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Example 2

In this example, everyday sampling was initiated following the first observed exceedance as required by 40 CFR 58.12. Accordingly, the first observed exceedance would not be adjusted for incomplete sampling. During the next three quarters, 1.2 exceedances were estimated. In this case, the estimated exceedances for the year would be 1.0 + 1.2 + 0.0 + 0.0 which equals 2.2. If, as before, no exceedances were observed for the two previous years, then the estimated exceedances for the 3-year period would then be \((\frac{1}{3}) \times (2.2 + 0.0 + 0.0) = 0.7\), and the monitoring site would not fail the attainment test.

3.2 Adjustments for Non-Scheduled Sampling Days

(a) If a systematic sampling schedule is used and sampling is performed on days in addition to the days specified by the systematic sampling schedule, e.g., during episodes of high pollution, then an adjustment must be made in the equation for the estimation of exceedances. Such an adjustment is needed to eliminate the bias in the estimate of the quarterly and annual number of exceedances that would occur if the chance of an exceedance is different for scheduled than for non-scheduled days, as would be the case with episode sampling.

(b) The required adjustment treats the systematic sampling schedule as a stratified sampling plan. If the period from one scheduled sample until the day preceding the next scheduled sample is defined as a sampling stratum, then there is one stratum for each scheduled sampling day. An average number of observed exceedances is computed for each of these sampling strata. With nonscheduled sampling days, the estimated number of exceedances is defined as:

\[
e_q = \left( \frac{N_q}{m_q} \right) \times \sum_{j=1}^{m_q} \left( \frac{v_j}{k_j} \right)
\]

Where:
- \(e_q\) = the estimated number of exceedances for the quarter;
- \(N_q\) = the number of days in the quarter;
- \(m_q\) = the number of strata with samples during the quarter;
- \(v_j\) = the number of observed exceedances in stratum \(j\); and
- \(k_j\) = the number of actual samples in stratum \(j\).

(c) Note that if only one sample value is recorded in each stratum, then Equation 3 reduces to Equation 1.

Example 3

A monitoring site samples according to a systematic sampling schedule of one sample every 6 days, for a total of 15 scheduled samples in a quarter out of a total of 92 possible samples. During one 6-day period, potential episode levels of PM<sub>2.5</sub> were suspected, so 5 additional samples were taken. One of the regular scheduled samples was missed, so a total of 19 samples in 14 sampling strata were measured. The one 6-day sampling stratum with 6 samples recorded 2 exceedances. The remainder of the quarter with one sample per stratum recorded zero exceedances. Using Equation 3, the estimated number of exceedances for the quarter is:

\[
Eq = (92/14) \times (2/6 + 0 + \ldots + 0) = 2.19.
\]

[71 FR 61224, Oct. 17, 2006]

APPENDIX L TO PART 50—REFERENCE METHOD FOR THE DETERMINATION OF FINE PARTICULATE MATTER AS PM<sub>2.5</sub> IN THE ATMOSPHERE

1.0 Applicability.

1.1 This method provides for the measurement of the mass concentration of fine particulate matter having an aerodynamic diameter less than or equal to a nominal 2.5 micrometers (PM<sub>2.5</sub>) in ambient air over a 24-hour period for purposes of determining whether the primary and secondary national ambient air quality standards for fine particulate matter specified in §50.7 and §50.13 of this part are met. The measurement process is considered to be nondestructive, and the PM<sub>2.5</sub> sample obtained can be subjected to subsequent physical or chemical analyses. Quality assurance procedures are provided in part 58, appendix A of this chapter, and quality assurance guidance are provided in references 1, 2, and 3 in section 13.0 of this appendix.

1.2 This method will be considered a reference method for purposes of part 58 of this chapter only if:

(a) The associated sampler meets the requirements specified in this appendix and the applicable requirements in part 58 of this chapter, and

(b) The method and associated sampler have been designated as a reference method in accordance with part 53 of this chapter.

1.3 PM<sub>2.5</sub> samplers that meet nearly all specifications set forth in this method but have minor deviations and/or modifications of the reference method sampler will be designated as “class I” equivalent methods for PM<sub>2.5</sub> in accordance with part 53 of this chapter.

2.0 Principle.

2.1 An electrically powered air sampler draws ambient air at a constant volumetric flow rate into a specially shaped inlet and through an inertial particle size separator.
(impactor) where the suspended particulate matter in the PM$_{2.5}$ size range is separated for collection on a polytetrafluoroethylene (PTFE) filter over the specified sampling period. The required sample period and other aspects of this reference method are specified either explicitly in this appendix or generally with reference to other applicable regulations or guidance.

2.2 Each filter is weighed (after moisture and temperature conditioning) before and after sample collection to determine the net gain due to collected PM$_{2.5}$. The total volume of air sampled is determined by the sampler from the measured flow rate at actual ambient temperature and pressure and the sampling time. The mass concentration of PM$_{2.5}$ in the ambient air is computed as the total mass of collected particles in the PM$_{2.5}$ size range divided by the actual volume of air sampled, and is expressed in micrograms per cubic meter of air ($\mu$g/m$^3$).

3.0 PM$_{2.5}$ Measurement Range.

3.1 Lower concentration limit. The lower detection limit of the mass concentration measurement range is estimated to be approximately 2 $\mu$g/m$^3$, based on noted mass changes in field blanks in conjunction with the 24 m$^3$ nominal total air sample volume specified for the 24-hour sample.

3.2 Upper concentration limit. The upper limit of the mass concentration range is determined by the filter mass loading beyond which the sampler can no longer maintain the operating flow rate within specified limits due to increased pressure drop across the loaded filter. This upper limit cannot be specified precisely because it is a complex function of the ambient particle size distribution and type, humidity, the individual filter used, the capacity of the sampler flow rate control system, and perhaps other factors. Nevertheless, all samplers are estimated to be capable of measuring 24-hour PM$_{2.5}$ mass concentrations of at least 200 $\mu$g/m$^3$ while maintaining the operating flow rate within the specified limits.

3.3 Sample period. The required sample period for PM$_{2.5}$ concentration measurements by this method shall be 1,380 to 1500 minutes (21 to 25 hours). However, when a sample period is less than 1,380 minutes, the measured concentration (as determined by the collected PM$_{2.5}$ mass divided by the actual sampled air volume), multiplied by the actual number of minutes in the sample period and divided by 1,440, may be used as if it were a valid concentration measurement for the specific purpose of determining a violation of the NAAQS. This value assumes that the PM$_{2.5}$ concentration is zero for the remaining portion of the sample period and therefore represents the minimum concentration that could have been measured for the full 24-hour sample period. Accordingly, if the value thus calculated is high enough to be an exceedance, such an exceedance would be a valid exceedance for the sample period. When reported to AIRS, this data value should receive a special code to identify it as not to be commingled with normal concentration measurements or used for other purposes.

4.0 Accuracy.

4.1 Because the size and volatility of the particles making up ambient particulate matter vary over a wide range and the mass concentration of particles varies with particle size, it is difficult to define the accuracy of PM$_{2.5}$ measurements in an absolute sense. The accuracy of PM$_{2.5}$ measurements is therefore defined in a relative sense, referenced to measurements provided by this reference method. Accordingly, accuracy shall be defined as the degree of agreement between a subject field PM$_{2.5}$ sampler and a colocated PM$_{2.5}$ reference method audit sampler operating simultaneously at the monitoring site location of the subject sampler and includes both random (precision) and systematic (bias) errors. The requirements for this field sampler audit procedure are set forth in part 58, appendix A of this chapter.

4.2 Measurement system bias. Results of colocated measurements where the duplicate sampler is a reference method sampler are used to assess a portion of the measurement system bias according to the schedule and procedure specified in part 58, appendix A of this chapter.

4.3 Audits with reference method samplers to determine system accuracy and bias. According to the schedule and procedure specified in part 58, appendix A of this chapter, a reference method sampler is required to be located at each of selected PM$_{2.5}$ SLAMS sites as a duplicate sampler. The results from the primary sampler and the duplicate reference method sampler are used to calculate accuracy of the primary sampler on a quarterly basis, bias of the primary sampler on an annual basis, and bias of a single reporting organization on an annual basis. Reference 2 in section 13.0 of this appendix provides additional information and guidance on these reference method audits.

4.4 Flow rate accuracy and bias. Part 58, appendix A of this chapter requires that the flow rate accuracy and bias of individual PM$_{2.5}$ samplers used in SLAMS monitoring networks be assessed periodically via audits of each sampler’s operational flow rate. In addition, part 58, appendix A of this chapter requires that flow rate bias for each reference and equivalent method operated by each reporting organization be assessed quarterly and annually. Reference 2 in section 13.0 of this appendix provides additional information and guidance on flow rate accuracy audits and calculations for accuracy and bias.

5.0 Precision. A data quality objective of 10 percent coefficient of variation or better has
been established for the operational precision of PM$_{2.5}$ monitoring data.

5.1 Tests to establish initial operational precision for each reference method sampler are specified as part of the requirements for designation as a reference method under §53.58 of this chapter.

5.2 Measurement System Precision. Collocated sampler results, where the duplicate sampler is not a reference method sampler but is a sampler of the same designated method as the primary sampler, are used to assess measurement system precision according to the schedule and procedure specified in part 58, appendix A of this chapter. Part 58, appendix A of this chapter requires that these collocated sampler measurements be used to calculate quarterly and annual precision estimates for each primary sampler and for each designated method employed by each reporting organization. Reference 2 in section 13.0 of this appendix provides additional information and guidance on this requirement.

6.0 Filter for PM$_{2.5}$, Sample Collection. Any filter manufacturer or vendor who sells or offers to sell filters specifically identified for use with this PM$_{2.5}$ reference method shall certify that the required number of filters from each lot of filters offered for sale as such have been tested as specified in this section 6.0 and meet all of the following design and performance specifications.

6.1 Size. Circular, 46.2 mm diameter ±0.25 mm.

6.2 Medium. Polytetrafluoroethylene (PTFE Teflon), with integral support ring.

6.3 Support ring. Polyethylene (PE) or equivalent inert material, 0.38 ±0.04 mm thick, outer diameter 46.2 mm ±0.25 mm, and width of 3.68 mm ±0.00, -0.51 mm.

6.4 Pore size. 2 μm as measured by ASTM F 316–94.

6.5 Filter thickness. 30 to 50 μm.

6.6 Maximum pressure drop (clean filter). 30 cm H$_2$O column @ 16.67 L/min clean air flow.

6.7 Maximum moisture pickup. Not more than 10 μg weight increase after 24-hour exposure to air of 48 percent relative humidity, relative to weight after 24-hour exposure to air of 35 percent relative humidity.

6.8 Collection efficiency. Greater than 99.7 percent, as measured by the DOP test (ASTMD 2986-91) with 0.3 μm particles at the sampler’s operating face velocity.

6.9 Filter weight stability. Filter weight loss shall be less than 20 μg, as measured in each of the following two tests specified in sections 6.9.1 and 6.9.2 of this appendix. The following conditions apply to both of these tests: Filter weight loss shall be the average difference between the initial and the final filter weights of a random sample of test filters selected from each lot prior to sale. The number of filters tested shall be not less than 0.1 percent of the filters of each manufacturing lot, or 10 filters, whichever is greater. The filters shall be weighed under laboratory conditions and shall have had no air sample passed through them, i.e., filter blanks. Each test procedure must include initial conditioning and weighing, the test, and final conditioning and weighing. Conditioning and weighing shall be in accordance with sections 8.0 through 8.2 of this appendix and general guidance provided in reference 2 of section 13.0 of this appendix.

6.9.1 Test for loose, surface particle contamination. After the initial weighing, install each test filter, in turn, in a filter cassette (Figures L–27, L–28, and L–29 of this appendix) and drop the cassette from a height of 25 cm to a flat hard surface, such as a particle-free wood bench. Repeat two times, for a total of three drop tests for each test filter. Remove the test filter from the cassette and weigh the filter. The average change in weight must be less than 20 μg.

6.9.2 Test for temperature stability. After weighing each filter, place the test filters in a drying oven set at 40 °C ±2 °C for not less than 48 hours. Remove, condition, and reweigh each test filter. The average change in weight must be less than 20 μg.

6.10 Alkalinity. Less than 25 microequivalents/gram of filter, as measured by the guidance given in reference 2 in section 13.0 of this appendix.

6.11 Supplemental requirements. Although not required for determination of PM$_{2.5}$ mass concentration under this reference method, additional specifications for the filter must be developed by users who intend to subject PM$_{2.5}$ filter samples to subsequent chemical analysis. These supplemental specifications include background chemical contamination of the filter and any other filter parameters that may be required by the method of chemical analysis. All such supplemental filter specifications must be compatible with and secondary to the primary filter specifications given in this section 6.0 of this appendix.

7.0 PM$_{2.5}$ Sampler.

7.1 Configuration. The sampler shall consist of a sample air inlet, downtube, particle size separator (impactor), filter holder assembly, air pump and flow rate control system, flow rate measurement device, ambient and filter temperature monitoring system, barometric pressure measurement system, timer, outdoor environmental enclosure, and suitable mechanical, electrical, or electronic control capability to meet or exceed the design and functional performance as specified in this section 7.0 of this appendix. The performance specifications require that the sampler:

(a) Provide automatic control of sample volumetric flow rate and other operational parameters.

(b) Monitor these operational parameters as well as ambient temperature and pressure.

(c) Provide this information to the sampler operator at the end of each sample period in
digital form, as specified in table L–1 of section 7.4.19 of this appendix.

7.2 Nature of specifications. The PM<sub>2.5</sub> sampler is specified by a combination of design and operational requirements. Each of the Sampler, Inlet, Downtube, Particle Size Discriminator, Filter Cassette, and the Internal Configuration of the filter holder assembly are specified by design figures and associated mechanical dimensions, tolerances, materials, surface finishes, assembly instructions, and other necessary specifications. All other aspects of the sampler are specified by required operational function and performance, and the design of these other aspects (including the design of the lower portion of the filter holder assembly) is optional, subject to acceptable operational performance. Test procedures to demonstrate compliance with both the design and performance requirements are set forth in subpart E of part 53 of this chapter.

7.3 Design specifications. Except as indicated in this section 7.3 of this appendix, these components must be manufactured or reproduced exactly as specified, in an ISO 9001-registered facility, with registration initially approved and subsequently maintained during the period of manufacture. See §3.1(c) of this chapter for the definition of an ISO-registered facility. Minor modifications or variances to one or more components that clearly would not affect the aerodynamic performance of the inlet, downtube, impactor, or filter cassette will be considered for specific approval. Any such proposed modifications shall be described and submitted to the EPA for specific individual acceptability either as part of a reference or equivalent method application under part 53 of this chapter or in writing in advance of such an intended application under part 53 of this chapter.

7.3.1 Sample inlet assembly. The sample inlet assembly, consisting of the inlet, downtube, and impactor, shall be configured and assembled as indicated in Figure L–1 of this appendix and shall meet all associated requirements. A portion of this assembly shall also be subject to the maximum overall sampler leak rate specification under section 7.4.6 of this appendix.

7.3.2 Inlet. The sample inlet shall be fabricated as indicated in Figures L–2 through L–11 of this appendix and shall meet all associated requirements.

7.3.3 Downtube. The downtube shall be fabricated as indicated in Figure L–19 of this appendix and shall meet all associated requirements.

7.3.4 Particle size separator. The sampler shall be configured with either one of the two alternative particle size separators described in this section 7.3.4. One separator is an impactor-type separator (WINS impactor) described in sections 7.3.4.1, 7.3.4.2, and 7.3.4.3 of this appendix. The alternative separator is a cyclone-type separator (VSCCTM) described in section 7.3.4.4 of this appendix.

7.3.4.1 The impactor (particle size separator) shall be fabricated as indicated in Figures L–20 through L–24 of this appendix, and shall meet all associated requirements. Following the manufacture and finishing of each upper impactor housing (Figure L–23 of this appendix), the dimension of the impactation jet must be verified by the manufacturer using an equivalent method.

7.3.4.2 Impactor filter specifications:

(a) Size. Circular, 35 to 37 mm diameter.
(b) Material. Borosilicate glass fiber, without binder.
(c) Pore size. 1 to 1.5 micrometer, as measured by ASTM F 316–80.
(d) Thickness. 300 to 500 micrometers.
(e) Composition. Diocyl sebacate (DOS), single-compound diffusion oil.
(f) Vapor pressure. Maximum 2×10<sup>−3</sup> mm Hg at 25°C.
(g) Density. 1.06 to 1.07 g/cm<sup>3</sup> at 25°C.
(h) Quantity. 1 mL ±0.1 mL.

7.3.4.3 Impactor oil specifications:

(a) Size. Circular, 35 to 37 mm diameter.
(b) Composition. Dioctyl sebacate (DOS), single-compound diffusion oil.
(c) Pore size. 1 to 1.5 micrometer, as measured by ASTM F 316–80.
(d) Thickness. 300 to 500 micrometers.
(e) Composition. Diocyl sebacate (DOS), single-compound diffusion oil.
(f) Vapor pressure. Maximum 2×10<sup>−3</sup> mm Hg at 25°C.
(g) Density. 1.06 to 1.07 g/cm<sup>3</sup> at 25°C.
(h) Quantity. 1 mL ±0.1 mL.

7.3.4.4 The cyclone-type separator is identified as a BGI VSCCTM Very Sharp Cut Cyclone particle size separator specified as part of an ISO-registered facility. Minor modifications or variances to one or more components that clearly would not affect the aerodynamic performance of the inlet, downtube, impactor, or filter cassette will be considered for specific approval. Any such proposed modifications shall be described and submitted to the EPA for specific individual acceptability either as part of a reference or equivalent method application under part 53 of this chapter. See Table L–1 of this appendix, the dimension of the impaction jet must be verified by the manufacturer using an equivalent method.

7.3.5 Filter holder assembly. The sampler shall have a sample filter holder assembly to adapt and seal to the down tube and to hold and seal the specified filter, under section 6.0 of this appendix, in the sample air stream in a horizontal position below the downtube such that the sample air passes downward through the filter at a uniform face velocity. The upper portion of this assembly shall be fabricated as indicated in Figures L–25 and L–26 of this appendix and shall accept and seal with the filter cassette, which shall be fabricated as indicated in Figures L–27 through L–29 of this appendix.

(a) The lower portion of the filter holder assembly shall be of a design and construction that:
(1) Mates with the upper portion of the assembly to complete the filter holder assembly.
(2) Completes both the external air seal and the internal filter cassette seal such that all seals are reliable over repeated filter changings, and
(3) Facilitates repeated changing of the filter cassette by the sampler operator.

(b) Leak-test performance requirements for the filter holder assembly are included in section 7.4.6 of this appendix.

(c) If additional or multiple filters are stored in the sampler as part of an automatic sequential sample capability, all such
filters, unless they are currently and directly installed in a sampling channel or sampling configuration (either active or inactive), shall be covered or (preferably) sealed in such a way as to:

(1) Preclude significant exposure of the filter to possible contamination or accumulation of dust, insects, or other material that may be present in the air to the sampler, or sampler ventilation air during storage periods either before or after sampling; and

(2) To minimize loss of volatile or semi-volatile PM sample components during storage periods either before or after sampling; and

or sampler ventilation air during storage periods.

or sampler ventilation air during storage periods.

7.3.6 Flow rate measurement adapter. A flow rate measurement adapter as specified in Figure L–30 of this appendix shall be furnished with each sampler.

7.3.7 Surface finish. All internal surfaces exposed to sample air prior to the filter shall be treated electrolytically in a sulfuric acid bath to produce a clear, uniform anodized surface finish of not less than 1000 mg ft² (1.08 mg cm²) in accordance with military standard specification (mil. spec.) 8625F, Type II, Class 1 in reference 4 of section 13.0 of this appendix. This anodic surface coating shall not be dyed or pigmented. Following anodization, the surfaces shall be sealed by immersion in boiling deionized water for not less than 15 minutes. Section 53.51(d)(2) of this chapter should also be consulted.

7.3.8 Sampling height. The sampler shall be equipped with legs, a stand, or other means to maintain the sampler in a stable, upright position and such that the center of the sample air entrance to the inlet, during sample collection, is maintained in a horizontal plane and is 2.0 ± 0.2 meters above the floor or other horizontal supporting surface. Suitable bolt holes, brackets, tie-downs, or other means should be provided to facilitate mechanically securing the sample to the supporting surface to prevent topping of the sampler due to wind.

7.4 Performance specifications.

7.4.1 Sample flow rate. Proper operation of the impactor requires that specific air velocities be maintained through the device. Therefore, the design sample air flow rate through the inlet shall be 10.67 L/min (1.00 m³/hour) measured as actual volumetric flow rate at the temperature and pressure of the sample air entering the inlet.

7.4.2 Sample air flow rate control system. The sampler shall have a sample air flow rate control system which shall be capable of providing a sample air volumetric flow rate within the specified range, under section 7.4.1 of this appendix, for the specified filter, under section 6.0 of this appendix, at any atmospheric conditions specified, under section 7.4.7 of this appendix, at a filter pressure drop equal to that of a clean filter plus up to 75 cm water column (55 mm Hg), and over the specified range of supply line voltage, under section 7.4.15.1 of this appendix. This flow control system shall allow for operator adjustment of the operational flow rate of the sampler over a range of at least ±15 percent of the flow rate specified in section 7.4.1 of this appendix.

7.4.3 Sample flow rate regulation. The sample flow rate shall be regulated such that for the specified filter, under section 6.0 of this appendix, at any atmospheric conditions specified, under section 7.4.7 of this appendix, at a filter pressure drop equal to that of a clean filter plus up to 75 cm water column (55 mm Hg), and over the specified range of supply line voltage, under section 7.4.15.1 of this appendix, the flow rate is regulated as follows:

7.4.3.1 The volumetric flow rate, measured or averaged over intervals of not more than 5 minutes over a 24-hour period, shall not vary more than ±5 percent from the specified 16.67 L/min flow rate over the entire sample period.

7.4.3.2 The coefficient of variation (sample standard deviation divided by the mean) of the flow rate, measured over a 24-hour period, shall not be greater than 2 percent.

7.4.3.3 The amplitude of short-term flow rate pulsations, such as may originate from some types of vacuum pumps, shall be attenuated such that they do not cause significant flow measurement error or affect the collection of particles on the particle collection filter.

7.4.4 Flow rate cut off. The sampler’s sample air flow rate control system shall terminate sample collection and stop all sample flow for the remainder of the sample period in the event that the sample flow rate deviates by more than 10 percent from the sampler design flow rate specified in section 7.4.1 of this appendix for more than 60 seconds. However, this sampler cut-off provision shall not apply during periods when the sampler is inoperative due to a temporary power interruption, and the elapsed time of the inoperative period shall not be included in the total sample time measured and reported by the sampler, under section 7.4.18 of this appendix.

7.4.5 Flow rate measurement.

7.4.5.1 The sampler shall provide a means to measure and indicate the instantaneous sample air flow rate, which shall be measured as volumetric flow rate at the temperature and pressure of the sample air entering the inlet, with an accuracy of ±2 percent. The measured flow rate shall be available for display to the sampler operator at any time in either sampling or standby modes, and the measurement shall be updated at least every 30 seconds. The sampler shall also provide a simple means by which the sampler operator can manually start the sample flow temporarily during non-sampling modes of operation, for the purpose of checking the sample flow rate or the flow rate measurement system.

7.4.5.2 During each sample period, the sampler’s flow rate measurement system shall
automatically monitor the sample volumetric flow rate, obtaining flow rate measurements at intervals of not greater than 30 seconds.

Using these interval flow rate measurements, the sampler shall determine or calculate the following flow-related parameters, scaled in the specified engineering units:

1. The instantaneous or interval-average flow rate, in L/min.
2. The value of the average sample flow rate for the sample period, in L/min.
3. The value of the coefficient of variation (sample standard deviation divided by the average) of the sample flow rate for the sample period, in percent.
4. The occurrence of any time interval during the sample period in which the measured sample flow rate exceeds a range of ±5 percent of the average flow rate for the sample period for more than 5 minutes, in which case a warning flag indicator shall be set.
5. The value of the integrated total sample volume for the sample period, in m³.

(b) Determination or calculation of these values shall properly exclude periods when the sampler is inoperative due to temporary interruption of electrical power, under section 7.4.33 of this appendix, or flow rate cut off, under section 7.4.4 of this appendix.

(c) These parameters shall be accessible to the sampler operator as specified in table L–1 of section 7.4.19 of this appendix. In addition, it is strongly encouraged that the flow rate for each 5-minute interval during the sample period be available to the operator following the end of the sample period.

7.4.6 Leak test capability.
7.4.6.1 External leakage. The sampler shall include an external air leak-test capability consisting of components, accessory hardware, operator interface controls, a written procedure in the associated Operation/Instruction Manual, under section 7.4.18 of this appendix, and all other necessary functional capability to permit and facilitate the sampler operator to conveniently carry out a leak test of the sampler at a field monitoring site without additional equipment. The sampler components to be subjected to this leak test include all components and their interconnections in which external air leakage would or could cause an error in the sampler’s measurement of the total volume of sample air that passes through the sample filter.

(a) The suggested technique for the operator to use for this leak test is as follows:

(1) Remove the sampler inlet and installs the flow rate measurement adapter supplied with the sampler, under section 7.3.6 of this appendix.

(2) Close the valve on the flow rate measurement adapter and use the sampler air pump to draw a partial vacuum in the sampler, including (at least) the impactor, filter holder assembly (filter in place), flow measurement device, and interconnections between these devices, of at least 55 mm Hg (75 cm water column), measured at a location downstream of the filter holder assembly.

(3) Plug the flow system downstream of these components to isolate the components under vacuum from the pump, such as with a built-in valve.

(4) Stop the pump.

(5) Measure the trapped vacuum in the sampler with a built-in pressure measuring device.

(b) The associated leak test procedure shall require that for successful passage of this test, the difference between the two pressure measurements shall not be greater than the number of mm of Hg specified for the sampler by the manufacturer, based on the actual internal volume of the sampler, that indicates a leak of less than 80 mL/min.

(c) Variations of the suggested technique or an alternative external leak test technique may be required for samplers whose design or configuration would make the suggested technique impossible or impractical. The specific proposed external leak test procedure, or particularly an alternative leak test technique, proposed for a particular candidate sampler may be described and submitted to the EPA for specific individual acceptability either as part of a reference or equivalent method application under part 53 of this chapter or in writing in advance of such an intended application under part 53 of this chapter.

7.4.6.2 Internal, filter bypass leakage. The sampler shall include an internal, filter bypass leak-check capability consisting of components, accessory hardware, operator interface controls, a written procedure in the Operation/Instruction Manual, and all other necessary functional capability to permit and facilitate the sampler operator to conveniently carry out a test for internal filter bypass leakage in the sampler at a field monitoring site without additional equipment. The purpose of the test is to determine that any portion of the sample flow rate that leaks past the sample filter without passing through the filter is insignificant relative to the design flow rate for the sampler.

(a) The suggested technique for the operator to use for this leak test is as follows:
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7.4.8 Ambient temperature sensor. The sampler shall have capability to measure the temperature of the ambient air surrounding the sampler over the range of -30 to +45 °C, with a resolution of 0.1 °C and accuracy of ±2.0 °C, referenced as described in reference 3 in section 13.0 of this appendix, with and without maximum solar insolation.

7.4.8.3 The ambient temperature sensor shall be mounted external to the sampler enclosure and shall have a passive, naturally ventilated sun shield. The sensor shall be located such that the entire sun shield is at least 5 cm above the horizontal plane of the sampler case or enclosure (disregarding the inlet and downtube) and external to the vertical plane of the nearest side or protruberance of the sampler case or enclosure. The maximum temperature measurement error of the ambient temperature measurement system shall be less than 1.6 °C at 1 m/s wind speed and 1000 W/m² solar radiation intensity.

7.4.8.2 The ambient temperature sensor shall be of such a design and mounted in such a way as to facilitate its convenient dismounting and immersion in a liquid for calibration and comparison to the filter temperature sensor, under section 7.4.11 of this appendix.

7.4.8.3 This ambient temperature measurement shall be updated at least every 30 seconds during both sampling and standby (non-sampling) modes of operation. A visual indication of the current (most recent) value of the ambient temperature measurement, updated at least every 30 seconds, shall be available to the sampler operator during both sampling and standby (non-sampling) modes of operation, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.8.4 This ambient temperature measurement shall be used for the purpose of effecting filter temperature control, under section 7.4.10 of this appendix, or computation of volumetric flow rate, under sections 7.4.1 to 7.4.5 of this appendix, if appropriate.

7.4.8.5 Following the end of each sample period, the sampler shall report the maximum, minimum, and average temperature for the sample period, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.9 Ambient barometric sensor. The sampler shall have capability to measure the barometric pressure of the air surrounding the sampler over a range of 600 to 800 mm Hg referenced as described in reference 3 in section 13.0 of this appendix; also see part 53, subpart E of this chapter. This barometric pressure measurement shall have a resolution of 5 mm Hg and an accuracy of ±10 mm Hg and shall be updated at least every 30 seconds. A visual indication of the value of the current

7.4.7 Range of operational conditions. The sampler is required to operate properly and meet all requirements specified in this appendix over the following operational ranges.

7.4.7.1 Ambient temperature. -30 to +45 °C

(Note: Although for practical reasons, the temperature range over which samplers are required to be tested under part 53 of this chapter is -20 to +40 °C, the sampler shall be designed to operate properly over this wider temperature range.)

7.4.7.2 Ambient relative humidity. 0 to 100 percent.

7.4.7.3 Barometric pressure range. 600 to 800 mm Hg.
(most recent) barometric pressure measurement, updated at least every 30 seconds, shall be available to the sampler operator during both sampling and standby (non-sampling) modes of operation, as specified in table L-1 of section 7.4.19 of this appendix.

This barometric pressure measurement may be used for purposes of computation of volume and barometric pressures for the sample period, as specified in table L-1 of section 7.4.19 of this appendix, if appropriate. Following the end of a sample period, the sampler shall report the maximum, minimum, and mean barometric pressures for the sample period, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.10 Filter temperature control (sampling and post-sampling). The sampler shall provide a means to limit the temperature rise of the sample filter (all sample filters for sequential samplers) from insolation and other sources, to no more than 5 °C above the temperature of the ambient air surrounding the sampler, during both sampling and post-sampling periods of operation. The post-sampling period is the non-sampling period between the end of the active sampling period and the time of retrieval of the sample filter by the sampler operator.

7.4.11 Filter temperature sensor(s).

7.4.11.1 The sampler shall have the capability to monitor the temperature of the sample filter (all sample filters for sequential samplers) over the range of -30 to +45 °C during both sampling and non-sampling periods. While the exact location of this temperature sensor is not explicitly specified, the filter temperature measurement system must demonstrate agreement, within 1 °C, with a test temperature sensor located within 1 cm of the center of the filter downstream of the filter during both sampling and non-sampling modes, as specified in the filter temperature measurement test described in part 53, subpart E of this chapter. This filter temperature measurement shall have a resolution of 0.1 °C and accuracy of ±1.0 °C, referenced as described in reference 3 in section 13.0 of this appendix. This temperature sensor shall be of such a design and mounted in such a way as to facilitate its reasonably convenient dismounting and immersion in a liquid for calibration and comparison to the ambient temperature sensor under section 7.4.8 of this appendix.

7.4.11.2 The filter temperature measurement shall be updated at least every 30 seconds during both sampling and standby (non-sampling) modes of operation. A visual indication of the current (most recent) value of the filter temperature measurement, updated at least every 30 seconds, shall be available to the sampler operator during both sampling and standby (non-sampling) modes of operation, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.11.3 For sequential samplers, the temperature of each filter shall be measured individually unless it can be shown, as specified in the filter temperature measurement test described in §53.57 of this chapter, that the temperature of each filter can be represented by fewer temperature sensors.

7.4.11.4 The sampler shall also provide a warning flag indicator following any occurrence in which the filter temperature (any filter temperature for sequential samplers) exceeds the ambient temperature by more than 5 °C for more than 30 consecutive minutes during either the sampling or post-sampling periods of operation, as specified in table L-1 of section 7.4.19 of this appendix, under section 10.12 of this appendix, regarding sample validity when a warning flag occurs. It is further recommended (not required) that the sampler be capable of recording the maximum differential between the measured filter temperature and the ambient temperature and its time and date of occurrence during both sampling and post-sampling (non-sampling) modes of operation and providing those data to be accessible to the sampler operator following the end of the sample period, as suggested in table L-1 of section 7.4.19 of this appendix.

7.4.12 Clock/timer system.

(a) The sampler shall have a programmable real-time clock/timer system that:

(1) Is capable of maintaining local time and date, including year, month, day-of-month, hour, minute, and second to an accuracy of ±1.0 minute per month.

(2) Provides a visual indication of the current system time, including year, month, day-of-month, hour, and minute, updated at least each minute, for operator verification.

(3) Provides appropriate operator controls for setting the correct local time and date.

(4) Is capable of starting the sample collection period and sample air flow at a specific, operator-settable time and date, and stopping the sample air flow and terminating the sampler collection period 24 hours (1440 minutes) later, or at a specific, operator-settable time and date.

(b) These start and stop times shall be readily settable by the sampler operator to within ±1.0 minute. The system shall provide a visual indication of the current start and stop time settings, readable to ±1.0 minute, for verification by the operator, and the start and stop times shall also be available via the data output port, as specified in table L-1 of section 7.4.19 of this appendix. Upon execution of a programmed sample period start, the sampler shall automatically reset all sample period information and warning flag indications pertaining to a previous sample period. Refer also to section 7.4.15.4 of this appendix regarding retention of current date and time and programmed start and stop times during a temporary electrical power interruption.

7.4.13 Sample time determination. The sampler shall be capable of determining the
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elapsed sample collection time for each PM₁₀ sample, accurate to within ±1.0 minute, measured as the time between the start of the sampling period, under section 7.4.12 of this appendix and the termination of the sample period, under section 7.4.12 of this appendix or section 7.4.4 of this appendix. This elapsed sample time shall not include periods of inoperative due to a temporary interruption of electrical power, under section 7.4.15.4 of this appendix. In the event that the elapsed sample time determined for the sample period is not within the range specified for the required sample period in section 3.3 of this appendix, the sampler shall set a warning flag indicator. The date and time of the start of the sample period, the value of the elapsed sample time for the sample period, and the flag indicator status shall be available to the sampler operator following the end of the sample period, as specified in table L–1 of section 7.4.19 of this appendix.

7.4.14 Outdoor environmental enclosure. The sampler shall have an outdoor enclosure (or enclosures) suitable to protect the filter and other non-weatherproof components of the sampler from precipitation, wind, dust, extremes of temperature and humidity; to help maintain temperature control of the filter (or filters, for sequential samplers); and to provide reasonable security for sampler components and settings.

7.4.15 Electrical power supply.

7.4.15.1 The sampler shall be operable and function as specified herein when operated on an electrical power supply voltage of 105 to 125 volts AC (RMS) at a frequency of 59 to 61 Hz. Optional operation as specified at additional power supply voltages and/or frequencies shall not be precluded by this requirement.

7.4.15.2 The design and construction of the sampler shall comply with all applicable National Electrical Code and Underwriters Laboratories electrical safety requirements.

7.4.15.3 The design of all electrical and electronic controls shall be such as to provide reasonable resistance to interference or malfunction from ordinary or typical levels of stray electromagnetic fields (EMF) as may be found at various monitoring sites and from typical levels of electrical transients or electronic noise as may often or occasionally be present on various electrical power lines.

7.4.15.4 In the event of temporary loss of electrical supply power to the sampler, the sampler shall not be required to sample or provide other specified functions during such loss of power, except that the internal clock/timer system shall maintain its local time and date setting within ±1 minute per week, and the sampler shall retain all other time and programmable settings and all data required to be available to the sampler operator following each sample period for at least 7 days without electrical supply power. When electrical power is absent at the operator-set time for starting a sample period or is interrupted during a sample period, the sampler shall automatically start or resume sampling when electrical power is restored, if such restoration of power occurs before the operator-set stop time for the sample period. 7.4.15.5 The sampler shall have the capability to record and retain a record of the year, month, day-of-month, hour, and minute of the start of each power interruption of more than 1 minute duration, up to 10 such power interruptions per sample period. (More than 10 such power interruptions shall invalidate the sample, except where an exceedance is measured, under section 3.3 of this appendix.) The sampler shall provide for these power interruption data to be available to the sampler operator following the end of the sample period, as specified in table L–1 of section 7.4.19 of this appendix.

7.4.16 Control devices and operator interface.

The sampler shall have mechanical, electrical, or electronic controls, control devices, electrical or electronic circuits as necessary to provide the timing, flow rate measurement and control, temperature control, data storage and computation, operator interface, and other functions specified. Operator-accessible controls, data displays, and interface devices shall be designed to be simple, straightforward, reliable, and easy to learn, read, and operate under field conditions. The sampler shall have provision for operator input and storage of up to 64 characters of numeric (or alphanumeric) data for purposes of site, sampler, and sample identification. This information shall be available to the sampler operator for verification and change and for output via the data output port along with other data following the end of a sample period, as specified in table L–1 of section 7.4.19 of this appendix. All data required to be available to the operator following a sample collection period or obtained during standby mode in a post-sampling period shall be retained by the sampler until reset, either manually by the operator or automatically by the sampler upon initiation of a new sample collection period.

7.4.17 Data output port requirement. The sampler shall have a standard RS–232C data output port connection through which digital data may be exported to an external data storage or transmission device. All information which is required to be available at the end of each sample period shall be accessible through this data output connection. The information that shall be accessible though this output port is summarized in table L–1 of section 7.4.19 of this appendix. Since no specific format for the output data is provided, the sampler manufacturer or vendor shall make available to sampler purchasers appropriate computer software capable of receiving exported sampler data and correctly
translating the data into a standard spreadsheet format and optionally any other formats as may be useful to sampler users. This requirement shall not preclude the sampler from offering other types of output connections in addition to the required RS-232C port.

7.4.18 Operation/instruction manual. The sampler shall include an associated comprehensive operation or instruction manual, as required by part 53 of this chapter, which includes detailed operating instructions on the setup, operation, calibration, and maintenance of the sampler. This manual shall provide complete and detailed descriptions of the operational and calibration procedures prescribed for field use of the sampler and all instruments utilized as part of this reference method. The manual shall include adequate warning of potential safety hazards that may result from normal use or malfunction of the method and a description of necessary safety precautions. The manual shall also include a clear description of all procedures pertaining to installation, operation, periodic, and corrective maintenance, and troubleshooting, and shall include parts identification diagrams.

7.4.19 Data reporting requirements. The various information that the sampler is required to provide and how it is to be provided is summarized in the following table L–1.

<table>
<thead>
<tr>
<th>Information to be provided</th>
<th>Appendix L section reference</th>
<th>Availability</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow rate, 30-second maximum interval.</td>
<td>7.4.5.1✓</td>
<td>✓</td>
<td>XX.X L/min</td>
</tr>
<tr>
<td>Flow rate, average for the sample period.</td>
<td>7.4.5.2✓</td>
<td>✓</td>
<td>XX.X L/min</td>
</tr>
<tr>
<td>Flow rate, CV, for sample period.</td>
<td>7.4.5.2✓</td>
<td>✓</td>
<td>XX.X %</td>
</tr>
<tr>
<td>Flow rate, 5-min. average out of spec. (FLAG6).</td>
<td>7.4.5.2✓</td>
<td>✓</td>
<td>On/Off</td>
</tr>
<tr>
<td>Sample volume, total.</td>
<td>7.4.5.2✓</td>
<td>✓</td>
<td>XX.X m³</td>
</tr>
<tr>
<td>Temperature, ambient, 30-second interval.</td>
<td>7.4.8✓</td>
<td>✓</td>
<td>XX.X °C</td>
</tr>
<tr>
<td>Temperature, ambient, min., max., average for the sample period.</td>
<td>7.4.8✓</td>
<td>✓</td>
<td>XX.X °C</td>
</tr>
<tr>
<td>Baro. pressure, ambient, 30-second interval.</td>
<td>7.4.9✓</td>
<td>✓</td>
<td>XXX mm Hg</td>
</tr>
<tr>
<td>Baro. pressure, ambient, min., max., average for the sample period.</td>
<td>7.4.9✓</td>
<td>✓</td>
<td>XXX mm Hg</td>
</tr>
<tr>
<td>Filter temperature, 30-second interval.</td>
<td>7.4.11✓</td>
<td>✓</td>
<td>XX.X °C</td>
</tr>
<tr>
<td>Filter temp. differential, 30-second interval, out of spec. (FLAG6).</td>
<td>7.4.11✓</td>
<td>✓</td>
<td>On/Off</td>
</tr>
<tr>
<td>Filter temp. maximum differential from ambient, date, time of occurrence.</td>
<td>7.4.11✓</td>
<td>✓</td>
<td>X.X, YY/MM/DD HH:mm. °C, Yr/Mon/Day Hrs. min</td>
</tr>
<tr>
<td>Date and Time</td>
<td>7.4.12✓</td>
<td>✓</td>
<td>YY/MM/DD HH:mm. Yr/Mon/Day Hrs. min</td>
</tr>
<tr>
<td>Sample start and stop time settings</td>
<td>7.4.12✓</td>
<td>✓</td>
<td>YY/MM/DD HH:mm. Yr/Mon/Day Hrs. min</td>
</tr>
</tbody>
</table>
8.0 Filter Weighing. See reference 2 in section 13.0 of this appendix, for additional, more detailed guidance.

8.1 Analytical balance. The analytical balance used to weigh filters must be suitable for weighing the type and size of filters specified, under section 6.0 of this appendix, and have a readability of ±1 μg. The balance shall be calibrated as specified by the manufacturer at installation and recalibrated immediately prior to each weighing session. See reference 2 in section 13.0 of this appendix for additional guidance.

8.2 Filter conditioning. All sample filters used shall be conditioned immediately before both the pre- and post-sampling weighings as specified below. See reference 2 in section 13.0 of this appendix for additional guidance.

8.2.1 Mean temperature. 20 - 23 °C.

8.2.2 Temperature control. ±2 °C over 24 hours.

8.2.3 Mean humidity. Generally, 30-40 percent relative humidity; however, where it can be shown that the mean ambient relative humidity during sampling is less than 30 percent, conditioning is permissible at a mean relative humidity within ±5 percent of the mean ambient relative humidity during sampling, but not less than 20 percent.

8.2.4 Humidity control. ±5 percent relative humidity percent over 24 hours.

8.2.5 Conditioning time. Not less than 24 hours.

8.3 Weighing procedure.

8.3.1 New filters should be placed in the conditioning environment immediately upon arrival and stored there until the pre-sampling weighing. See reference 2 in section 13.0 of this appendix for additional guidance.

8.3.2 The analytical balance shall be located in the same controlled environment in which the filters are conditioned. The filters shall be weighed immediately following the conditioning period without intermediate or transient exposure to other conditions or environments.

8.3.3 Filters must be conditioned at the same conditions (humidity within ±5 percent relative humidity percent) before both the pre- and post-sampling weighings.

8.3.4 Both the pre- and post-sampling weighings should be carried out on the same

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### TABLE L–1 TO APPENDIX L OF PART 50—SUMMARY OF INFORMATION TO BE PROVIDED BY THE SAMPLER—Continued

<table>
<thead>
<tr>
<th>Information to be provided</th>
<th>Availability</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample period start time.</td>
<td>anytime</td>
<td></td>
</tr>
<tr>
<td>Elapsed sample time.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elapsed sample time, out of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>spec. (FLAG 8).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power interruptions &lt;1 min.,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>start time of first 10.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>User-entered information, such as sampler and site identification,</td>
<td>anytime</td>
<td>As entered.</td>
</tr>
</tbody>
</table>

✓ Provision of this information is required.

* Provision of this information is optional. If information related to the entire sample period is optionally provided prior to the end of the sample period, the value provided should be the mean calculated for the portion of the sampler period completed up to the time the information is provided.

■ Indicates that this information is also required to be provided to the Air Quality System (AQS) data bank; see § 58.16 of this chapter. For ambient temperature and barometric pressure, only the average for the sample period must be reported.

1. Information is required to be available to the operator at any time the sampler is operating, whether sampling or not.

2. Information relates to the entire sampler period and must be provided following the end of the sample period until reset manually by the operator or automatically by the sampler upon the start of a new sample period.

3. Information shall be available to the operator visually.

4. Information is to be available as digital data at the sampler’s data output port specified in section 7.4.16 of this appendix following the end of the sample period until reset manually by the operator or automatically by the sampler upon the start of a new sample period.

5. Digital readings, both visual and data output, shall have not less than the number of significant digits and resolution specified.

6. Flag warnings may be displayed to the operator by a single flag indicator or each flag may be displayed individually. Only a set (on) flag warning must be indicated; an off (unset) flag may be indicated by the absence of a flag warning. Sampler users should refer to section 10.12 of this appendix regarding the validity of samples for which the sampler provided an associated flag warning.
analytical balance, using an effective technique to neutralize static charges on the filter, under reference 2 in section 13.0 of this appendix. If possible, both weighings should be carried out by the same analyst.

8.3.5 The pre-sampling (tare) weighing shall be within 30 days of the sampling period.

8.3.6 The post-sampling conditioning and weighing shall be completed within 240 hours (10 days) after the end of the sample period, unless the filter sample is maintained at temperatures below the average ambient temperature. If the sampler is stored at a temperature less than 4 °C during the time between retrieval from the sampler and the start of the conditioning, in which case the period shall not exceed 30 days. Reference 2 in section 13.0 of this appendix has additional guidance on transport of cooled filters.

8.3.7 Filter blanks.

8.3.7.1 New field blank filters shall be weighed along with the pre-sampling (tare) weighing of each lot of PM$_{2.5}$ filters. These blank filters shall be transported to the sampling site, installed in the sampler, retrieved from the sampler without sampling, and reweighed as a quality control check.

8.3.7.2 New laboratory blank filters shall be weighed along with the pre-sampling (tare) weighing of each set of PM$_{2.5}$ filters. These laboratory blank filters should remain in the laboratory in protective containers during the field sampling and should be reweighed as a quality control check.

8.3.8 Additional guidance for proper filter weighing and related quality assurance activities is provided in reference 2 in section 13.0 of this appendix.

9.0 Calibration. Reference 2 in section 13.0 of this appendix contains additional guidance.

9.1 General requirements.

9.1.1 Multipoint calibration and single-point verification of the sampler's flow rate measurement device must be performed periodically to establish and maintain traceability of subsequent flow measurements to a flow rate standard.

9.1.2 An authoritative flow rate standard shall be used for calibrating or verifying the sampler's flow rate measurement device with an accuracy of ±2 percent. The flow rate standard shall be a separate, stand-alone device designed to compare the flow rate measurement to the flow rate indicated by the flow rate standard. Figure L-30 of this appendix illustrates the general steps involved in the calibration of a PM$_{2.5}$ sampler.

9.2 Flow rate calibration/verification procedure.

9.2.1 PM$_{2.5}$ samplers may employ various types of flow control and flow measurement devices. The specific procedure used for calibration or verification of the flow rate measurement device will vary depending on the type of flow control and flow rate measurement employed. Calibration shall be in terms of actual ambient volumetric flow rates ($Q_a$), measured at the sampler's inlet orifice. The specific procedure used for calibrating or verifying the flow rate measurement device will vary depending on the type of flow control and flow measurement device employed.

9.2.2 The flow rate standard used for flow rate calibration shall have its own certification and be traceable to a NIST primary standard for volume or flow rate. A calibration relationship for the flow rate standard, e.g., an equation, curve, or family of curves relating actual flow rate ($Q_a$) to the flow rate indicator reading, shall be established that is accurate to within 2 percent over the expected range of ambient temperatures and pressures at which the flow rate standard may be used. The flow rate standard must be re-calibrated or re-verified at least annually.

9.2.3 The sampler flow rate measurement device shall be calibrated or verified by removing the sampler inlet and connecting the flow rate standard to the sampler's flow rate measurement device. The sampler operator shall first carry out a sampler leak check and confirm that the sampler is leak-free and that no leaks exist between the flow rate standard and the sampler.

9.2.4 The calibration relationship between the flow rate (in actual L/min) indicated by the flow rate standard and the sampler's flow rate measurement device shall be established or verified in accordance with the sampler operation/instruction manual. Temperature and pressure corrections to the flow rate indicated by the flow rate standard may be required for certain types of flow rate standards. Calibration of the sampler's flow rate measurement device shall consist of at least three separate flow rate measurements (multipoint calibration) evenly spaced within the range of -10 percent to +10 percent of the sampler's operational flow rate, section 7.4.1 of this appendix. Verification of the sampler's flow rate shall consist of one flow rate measurement.
10.0 PM$_{2.5}$ Measurement Procedure. The detailed procedure for obtaining valid PM$_{2.5}$ measurements with each specific sampler designated as part of a reference method for PM$_{2.5}$ under part 53 of this chapter shall be provided in the sampler-specific operation or instruction manual required by section 7.4.18 of this appendix. Supplemental guidance is provided in section 2.12 of the Quality Assurance Handbook listed in reference 2 in section 13.0 of this appendix. The generic procedure given here serves to illustrate the general steps involved in the PM$_{2.5}$ sample collection and measurement, using a PM$_{2.5}$ reference method sampler.

10.1 The sampler shall be set up, calibrated, and operated in accordance with the specific, detailed guidance provided in the specific sampler’s operation or instruction manual and in accordance with a specific quality assurance program developed and established by the user, the method or applicable supplementary guidance provided in reference 2 in section 13.0 of this appendix.

10.2 Each new sample filter shall be inspected for correct type and size and for pin-holes, particles, and other imperfections. Unacceptable filters should be discarded. A unique identification number shall be assigned to each filter, and an information record shall be established for each filter. If the filter identification number is not or cannot be marked directly on the filter, alternate means, such as a number-identified storage container, must be established to maintain positive filter identification.

10.3 Each filter shall be conditioned in the conditioning environment in accordance with the requirements specified in section 8.2 of this appendix.

10.4 Following conditioning, each filter shall be weighed in accordance with the requirements specified in section 8.6 of this appendix and the presampling weight recorded with the filter identification number.

10.5 A numbered and preweighed filter shall be installed in the sampler cassette securely such that the cover shall not come in contact with the filter’s surfaces. Reference 2 in section 13.0 of this appendix contains additional guidance.

10.6 The sampler shall be checked and prepared for sample collection in accordance with instructions provided in the sampler operation or instruction manual and with the specific quality assurance program established for the sampler by the user.

10.7 The sampler’s timer shall be set to start the sample collection at the beginning of the desired sample period and stop the sample collection 24 hours later.

10.8 Information related to the sample collection (site location or identification number, sample date, filter identification number, and sampler model and serial number) shall be recorded and, if appropriate, entered into the sampler.

10.9 The sampler shall be allowed to collect the PM$_{2.5}$ sample during the set 24-hour time period.

10.10 Within 177 hours (7 days, 9 hours) of the end of the sample collection period, the filter, while still contained in the filter cassette, shall be carefully removed from the sampler, following the procedure provided in the sampler operation or instruction manual and the quality assurance program, and placed in a protective container. The protective container shall contain no loose material that could be transferred to the filter. The protective container shall hold the filter cassette securely such that the cover shall not come in contact with the filter’s surfaces. Reference 2 in section 13.0 of this appendix contains additional information.

10.11 The total sample volume in actual m$^3$ for the sampling period and the elapsed sample time shall be obtained from the sampler and recorded in accordance with the instructions provided in the sampler operation or instruction manual. All sampler warning flag indications and other information required by the local quality assurance program shall also be recorded.

10.12 All factors related to the validity or representativeness of the sample, such as sampler tampering or malfunctions, unusual meteorological conditions, construction activity, fires or dust storms, etc. shall be recorded as required by the local quality assurance program. The occurrence of a flag warning during a sample period shall not necessarily indicate an invalid sample but rather shall indicate the need for specific review of the QC data by a quality assurance officer to determine sample validity.
10.13 After retrieval from the sampler, the exposed filter containing the PM$_{2.5}$ sample should be transported to the filter conditioning environment as soon as possible, ideally to arrive at the conditioning environment within 24 hours for conditioning and subsequent weighing. During the period between filter retrieval from the sampler and the start of the conditioning, the filter shall be maintained as cool as practical and continuously protected from exposure to temperatures over 25 °C to protect the integrity of the sample and minimize loss of volatile components during transport and storage. See section 8.3.6 of this appendix regarding time limits for completing the post-sampling weighing. See reference 2 in section 13.0 of this appendix for additional guidance on transporting filter samplers to the conditioning and weighing laboratory.

10.14 The exposed filter containing the PM$_{2.5}$ sample shall be re-conditioned in the conditioning environment in accordance with the requirements specified in section 8.2 of this appendix.

10.15 The filter shall be reweighed immediately after conditioning in accordance with the requirements specified in section 8.0 of this appendix, and the postsampling weight shall be recorded with the filter identification number.

10.16 The PM$_{2.5}$ concentration shall be calculated as specified in section 12.0 of this appendix.

11.0 Sampler Maintenance. The sampler shall be maintained as described by the sampler’s manufacturer in the sampler-specific operation or instruction manual required under section 7.4.18 of this appendix and in accordance with the specific quality assurance program developed and established by the user based on applicable supplementary guidance provided in reference 2 in section 13.0 of this appendix.

12.0 Calculations

12.1 (a) The PM$_{2.5}$ concentration is calculated as:

$$\text{PM}_{2.5} = \frac{(W_f - W_i) \cdot V_a}{W_f - W_i}$$

where:

- $\text{PM}_{2.5}$ = mass concentration of PM$_{2.5}$, μg/m$^3$;
- $W_f$, $W_i$ = final and initial weights, respectively, of the filter used to collect the PM$_{2.5}$ particle sample, μg;
- $V_a$ = total air volume sampled in actual volume units, as provided by the sampler, m$^3$.

Note: Total sample time must be between 1,380 and 1,500 minutes (23 and 25 hrs) for a fully valid PM$_{2.5}$ sample; however, see also section 3.3 of this appendix.

13.0 References.


14.0 Figures L–1 through L–30 to Appendix L.
FIGURE L-1. PM2.5 SAMPLER, ASSEMBLY

ATTACH WATER COLLECTOR HARDWARE

FOR EXAMPLE: 1/4” NPT GLASS JAR

BRASS: LONG NIPPLE, 1/4” MNPT X 2” LONG

BRASS: BUSHING, 1/4” FNPT X 3/8” MNPT

BRASS: PLUG, 1/4” MNPT

DOTTED LINE INDICATES
TOP OF SAMPLER CASE

ALL DIMENSIONS ARE INCHES

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>±0.010</th>
<th>±0.025</th>
<th>±0.004</th>
<th>±15°</th>
</tr>
</thead>
</table>

95
FIGURE L-2. 10-MICRON INLET, ASSEMBLY

NOTES:
(1) SEE ASSEMBLY UPPER AND LOWER SECTION FOR ITEM DETAILS

ALL DIMENSIONS ARE INCHES

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCE</th>
<th>7/16</th>
<th>3/8</th>
<th>1/2</th>
<th>5/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>0.010</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>ALIGN</td>
<td>0.010</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
</tbody>
</table>

0.104 DIA. X 0.195 DEEP (AFTER ASSEMBLY)
THROUGH 2 PARTS - 2 PLACES
INSERT NO. 4 X 3/16 LONG DRIVE SCREW (18-8 STAINLESS)
FIGURE L-3. 10-MICRON ASSEMBLY, UPPER SECTION

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10-MICRON INLET, TOP (FIGURE L-5)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>8-32 X 3/8 RD. HEAD SCREW</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>10-MICRON GASKET (FIGURE L-6)</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>10-MICRON WIND DEFLECTOR (FIGURE L-7)</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>10-MICRON SCREEN (FIGURE L-8)</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>10-MICRON INLET, LOWER (FIGURE L-10)</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>10-MICRON RAIN DEFLECTOR (FIGURE L-12)</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>1/8 DIA. VELD</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>10-MICRON NOZZLE ENTRY SECT. (FIGURE L-13)</td>
<td>1</td>
</tr>
</tbody>
</table>

NOTES:
(1) AFFIX ITEM 3 (10-MICRON GASKET) TO ITEMS 1 (10-MICRON INLET, TOP) AND 4 (10-MICRON WIND DEFLECTOR) USING APPROPRIATE ADHESIVE.

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>PLUS</th>
<th>MINUS</th>
<th>PAR</th>
<th>TOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLUS</td>
<td>+/- 0.005</td>
<td>+/- 0.005</td>
<td>+/- 0.004</td>
<td>+/- 15&quot;</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES.
FIGURE L-4. 10-MICRON ASSEMBLY, LOWER SECTION

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10-MICRON MANIFOLD NOZZLE (FIGURE L-11)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>10-MICRON OUTER TUBE (FIGURE L-15)</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>10-MICRON NOZZLE INSERT (FIGURE L-14)</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>10-MICRON RECEIVER TUBE (FIGURE L-16)</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>10-MICRON TARGET PLATE (FIGURE L-17)</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>10-MICRON EXIT ADAPTOR (FIGURE L-18)</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>AS 568-026 O-RING</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>AS 568-036 O-RING</td>
<td>2</td>
</tr>
</tbody>
</table>

FINISH: CLEAR ANODIZE

9/16" DIA. DRILL X 1.0 DEEP TAP 3/8-18 NPT

PRESS FIT

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>+0.010</th>
<th>+0.005</th>
<th>-0.004</th>
<th>-0.015</th>
</tr>
</thead>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-5. 10-MICRON INLET, TOP

NOTES:
(1) COMMERCIAL SPINNING TOLERANCES ARE ACCEPTABLE
(2) MATERIAL IS SPUN 6061-T6 ALUMINUM, POST-HEAT TREATED TO -T4
(3) CLEAR ANODIZE

### TOLERANCES

<table>
<thead>
<tr>
<th>PLUS</th>
<th>MINUS</th>
<th>TOL</th>
<th>HOLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>+0.0010</td>
<td>-0.005</td>
<td>+0.004</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE IN INCHES.
FIGURE L-6. 10-MICRON GASKET

NOTES:
(1) MATERIAL: 0.031 THK. SCE-41 CSN PSA 2 SIDES

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>PLUS</th>
<th>MINUS</th>
<th>PINOC</th>
<th>ANGLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+0.010</td>
<td>+0.005</td>
<td>+0.154</td>
<td>+0.15</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-7. 10-MICRON WIND DEFLECTOR

NOTES:
(1) COMMERCIAL SPINNING TOLERANCES ARE ACCEPTABLE
(2) MATERIAL IS SPUN 6061-TO ALUMINUM, POST-HEAT TREATED TO-T4
(3) CLEAR ANODIZE

<table>
<thead>
<tr>
<th>TOLERANCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOL.</td>
</tr>
<tr>
<td>+0.010</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-8. 10-MICRON SCREEN

NOTES:
(1) MATERIAL: 0.01 +/- 0.001 DIA. WIRE SCREEN, 18 MESH X 14 MESH, STAINLESS STEEL. SECURE AS REQUIRED TO KEEP MAXIMUM OPEN AREA.

ALL DIMENSIONS ARE INCHES

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>TOLERANCES</th>
<th>TOLERANCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
<td>+/- 0.05</td>
</tr>
<tr>
<td>+/- 0.15</td>
<td>+/- 0.15</td>
<td>+/- 0.15</td>
</tr>
</tbody>
</table>
FIGURE L-9. 10-MICRON SPACER

NOTES:
(1) BREAK ALL SHARP EDGES
(2) MATERIAL IS ALUMINUM TUBING
(1/4 OD X 0.072 WALL)
(3) CLEAR ANODIZE
(4) 4 REQUIRED PER UNIT

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCE</th>
<th>ALL DIMENSIONS ARE INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 PCS</td>
<td>+/- 0.010</td>
</tr>
<tr>
<td>3 PCS</td>
<td>+/- 0.005</td>
</tr>
<tr>
<td>4 PCS</td>
<td>+/- 0.005</td>
</tr>
<tr>
<td>1/8 IN.</td>
<td>+/- 1/64</td>
</tr>
<tr>
<td>1/16 IN.</td>
<td>+/- 1/15°</td>
</tr>
</tbody>
</table>

6-32 UNC-2B X 1/2 DEEP
BOTH ENDS
FIGURE L-10. 10-MICRON RAIN DEFLECTOR

NOTES:
(1) BREAK ALL SHARP EDGES
(2) MATERIAL IS STAINLESS 304

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCE</th>
<th>MIN.</th>
<th>MAX.</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD</td>
<td>+0.010</td>
<td>+0.005</td>
</tr>
<tr>
<td>ID</td>
<td>-0.010</td>
<td>+0.014</td>
</tr>
<tr>
<td>stock</td>
<td>+/- 0.031</td>
<td></td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
**FIGURE L-11. 10-MICRON INLET, LOWER**

NOTES:

1. BEND RADIUS MINIMUM PER COMMERCIAL SPINNING OR STAMPING STANDARDS
2. BREAK ALL SHARP EDGES
3. MATERIAL IS SPUN ALUMINUM 6061-T6, POST-HEAT TREATED TO -T6
4. CLEAR ANODIZE

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>TOTAL</th>
<th>TIGHT</th>
<th>MAX</th>
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</thead>
<tbody>
<tr>
<td>CLEARANCE</td>
<td>0.000</td>
<td>0.010</td>
<td>0.020</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES.
NOTES:
(1) BEND RADI TO BE MINIMUM PER COMMERCIAL SPINNING STANDARDS
(2) BREAK ALL SHARP EDGES
(3) MATERIAL IS SPUN ALUMINUM 6061-T6, POST-HEAT TREATED TO -T4
(4) CLEAR ANODIZE

---

**TABLE:**

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>PLUS</th>
<th>MINUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.20</td>
<td>±0.005</td>
<td>±0.005</td>
</tr>
<tr>
<td>6.90</td>
<td>±0.005</td>
<td>±0.005</td>
</tr>
</tbody>
</table>

**FIGURE L-12. 10-MICRON NOZZLE ENTRY SECTION**

- 0.149 DIA. 4 PLCS. EQUALLY SPACED ON A 6.500 DIA. B.C.
- RADIAL SYMMETRICAL ABOUT C/I.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.627</td>
<td></td>
</tr>
<tr>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>0.063 STOCK</td>
<td></td>
</tr>
<tr>
<td>5.20</td>
<td></td>
</tr>
<tr>
<td>6.90</td>
<td></td>
</tr>
<tr>
<td>5.95 REF.</td>
<td></td>
</tr>
</tbody>
</table>

**ALL DIMENSIONS ARE INCHES**
FIGURE L-13. 10-MICRON IMPACTOR NOZZLE

NOTES:
(1) PRESS FIT WITH 10-MICRON NOZZLE INSERT (FIGURE L-14)
(2) BREAK ALL SHARP EDGES
(3) MATERIAL IS ALUMINUM 6061-T6
(4) CLEAR ANODIZE

TOLERANCES

<table>
<thead>
<tr>
<th>+/-</th>
<th>+/-</th>
<th>MAX.</th>
<th>MIN.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.010</td>
<td>-0.005</td>
<td>-0.004</td>
<td>-0.003</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-14. 10-MICRON NOZZLE INSERT

NOTES:
(1) PRESS FIT INTO 10-MICRON IMPACTOR NOZZLE (FIGURE L-13)
(2) BREAK ALL SHARP EDGES
(3) MATERIAL IS ALUMINUM 6061-T6
(4) CLEAR ANODIZE
(5) FINISH #63

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCE</th>
<th>TOLERANCE</th>
<th>TOLERANCE</th>
<th>ANGLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 POSE</td>
<td>1 POSE</td>
<td>1 POSE</td>
<td>+/- 15</td>
</tr>
<tr>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
<td>+/- 0.004</td>
<td>+/- 15</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
NOTES:
(1) BREAK ALL SHARP EDGES
(2) CLEAR ANODIZE
(3) TUBING 2.75 O.D. x 2.38 I.D.
(4) FINISH #63

FIGURE L-15. 10-MICRON OUTER TUBE

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCE</th>
<th>MINUS</th>
<th>PLUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.735</td>
<td>±0.005</td>
<td>±0.010</td>
</tr>
<tr>
<td>0.020</td>
<td>±0.000</td>
<td>±0.000</td>
</tr>
<tr>
<td>0.750</td>
<td>±0.000</td>
<td>±0.000</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-16. 10-MICRON RECEIVER TUBE

NOTES:
(1) 0.562 DIA. O.D. TO PRESS INTO 10-MICRON TARGET PLATE (FIGURE L-17)
(2) BREAK ALL SHARP EDGES
(3) MATERIAL IS ALUMINUM 6061-T6
(4) CLEAR ANODIZE
(5) FINISH #63
(6) 3 REQ'D PER UNIT

TOLERANCES

<table>
<thead>
<tr>
<th>SPACE</th>
<th>SPACE</th>
<th>SPACE</th>
<th>ANGLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
<td>+/- 0.005</td>
<td>+/- 15°</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-17. 10 MICRON TARGET PLATE

NOTES:
(1) BREAK ALL SHARP EDGES
(2) MATERIAL IS ALUMINUM 6061-T6
(3) CLEAR ANODIZE
(4) FINISH #63

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCE</th>
<th>VALUE</th>
</tr>
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<tbody>
<tr>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
</tr>
<tr>
<td>+/- 0.164</td>
<td>+/- 0.16</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-18. 10-MICRON EXIT ADAPTOR

NOTES:
(1) BREAK ALL SHARP EDGES
(2) MATERIAL IS ALUMINUM 6061-T6
(3) CLEAR ANODIZE
(4) 2.75 O.D. RD. STK.

TOLERANCES

<table>
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<tr>
<th>SIGN</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/−</td>
<td>0.010</td>
</tr>
<tr>
<td>+/−</td>
<td>0.005</td>
</tr>
<tr>
<td>+/−</td>
<td>1/64</td>
</tr>
<tr>
<td>+/−</td>
<td>1/16</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES.
FIGURE L-19. 10-MICRON DOWN TUBE

NOTES:
(1) BREAK ALL SHARP EDGES
(2) MATERIAL IS ALUMINUM
(3) CLEAR ANODIZE
(4) BOXED DIMENSIONS ARE OPTIONAL
(5) PART MAY BE MADE FROM TWO PIECES WELDED
(6) 64 RMS FINISH ALL OVER

ALL DIMENSIONS ARE INCHES

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>2+1/3</th>
<th>3+1/4</th>
<th>RND</th>
<th>ANGLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/- 0.005</td>
<td>+/- 0.005</td>
<td>+/- 0.005</td>
<td>+/- 0.005</td>
<td>+/- 15</td>
</tr>
</tbody>
</table>
**FIGURE L-20. 2.5-MICRON IMPACTOR ASSEMBLY**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QTY</th>
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<tbody>
<tr>
<td>1</td>
<td>2.5-MICRON IMPACTOR HOUSING, UPPER (FIGURE L-21)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2.5-MICRON IMPACTOR WELL, UPPER (FIGURE L-22)</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2.5-MICRON IMPACTOR WELL, LOWER (FIGURE L-23)</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2.5-MICRON IMPACTOR HOUSING, LOWER (FIGURE L-24)</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>O-RING: AS588-002 (VITON&lt;sup&gt;®&lt;/sup&gt;)</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>O-RING: AS588-004 (VITON&lt;sup&gt;®&lt;/sup&gt;)</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>IMPACTION OIL</td>
<td>1 mL</td>
</tr>
<tr>
<td>8</td>
<td>FILTER</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>O-RING: AS588-006 (VITON&lt;sup&gt;®&lt;/sup&gt;)</td>
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</table>

**TOLERANCES**

<table>
<thead>
<tr>
<th>TOLERANCES</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>PLUS</td>
<td>-0.010</td>
<td>-0.005</td>
<td>+/- 1/64</td>
</tr>
</tbody>
</table>

VITON<sup>®</sup> is a trademark of DuPont Dow Elastomers LLC.

Use of this name does not constitute an endorsement of EPA.
FIGURE L-21. 2.5-MICRON IMPACTOR HOUSING, UPPER

NOTES:

(1) CLEAR ANODIZE
(2) 32 RMS FINISH ALL OVER
(3) 0.182 PIN TO GO COMPLETELY THROUGH, 0.156 PIN NOT TO GO FROM EITHER END
(4) BOXED DIMENSIONS ARE OPTIONAL
(5) MATERIAL IS ALUMINUM 6061-T6
(6) CENTER NOZZLE MAY BE MACHINED SEPARATELY AND ATTACHED USING SCREW THREADS OR PRESS FIT; ALL INTERIOR SURFACES MUST BE AS SHOWN

TOLERANCES

<table>
<thead>
<tr>
<th>Tolerance Type</th>
<th>Tolerance Value</th>
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</thead>
<tbody>
<tr>
<td>Shaft</td>
<td>±0.010</td>
</tr>
<tr>
<td>Sleeve</td>
<td>±0.005</td>
</tr>
<tr>
<td>Pin</td>
<td>±0.004</td>
</tr>
<tr>
<td>Hole</td>
<td>±0.010</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-22. 2.5-MICRON IMPACTOR WELL, UPPER SECTION

NOTES:
(1) FINISH: CLEAR ANODIZE
(2) 32 RMS FINISH ALL OVER
(3) MATERIAL IS ALUMINUM 6061-T6

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCE</th>
<th>PLUS (+)</th>
<th>MINUS (-)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLUS</td>
<td>±0.010</td>
<td>±0.005</td>
<td>±0.015</td>
</tr>
<tr>
<td>MINUS</td>
<td>±0.010</td>
<td>±0.005</td>
<td>±0.015</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE IN INCHES
FIGURE L-23. 2.5-MICRON IMPACTOR WELL, LOWER SECTION

NOTES:
(1) CLEAR ANODIZE
(2) 32 RMS FINISH ALL OVER
(3) MATERIAL IS ALUMINUM 6061-T6

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCE</th>
<th>PLUS</th>
<th>MINUS</th>
<th>ANGLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
<td>+/- 0.005</td>
<td>+/- 15'</td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-24. 2.5-MICRON IMPACTOR HOUSING, LOWER

NOTES:
(1) MATERIAL IS ALUMINUM 6061-T6
(2) CLEAR ANODIZE
(3) BOXED DIMENSIONS ARE OPTIONAL
(4) THIS PART AND FILTER HOLDER, TOP (FIGURE L-26) MAY BE MACHINED AS ONE PIECE; INTERNAL SURFACES AND DIMENSIONS MUST BE AS SHOWN

ALL DIMENSIONS ARE INCHES

TOLERANCES

<table>
<thead>
<tr>
<th>Type</th>
<th>Plus</th>
<th>Minus</th>
<th>Size</th>
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</thead>
<tbody>
<tr>
<td>2 PLCC</td>
<td>±0.010</td>
<td>±0.005</td>
<td>±0.034</td>
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</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-25. FILTER HOLDER, ASSEMBLY

<table>
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<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FILTER HOLDER, TOP (FIGURE L-26)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>FILTER CASSETTE, UPPER (FIGURE L-27)</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>FILTER CASSETTE, LOWER (FIGURE L-29)</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>FILTER SCREEN (FIGURE L-28) AND FILTER</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>O-RING: AS568-135</td>
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ALL DIMENSIONS ARE INCHES

TOLERANCES

<table>
<thead>
<tr>
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<th>ALL DIMENSIONS ARE INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
</tr>
<tr>
<td>+/- 1.54</td>
<td>+/- 15°</td>
</tr>
</tbody>
</table>
FIGURE L-26. FILTER HOLDER, TOP

NOTES:
(1) MATERIAL IS ALUMINUM
(2) CLEAR ANODIZE
(3) 32 RMS FINISH ALL OVER
(4) BOXED DIMENSIONS ARE OPTIONAL
(5) THIS PART AND 2.5-MICRON IMPACTOR HOUSING, LOWER (FIGURE L-24) MAY BE MACHINED AS ONE PIECE, INTERNAL SURFACES AND DIMENSIONS MUST BE AS SHOWN

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>TOL</th>
<th>TOL</th>
<th>PROF</th>
<th>ANGLE</th>
<th>ALL DIMENSIONS ARE INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
<td>+/- 0.005</td>
<td>+/- 0.005</td>
<td>+/- 0.005</td>
<td></td>
</tr>
</tbody>
</table>
FIGURE L-27. FILTER CASSETTE, UPPER SECTION

NOTES:
(1) MATERIAL IS WHITE DELRIN®

DELRIN® is a trademark of Dupont Engineering Polymers.
USE OF THIS NAME DOES NOT CONSTITUTE AN ENDORSEMENT OF EPA

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCES</th>
<th>PLUS</th>
<th>PLUS</th>
<th>MINUS</th>
<th>ANGLE</th>
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<tr>
<td></td>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
<td>+/- 0.001</td>
<td>+/- 15°</td>
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</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-28. FILTER SCREEN

NOTES:
(1) MATERIAL IS 302 OR 304 STAINLESS (FULL OR HALF HARD)
(2) 1.530 DIA. AREA IS PERFORATED IN HOLE PATTERN SHOWN

HOLE PATTERN

TOLERANCES

<table>
<thead>
<tr>
<th>TOLERANCE</th>
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<th>UNIFORM</th>
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<td>+/- 0.010</td>
<td>+/- 0.003</td>
<td>+/- 0.004</td>
<td>+/- 1.56</td>
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</table>

ALL DIMENSIONS ARE INCHES
NOTES:

(1) MATERIAL IS WHITE DELRIN©

DELRIN© IS A TRADEMARK OF DUPONT ENGINEERING POLYMERS.
USE OF THIS NAME DOES NOT CONSTITUTE AN ENDORSEMENT OF EPA.

TOLERANCES

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<th>2 PCE</th>
<th>3 PCE</th>
<th>TOL.</th>
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<td>1.000</td>
<td>± 0.010</td>
<td>± 0.005</td>
<td>± 0.016</td>
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</tbody>
</table>

ALL DIMENSIONS ARE INCHES
FIGURE L-30. FLOW RATE MEASUREMENT ADAPTER

NOTES:
1) MATERIAL IS ALUMINUM 6061-T6

BRASS AIR HOSE COCK OR EQUIVALENT WITH A 3/8" HOSE BARB AND 1/4" MALE PIPE THREADS

TOLERANCES

<table>
<thead>
<tr>
<th>STYLE</th>
<th>PLUS</th>
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<th>RANDOM</th>
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<tbody>
<tr>
<td>3/8</td>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
<td>+/- 1/64</td>
</tr>
<tr>
<td>1/4&quot; NPT</td>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
<td>+/- 1/64</td>
</tr>
<tr>
<td>1&quot; NPT</td>
<td>+/- 0.010</td>
<td>+/- 0.005</td>
<td>+/- 1/64</td>
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</tbody>
</table>

ALL DIMENSIONS ARE INCHES