U.S Environmental Protection Agency
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STANDARD OPERATING PROCEDURE

SOP Title: Collection and Extraction of Challenge Aerosol for Subsequent Coulter Analysis

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*See discipline descriptions on the NERL Scientific and Technical SOP intranet site

JACOBS

Collection and Extraction of Challenge Aerosol for Subsequent Coulter Analysis

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Prepared for

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1.0 Scope and Application

This standard operating procedure (SOP) describes the procedures used to collect aerosolized particle size standards onto membrane filters and the subsequent extraction into electrolyte solution for the purpose of analysis by the Coulter principle.

2.0 Summary of Method

The size selective performance of ambient particle inlets is evaluated in an aerosol wind tunnel containing an atmosphere of airborne particles. Samples are collected at three equidistant positions within the wind tunnel for confirmation of uniform dispersion of the airborne particles, referred to herein as "aerosol uniformity" or simply "uniformity". Procedures for setup and collection of samples are provided. These samples are collected on filter media and extracted using Isoton II, a proprietary electrolyte solution manufactured by Beckman Coulter, Inc. Glycerol is added to the Isoton II electrolyte in order to increase the viscosity of the solution. The increased viscosity prolongs the suspension of particles during analysis. This improves the accuracy for obtaining a representative analysis of the entire particle size range in the extracted sample. This SOP does not discuss the specifics of the candidate samplers themselves, but rather presents overall procedures to install samplers in the aerosol wind tunnel and to collect particles on track-etched polycarbonate membrane filters introduced in the wind tunnel. Therefore, while the 47-mm Nuclepore filter is used for the candidate sampler in this particular example, this procedure is not limited to just one type or size of candidate sampler or filter. These samplers were used for evaluation purposes. Nuclepore filters to date have yielded more consistent results within the setup described. This procedure is used during evaluation of candidate samplers inside the sampler test section (STS) of the wind tunnel.

3.0 Definitions

aLpm	actual liters per minute	Lpm	liters per minute
DI H_2O	deionized water	MeOH	methanol
g	gram	mL	milliliter
g/cc	grams per cubic centimeter	mm	millimeter
GISO	mixture of glycerol and Isoton	µm	micrometer
HEPA	high-efficiency particulate air	PM	particulate matter
HETS	human exposure test section	psi	pounds per square inch
IPA	isopropyl alcohol	QAPP	quality assurance project plan
kg	kilogram	SS	stainless steel
km/h	kilometers/hour	STS	sampler test section
L	liter	VDC	volts direct current

4.0 Health and Safety Warnings

4.1 Methanol (MeOH) is used to rinse lab ware after washing to displace water and reduce drying time. It should only be handled in a negative-pressure exhaust hood by personnel wearing protective clothing.

4.2 Particle mixtures should only be handled within a well-ventilated environment (hood or spot ventilation system) to mitigate the risk of personal exposure.

5.0 Interferences

5.1 Filters are washed with deionized water (DI H_2O) and then MeOH and sampler assemblies are washed with DI H_2O prior to use to remove background contaminants. Clean items should be placed in a laminar flow cabinet with HEPA-filtered air to avoid further contamination. Covering of items is not required.

5.2 To reduce background particle concentration in the wind tunnel, maintain a low velocity by operating the wind tunnel fan at low voltage while the aerosol generator is inactive. This will ensure the air is actively filtered to reduce background particle counts during non-sampling periods.

5.3 Consideration must be given to the order in which test preparation procedures are conducted inside the wind tunnel to avoid resuspension of particles from surfaces. All preparation activities required upstream of the sampler test section (STS) should be conducted prior to deployment of the samplers to avoid contaminating the samples.

6.0 Personnel Qualifications

6.1 Personnel must have knowledge of laboratory safety practices.

6.2 Personnel should have sufficient background in aerosol science to perform the procedure without direct supervision.

7.0 Equipment and Supplies

7.1 Equipment

Reference samplers for determination of reference aerosol concentration at each wind speed, consisting of isokinetic nozzles (Figure 1), 90-mm filter cassettes, sampler bases, backing screens, and threaded collars

Sonic nozzle for producing constant volumetric flow for aerosol distribution

Vacuum source for each sampler (Reference samplers with 90-mm Nuclepore membrane filters require 10-in. H_2O pressure drop.)

Reference sampler flow controller

Figure 1. Nozzles for wind speeds 2, 8, and 24 km/h from left to right.

Mass flow meters (3) (TSI model 4043)

Balance (Ohaus Scout Pro model SP4001)

Laminar flow cabinet with HEPA filtration (Air Sciences USA LLC, model PurAir Flow-48)

Pressurized electrolyte filtration vessel (Figure 2)

Ultrasonic water bath (Branson 8510)

Sampler mounting posts (Figure 3)

Figure 2. Pressurized electrolyte filtration vessel and dispensing station.

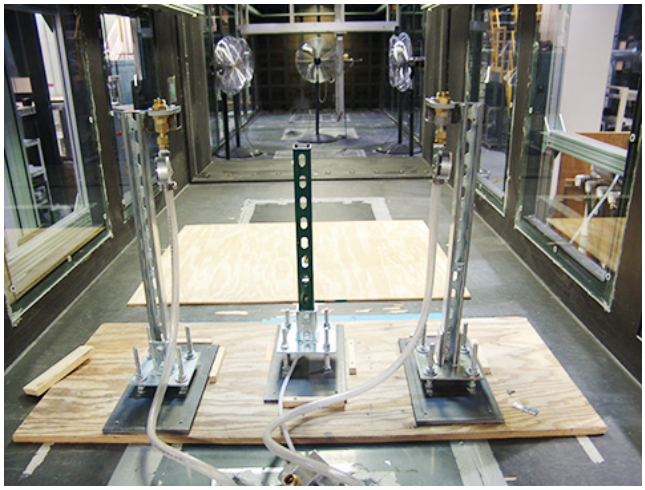

Figure 3. Mounting posts: Sampler mounting posts in foreground. Reference sampler posts are located to right and left with candidate sampler post in center.

7.2 Materials and Supplies

Methanol (MeOH)

Deionized water (DI H_2O)

Premoistened Clean-Wipes 70% IPA/30% DI H_2O (VWR Catalog no. 21910-110)

Isoton II (P/N: 8546719, Beckman Coulter, Inc.)

Non-ionic dispersant Type IC (Beckman Coulter, Inc., item no. 6600705)

Glycerol, laboratory grade, 99.7% (VWR stock no. BDH1172-1LP)

Mild laboratory detergent (Sparkleen) for washing sampler components (Fisher catalog no. 04-320-4)

¾-in. Swagelok fittings

90-mm, 1.0-µm Whatman Nuclepore track-etch membranes (VWR stock no. 97058-236)

Laboratory spatula (VWR stock no. 82027-532)

Forceps for filter handling (Fisher catalog no. XX6200006P)

Nitrile gloves, powder free (VWR stock no. 82026-428)

Capsule filters for liquid, 0.45-µm pore diameter (Aqua Prep, Pall Life Sciences, P/N: 4270)

115-mm glass Petri dishes (VWR catalog no. 89001-246)

Pipette with pipette controller or a squirt bottle for dispensing electrolyte during sample extraction

100-µm aperture for Multisizer 4 (Beckman Coulter, Inc. P/N: A36394)

100-mL and 400-mL Coulter beaker(s) (Beckman Coulter, Inc. P/N: A35595 and A35597)

1-L stainless steel (SS) containers with lids, Polar Ware 300 series (VWR stock no. 36312-004)

Spray bottle with misting nozzle

Carrier racks for reference samplers

Countdown timer

8.0 Instrument Calibration and Standardization

TSI mass flow meters are calibrated by the manufacturer. Confirm that the calibration date on each unit is up to date.

9.0 Sample Collection, Handling, and Preservation

9.1 Sampler Inlet Cleaning and Loading Procedures

Figure 4. Laminar flow cabinet.

1. Clean the surfaces inside a laminar flow cabinet (Figure 4) with premoistened IPA Clean-Wipes.
2. Wash sampler components with a dilute solution of laboratory detergent (Sparkleen) in warm water and rinse with clean water. Set them out to dry in a laminar flow cabinet. Components include isokinetic nozzles, filter cassettes, and backing screens.
3. Polycarbonate Nuclepore membrane filters must be rinsed prior to use to remove extraneous material that would otherwise contribute to background particle counts during analysis. Follow the procedure below, handling the membrane filters only while wearing a glove or using clean, MeOH-rinsed forceps:
    a. Load Petri dishes with Nuclepore membrane filters, one per dish, with the shiny side of the membrane up.
    b. Rinse each filter with filtered DI H_2O, and then rinse once more with MeOH.

c. Place loaded Petri dishes in a laminar flow cabinet and remove the tops for filter drying. To conserve space within the laminar flow cabinet, membrane filters can be combined into dishes after they are dry.

d. Store the clean membrane filters in covered Petri dishes inside the laminar flow cabinet to avoid contamination.

4. Assemble the sampler inlet components with clean dry 90-mm Nuclepore membrane filters by inserting a backing screen and the appropriate filter into the filter cassette. Assemble two reference samplers for candidate sampler evaluation or three reference samplers for aerosol uniformity evaluation.

9.2 Sampler Deployment

1. Transport the loaded sampler inlets to the wind tunnel STS for deployment as shown in Figure 5.

2. Mount the loaded sampler inlets to the supports in the STS using the ¾-in. Swagelok bulkhead fittings connected to a vacuum source. The reference samplers should be mounted in the upright position to allow the technician sufficient clearance for attaching a TSI mass flow meter to the inlet (Figure 6).

Figure 5. Reference and candidate samplers on carrier ready for installation on mounting post in STS.

Figure 6. Mounted reference samplers with PM_{10} candidate sampler in center.

3. Reference sampler flow rate is maintained automatically by an automated flow control system. The flow controller channels should be switched from “off” to “auto” immediately after connecting the reference samplers. Exit the STS and switch the flow controller from “off” to “auto”.
4. Using a TSI mass flow meter, measure and record the ambient temperature and pressure within the STS on the data sheet (Appendix A). Then affix the meter to the inlet of the sampler (Figure 7). The TSI mass flow meter that is permanently affixed downstream of each reference sampler displays the mass flow rate in each channel for the corresponding reference sampler.
5. Wait until the flow control system has accurately adjusted the metering valves for the target flow rate. The TSI mass flow meter at the inlet should read 100 ± 2 aLpm before proceeding.

Figure 7. TSI mass flow meter connected to the reference sampler.

6. Rotate the reference sampler inlets 90 degrees into sampling position, facing upstream, and connect all inlets to a common electrical ground using a copper wire. The wind tunnel ceiling or metal wall is simplest. Then inspect the positioning of the samplers to verify that the alignment and position of each meets the objective of the test. A spacing of 18 in. from center should accommodate most candidate samplers. If a wider spacing is necessary, refer to Appendix B. Figure 8 shows the relative placement and orientation of samplers configured to evaluate the size selective performance of an omnidirectional inlet.
7. Exit the STS.

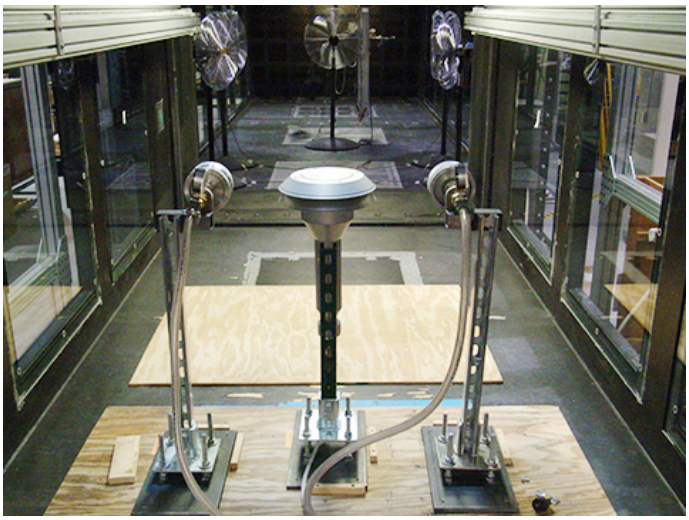

Figure 8. Reference and candidate samplers ready for sample collection.

9.3 Particle Dispersion and Test Operation

1. Set the wind tunnel fan voltage to the predetermined set point to achieve the desired wind speed. For details regarding wind tunnel fan set point, aerosol generation assembly, and mixing fans, refer to SOP-J15-001.0 (formerly draft SOP-ZD-14-01(1)), "Producing a Spatially Uniform Challenge Aerosol in a Large Wind Tunnel Using Commercially Available Polydisperse Size Standards."
2. Connect the power source to start the mixing fans (four total) in the human exposure test section (HETS) of the wind tunnel. Cross-flow mixing fans should be set to high for all wind tunnel velocities. To adjust fan speed, use the pull cord on the back of each fan to set them to high speed. There are four settings: off, high, medium, and low. Adjust the fan speed to off, and then pull the cord once more to set it to high speed, once more for medium, and so on.
3. Connect the power source to the stationary fan located immediately downstream of the aerosol generator. It should be oriented to blow upstream. Refer to Table 1 for stationary fan settings at each wind tunnel velocity.

Table 1. Stationary Booster Fan Settings for Different Wind Tunnel Velocities

Wind Tunnel Velocity (km/h)	Stationary Booster Fan Setting
2	Off
8	Medium
24	High

4. Connect the air pressure line to the sonic nozzle, and verify the reading on the pressure gauge is ≥ 80 psi.
5. Set the countdown timer for 90 minutes.
6. Start the aerosol generator by connecting the power source that controls the dust feed agitator, the ionizer, and the dust feeder.
7. Start the countdown timer, and record the start time and initial flow rates on the data sheet.

9.4 Sample Retrieval

1. Disconnect power from the aerosol generator components and all fans, and then disconnect the high-pressure air line from the source to stop the flow of air to the sonic nozzle.
2. Adjust the wind tunnel fan voltage to a very low VDC value to allow for entry into the wind tunnel.
3. Enter the STS downstream of the sampler inlets.
4. Rotate the reference sampler inlets to the upright position.

5. Remove one sampler inlet at a time by first loosening the Swagelok connections and then slowly lifting the inlet off the vacuum source.
6. Place the reference sampler inlets and any candidate inlet that were used on the carrier and cover each inlet with a Nalgene cap.
7. Transport the samples back to the laboratory for extraction.

9.5 Reference Sample Extraction

1. Prepare a 20% glycerol in Isoton II electrolyte solution. The simplest approach is to prepare the solution in 1 kg batches using the laboratory balance as follows:
   a. Obtain a 1-L container with a tight-fitting lid and place it on the balance without the lid and tare, or zero, the balance.
   b. Add 800 g of Isoton II and then 200 g of glycerol to the container.
   c. Secure the lid and shake the contents until the glycerol is thoroughly dissolved in the Isoton II, about 10 seconds.
   d. Then pour the solution into the pressurized electrolyte filtration vessel for dispensing. The resulting solution density, at room temperature should measure 1.054 g/cc.
2. Install a new capsule filter on the outlet of the electrolyte filtration system, and apply 30 psi to the system.
3. Obtain three clean SS containers, determine the appropriate extraction volume for each sampler, and add that amount of filtered electrolyte to each container, by mass, using the balance. Appendix C provides details and instructions regarding the determination of extraction volume.
4. Remove the threaded collar from the reference samplers, and clean the exterior of each inlet using a premoistened Clean-Wipe to remove any dust remaining on the exterior surfaces of the inlets.
5. Apply mist to one reference sampler at a time prior to extraction as follows. Wetting the filter and inner surface of the isokinetic nozzle reduces the risk of resuspension of collected particles from surfaces when preparing for extraction.
   a. Obtain the mist applicator spray bottle and add 30–50 mL of filtered DI H_2O to the bottle.
   b. Replace the spray nozzle onto the bottle and tighten the cap.
   c. Prime the nozzle by squeezing the grip 5–10 times with the bottle in the upright position.
   d. With the mist applicator bottle inverted 90 degrees, position the misting nozzle just above the opening of the isokinetic reference sampler inlet and apply mist using a half stroke of the grip.
6. Move the reference sampler inlet to the extraction work space and place a clean empty SS container under the extraction funnel.

7. Remove the isokinetic nozzle from the reference sampler and place it, with inlet down, into the extraction funnel. The top half of the filter cassette should remain attached to the nozzle (Figure 9).
8. Using a pipette with pipette controller, rinse the inside surface of the isokinetic nozzle with 100 mL of GISO (Figure 10), and then set the nozzle aside.
9. Remove the bottom half of the filter cassette with the filter from the reference sampler base and place it in the extraction funnel, with filter side up.
10. Use one hand to hold the cassette at an angle in the extraction funnel and the other to rinse the surface of the filter into the funnel with the 700 mL of GISO remaining in the container. Dispense the GISO slowly over the surface of the filter while rotating the cassette inside the funnel to extract any dust that might be trapped in the contoured surfaces of the filter cassette assembly (Figure 11).

Figure 9. Isokinetic nozzle in funnel ready for extraction.

Figure 10. Rinsing nozzle with GISO solution.

Figure 11. Rinsing Nuclepore filter side with cassette into SS container.

11. Collect any remaining drops of GISO from the filter cassette assembly and funnel in the SS container.
12. Set aside the SS container containing the extracted sample and replace the lid.
13. Repeat steps 5 through 12 for all remaining reference samplers.

9.6 Candidate Sample Extraction

1. Remove the top half of the candidate sampler filter holder/inlet assembly to expose the filter.
2. Invert the mist applicator 90 degrees, position the mist nozzle at least 10 in. above the filter, and apply the same volume of mist as was done for the reference sample extraction.
3. Place a clean Petri dish over the candidate filter cassette until ready for extraction.
4. Place a clean SS funnel in a ring stand support above the work surface. Adjust the height of the support to allow enough space for a 100-mL Coulter beaker.
5. Place an empty 100-mL Coulter beaker under the funnel for the candidate sampler extraction.
6. Place the candidate sampler filter cassette in the SS funnel.
7. Using a laboratory spatula, separate the top half of the filter cassette from the bottom half. Rinse the filter cassette assembly with 100 mL of electrolyte solution into the Coulter beaker, and then cover the beaker with its lid when finished.

9.7 Preparation for Coulter Analysis

1. Place each SS container with extracted samples in ultrasonic bath for 10 seconds (Figure 12).

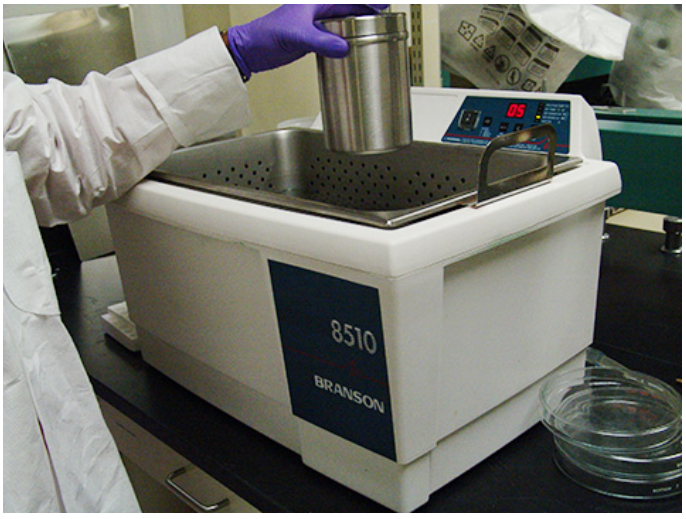

Figure 12. Extract within SS container ready for sonication.

2. Wipe the exterior of the sample container to remove ultrasonication bath liquid.
3. Set two clean 400-mL Coulter beakers on the work surface right-side up. (Candidate samplers have only one 100-mL beaker.)
4. Transfer the contents of the extracted sample to an empty SS container and back again. Repeat this mixing process a minimum of 10 times rapidly (Figures 13 and 14).
5. After mixing the extract, transfer half of the extract to one of the two 400-mL Coulter beakers (Figure 15).
6. Repeat the mixing process a second time with the remaining extracted sample, and then pour the contents into the second 400-mL Coulter beaker.

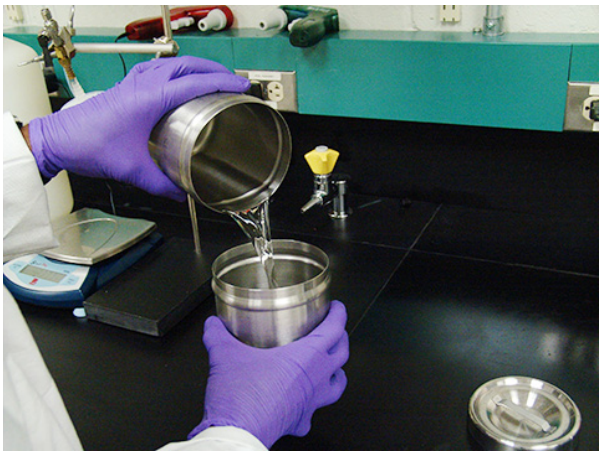

Figure 13. Transferring sonicated extract to another SS container.

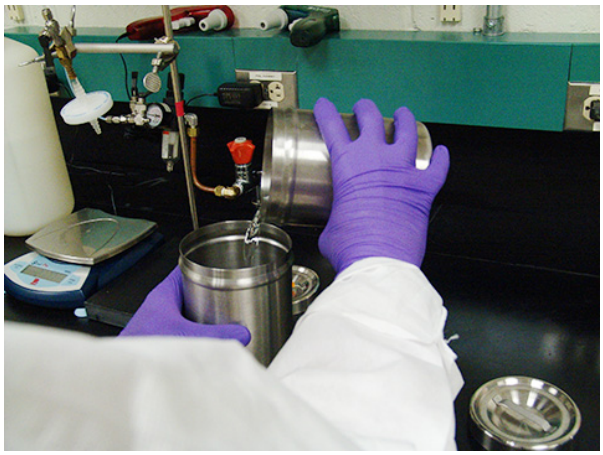

Figure 14. Transferring process is repeated back and forth 10 times.

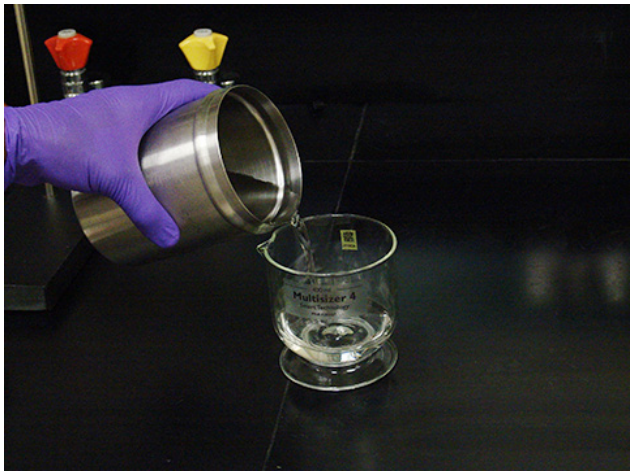

Figure 15. Transferring extract to Coulter beaker for reference samples.

7. Cover the two Coulter beakers and affix an appropriate label to each (e.g., “R1a” and “R1b”), as shown in Figure 16.
8. Set the beakers aside for Coulter analysis.

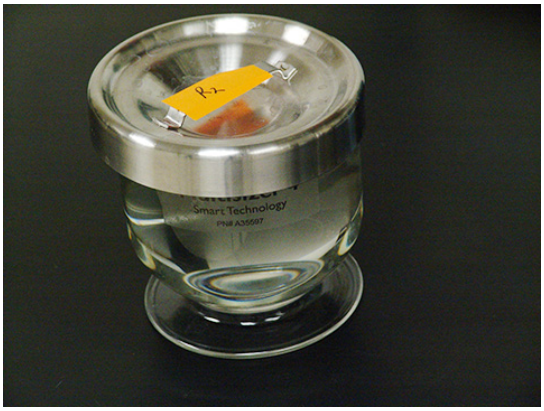

Figure 16. Labeled reference sample Coulter beaker.

10.0 Troubleshooting

See the troubleshooting guides in the operator manuals listed in section 14 for guidance on troubleshooting instruments and equipment.

11.0 Data Calculations

Dilution might be necessary to decrease the concentration of particles in the sample extract prior to analysis. Use the equation below to determine the particle counts in the sample when analyzing a diluted sample, given the volumes used for dilution and the resulting particle concentration returned by Coulter analysis of the diluted sample.

$$Particle\ Concentration\ (N/mL) = \frac{N}{V_{injected}} \times \frac{V_{diluted\ sample}}{V_{orginal\ sample}}$$

where N = particles counted by Coulter Counter

V = volume (mL)

12.0 Quality Control and Quality Assurance

12.1 Flow rates are monitored continuously to ensure that isokinetic sampling velocities are maintained. They must be within ± 2.5% of the target or the test is aborted and restarted after the flows are adjusted.

12.2 Samples are labeled when the samples are removed from the tunnel. The sample information is recorded on the data sheet, in the laboratory notebook, and electronically.

12.3 GISO (electrolyte solution) background samples are analyzed daily. If the concentrations of reference sampler 1 and reference sampler 2 differ by more than 10%, the test is aborted and data are considered invalid.

13.0 Data and Records Management

Extraction volumes are recorded on the data sheet (Appendix A). All records will be maintained in a laboratory notebook or instrument logbook in accordance with the policies and procedures specified in the QAPP.

14.0 References

SOP-J15-001.0 (formerly draft SOP-ZD-14-01(1) prepared by Alion Science and Technology and RTI International), Producing a Spatially Uniform Challenge Aerosol in a Large Wind Tunnel Using Commercially Available Polydisperse Size Standards, August 2014. Research Triangle Park, NC: Jacobs Technology Inc.

SOP-J15-003.0, (formerly draft SOP-ZD-14-03(1) prepared by Alion Science and Technology and RTI International), Determining Aerosol Size Distribution Using the Multisizer 4 Coulter Counter, August 2014. Research Triangle Park, NC: Jacobs Technology Inc.

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Appendix A:
Wind Tunnel Evaluation Data Sheet

Wind Tunnel Evaluation of Candidate Sampler

Date	
Candidate Sampler(s)	
Wind Speed (kmph)	
Replcate, Today	
Total Replicates in Series	

Conditions

Wind tunnel fan manual set point (VDC)	
Challenge Aerosol	
Particle Density (g/cc)	
Feed Rate	
Cross-flow Fans (# - setting)	
Stationary Upstream Fan (# - setting)	
Duration	

Sample Information — *Test Data* — *Analysis Data*

			START		STOP		SAMPLE EXTRACTION			
Sampler ID	*FILTER*	*POS.*	*Time*	*Vac. (in.Hg)*	*Time*	*Vac. (in.Hg.)*	*(mL)*	*[%]*	*[#/mL]*	*%CV*
REFERENCE SAMPLER 1										
CANDIDATE SAMPLER 1										
CANDIDATE SAMPLER 2										
CANDIDATE SAMPLER 3										
REFERENCE SAMPLER 2										
OTHER										

Results — *File Name :*

WIND TUNNEL AEROSOL CONC. [#/m^3]		***CANDIDATE SAMPLER 1***		***CANDIDATE SAMPLER 2***		***CANDIDATE SAMPLER 3***	
AVERAGE [REF.]		*$\bar{X}$ [#/m^3] =*		*$\bar{X}$ [#/m^3] =*		*$\bar{X}$ [#/m^3] =*	
MEDIAN Diam. (µm)		*5 µm C/R*		*5 µm C/R*		*5 µm C/R*	
d90 (µm)		*10 µm C/R*		*10 µm C/R*		*10 µm C/R*	
AEROSOL UNIFORMITY		*15 µm C/R*		*15 µm C/R*		*15 µm C/R*	
AVG. R1/R2		*$\bar{X}$ C/R*		*$\bar{X}$ C/R*		*$\bar{X}$ C/R*	
SLOPE (<30 µm)		*SLOPE (<30 µm)*		*SLOPE (<30 µm)*		*SLOPE (<30 µm)*	

Comments

Appendix B: Considerations for Positioning Samplers in the STS

Spatial positioning considerations for reference samplers are sometimes constrained by the dimensions of the candidate sampler being evaluated.

Reference samples are collected at an isokinetic velocity of 100 Lpm to provide an accurate representation of the concentration of challenge aerosol in the STS. The position of the reference samplers must allow for the accommodation of a third sampler (either candidate or reference) between them (on the central line of the STS) such that any effects of that sampler do not interfere with movement of air flow around the others. This is a consideration that is critical for the accurate measurement of the challenge aerosol concentration in the STS used to evaluate the effectiveness of candidate samplers.

For determination of aerosol uniformity within the STS, three isokinetic reference samplers are placed in the STS, one on the central line of the STS and one on either side placed 12 inches away on center. In practice, the position nearest the inside wall of the STS is referred to as reference sampler position 1, or R1, and the opposite side is referred to as reference sampler position 2, or R2. Spatial considerations of R1 and R2 to accommodate a sampler in the center, the candidate or C position, must include any effects that sampler might have on R1 and R2 due to turbulence and/or the volumetric flow rate of the sampler.

Collecting velocity measurements at the R1 and R2 positions is the simplest approach when determining the best positions for the reference samplers during a candidate sampler evaluation. In this approach, velocity measurements are collected at R1 and R2 with the candidate sampler installed and operating at its normal flow rate in the center position. Effects of the candidate sampler on the velocity measured at R1 and R2 would be evident by the comparison of these values. If the velocities measured at R1 and R2 differ by more than 10% from each other or from what was previously determined in SOP-J15-001.0 (formerly draft SOP-ZD-14-01(1)), “Producing a Spatially Uniform Challenge Aerosol in a Large Wind Tunnel Using Commercially Available Polydisperse Size Standards,” then an adjustment to positions R1 and R2 will be necessary. In this case, R1 and R2 can be moved farther from the center line toward the walls or farther upstream since the effects of the isokinetic reference samplers are minimal.

Appendix C: Extraction Volume Considerations

Determining the correct volume of electrolyte solution to extract particles from sample filters collected in the wind tunnel requires consideration of the conditions during sample collection. The resulting particle concentration in the extract should not exceed 10% solids by volume as measured by the Multisizer 4 following SOP-J15-003.0 (formerly draft SOP-ZD-14-03(1)), "Determining Aerosol Size Distribution Using the Multisizer 4 Coulter Counter."

Reference samples collected at 100 Lpm on 90-mm filters at isokinetic velocity for 90 minutes should be extracted in 800 mL of electrolyte solution and analyzed per SOP-J15-003.0. If the particle concentration in the extraction solution is greater than 10% solids by volume, then dilution is required. Otherwise continue analysis. Diluting samples in liquid that contains particles with greater density should be conducted with care in order to maintain a particle concentration in each fraction of the extracted sample that is an accurate representation of the total sample.

Particle settling due to gravitational forces will require consistent mixing if the total sample is to be divided for analysis. In practice, this is achieved by repeatedly transferring the extracted sample from one container to another and then immediately parsing the extract. Given the particle concentration in extract, follow the suggested dilution volumes in Table C-1.

Table C-1. Suggested Dilution Volumes

Particle Concentration Extract (%)	Increase in Total Electrolyte Volume for Dilution
11–18	2x
18–25	3x
25–35	4x

With respect to aerosol concentration within the wind tunnel at 2 km/h, concentration on the filter is diluted by a factor of 4 when wind speed is increased to 8 km/h and 12 when increased to 24 km/h. Assuming a consistent sampling duration between replicate tests at different wind speeds, two parameters should be adjusted to result in an accurate particle concentration in the wind tunnel. Of primary importance is the aerosol generation feed rate, which should be increased with increasing wind speed and decreased at lower wind speeds. Refer to SOP-J15-001.0 (formerly draft SOP-ZD-14-01(1)), "Producing a Spatially Uniform Challenge Aerosol in a Large Wind Tunnel Using Commercially Available Polydisperse Size Standards," for recommended set points.