weight of the filter after the blow-off phase subtracted from the initial weight of the filter.

(2) Corrected residual mass (CRM) is defined as the residual mass of the filter from the candidate sampler multiplied by the ratio of the reference method flow rate to the candidate method flow rate.

(c) *Facilities and equipment required*—(1) *Environmental chamber.* Because the nature of a volatile aerosol is greatly dependent upon environmental conditions, all phases of this test shall be conducted at a temperature of 22.0 ±0.5 °C and a relative humidity of 40 ±3 percent. For this reason, it is strongly advised that all weighing and experimental apparatus be housed in an environmental chamber capable of this level of control.

(2) *Aerosol generator.* The aerosol generator shall be a pressure nebulizer operated at 20 to 30 psig (140 to 207 kPa) to produce a polydisperse, semi-voltile aerosol with a mass median diameter larger than 1 µm and smaller than 2.5 µm. The nebulized liquid shall be A.C.S. reagent grade glycerol (C_3H_8O, FW = 92.09, CAS 56–81–5) of 99.5 percent minimum purity. For the purpose of this test the accepted mass median diameter is predicated on the stable aerosol inside the internal chamber and not on the aerosol emerging from the nebulizer nozzle. Aerosol monitoring and its stability are described in (c)(3) and (c)(4) of this section.

(3) *Aerosol monitoring equipment.* The evaporation and condensation dynamics of a volatile aerosol is greatly dependent upon the vapor pressure of the volatile component in the carrier gas. The size of an aerosol becomes fixed only when an equilibrium is established between the aerosol and the surrounding vapor; therefore, aerosol size measurement shall be used as a surrogate measure of this equilibrium. A suitable instrument with a range of 0.3 to 10 µm, an accuracy of 0.5 µm, and a resolution of 0.2 µm (e.g., an optical particle sizer, or a time-of-flight instrument) shall be used for this purpose. The parameter monitored for stability shall be the mass median instrument measured diameter (i.e. optical diameter if an optical particle counter is used). A stable aerosol shall be defined as an aerosol with a mass median diameter that has changed less than 0.25 µm over a 4 hour time period.

(4) *Internal chamber.* The time required to achieve a stable aerosol depends upon the time during which the aerosol is resident with the surrounding air. This is a function of the internal volume of the aerosol transport system and may be facilitated by recirculating the challenge aerosol. A chamber with a volume of 0.5 m^3 and a recirculating loop (airflow of approximately 500 cfm) is recommended for this purpose. In addition, a baffle is recommended to dissipate the jet of air that the recirculating loop can create. Furthermore, a HEPA filtered hole in the wall of the chamber is suggested to allow makeup air to enter the chamber or excess air to exit the chamber to maintain a system flow balance. The concentration inside the chamber shall be maintained at 1 mg/m^3 ±20 percent to obtain consistent and significant filter loading.

(5) *Aerosol sampling manifold.* A manifold shall be used to extract the aerosol from the area in which it is equilibrated and transport it to the candidate method sampler, the reference method sampler, and the aerosol monitor. The losses in each leg of the manifold shall be equivalent such that the

three devices will be exposed to an identical aerosol.

(6) *Chamber air temperature recorders.* Minimum range 15-25 °C, certified accuracy to within 0.2 °C, resolution of 0.1 °C. Measurement shall be made at the intake to the sampling manifold and adjacent to the weighing location.

(7) *Chamber air relative humidity recorders.* Minimum range 30 - 50 percent, certified accuracy to within 1 percent, resolution of 0.5 percent. Measurement shall be made at the intake to the sampling manifold and adjacent to the weighing location.

(8) *Clean air generation system.* A source of aerosol and aerosol-vapor free air is required for phase C of this test. This clean air shall be produced by filtering air through an absolute (HEPA) filter.

(9) *Balance.* Minimum range 0 - 200 mg, certified accuracy to within 10 µg, resolution of 1 µg.

(d) *Additional filter handling conditions.* (1) *Filter handling.* Careful handling of the filter during sampling, conditioning, and weighing is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. All filters must be weighed immediately after phase A dynamic conditioning and phase C.

(2) *Dynamic conditioning of filters.* Total dynamic conditioning is required prior to the initial weight determined in phase A. Dynamic conditioning refers to pulling clean air from the clean air generation system through the filters. Total dynamic conditioning can be established by sequential filter weighing every 30 minutes following repetitive dynamic conditioning. The filters are considered sufficiently conditioned if the sequential weights are repeatable to ±3 µg.

(3) *Static charge.* The following procedure is suggested for minimizing charge effects. Place six or more Polonium static control devices (PSCD) inside the microbalance weighing chamber, (MWC). Two of them must be placed horizontally on the floor of the MWC and the remainder placed vertically on the back wall of the MWC. Taping two PSCD's together or using double-sided tape will help to keep them from falling. Place the filter that is to be weighed on the horizontal PSCDs facing aerosol coated surface up. Close the MWC and wait 1 minute. Open the MWC and place the filter on the balance dish. Wait 1 minute. If the charges have been neutralized the weight will stabilize within 30-60 seconds. Repeat the procedure of neutralizing charges and weighing as prescribed above several times (typically 2-4 times) until consecutive weights will differ by no more than 3 micrograms. Record the last measured weight and use this value for all subsequent calculations.

(e) *Test procedure*—(1) *Phase A - Preliminary steps.* (i) Generate a polydisperse glycerol test aerosol.

(ii) Introduce the aerosol into the transport system.

(iii) Monitor the aerosol size and concentration until stability and level have been achieved.

(iv) Condition the candidate method sampler and reference method sampler filters until total dynamic conditioning is achieved as specified in paragraph (d)(2) of this section.

(v) Record the dynamically conditioned weight as $InitWt_c$ and $InitWt_r$ where c is the candidate method sampler and r is the reference method sampler.

(2) *Phase B - Aerosol loading.* (i) Install the dynamically conditioned filters into the appropriate samplers.

(ii) Attach the samplers to the manifold.

(iii) Operate the candidate and the reference samplers such that they simultaneously sample the test aerosol for 30 minutes.

(3) *Phase C - Blow-off.* (i) Alter the intake of the samplers to sample air from the clean air generation system.

(ii) Sample clean air for one of the required blow-off time durations (1, 2, 3, and 4 hours).

(iii) Remove the filters from the samplers.

(iv) Weigh the filters immediately and record this weight, $FinalWt_c$ and $FinalWt_r$, where c is the candidate method sampler and r is the reference method sampler.

(v) Calculate the residual mass for the reference method sampler:

Equation 41a

$$RM_{(ij)} = \left(FinalWt_r - InitWt_r\right)$$

where:

i = repetition number; and
j = blow-off time period.

(vi) Calculate the corrected residual mass for the candidate method sampler as:

Equation 41b

$$CRM_{(ij)} = \left(FinalWt_r - InitWt_r\right) \times \frac{Q_r}{Q_c}$$

where:

i = repetition number;
j = blow-off time period;
Q_c = candidate method sampler flow rate, and
Q_r = reference method sampler flow rate.

(4) Repeat steps in paragraph (e)(1) through (e)(3) of this section until three repetitions have been completed for each of the required blow-off time durations (1, 2, 3, and 4 hours).

(f) *Calculations and analysis.* (1) Perform a linear regression with the candidate method CRM as the dependent variable and the reference method RM as the independent variable.

(2) Determine the following regression parameters: slope, intercept, and correlation coefficient (r).

(g) *Test results.* The candidate method passes the volatility test if the regression parameters meet the acceptance criteria specified in table F–1 of this subpart.

TABLE F–1 TO SUBPART F—PERFORMANCE SPECIFICATIONS FOR $PM_{2.5}$ CLASS II EQUIVALENT SAMPLERS

Performance Test	Specifications	Acceptance Criteria
§ 53.62 Full Wind Tunnel Evaluation	Solid VOAG produced aerosol at 2 km/hr and 24 km/hr.	Dp_{50} = 2.5 μm ±0.2 μm; Numerical Analysis Results: 95% ≤R_c≤105%
§ 53.63 Wind Tunnel Inlet Aspiration Test.	Liquid VOAG produced aerosol at 2 km/hr and 24 km/hr.	Relative Aspiration: 95% ≤A≤105%
§ 53.64 Static Fractionator Test	Evaluation of the fractionator under static conditions.	Dp_{50} = 2.5 μm ±0.2 μm; Numerical Analysis Results: 95% ≤R_c≤105%
§ 53.65 Loading Test	Loading of the clean candidate under laboratory conditions.	Acceptance criteria as specified in the post-loading evaluation test (§ 53.62, § 53.63, or § 53.64)
§ 53.66 Volatility Test	Polydisperse liquid aerosol produced by air nebulization of A.C.S. reagent grade glycerol, 99.5% minimum purity.	Regression Parameters Slope = 1 ±0.1, Intercept = 0 ±0.15 r ≥ 0.97

TABLE F–2 TO SUBPART F—PARTICLE SIZES AND WIND SPEEDS FOR FULL WIND TUNNEL TEST, WIND TUNNEL INLET ASPIRATION TEST, AND STATIC CHAMBER TEST

Primary Partical Mean Size [a] (μm)	Full Wind Tunnel Test		Inlet Aspiration Test		Static Fractionator Test	Volatility Test
	2 km/hr	24 km/hr	2 km/hr	24 km/hr		
1.5±0.25	S	S			S	
2.0±0.25	S	S			S	
2.2±0.25	S	S			S	
2.5±0.25	S	S			S	
2.8±0.25	S	S			S	
3.0±0.25			L	L		
3.5±0.25	S	S			S	
4.0±0.5	S	S			S	
Polydisperse Glycerol Aerosol						L

[a] Aerodynamic diameter.
S=Solid particles.
L=Liquid particles.

Table F–3 to Subpart F—Critical Parameters of Idealized Ambient Particle Size Distributions

Idealized Distribution	Fine Particle Mode			Coarse Particle Mode			$PM_{2.5}$/ PM_{10} Ratio	FRM Sampler Expected Mass Conc. (µg/m³)
	MMD (µm)	Geo. Std. Dev.	Conc. (µg/m³)	MMD (µm)	Geo. Std. Dev.	Conc. (µg/m³)		
Coarse	0.50	2	12.0	10	2	88.0	0.27	13.814
‘‘Typical’’	0.50	2	33.3	10	2	66.7	0.55	34.284
Fine	0.85	2	85.0	15	2	15.0	0.94	78.539

Table F–4 to Subpart F—Estimated Mass Concentration Measurement of $PM_{2.5}$ for Idealized Coarse Aerosol Size Distribution

Particle Aerodynamic Diameter (µm)	Test Sampler			Ideal Sampler		
	Fractional Sampling Effectiveness	Interval Mass Concentration (µg/m³)	Estimated Mass Concentration Measurement (µg/m³)	Fractional Sampling Effectiveness	Interval Mass Concentration (µg/m³)	Estimated Mass Concentration Measurement (µg/m³)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
<0.500	1.000	6.001		1.000	6.001	6.001
0.625		2.129		0.999	2.129	2.127
0.750		0.982		0.998	0.982	0.980
0.875		0.730		0.997	0.730	0.728
1.000		0.551		0.995	0.551	0.548
1.125		0.428		0.991	0.428	0.424
1.250		0.346		0.987	0.346	0.342
1.375		0.294		0.980	0.294	0.288
1.500		0.264		0.969	0.264	0.256
1.675		0.251		0.954	0.251	0.239
1.750		0.250		0.932	0.250	0.233
1.875		0.258		0.899	0.258	0.232
2.000		0.272		0.854	0.272	0.232
2.125		0.292		0.791	0.292	0.231
2.250		0.314		0.707	0.314	0.222
2.375		0.339		0.602	0.339	0.204
2.500		0.366		0.480	0.366	0.176
2.625		0.394		0.351	0.394	0.138
2.750		0.422		0.230	0.422	0.097
2.875		0.449		0.133	0.449	0.060
3.000		0.477		0.067	0.477	0.032
3.125		0.504		0.030	0.504	0.015
3.250		0.530		0.012	0.530	0.006
3.375		0.555		0.004	0.555	0.002
3.500		0.579		0.001	0.579	0.001
3.625		0.602		0.000000	0.602	0.000000
3.750		0.624		0.000000	0.624	0.000000
3.875		0.644		0.000000	0.644	0.000000
4.000		0.663		0.000000	0.663	0.000000
4.125		0.681		0.000000	0.681	0.000000
4.250		0.697		0.000000	0.697	0.000000
4.375		0.712		0.000000	0.712	0.000000
4.500		0.726		0.000000	0.726	0.000000
4.625		0.738		0.000000	0.738	0.000000
4.750		0.750		0.000000	0.750	0.000000
4.875		0.760		0.000000	0.760	0.000000
5.000		0.769		0.000000	0.769	0.000000
5.125		0.777		0.000000	0.777	0.000000
5.250		0.783		0.000000	0.783	0.000000
5.375		0.789		0.000000	0.789	0.000000
5.500		0.794		0.000000	0.794	0.000000
5.625		0.798		0.000000	0.798	0.000000
5.75		0.801		0.000000	0.801	0.000000
		$C_{sam(exp)}$=			$C_{ideal(exp)}$=	13.814

Table F–5 to Subpart F—Estimated Mass Concentration Measurement of PM$_{2.5}$ for Idealized ''Typical'' Coarse Aerosol Size Distribution

Particle Aerodynamic Diameter (μm)	Test Sampler			Ideal Sampler		
	Fractional Sampling Effectiveness	Interval Mass Concentration (μg/m^3)	Estimated Mass Concentration Measurement (μg/m^3)	Fractional Sampling Effectiveness	Interval Mass Concentration (μg/m^3)	Estimated Mass Concentration Measurement (μg/m^3)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
<0.500	1.000	16.651		1.000	16.651	16.651
0.625		5.899		0.999	5.899	5.893
0.750		2.708		0.998	2.708	2.703
0.875		1.996		0.997	1.996	1.990
1.000		1.478		0.995	1.478	1.471
1.125		1.108		0.991	1.108	1.098
1.250		0.846		0.987	0.846	0.835
1.375		0.661		0.980	0.661	0.648
1.500		0.532		0.969	0.532	0.516
1.675		0.444		0.954	0.444	0.424
1.750		0.384		0.932	0.384	0.358
1.875		0.347		0.899	0.347	0.312
2.000		0.325		0.854	0.325	0.277
2.125		0.314		0.791	0.314	0.248
2.250		0.312		0.707	0.312	0.221
2.375		0.316		0.602	0.316	0.190
2.500		0.325		0.480	0.325	0.156
2.625		0.336		0.351	0.336	0.118
2.750		0.350		0.230	0.350	0.081
2.875		0.366		0.133	0.366	0.049
3.000		0.382		0.067	0.382	0.026
3.125		0.399		0.030	0.399	0.012
3.250		0.416		0.012	0.416	0.005
3.375		0.432		0.004	0.432	0.002
3.500		0.449		0.001	0.449	0.000000
3.625		0.464		0.000000	0.464	0.000000
3.750		0.480		0.000000	0.480	0.000000
3.875		0.494		0.000000	0.494	0.000000
4.000		0.507		0.000000	0.507	0.000000
4.125		0.520		0.000000	0.520	0.000000
4.250				0.000000	0.532	0.000000
4.375				0.000000	0.543	0.000000
4.500				0.000000	0.553	0.000000
4.625				0.000000	0.562	0.000000
4.750				0.000000	0.570	0.000000
4.875				0.000000	0.577	0.000000
5.000				0.000000	0.584	0.000000
5.125				0.000000	0.590	0.000000
5.250				0.000000	0.595	0.000000
5.375				0.000000	0.599	0.000000
5.500				0.000000	0.603	0.000000
5.625				0.000000	0.605	0.000000
5.75				0.000000	0.608	0.000000
		$C_{sam(exp)}$=			$C_{ideal(exp)}$=	34.284

Table F–6 to Subpart F—Estimated Mass Concentration Measurement of PM$_{2.5}$ for Idealized Fine Aerosol Size Distribution

Particle Aerodynamic Diameter (μm)	Test Sampler			Ideal Sampler		
	Fractional Sampling Effectiveness	Interval Mass Concentration (μg/m^3)	Estimated Mass Concentration Measurement (μg/m^3)	Fractional Sampling Effectiveness	Interval Mass Concentration (μg/m^3)	Estimated Mass Concentration Measurement (μg/m^3)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
<0.500	1.000	18.868		1.000	18.868	18.868
0.625		13.412		0.999	13.412	13.399
0.750		8.014		0.998	8.014	7.998
0.875		6.984		0.997	6.984	6.963
1.000		5.954		0.995	5.954	5.924
1.125		5.015		0.991	5.015	4.970

Particle Aerodynamic Diameter (µm)	Test Sampler			Ideal Sampler		
	Fractional Sampling Effectiveness	Interval Mass Concentration (µg/m^3)	Estimated Mass Concentration Measurement (µg/m^3)	Fractional Sampling Effectiveness	Interval Mass Concentration (µg/m^3)	Estimated Mass Concentration Measurement (µg/m^3)
1.250		4.197		0.987	4.197	4.142
1.375		3.503		0.980	3.503	3.433
1.500		2.921		0.969	2.921	2.830
1.675		2.438		0.954	2.438	2.326
1.750		2.039		0.932	2.039	1.900
1.875		1.709		0.899	1.709	1.536
2.000		1.437		0.854	1.437	1.227
2.125		1.212		0.791	1.212	0.959
2.250		1.026		0.707	1.026	0.725
2.375		0.873		0.602	0.873	0.526
2.500		0.745		0.480	0.745	0.358
2.625		0.638		0.351	0.638	0.224
2.750		0.550		0.230	0.550	0.127
2.875		0.476		0.133	0.476	0.063
3.000		0.414		0.067	0.414	0.028
3.125		0.362		0.030	0.362	0.011
3.250		0.319		0.012	0.319	0.004
3.375		0.282		0.004	0.282	0.001
3.500		0.252		0.001	0.252	0.000000
3.625		0.226		0.000000	0.226	0.000000
3.750		0.204		0.000000	0.204	0.000000
3.875		0.185		0.000000	0.185	0.000000
4.000		0.170		0.000000	0.170	0.000000
4.125		0.157		0.000000	0.157	0.000000
4.250		0.146		0.000000	0.146	0.000000
4.375		0.136		0.000000	0.136	0.000000
4.500		0.129		0.000000	0.129	0.000000
4.625		0.122		0.000000	0.122	0.000000
4.750		0.117		0.000000	0.117	0.000000
4.875		0.112		0.000000	0.112	0.000000
5.000		0.108		0.000000	0.108	0.000000
5.125		0.105		0.000000	0.105	0.000000
5.250		0.102		0.000000	0.102	0.000000
5.375		0.100		0.000000	0.100	0.000000
5.500		0.098		0.000000	0.098	0.000000
5.625		0.097		0.000000	0.097	0.000000
5.75		0.096		0.000000	0.096	0.000000
		$C_{sam(exp)}$=			$C_{ideal(exp)}$=	78.539

FIGURE E–1 TO SUBPART F—DESIGNATION TESTING CHECKLIST

DESIGNATION TESTING CHECKLIST FOR CLASS II

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Auditee Auditor signature Date

Compliance Status: Y = Yes N = No NA = Not applicable/Not available				Verification Comments (Includes documentation of who, what, where, when, why) (Doc. #, Rev. #, Rev. Date)
Verification			Verified by Direct Observation of Process or of Documented Evidence: Performance, Design or Application Spec. Corresponding to Sections of 40 CFR Part 53, Subparts E and F	
Y	N	NA		
			Subpart E: Performance Specification Tests	
			Evaluation completed according to Subpart E § 53.50 to § 53.56	
			Subpart E: Class I Sequential Tests	
			Class II samplers that are also Class I (sequentialized) have passed the tests in § 53.57	
			Subpart F: Performance Spec/Test	

Compliance Status: Y = Yes N = No NA = Not applicable/Not available				Verification Comments (Includes documentation of who, what, where, when, why) (Doc. #, Rev. #, Rev. Date)
Verification			Verified by Direct Observation of Process or of Documented Evidence: Performance, Design or Application Spec. Corresponding to Sections of 40 CFR Part 53, Subparts E and F	
Y	N	NA		
			Evaluation of Physical Characteristics of Clean Sampler - One of these tests must be performed: § 53.62 - Full Wind Tunnel § 53.63 - Inlet Aspiration § 53.64 - Static Fractionator	
			Evaluation of Physical Characteristics of Loaded Sampler § 53.65 Loading Test One of the following tests must be performed for evaluation after loading: § 53.62, § 53.63, § 53.64	
			Evaluation of the Volatile Characteristics of the Class II Sampler § 53.66	

APPENDIX A TO SUBPART REFERENCES

(1) Marple, V.A., K.L. Rubow, W. Turner, and J.D. Spangler, Low Flow Rate Sharp Cut Impactors for Indoor Air Sampling: Design and Calibration., JAPCA, 37: 1303-1307 (1987).

(2) Vanderpool, R.W. and K.L. Rubow, Generation of Large, Solid Calibration Aerosols, J. of Aer. Sci. and Tech., 9:65-69 (1988).

(3) Society of Automotive Engineers Aerospace Material Specification (SAE AMS) 2404C, Electroless Nickel Planting, SAE, 400 Commonwealth Drive, Warrendale PA-15096, Revised 7-1-84, pp. 1-6.

PART 54—PRIOR NOTICE OF CITIZEN SUITS

Sec.
54.1 Purpose.
54.2 Service of notice.
54.3 Contents of notice.

AUTHORITY: Sec. 304 of the Clean Air Act, as amended (sec. 12, Pub. L. 91–604, 84 Stat. 1706).

SOURCE: 36 FR 23386, Dec. 9, 1971, unless otherwise noted.

§ 54.1 Purpose.

Section 304 of the Clean Air Act, as amended, authorizes the commencement of civil actions to enforce the Act or to enforce certain requirements promulgated pursuant to the Act. The purpose of this part is to prescribe procedures governing the giving of notices required by subsection 304(b) of the Act (sec. 12, Pub. L. 91–604; 84 Stat. 1706) as a prerequisite to the commencement of such actions.

§ 54.2 Service of notice.

(a) Notice to Administrator: Service of notice given to the Administrator under this part shall be accomplished by certified mail addressed to the Administrator, Environmental Protection Agency, Washington, DC 20460. Where notice relates to violation of an emission standard or limitation or to violation of an order issued with respect to an emission standard or limitation, a copy of such notice shall be mailed to the Regional Administrator of the Environmental Protection Agency for the Region in which such violation is alleged to have occurred.

(b) Notice to State: Service of notice given to a State under this part regarding violation of an emission standard or limitation, or an order issued with respect to an emission standard or limitation shall be accomplished by certified mail addressed to an authorized representative of the State agency charged with responsibility for air pollution control in the State. A copy of such notice shall be mailed to the Governor of the State.

(c) Notice to alleged violator: Service of notice given to an alleged violator under this part shall be accomplished by certified mail addressed to, or by personal service upon, the owner or managing agent of the building, plant,