RESEARCH TRIANGLE INSTITUTE

TEST/QA PLAN
FOR PAINT OVERSPRAY ARRESTORS

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Prepared for:

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National Risk Management Research Laboratory
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LIST OF ACRONYMS/ABBREVIATIONS

ADQ	Audit of data quality
ANSI	American National Standards Institute
APCT	Air Pollution Control Technology
ASME	American Society of Mechanical Engineers
cfm	Cubic feet per minute
CV	Coefficient of variance
DQO	Data Quality Objective
EPA	Environmental Protection Agency
ESE	RTI’s Environmental Sciences and Engineering Unit
ETV	Environmental Technology Verification
fpm	Feet per minute
HEPA	High Efficiency Particulate Air
ISO	International Standards Organization
KCl	Potassium chloride
NESHAP	National Emission Standard for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
OPC	Optical particle counter
PE	Performance evaluation
POA	Paint overspray arrestor
PSL	Polystyrene-latex
QA	Quality Assurance
QAO	Quality Assurance Officer
QC	Quality Control
QMP	Quality Management Plan
RH	Relative humidity
RTI	Research Triangle Institute
SOP	Standard operating procedure
TSA	Technical systems audit

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SECTION A: PROJECT MANAGEMENT

A1: Project/Task Organization

The US Environmental Protection Agency (EPA) has overall responsibility for the Environmental Technology Verification (ETV) Program for Air Pollution Control Technology (APCT). Research Triangle Institute (RTI) is EPA's verification partner in this effort. The APCT program has selected paint overspray arrestors (POA) as a technology to be verified.

Management and testing within the POA program are performed in accordance with procedures and protocols defined by a series of quality management documents. These include EPA's Quality Management Plan (QMP) for the overall ETV program, RTI's Environmental Sciences and Engineering (ESE) Quality Manual, the QMP for the overall APCT program, the Generic Verification Protocol for Paint Overspray Arrestors, and Test/QA Plans prepared by each participating test laboratory. Table 1 summarizes these documents.

RTI will conduct laboratory tests on paint overspray arrestors, analyze data, and prepare verification reports and verification statements. The various quality assurance (QA) and management responsibilities are divided between EPA and RTI key project personnel as defined below. The lines of authority between key personnel for this project are shown on the project organization chart in Figure 1.

A1.1 Management Responsibilities

Project management responsibilities are divided among the EPA personnel and RTI personnel as listed below.

A1.1.1 EPA Project Manager

The EPA Project Manager, Dr. Ted Brna, has overall responsibility for the APCT program. He is responsible for granting final approval of project plans and reports and seeing that plans are implemented according to schedule, and he requests the resources necessary to meet project objectives and requirements.

A1.1.2 RTI Project Manager

The RTI Project Manager for the APCT program is Mr. Jack Farmer. He has overall responsibility for QA in the APCT program and in technology-specific verification tests. He will assign technology verification task leaders; oversee verifications; review technical panel makeup; and review generic verification protocol and test-specific quality documents. These responsibilities are described in greater detail in Section 2 of the QMP.

Table 1. Quality Management Documents Applicable to the POA Task

Document	Description
EPA's ETV QMP	EPA's ETV QMP lays out the definitions, procedures, processes, inter-organizational relationships, and outputs that will assure the quality of both the data and the programmatic elements of ETV. Part A of the ETV QMP contains the specifications and guidelines that are applicable to common or routine quality management functions and activities necessary to support the ETV program. Part B of the ETV QMP contains the specifications and guidelines that apply to test-specific environmental activities involving the generation , collection, analysis, evaluation, and reporting of test data. (EPA's Quality and Management Plan for the Pilot Period (1995-2000), May 1998.)
ESE Quality Manual	ESE's Quality Manual describes the quality systems in place for RTI's technical research unit containing the APCT program. ESE's quality manual complies with ANSI/ASQC Standard E4-1994. The scope of this manual encompasses performance criteria, requirements, and procedures for managing the quality of all work conducted by or on behalf of ESE. Therefore, ESE's quality manual applies to all ESE staff as well as people who perform work on behalf of ESE, such as staff from other RTI research and administrative units, and others who contribute to projects managed by ESE.
APCT's QMP	APCT's QMP describes the quality systems in place for the overall APCT program. It was prepared by RTI and approved by EPA. Among other quality management items, it defines what must be covered in the generic verification protocols and Test/QA plans for technologies undergoing verification testing.
Generic Verification Protocols	Generic Verification Protocols are prepared for each technology to be verified. These documents describe the overall procedures to be used for testing a specific technology and define the data quality objectives (DQOs). With input from the POA Technical Panel, RTI prepared the generic verification protocol for POA and the document was reviewed and approved by EPA. While specific to the testing of paint overspray arrestors, the document is "generic" in that it applies to many types and brands of paint overspray arrestors.
Test/QA Plans	Test/QA Plans are prepared by each participating test laboratory. The Test/QA Plan describes, in detail, how the testing laboratory will implement and meet the requirements of the Generic Verification Protocol. The Test/QA Plan addresses issues such as the laboratory's management organization, test schedule, documentation, analytical method and data collection requirements, calibration traceability, and specifies the QA and QC requirements for obtaining verification data of sufficient quantity and quality to satisfy the DQOs of the Generic Verification Protocol.

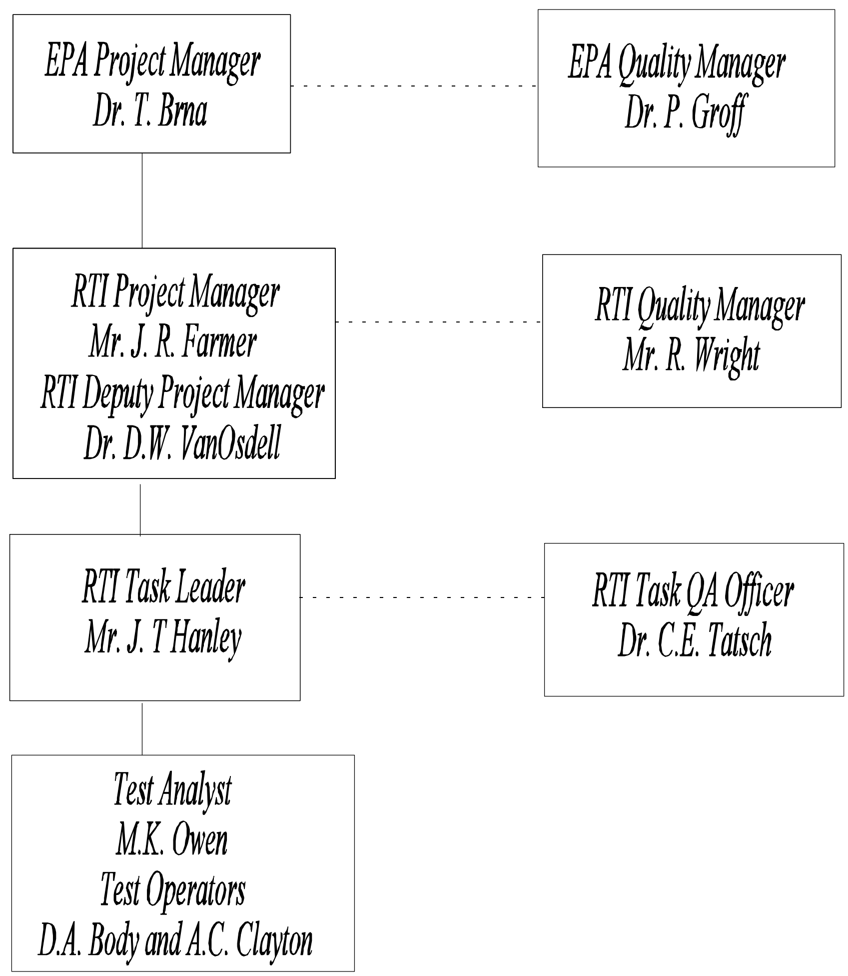

Figure 1. Organization Chart. Dashed lines indicate organizational independence.

The Deputy Manager, Dr. Douglas VanOsdell, reports to the APCT Project Manager and substitutes for the APCT Project Manager if that individual is absent. The Deputy manager is responsible for any functions delegated to him by the APCT Project Manager.

A1.1.3 RTI Task Leader

The RTI task leader for the POA tests is Mr. James Hanley. He will manage the POA technology verification test. With the concurrence of the APCT Program Director, the task leader will select a task QA Officer, prepare a preliminary generic verification protocol, a test/QA plan and any standard operating procedures (SOPs) that are needed for the specific technology verification test in cooperation with the task QA Officer; develop staffing requirements; identify candidates for the Technical Panel; and propose a budget for the technology verification test from test start through development of the generic verification protocol. After a technical assessment, the technology verification task leader is responsible for developing and implementing corrective actions. These responsibilities are described in greater detail in Section 2 of the QMP.

Mr. Hanley will be assisted by Ms. M. Katheen Owen, Mr. DeVaughn A. Body, and Mr. A. Clint Clayton. Ms. Owen will be the test analyst, will perform data analysis and report preparation, and will be the sample custodian. Mr. Body and Mr. Clayton will be the test operators performing the actual testing. Each of these persons is experienced in carrying out their respective duties.

A1.2 Quality Assurance Responsibilities

QA responsibilities are divided among the EPA personnel and RTI personnel as listed below.

A1.2.1 EPA Quality Manager

The EPA Quality Manager for the POA task is Mr. Paul Groff. He is responsible for ensuring adherence with ETV quality requirements and auditing APCT Program testing. While EPA will audit RTI's testing, RTI will audit the testing by other laboratories; however, EPA retains the option to conduct audits of the other laboratories. Mr. Groff will be available to resolve any QA issues relating to conformance to EPA's QA requirements. Specific functions and duties of the EPA Quality Manager include approving the contents of this Test/QA Plan and subsequent revisions and reviewing QA reports prepared by RTI, including QA evaluations and audits.

A1.2.2 RTI Quality Manager

The RTI Quality Manager for the APCT program is Mr. Robert S. Wright. He is responsible for preparation of the QMP, for review of generic verification protocol and test-specific quality documents, and for conducting independent technical assessments of the verification tests. These responsibilities are described in greater detail in Section 2 of the QMP. The RTI Quality Manager is independent of the unit generating the data.

A1.2.3 RTI Task QA Officer

The RTI Task QA Officer for the POA tests is Dr. C. E. Tatsch. He will handle the QA activities directly associated with specific verification tests, including conducting task-specific technical assessments and preparing task-specific test/QA plans and any needed SOPs in cooperation with the technology verification task leader to ensure that technology verification tests are implemented in conformance with these documents. These responsibilities are described in greater detail in Section 2 of the QMP. The RTI Task QA Officer is independent of the unit generating the data.

A2: Problem Definition/Background

(The protocol provides extended discussions on problem definition and background from which portions of the following have been extracted.)

Paint overspray arrestors are particle collection devices (e.g., filters) used to control particle emissions from paint spraying operations. Much of the impetus for this verification program comes from the recently promulgated National Emission Standard for Hazardous Air Pollutants (NESHAP) for Aerospace Manufacturing and Rework Facilities (*Code of Federal Regulations*, Volume 40, Part 63, Appendix A). The NESHAP establishes filtration efficiency requirements for paint overspray arrestors used in new and existing aerospace facilities, shown in Tables 2 - 5, and presents the test method to be used to make these filtration efficiency determinations (Method 319, "Determination of Filtration Efficiency for Paint Overspray Arrestors").

The objective of the Paint Overspray Arrestor program is to verify the filtration efficiency performance of arrestors using Method 319 and to produce verification statements for dissemination to the public.

A3: Project/Task Description and Schedule

A.3.1 Project/Task Description

(The protocol provides extended discussions on project/task description from which portions of the following have been extracted.)

Testing will be performed on dry-type paint overspray arrestors; water-wash systems are not included. The arrestors must be commercial-ready. The focus will be on arrestors used in the aerospace industry, but arrestors used in other fields may also be evaluated. The test arrestors will not exceed 24-inch x 24-inch face dimensions.

For arrestors that operate on principles not compatible with testing by Method 319 (as may occur with innovative technologies), the APCT program will prepare separate verification protocols for these technologies. These protocols must be approved by the Technical Panel prior to

**TABLE 2. EXISTING FACILITIES;
LIQUID-PHASE CHALLENGE AEROSOL PARTICLES**

Filtration efficiency requirement, %	Aerodynamic particle diameter range, µm
> 90	> 5.7
> 50	> 4.1
> 10	> 2.2

**TABLE 3. EXISTING FACILITIES;
SOLID-PHASE CHALLENGE AEROSOL PARTICLES**

Filtration efficiency requirement, %	Aerodynamic particle diameter range, µm
> 90	> 8.1
> 50	> 5.0
> 10	> 2.6

**TABLE 4. NEW FACILITIES;
LIQUID-PHASE CHALLENGE AEROSOL PARTICLES**

Filtration efficiency requirement, %	Aerodynamic particle diameter range, µm
> 95	> 2.0
> 80	> 1.0
> 65	> 0.42

**TABLE 5. NEW FACILITIES;
SOLID-PHASE CHALLENGE AEROSOL PARTICLES**

Filtration efficiency requirement, %	Aerodynamic particle diameter range, µm
> 95	> 2.5
> 85	> 1.1
> 75	> 0.70

performing verification testing. The general approach of these protocols, if needed, will be to use Method 319 to the extent that is reasonable and have any deviations remain consistent in spirit with Method 319 (i.e., verifying an arrestor's filtration efficiency performance for respirable particles as listed in Tables 2 - 5).

Verification parameters will consist of the 0.3 - 10 µm filtration efficiency (curves and data tables), the computed filtration efficiency corresponding to the particle diameters specified in the Aerospace NESHAP (see Tables 2 - 5), and the pressure drop across the arrestor at the test flow rate.

A.3.2. Schedule

To provide a controlled start to the testing program, testing will be conducted in rounds. As specified in the protocol, Round 1 will consist of arrestors intended by the manufacturers to meet the NESHAP requirements for new facilities (i.e., these are the higher efficiency type of arrestors). Following a notice to manufacturers, six manufacturers have agreed to participate in Round 1 testing. Each of these manufactures will submit one arrestor model for testing (following procedures specified in the protocol). Testing is currently planned to begin in late February or early March 1999. The Round 1 tests will take approximately 3 weeks to complete. Round 2 testing will consist of arrestors intended by the manufacturers to meet the NESHAP requirements for existing facilities. It is anticipated that up to approximately ten manufacturers may participate in the Round 2 testing. These tests are tentatively planned to be conducted during the Summer of 1999. After Round 2, testing is anticipated to be conducted on a "by request" basis.

A4: Quality Objectives and Criteria for Measurement Data

The data quality objectives (DQOs) are presented in Table 6. The DQOs contain all the DQOs specified in the protocol with added criteria for arrestor pressure drop and acceptable ranges of test temperature and relative humidity (based on requirements within Method 319).

A5: Special Training Requirements/Certification

The task leader and test analyst should have extensive experience in filtration efficiency measurements, the theory and operation of aerosol particle counters, an understanding of filtration mechanisms that lead to particle collection in filters (e.g., inertial impaction, interception, and diffusion), be familiar with the characteristic shape of filtration efficiency curves, be knowledgeable of the aerosol generation process, and be knowledgeable of aerosol transport in sample lines.

The test operators should be thoroughly familiar with the operation of the test duct, the aerosol generator, and the particle counter. They should be experienced in testing paint overspray arrestors, or similar filtration devices, for filtration efficiency over the 0.3 - 10 µm size range.

TABLE 6. Data Quality Objectives

Parameter	Frequency and description	Control Limits
Minimum counts per channel for challenge aerosol	Each efficiency test.	Minimum total of 500 particle counts per channel.
Maximum particle concentration	Each efficiency test. Needed to ensure OPC is not overloaded.	<10% of manufacturer's claimed upper limit corresponding to a 10% count error.
Standard Deviation of Penetration	Computed for each efficiency test based on the coefficient of variation (CV) of the upstream and downstream counts.	<0.10 for 0.3 to 3 µm diameter <0.30 for >3 µm diameter
0% Penetration	Monthly.	<0.01
100% Penetration - Solid-phase aerosol (KCl)	A 100% penetration test using KCl aerosol is performed immediately before each KCl arrestor efficiency test.	Particle Size range / Acceptable Penetration Range: 0.3 to 1µm: 0.90 to 1.10 1 to 3µm: 0.75 to 1.25 3 to 10µm: 0.50 to 1.50
100% Penetration - Liquid-phase aerosol (oleic acid)	A 100% penetration test using oleic acid aerosol is performed immediately before each oleic acid arrestor efficiency test.	Particle Size range / Acceptable Penetration Range: 0.3 to 1µm: 0.90 to 1.10 1 to 3µm: 0.75 to 1.25 3 to 10µm: 0.50 to 1.50
Temperature	The test duct air temperature measured for each run.	50 - 100 °F acceptable test condition range. Measurement accuracy of +/- 2 °F
Relative Humidity	The test duct relative humidity measured for each run.	< 65% acceptable test condition range. Measurement accuracy of +/- 10 % RH
Airflow accuracy	Every 6-months. Compare duct airflow measurement to reference flow device.	Duct airflow measurements must be within +/- 5% of reference measurement.
Precision of airflow measurement	For a given airflow setting, the measurement device must provide a steady airflow reading. Checked annually.	Ten consecutive measures of airflow made at 10-second intervals. Precision computed as the 95% confidence interval for the mean airflow measurement. Precision must be within +/- 5% of the set point airflow.
Resolution of Airflow measurement	Airflow measurement must be readable to within 5% of set point. Changes in airflow of 5% from set point must be clearly discernable. Checked annually.	The resolution of the airflow measurement system shall not exceed 5% of the set point airflow.
OPC zero count	Each test. OPC samples HEPA-filtered air.	<50 counts per minute.
OPC sizing accuracy check: Polystyrene latex spheres (PSL)	Daily. Sample aerosolized PSL spheres.	Peak of distribution should be in correct OPC channel.
OPC sizing accuracy check: Reference filter	Performed immediately prior to beginning Method 319 test of a product. Measure filtration efficiency of laboratory reference filter.	Measured efficiency must fall within +/- 10% of previous measurements (i.e., within a 10% shift in particle size and/or filtration efficiency) when compared to efficiency of reference filter measured after primary OPC calibration.
OPC calibration: Primary calibration	Primary calibration performed by manufacturer at manufacturer-specified intervals; but at least annually.	Manufacturer provides certificate of calibration.
Pressure drop across the arrestor	Annual. Compare to reference manometer.	Inclined manometer readable to within +/- 0.01 in. H_2O. 10% or better accuracy.
Aerosol charge neutralizer	Monthly. Confirm activity of radioactive charge neutralizers. Confirm balance of corona discharge neutralizers.	Activity must be detected in radioactive neutralizers. Corona discharge neutralizers must be in balance.

All test personnel that handle the aerosol neutralizer (a radioactive source) must receive appropriate radiation safety training.

A6: Documentation and Records

Requirements for record keeping and data management for the overall APCT program are found in Section 3.6 of the APCT QMP. All verification test data, calibration data, certificates of calibration, assessment reports, verification reports, and verification statements will be retained by the APCT program office for a period of not less than 7 years after the final payment of the assistance agreement as per Part A, Section 5.3 of the ETV QMP.

A6.1 Laboratory Documentation

The test operator records test data and notes on test run sheets prepared specifically for these tests (presented in Appendix A). The sheets are kept in a labeled 3-ring binder. The run sheets are designed to prompt the test operator for all required test information:

- Testing date, time, and operator
- Manufacturer and model number of arrestor
- Physical description of filter
- QA checks on the equipment and data
- Test conditions (T, RH, atmospheric pressure, flow rate, arrestor pressure drop)
- Data quality checks

The particle count data generated by the OPC are printed as they are obtained, and inserted into the test notebook upon test completion. These data are simultaneously stored on the data acquisition computer hard drive as the samples are obtained. The test run sheet includes an entry for the file name. Each file name is unique and is based on the date (MMDDYY) and sequential run (SS) of that day: MMDDYYSS. This number is used on the run sheets, written on the test arrestor, written on the OPC printout, and used as the computer file name.

After each test, the data are transferred from the data acquisition computer's hard drive to a computer diskette, labeled with the test number, and loaded into a spreadsheet program on the laboratory data analysis computer to inspect the data. Within the spreadsheet, the run number is inserted to "tag" the data. The spreadsheet file is saved on the data analysis computer using the same unique file name.

Upon completion of the test series for an arrestor, the data files are copied onto the diskette and taken the to test analyst's office. The test analyst copies the data onto an office computer and stores the diskette.

A6.2 QA/QC Reports

After the completion of verification tests, control test data, sample inventory logs, calibration records, and certificates of calibration will be stored with the verification test data in the APCT Program Office. Calibration records will include such information as the instrument being calibrated, raw calibration data, calibration equations, analyzer identifications, calibration dates, calibration standards used and their traceabilities, identification of calibration equipment used, and staff conducting the calibration. Final reports of self-assessments and independent assessments (i.e., technical systems audits, performance evaluations, and audits of data quality [TSAs, PEs, and ADQs]) will be retained in the APCT Program Office. Each verification report and verification statement will contain a quality assurance section, which will describe the extent that verification test data comply with data quality objectives.

A6.3 Verification Reports and Verification Statements

The content and format for the Verification Reports and Verification Statements are specified in the Section 4 of the protocol.

Verification reports and verification statements will be prepared by the RTI task leader and the RTI Task QA Officer, will be reviewed by the RTI Project Manager and the RTI Quality Manager, and will be submitted to the EPA Project Manager for approval. Procedures for the preparation, review, and dissemination of verification reports and verification statements are described in Sections 5 and 14 of the protocol and in Section 2.5 of the APCT QMP.

SECTION B: MEASUREMENT/DATA ACQUISITION

B1: Sample Process Design (Experimental Design)

The protocol provides extended discussions on experimental design of this project. A brief summary is provided below.

The test program will measure the filtration efficiency of paint overspray arrestors. The test method is EPA's Method 319 "Determination of Filtration Efficiency for Paint Overspray Arrestors." Manufacturer's will submit arrestors for testing that they wish to have verified. To verify an arrestor's performance, a series of filtration efficiency tests are performed using solid-phase and liquid-phase challenge aerosols. The efficiency tests are performed in triplicate. Control tests consisting of a reference filter test and 0% and 100% penetration tests are also performed. Table 7 shows the anticipated test sequence.

The test arrestors will be supplied to the test laboratory directly from the manufacturer with a letter signed by the manufacturer's CEO (or other responsible corporate representative) attesting that the arrestors were selected in an unbiased manner from a minimum of 100 similar arrestors and have not been treated in any manner different from the arrestors they offer to the public. The manufacturer will supply the test laboratory with 18 arrestors; from these 18 arrestors, the test laboratory will randomly select 6 arrestors for testing.

All test data are collected in real time during an approximate 16-hr testing period. There are no post-sampling procedures.

All tests will be performed in RTI's Bay 6 laboratory located in Bldg. 11 of its RTP, NC campus.

The critical measurement parameters are the parameters listed in Table 6. There are no additional critical measurements.

The non-critical measurements are limited to atmospheric pressure, which is recorded as part of the test condition documentation.

B2: Sampling Methods Requirements

B2.1 Test Duct

The tests will be conducted in RTI's air cleaner test facility (Figure 2) which meets all the requirements specified in Method 319. The test rig's ducting is primarily 24- x 24-in. square cross section and made of 14-gauge stainless steel. The blower is rated at 15 hp with a flow capacity of 3000 cfm at 13 in. H_2O. The inlet and outlet filter banks consist of two 24- x 24- x 2-in. prefilters and two 24- x 24- x 12-in high efficiency particulate air (HEPA) filters rated at 2000 cfm each. The system operates at positive pressure to minimize infiltration of room

TABLE 7. EXAMPLE RUN SEQUENCE FOR METHOD 319 TESTING

Run No.	TEST				Challenge Aerosol
	Reference Filter	No Filter	Test Arrestor	HEPA Filter	
1		X			Solid-Phase
2	X				
3		X			
4			X		
5		X			
6			X		
7		X			
8			X		
9				X*	
10		X			Liquid-Phase
11			X		
12		X			
13			X		
14		X			
15			X		

* HEPA filter test performed on a monthly basis.

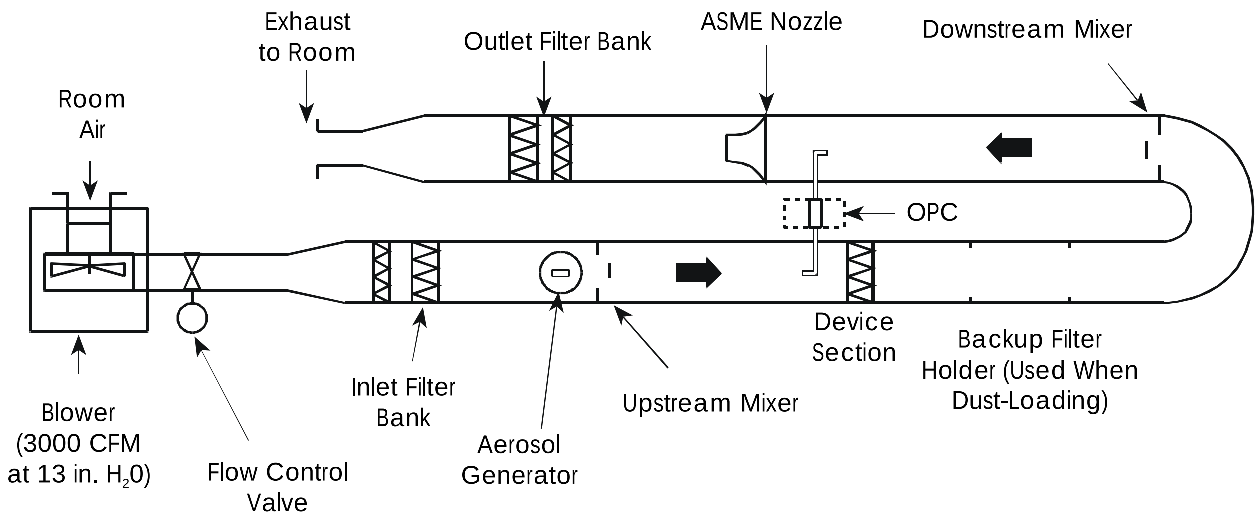

Figure 2. Schematic illustration of the fractional efficiency test rig.

air aerosol. In accordance with section 11.1.2.3 of Method 319, the arrestors will be tested with a nominal face velocity of 120 fpm. For arrestors having nominal 24- x 24-in. face dimensions, this corresponds to 480 cfm.

To mix the test aerosol with the air stream, an orifice plate and mixing baffle are located immediately downstream of the aerosol injection point. An identical orifice plate/mixing baffle is located after the 180° bend. The downstream orifice serves two purposes. It straightens out the flow after going around the bend and it mixes any aerosol that penetrates the air cleaning device. Mixing the penetrating aerosol with the air stream is necessary to obtain a representative downstream aerosol measurement.

B2.2 Aerosol Generation

Two types of challenge aerosol are used: liquid-phase and solid-phase. The liquid-phase challenge aerosol is oleic acid, a non-toxic, low-volatility liquid. The solid-phase aerosol is potassium chloride (KCl) generated from an aqueous solution (prepared by combining 280 g of KCl with 1 L of distilled water).

The oleic acid or the KCl solution was nebulized using a two-fluid (air and liquid) air atomizing nozzle (Spray Systems 1/4 J siphon spray nozzle). The nozzle was positioned at the top of a 12-in. diameter, 51-in. tall transparent acrylic spray tower. The tower served two purposes. It allowed the salt droplets to dry by providing an approximate 40-s mean residence time and it allowed larger-sized particles (of either KCl or oleic acid) to fall out of the aerosol. After generation, the aerosol passed through a TSI Model 3054 aerosol neutralizer (Kr-85 radioactive source) to neutralize any electrostatic charge on the aerosol (electrostatic charging is an unavoidable consequence of most aerosol-generation methods).

The KCl solution or oleic acid is fed to the atomizing nozzle at 1.2 mL/min by means of a pump. Varying the operating air pressure of the generator allows control of the number concentration of the challenge aerosol.

B2.3 Aerosol Sampling System

The aerosol sampling lines are 0.55-in. ID stainless steel lines and use gradual bends (radius of curvature = 2.25 in.) when needed. These dimensions were chosen to minimize particle losses in the sample lines. A custom-made "Y" fitting connects the upstream and downstream lines to the OPC. The two branches of the "Y" merge gradually to minimize particle loss in the intersection of the "Y" due to centrifugal or impaction forces. The upstream and downstream lines are identical in terms if diameter, horizontal lengths, vertical lengths, and bends so as to have approximately equal particle transport efficiency.

Immediately above the "Y," electrically actuated ball valves are installed in each branch (Parker Model EA Electro-Mechanical Valve Actuator). The opening and closing of the valves is automatically controlled by the OPC. The valves take approximately 2 s to complete an opening or closing maneuver.

Isokinetic sampling nozzles of the appropriate entrance diameter are placed on the ends of the sample probes to maintain isokinetic sampling for all the test flow rates.

B2.4 Test Procedures

The aerosol penetration of the test device will be calculated from the average of 10 upstream and 10 downstream samples taken sequentially (i.e., one upstream, one downstream, one upstream, one downstream, . . . until 10 each are obtained). This sequential sampling scheme was selected to minimize the effect of aerosol generator variability. Each sample will be approximately 1-minute in duration. The sampling also includes background upstream and downstream measurements at the beginning and end of each test. The test sequence is as follows:

1. Warm up OPC, install proper sample tips for isokinetic sampling.
2. Install air cleaner test device and bring test duct to desired flow rate.
3. With the aerosol generator off, obtain one pair of upstream and downstream background particle counts.
4. Turn on the aerosol generator and allow it to run for a minimum of 5 minutes to stabilize.
5. After the stabilization period, obtain 10 upstream and 10 downstream particle counts using a repeated upstream-downstream sampling sequence until 10 each are obtained.
6. Turn off the aerosol generator. After purging, obtain an additional pair of upstream and downstream background measurements.

B2.5 Control Tests

In addition to evaluating the test arrestor, 0% and 100% penetration control tests and reference filter tests will be conducted to ensure that reliable measurements are obtained.

The 100% penetration test is a relatively stringent test of the adequacy of the overall duct, sampling, measurement and aerosol generation system. These tests are performed as normal penetration tests except that the paint arrestor is not used. A perfect system would yield a measured penetration of 1 at all particle sizes. Deviations from 1 may occur due to particle losses in the duct, differences in the degree of aerosol uniformity (i.e., mixing) at the upstream and downstream probes, and differences in particle-transport efficiency in the upstream and downstream sampling lines. A 100% penetration test is run prior to each arrestor test. Results from the 100% penetration tests are used during data analysis to correct penetration measurements obtained for the subsequent arrestor test.

The 0% penetration test is performed by using a HEPA filter rather than a paint arrestor. This test confirms the adequacy of the instrument response time and sample line lag. The 0% penetration test is performed on a monthly basis.

The reference filter test consists of retesting a filter that the laboratory maintains for this purpose. By comparing the efficiency curve obtained to that from previous measurements on that same filter, shifts in the OPC calibration, if present, will be detected. The reference filter test is performed at the start of each Method 319 test sequence.

B3: Sample Handling and Custody Requirements

An inventory log will be maintained for the POA program. The inventory log will include entries for date of receipt, name of person receiving the arrestors, the manufacturer and model number of arrestors, condition of shipping boxes, condition of arrestors with details of any visual damage, location of storage, and date tested. The log will also contain an entry to indicate that the manufacturer has provided a letter certifying to the arrestors' representativeness as specified in the protocol.

Upon receipt of the arrestors, they will be serially numbered with a permanent marker (or other means as appropriate). All arrestors for this study will be stored in designated storage rooms or areas (more than one storage space may be needed) in a manner that prevents confusion/intermixing with other similar devices. The sample custodian will be Ms. Kathleen Owen.

After the completion of a verification test, the arrestor will be identified with the same unique number (MMDDYYSS) that will be used for the verification test data. After testing, the arrestors may be moved to a designated space within RTI's warehouse located a few miles from the test laboratory. (Regent Place, Morrisville, NC).

B4: Analytical Methods Requirements

The analytical methods to be used meet the requirements of Method 319. The primary analytical method involves the use of an aerosol optical particle counter to measure aerosol concentrations upstream and downstream of the arrestor from which the arrestor's filtration efficiency is determined. Analytical methods for determining pressure drop across the arrestor, air flow, temperature, and relative humidity are used to set and monitor the test conditions.

B4.1 Aerosol Concentration

Aerosol concentrations will be measured with either a Climet Instruments Model CI-226/8040 or a Climet Instruments Model CI-500 depending upon the availability of the CI-500 at the time of testing; the CI-500 is a new product currently in the final stages of development. Both OPCs use a high intensity illumination source (white light for the 226/8040, laser diode for the CI-500) and have a wide collection angle for the scattered light. Both have the same 15 contiguous particle sizing channels between 0.3 and 10 µm. The sampling rate for both OPCs is 0.25 cfm. Both OPCs provide a contact closure at the end of each sample and also provide a 15-s delay in particle counting after each sample. The contact closure is used to control the operation of electromechanical valve actuators in the upstream and downstream sample lines. The 15-s delay allows time for the new sample to be acquired.

B4.2 Pressure Drop Across the Arrestor

Pressure drop across the test arrestors will be measured with an inclined fluid manometer having minor divisions of 0.01 inch (Dwyer model 424-5 or equivalent)

B4.3 Temperature

The temperature of the test airflow will be measured with a mercury thermometer. The thermometer's indicated temperature will be compared to a reference thermometer to verify that the sensor is accurate to within the control limits.

B4.4 Relative Humidity

The relative humidity of the test airflow will be measured with a wet bulb / dry bulb psychrometer. A psychrometric chart will be used to obtain the relative humidity from the indicated dry bulb temperature and wet bulb depression. The psychrometer consists of a matched pair of mercury thermometers. The indicated temperature will be compared to a reference thermometer to verify that each thermometer is accurate to within the control limits.

B4.5 Airflow

Airflow in the test duct is measured with an ASME long-radius flow nozzle. The pressure drop across the nozzle is converted to airflow using a manufacturer-provided table relating pressure drop to airflow (based on ASHRAE Standard 52-68). The table incorporates an air density correction factor when the density differs from the table's standard density. The pressure drop across the nozzle is measured with a 0-10 in.H_2O (0.01-inch minor divisions) inclined manometer (Meriam Model 40HE35WM). Prior to use, the nozzle is visually inspected to be free from defects. The installation of the nozzle in the duct will be inspected to confirm that it is seated in place. The zero and level of the manometer used to measure the pressure drop will be confirmed and connecting tubing inspected for integrity.

B5: Quality Control Requirements

The quality control limits are specified in Table 6. The means of measuring and verifying attainment of the data quality objective, and corrective actions which will be taken if needed, are discussed below for each item. The results of these checks are recorded on the run sheets (Appendix A).

B5.1 Minimum Challenge Counts Per Channel: The minimum total particle counts per channel in the challenge air stream will be verified by summation of the 10 upstream challenge samples for each of the OPC's channels. During the time of the actual test, the test operator will inspect the particle count data during aerosol generator start up to see that the minimum count level is within the control limit. If it is not, he will increase the output of the aerosol generator as needed to meet the minimum count requirement. On the test run sheet, the operator denotes if an acceptable level was achieved. In the data analysis spread sheet, a summation of the ten challenge samples is made on a channel by channel basis. If the summation does not exceed the minimum acceptable level, a message is displayed to alert the operator.

B5.2 Maximum Particle Concentration:. Verification that the particle concentration is below the control limit will be performed by summation of the particle counts in each of the OPC's channels for each sample. During the actual test, the data collection program displays this total. At the start of the test, the test operator checks that the summation is within the control limit. If it is not, he adjusts the aerosol generator until an acceptable concentration level is achieved. On the test run sheet, the operator notes if an acceptable level was achieved. In the data analysis spread sheet, for each sample, a summation of the OPC's counts is made for all channels. If the summation exceeds the acceptable limit, a message is displayed to alert the operator.

For the CI-500 instrument, sampling at 0.25 cfm, the manufacturer's stated concentration limit is 4,000,000 particle counts per cubic foot of sampled air at a 10% error level.

For the CI-226 instrument, sampling at 0.25 cfm, the manufacturer's stated concentration limit is 6,500,000 particle counts per cubic foot of sampled air at a 10% error level.

B5.3 Standard Deviation of Penetration: The standard deviation (σ) of the measured penetration (P) for a given test at each of the 15 OPC sizing channels is computed from the coefficient of variation (CV, the standard deviation divided by the mean) of the ten upstream (U_i) and ten downstream (D_i) measurements as:

$$\sigma_P = P\sqrt{(CV_{upstream})^2 + (CV_{downstream})^2}$$

where:

$$CV_{upstream} = \frac{\left[\sum (U_i - \overline{U})^2 / (n-1)\right]^{1/2}}{\overline{U}}$$

where n = 10, i = 1,...,n
and U overbar denotes mean of 10 upstream measurements.

$$CV_{downstream} = \frac{\left[\sum (D_i - \overline{D})^2 / (n-1)\right]^{1/2}}{\overline{D}}$$

Where n = 10 and i = 1,..., n
and D overbar denotes mean of 10 downstream measurements.

P is computed per Section D 1.9.1.

For tests for which the standard deviation of the penetration does not meet the DQO, system maintenance (such as rinsing the atomizing nozzle of the aerosol generator) will be performed as needed and the test then repeated.

B5.4 0% Penetration: As described in Method 319, the 0% penetration test is a test performed with a HEPA filter installed as the test device. The purpose is to ensure that penetrations down to the control limit can be reliably measured. Cross contamination between the upstream and downstream samples and insufficient purging between samples are potential conditions that could limit the ability to meet this requirement. On at least a monthly basis, a HEPA filter will be tested following the same procedures as used for testing POAs. The resultant penetration values will be inspected to verify that the penetration was within the control limit's acceptable range for each particle size range. If the 0% penetration result does not meet the DQO, the test operator will contact the task leader for instruction on corrective actions that may be needed.

B5.5 100% Penetration: As described in Method 319, the 100% penetration test is performed before each arrestor test. The test is run as a normal POA test except that the test section is left empty (i.e., no POA or other filtration device is installed). The purpose is to ensure that the bias between the upstream and downstream samples is within acceptable limits. In RTI's test system, differences between the upstream and downstream samples can occur due to differences in particle transport efficiency within the upstream and downstream sample lines and incomplete mixing of the test aerosol with the airstream. As part of the test sequence, the 100% penetration test will be performed immediately prior to each arrestor test. The resultant penetrations will be compared to the control limits to verify that they are with the acceptable range. If they are found to be out of range, the data will be inspected for possible clues and corrective action (such as cleaning the sample lines) may be required to obtain acceptable results. The arrestor test can not be conducted until an acceptable 100% test is achieved.

B5.6 Temperature: The accuracy of the temperature sensor will be assessed by comparing its reading to a reference thermometer (Alnor thermo-anemometer providing temperature reading resolution of 0.1 ºF with an accuracy of +/- 0.4 ºF); agreement must be within the control limits. During testing, the indicated temperature must fall within the control limit range. If the accuracy does not meet the DQO, the task leader will be notified. The task leader will assess the situation and decide whether repairs or replacement of the temperature probe is needed. During testing, if the temperature is found to be outside the control range, the results will not be used; the test will be repeated when temperature is brought into the control range.

B5.7 Relative Humidity: The accuracy of the RH sensor (a wet bulb / dry bulb psychrometer) will be assessed by comparing the temperature reading of each of the thermometers when both thermometers are at the same temperature (i.e., when the wet bulb is dry, or when both thermometers are placed in a water bath). The temperature difference between the two thermometers under these conditions must not exceed 1°F. During testing, the indicated relative humidity must fall within the control limit range. If the accuracy does not meet the DQO, the task leader will be notified. The task leader will assess the situation and decide whether repairs or replacement of the humidity probe is needed. During testing, if the relative humidity is found to be outside the control range, the results will not be used; the test will be repeated when relative humidity is brought into the control range.

B5.8 Airflow

B5.8.1 Airflow Accuracy: Volumetric airflow in the test duct is measured with an ASME long-radius flow nozzle. Airflow accuracy will be checked on a 6-month basis by comparing the test duct's airflow reading to a calibrated laminar flow element (Meriam Model 50MH10-8). The laminar flow element will have received a NIST-traceable calibration by the manufacturer within the manufacturer's recommended recalibration period (12 months). If the accuracy does not meet the DQO, the task leader will be notified. The task leader will assess the situation and decide whether repair or replacement of the airflow nozzle, laminar flow element, and/or manometers is needed.

B5.8.2 Precision of the Airflow Measurement: The precision of the airflow measurement will be determined from 10 consecutive measures of airflow made at 10-second intervals. Precision will be computed as the 95% confidence interval for the mean airflow measurement as:

$$Precision = t_{\frac{a}{2}} \frac{s}{\sqrt{n}}$$

where t[a/2;n] is the value of Student's t-distribution for a = 0.05 and n = 10, s is the standard deviation, and n is the number of samples. The precision must be within the control limit. If the precision does not meet the DQO, the task leader will be notified. The task leader will assess the situation and decide what repairs or equipment replacements will be needed to meet the DQO.

B5.8.3 Resolution of the Airflow Measurement: To determine whether the resolution is within the control limit, the flow rate manometer reading associated with 480 cfm and 504 cfm (480 plus 5%) will be determined. The difference between the two readings must be greater than five minor scale divisions on the manometer. If the resolution does not meet the DQO, the task leader will be notified. The task leader will assess the situation and decide what repairs or equipment replacements will be needed to meet the DQO.

B5.9 Optical Particle Counter (OPC) Zero Count: The OPC's zero count level will be measured by sampling HEPA-filtered air. This will be done by attaching a HEPA capsule directly to the OPC sample inlet and/or by sampling the HEPA-filtered air of the test duct when the aerosol generator is turned off. This check is performed at the start of each efficiency test. The counts will be summed to confirm that they are below the control limit. On the test run sheet, the operator denotes if an acceptable zero count was achieved. If the zero count does not meet the DQO, the task leader will be notified. The task leader will assess the situation and decide what repairs or equipment replacements will be needed to meet the DQO.

B5.10 OPC Sizing Accuracy Check: PSL: The accuracy of the OPC's sizing is assessed by sampling known size monodisperse PSL spheres. This is a daily calibration check. The PSL will be in the 0.5 - 2 µm diameter range. The PSL spheres are aerosolized using RTI's PSL aerosol generator. The OPC response must fall within the control limits. If the PSL sizing accuracy check does not meet the DQO, the task leader will be notified. The task leader will assess the situation and decide what repairs or equipment replacements will be needed to meet the DQO.

B5.11 OPC Sizing Accuracy Check: Reference Filter: A minimum of three reference filters will be maintained for the sole purpose of conducting a reference filtration efficiency test at the start of each test series (see Table 7). The measured efficiency must fall within the control limits. If the result does not meet the DQO, the task leader will be notified. The task leader will assess the situation and decide what repairs or equipment replacements will be needed to meet the DQO.

B5.12 OPC Calibration: Primary Calibration: The optical particle counter will be returned to the manufacturer (Climet Instruments) for calibration at the manufacturer's recommended interval (6 months for the CI-226, 1 year for the CI-500) or sooner if a malfunction is observed.

B5.13 Aerosol Charge Neutralizer: On a monthly basis, a hand-held radiation monitor will be used to confirm the presence of activity in the radioactive aerosol charge neutralizer. The nature of the neutralizer is such that if it's ability to neutralize were no longer present, no activity would be present. If the neutralizer fails to show activity, the task leader will be notified. The task leader will assess the situation and decide what repairs or equipment replacements will be needed to meet the DQO.

B5.14 Fluid Manometer Calibration Check: The accuracy of the inclined manometers used to measure the pressure drop across the test arrestor and to obtain data for the air flow measurements will be assessed by comparison to a calibrated electronic micromanometer (Solomat, Model Zepher which reads differential pressures to 1/1000 inch H_2O with an accuracy of better than 1% of reading +/- 1 count). Agreement must be within the control limit. (Note that if the manometers have been properly set up, their accuracy may exceed that of the electronic micromanometer; thus no adjustments to the manometers are anticipated.) If a manometer does not meet the DQO, the task leader will be notified. The task leader will assess the situation and decide what repairs or equipment replacements will be needed to meet the DQO.

B5.15 Ancillary Measurements: In addition to the critical measurements described above, a non-critical measurement of the room atmospheric pressure will be made. On a weekly basis, a mercury barometer, located in an adjoining lab, will be used to check, and adjust as needed, a laboratory aneroid barometer located at the test rig. The aneroid barometer will then be used for barometric pressure readings during the tests.

B6: Instrument/Equipment Testing, Inspection, and Maintenance Requirements

As part of each test series, control tests are performed to assess the reliability of the optical particle counter (see B5.10, B5.11, and B5.12). The only on-site repair will be replacement of the lamp in the CI-226 should it burn out. Replacement of the bulb does not affect instrument calibration. Should an optical particle counter need other repair, it will be returned to the manufacturer. Because repairs (other than lamp replacement on the CI-226) may impact calibration, no repairs are performed on site and, hence, no spare parts are on hand.

The inclined fluid manometers used for flow rate and pressure drop measurements are checked for zero and level and the lines visually inspected to be secure and free of kinks and leaks.

B7: Instrument Calibration and Frequency

Calibration will be performed as outlined in Table 8. Instruments requiring factory calibration are the optical particle counter (calibrated for particle size and sample flow rate), laminar flow element, digital micromanometer, and thermo-anemometer (calibrated for temperature and air velocity). Using these factory-calibrated instruments, in-lab calibrations are performed for the test duct's temperature, humidity, air flow, and manometer readings.

In addition to the annual factory calibration of the particle counter, the OPC's zero count level and sizing accuracy are checked as part of each Method 319 test. These checks, incorporated directly in the project's DQO's and discussed above in Sections B5.10, B5.11, and B5.12, provide a means of detecting a drift in the calibration of the particle counter.

Instruments or devices that are found to be out of calibration will inspected by the task leader and repaired (e.g., fix a loose connection on a manometer), returned to the manufacturer for recalibration, or replaced. Repairs, recalibrations and replacement of instrumentation will be documented in a project notebook.

B8: Inspection/Acceptance Requirements for Supplies and Consumables

Test supplies consist of the KCl, oleic acid, and PSL aerosol materials. The KCl product specification must indicate at least 99% purity (current supplier is EM Scientific, product PX1405-1). The purity of the oleic acid (by titration) must be 98% or better (current supplier is J.T. Baker, product 0224-03). The PSL will be supplied by Duke Scientific Corporation and will be Uniform Latex Microspheres or higher grade. Upon receipt, these items will be checked by reading the product label and checking for damaged containers. Damaged or mis-labeled materials will not be used in this program.

The test paint arrestors will be inspected for shipping damage. Damaged products will not be tested. The manufacturer will be notified if the arrestors arrive in a damaged condition and a new shipment will be requested.

B9: Data Acquisition Requirements (Non-direct measurements)

No types of data are needed for project implementation or decision making that would be obtained from non-measurement sources such as computer databases, programs, literature files, or historical databases.

B10: Data Management

B10.1 Data Flow

All testing, data generation, and data analysis are performed within RTI's Building 11. All data is acquired in real time; there is no post sampling analysis of samples. The following shows the flow of data from its origin in the test lab to final storage.

A. Data origination in test laboratory (RTI, Bldg 11, Bay 6):

Data generated by OPC:

- read in real time by a data acquisition computer located at the test rig
- hard copy print out of each sample printed in real time

Data generated by observations:

- Temperature, relative humidity, atmospheric pressure, arrestor pressure drop and air flow readings are recorded manually on a test run sheet (Appendix A)

B. Inspection of OPC data for acceptance at the test site:

After each efficiency test, the data from the OPC data acquisition computer is transferred to a diskette labeled with the test number.

The diskette is installed into another computer located at the same desk area as the data acquisition computer for data-inspection. The OPC data from the diskette is loaded into a spreadsheet program template. The spreadsheet program computes the arrestor's filtration efficiency, and checks the DQOs associated with the particle count data.

Table 8. Instrument Calibration and Frequency

Instrument	Calibration Frequency	Calibration Method
Optical Particle Counter Climet Instruments, CI-500	Annual	Returned to factory for primary calibration using NIST traceable calibration spheres.
Laminar Flow Element Meriam Model 50MH10-8	Annual	Returned to factory for primary calibration with NIST traceable standard.
Micromanometer Solomat Zepher	Annual	Returned to factory for primary calibration with NIST traceability.
Alnor Thermo-anemometer (air temperature and velocity)	Annual	Returned to factory for primary calibration with NIST traceability.
Wet bulb / dry bulb psychrometer (matched pair of mercury thermometers)	Annual	Visual inspection for cracks and/or mercury separation. Comparison to co-located Alnor temperature reading (with both bulbs dry). Performed at a single temperature.
In-duct ASME Flow Nozzle	Annual	Compared to flow rate measured by laminar flow element (above) installed in series with ASME flow nozzle. Performed at flow rates of 333 and 480 cfm, the two flow rates used in testing.
Air flow manometer	Annual	Compared to Solomat micromanometer connected in parallel. Measurements will be made at three pressure levels spanning the range of pressures encountered in testing.
Arrestor pressure drop manometer	Annual	Compared to Solomat micromanometer connected in parallel. Measurements will be made at three pressure levels encompassing the range of pressures encountered in testing.

The spreadsheet program is saved to the diskette using the test number as the file name.

C. Spreadsheets:

Two spreadsheets are used in the program. A data analysis spreadsheet is used to analyze the data from each individual run. A data summary spreadsheet is used to combine the results from the triplicate tests and their associated control tests, and to compute filtration efficiency at particle sizes matching those of the NESHAP (as shown in Tables 2-5). Appendices B and C show spreadsheet printouts and their underlying formulations for the data analysis and data summary spreadsheets, respectively.

D. Draft Report Preparation:

The diskette and the test run sheets are delivered to the test analyst. The test analyst inspects the run sheets for completeness; if there are any omissions, the analyst immediately follows up with the test technicians to fill in any missing information.

Following the formats for the verification statement and report, the test analyst prepares these documents.

The test analyst will inspect all results for reasonableness and correctness relative to test number, date and times of samples, and arrestor identification (manufacturer, model number, and physical description).

The test analyst will maintain the diskette in an appropriate storage area.

E. Long-term Storage:

All verification test data, calibration data, certificates of calibration, assessment reports, verification reports, and verification statements will be retained by the APCT program office for a period of not less than 7 years after the final payment of the assistance agreement as per Part A, Section 5.3 of the ETV QMP. Depending upon the extensiveness of these documents, storage may be at RTI's warehouse facility.

B10.2 Data Recording

Data for this task will be collected by computer and by handwritten entries. Observations and test run sheets will be recorded manually in lab notebooks kept exclusively for this task. Output data generated by the OPC will be fed directly into a computer file and printed out in hard copy as the samples are collected. The printed output will be secured into the lab notebook.

It is worth noting that perhaps the most critical data, that being upstream and downstream particle count data from each test are included in hard copy in the verification report (as shown in Appendix C of the protocol).

B10.3 Data Quality Assurance Checks

Data quality assurance checks have been discussed in Section B5.1 through B5.14.

B10.4 Data Analysis

Data analysis will be performed using commercially available software capable of reading the raw data from a spreadsheet and making calculations. The data are analyzed using Quattro-Pro (DOS and Windows versions), reports are prepared in Word Perfect (version 7 and higher), the computers are run in Windows (versions 3.0 and Windows 95), and the OPC data are collected with an RTI data acquisition program written in Quick Basic language. The data acquisition program is easily verified by comparing instrument display and/or printout with what is recorded by the computer; it's simply reading the RS232 output of the OPC. The operations of the data analysis spreadsheet will be verified by independent computation of a data set.

B10.5 Data Storage and Retrieval

After the completion of a verification test, labeled three-ring binders containing manually recorded information and data output generated from instrumentation will be stored by the APCT Program Office with a copy retained by the task leader. After the completion of a verification test, a computer diskette containing spreadsheet data files will be stored by the APCT Program Office with a copy retained by the test analyst.

Storage of data on computer hard drives is on a "convenience" basis only; the hard copy printouts and diskettes are the archival data storage media. If the computer and diskette files were "lost" (i.e., became unreadable by the computer), the hard copy data could be re-entered manually and would involve less than about 2-hours of labor for an arrestor test series.

All data, verification reports, and verification statements will be retained by the APCT program office for a period of not less than 7 years per Part A, Section 5.3 of the ETV QMP.

SECTION C: ASSESSMENT/OVERSIGHT

C1: Assessments and Response Actions

The RTI Quality Manager and/or the RTI Task QA Officer will perform a TSA and/or a PE during Round 1 of the POA verification tests for the same DQOs. The RTI Quality Manager will conduct an ADQ for ten percent of all verification test data at the end of each round of the verification tests and will determine if these measurements allow a determination that the DQOs have been attained. These technical assessments will be performed in accordance with *EPA Guidance for Technical Assessments for Environmental Data Operations*(EPA QA/G-7).

The RTI Quality Manager will report the findings of these technical assessments to the RTI Project Manager and send copies to the EPA Project Manager and to the RTI task leader. The assessment report will recommend corrective actions, if such are indicated by these findings. The RTI task leader and the RTI Task QA Officer are responsible for developing, documenting, and implementing corrective actions. They will provide a written response to all assessment findings. Each finding will be addressed with specific corrective action steps and a schedule to implement them. Responses to adverse findings are required within 10 working days of receiving the assessment report in accordance with the requirements of Part B, Section 4.3 of EPA's Quality and Management Plan for the Environmental Technology Program. The RTP Project Manager will review and approve all corrective actions

Technical assessments and corrective actions are described in detail in Sections 3.4 and 3.5 of the APCT QMP.

Technical personnel working on each task will have the direct responsibility for ensuring that the Test/QA plan is implemented, that the operating parameters are within acceptable limits, and that corrective actions are taken when appropriate. Corrective action will be taken whenever measurements fall outside the limits of the data quality objectives for the critical measurements.

Corrective actions include:

- identifying the problem;
- attempting to find the cause;
- making immediate repairs (if possible);
- reporting or documenting the problem;
- planning for corrective action (if major repairs are needed);
- documenting the corrective actions taken; and
- recommending changes to instruments, Standard Operating Procedures (SOPs), etc. to avoid similar future occurrences.

RTI will cooperate with EPA on scheduling EPA's assessments on this program.

C2: Reports to Management

The RTI task leader will notify RTI's Project Manager, Task QA Officer, and Quality Manager when testing under this project is being conducted. The RTI task leader will submit verification reports and verification statements to the RTI Quality Officer. After technical assessments, the RTI Quality Manager will submit the assessment report to the RTI Project Manager. The RTI Project Manager will submit verification reports and verification statements to the EPA Project Manager and will submit assessment reports to the EPA Project Manager for informational purposes.

SECTION D: DATA VALIDATION AND USABILITY

D1: Data Review, Validation, and Verification Requirements

D1.1 Purpose/Background

Data verification is performed as an integral component of this work, is documented on the test runs sheets, and is embedded in the logic of the data analysis spreadsheet. The DQOs are the bases for the data review, validation and verification processes. Table 9 presents the review checklist that will be used to validate that reported results have satisfied all DQOs.

D1.2 Sampling Design

Data validation of the sampling design applies to how the paint overspray arrestors are selected for testing. Section B1 described how the manufactures select the 18 arrestors to submit for testing. Of those 18, RTI selects six to test. The RTI selection process is carried out by the sample custodian is as follows: The 18 arrestors are numbered 1 through 18. A random number table is then used to generate a random list of 6 different numbers in the range of 1 and 18. The arrestors having those six random numbers are selected for testing. A different column of the random number table is used for each set of 18 arrestors submitted.

D1.3 Sample Collection Procedures

Data validation of sample collection procedures applies to aerosol loss in the upstream and downstream sample lines leading to the optical particle counter. This element is incorporated in the DQOs as the 100% penetration test (Table 6 and Section B2.8). Attainment of the DQO for the 100% penetration test is incorporated in the review form presented in D1.1. Tests having data that fail to meet all the DQOs will not be used; such tests will be repeated (the tests are non-destructive).

D1.4 Sample Handling

Validation of sample handling is not applicable to this task because all samples are analyzed in real time. Handling of the paint overspray arrestors themselves is covered in Section B3. Aerosol transport is covered in Section B2.3.

D1.5 Analytical Procedures

Section B.6 "Quality Control Requirements" detailed the procedures and computations that will be used to determine if the collected data meet the DQOs. Attainment of the DQO for the 100% penetration test is incorporated in the review form presented in D1.1. Tests having data that fail to meet all the DQOs will not be used; such tests will be repeated (the tests are non-destructive).

TABLE 9.
CHECKLIST FOR DATA REVIEW AND VALIDATION
APCT POA Program

Reviewer Name: ______________________________
Review Date: ____________
Verification Test No.: ____________

Part A. Checks on parameters that require assessment for each test.

Parameter	Required Level	Level Achieved
Arrestor manufacturer and model number	Must match product label; confirm by visual inspection of a tested arrestor or photograph of the arrestor label taken at time of testing.	
Correct physical description of the arrestor	Must match product; confirm by visual inspection of a tested arrestor or photograph of arrestor taken at time of testing.	
Run number consistent on run sheets, diskette and report	Run numbers must be consistent.	
Date and time of OPC data	Date and time on spreadsheet printout must be consistent with date and time on run sheet.	
Upstream and downstream OPC samples properly paired	Date and time of upstream and downstream samples must intermesh.	
100% penetration results properly inserted into arrestor spreadsheet	"P100" line of arrestor data printouts must contain 100% penetration data of previous run.	
Minimum counts per channel for challenge aerosol	Minimum total of 500 particle counts per channel.	
Maximum particle concentration	<10% of manufacturer's claimed upper limit corresponding to a 10% count error.	
Standard deviation of penetration	<0.10 for 0.3 to 3 µm diameter <0.30 for >3 µm diameter	
100% Penetration - Solid-phase aerosol (KCl)	Particle Size range / Acceptable Penetration Range: 0.3 to 1µm: 0.90 to 1.10 1 to 3µm: 0.75 to 1.25 3 to 10µm: 0.50 to 1.50	
100% Penetration - Liquid-phase aerosol (oleic acid)	Particle Size range / Acceptable Penetration Range: 0.3 to 1µm: 0.90 to 1.10 1 to 3µm: 0.75 to 1.25 3 to 10µm: 0.50 to 1.50	
Temperature	50 - 100 °F acceptable test condition range.	
Relative Humidity	< 65% acceptable test condition range.	
OPC zero count	<50 counts per minute.	
OPC sizing accuracy check: Polystyrene latex (PSL) spheres	Peak of distribution in correct OPC channel.	
OPC sizing accuracy check: Reference filter	Measured efficiency must fall within +/- 10% of previous measurements (i.e., within a 10% shift in particle size and/or filtration efficiency) when compared to efficiency of reference filter measured after primary OPC calibration.	

Part B. Checks on parameters that require monthly, biannual or annual assessment.

Parameter	Required Level	Level Achieved
Accuracy of temperature measurement (mercury thermometer)	Measurement accuracy of +/- 2 °F confirmed within past 12 months.	
Accuracy of relative humidity measurement (wet bulb / dry bulb psychrometer)	Measurement accuracy of +/- 10 % RH confirmed within past 12 months.	
Accuracy of pressure drop measurement across the arrestor (fluid manometer)	Readable to within 0.01 in. H_2O with an accuracy of 10% or better confirmed within past 12 months.	
Accuracy of pressure drop measurement across the flow nozzle (fluid manometer)	Readable to within 0.01 in. H_2O with an accuracy of 10% or better confirmed within past 12 months.	
Accuracy of airflow measurement (duct-mounted ASME flow nozzle)	Measurement accuracy within 5% confirmed within past 6 months.	
Precision of airflow measurement (duct-mounted ASME flow nozzle)	Precision within 5% confirmed within past 12 months.	
Resolution of airflow measurement (duct-mounted ASME flow nozzle)	Resolution of airflow measurement system shall not exceed 5% of the set point airflow and confirmed within past 12 months.	
Calibration of OPC	Primary calibration by manufacturer within 6 months for CI-226, within 12 months for CI-500.	
Calibration of laminar flow element	Primary calibration by manufacturer within past 12 months.	
Calibration of Solomat micromanometer	Primary calibration by manufacturer within past 12 months.	
Calibration of Alnor thermo-anemometer	Primary calibration by manufacturer within past 12 months.	
0% Penetration Test	<0.01 and performed within past 30 days.	
Aerosol charge neutralizer	Activity must be detected in radioactive neutralizers. Corona discharge neutralizers must be in balance. Checked within past 30 days.	

D1.6 Quality Control

Section B.5 "Quality Control Requirements" detailed the procedures and computations that will be used to determine if the collected data meet the DQOs and described the corrective actions to be taken if the DQOs are not met. Tests having data that fail to meet all the DQOs will not be used; such tests will be repeated (the filter tests are non-destructive).

D1.7 Calibration

Calibration procedures and calibration checks are described in Section B7 and B5, respectively. Validation that the calibrations and calibration checks have been performed at the proper interval (e.g. an annual instrument calibrations and per test calibration checks) are incorporated into the review form presented in D1.1. Tests for which calibrations or calibration checks fail to meet all the DQOs will not be used; such tests will be repeated (the tests are non-destructive).

D1.8 Data Reduction and Processing

Data checks during testing and data analysis are described in Section B10. These checks will be verified during the planned technical assessments.

D1.9 Project Specific Calculations

D1.9.1 Computation of Filtration Efficiency

For each of the OPC's particle sizing channels, filtration efficiency is computed as follows:

Nomenclature

U = Upstream particle count
D = Downstream particle count
U_b = Upstream background count
D_b = Downstream background count
P_o = observed penetration = $\overline{D}/\overline{U}$
P' = 100% penetration value measured in a no-filter control test
P = Penetration corrected for P' value

Overbar denotes arithmetic mean of quantity.

Primed (′) quantities denote measurements made during a no filter control test.

Analysis of each test involves the following quantities:

- P' value from the blank (no-filter) test,

$$P' = (\overline{D'} - \overline{D'_b}) / (\overline{U'} - \overline{U'_b})$$

- 2 upstream background values,
- 2 downstream background values,
- 10 upstream values with aerosol generator on, and
- 10 downstream values with aerosol generator on.

Using the values associated with each sizing channel, the penetration associated with each particle sizing channel will be calculated as:

$$P = \frac{(\overline{D} - \overline{D_b}) \div (\overline{U} - \overline{U_b})}{P'}$$

Filtration efficiency is then calculated as:

$$Filtration\ Efficiency\ (\%) = 100\ (1 - P)$$

Examples of the filtration efficiency computation applied to actual data are shown in Appendix B.

D1.9.2 Computation of Average Filtration Efficiency

The results from the triplicate tests performed with solid-phase aerosol are averaged over the three runs to compute the average efficiency for each of the OPC's particle sizing channels. The average is computed as:

$$Average\ Efficiency = \frac{E1 + E2 + E3}{3}$$

where E1, E2, and E3 are the triplicate efficiency measurements corresponding to a given OPC channel. This is performed for each of the OPC's sizing channels.

Note that the averaging is performed over the three runs and not over particle size. Thus, the result is an average efficiency value for each of the OPC's sizing channels for the solid-phase challenge aerosol.

These same procedures are applied to the triplicate liquid-phase results to compute the average efficiency value for each of the OPC's sizing channels for the liquid-phase challenge aerosol

Examples of the average filtration efficiency computation applied to a data set is shown in Appendix B.

D1.9.3 Interpolation of Efficiency Results to Intermediate Particle Sizes

The aerospace NESHAP tabulates filtration efficiency requirements at prescribed aerodynamic particle diameters. To determine the filtration efficiency of the test arrestors at these prescribed diameters, linear interpolation between the nearest measured diameters is used.

Nomenclature:

D1: Nearest lower particle diameter for which efficiency is known
D2: Intermediate particle diameter for which efficiency is to be computed
D3: Nearest upper particle diameter for which efficiency is known

E1: Average efficiency measured at D1
E2: Intermediate efficiency to be determined corresponding to D2
E3: Average efficiency measured at D3

The value of E2 is computed by linear interpolation:

$$E2 = E1 + \left(\frac{D2 - D1}{D3 - D1}\right)(E3 - E1)$$

Examples of this interpolation applied to a data set is shown in Appendix B.

D1.9.4 Computation of Aerodynamic Particle Diameter

Over the 0.3-10 µm diameter size range, the "aerodynamic" particle diameter is often of more significance than the physical diameter (as measured by the OPC) relative to aerosol filtration and aerosol deposition within the human respiratory tract. As specified in Method 319, the aerodynamic diameter (D_{Aero}) is related to the physical diameter ($D_{Physical}$) by:

$$D_{Aero} = D_{Physical} \sqrt{\frac{d_{Particle}}{d_o} \quad \frac{CCF_{Physical}}{CCF_{Aero}}}$$

where

d_o is unit density of 1 g/cm^3
$d_{Particle}$ is the density of the particle, g/cm^3
$CCF_{Physical}$ is the Cunningham Correction Factor at $D_{Physical}$
CCF_{Aero} is the Cunningham Correction Factor at D_{Aero}

For oleic acid droplets having a density of 0.89 g/cm^3, the aerodynamic diameter will be about 6% smaller than the measured diameter. For KCl particles having a density of 1.98 g/cm^3, the aerodynamic diameter will be about 40% larger than the measured diameter.

The aerodynamic diameters associated with the 15 OPC sizing channels are tabulated in Table 10 for oleic acid and KCl. Also listed is the physical diameter size range for each channel based on the manufacturer's calibration curve using monodisperse polystyrene latex (PSL) spheres.

D2: Validation and Verification Methods

The process for validating and verifying data has been described in B10 and D1.1. If a test is found to not meet the DQOs, the task leader will initiate retesting of the arrestors (the tests are non-destructive).

Results of the testing are conveyed to the data users through the ETV Verification Statements and Verification Reports. Examples of these are presented in the protocol.

D3: Reconciliation with Data Quality Objectives

Stakeholder requirements have been defined in the protocol. Attainment of all DQOs is confirmed by the data validation process described in B10 and D1.1. The methods for data analysis and determination of possible anomalies are performed by the spreadsheet analysis described in B10.1. Tests not meeting all DQO requirements will be repeated.

Results from verification testing of an arrestor will be presented in a Verification Statement and a Verification Report as described in Section 4 of the protocol. The format and content of the statement and report are completely defined in the protocol and deviations are not expected; only the specifics in terms of manufacturer, arrestor model, and test results will vary.

The determination whether an arrestor meets the filtration efficiency requirements of the NESHAP (as shown in Tables 2 - 5) is a simple and straightforward comparison of the required efficiency values versus the measured efficiency values. The data reporting format of the verification statements and reports makes this a straightforward process for the end user (see Appendices B and C of the protocol). The determination that the data are suitable for use in these reports results from determining that the data have been collected as specified in this Test/QA Plan.

For paint overspray arrestors that are not compatible with testing procedures described herein, Section 2 of the protocol describes how these devices could be included in the POA program (requires a new protocol, approved by the POA Technical Panel, and, if needed, a new or amended Test/QA Plan).

Table 10. Physical and Aerodynamic Sizing Channels for the Calibration and Test Aerosols

	Particle Diameter Size Range (µm)*		
	PSL	OLEIC ACID	KCl
OPC Channel Number	Physical Diameter	Aerodynamic Diameter	Aerodynamic Diameter
1	0.3 - 0.4	0.28 - 0.37	0.45 - 0.59
2	0.4 - 0.5	0.37 - 0.47	0.59 - 0.73
3	0.5 - 0.55	0.47 - 0.52	0.73 - 0.80
4	0.55 - 0.7	0.52 - 0.66	0.80 - 1.02
5	0.7 - 1.0	0.66 - 0.94	1.02 - 1.44
6	1.0 - 1.3	0.94 - 1.22	1.44 - 1.86
7	1.3 - 1.6	1.22 - 1.51	1.86 - 2.28
8	1.6 - 2	1.51 - 1.88	2.28 - 2.85
9	2 - 2.2	1.88 - 2.07	2.85 - 3.13
10	2.2 - 3	2.07 - 2.83	3.13 - 4.25
11	3 - 4	2.83 - 3.77	4.25 - 5.66
12	4 - 5	3.77 - 4.71	5.66 - 7.07
13	5 - 5.5	4.71 - 5.18	7.07 - 7.77
14	5.5 - 7	5.18 - 6.60	7.77 - 9.88
15	7 - 10	6.60 - 9.43	9.88 - 14.1

* The particle diameter size ranges are defined as greater than the indicated lower limit and less than or equal to the indicated upper limit.

APPENDIX A

RUN PACKET
FOR USE WITH CI-500 OPTICAL PARTICLE COUNTER

Method 319 Status Sheet **page 1 of 10**
(Rev. 2/5/99)

Flow Rate:
480 CFM for 24 x 24
333 CFM for 20 x 20

Test Series (Enter run number as runs are performed)
(The test order may differ from that below. A no filter test always immediately precedes a filter test. HEPA test must be done at least monthly; a HEPA test is not needed if one was conducted within the last 30 days.)

Run Number	**KCL Aerosol**
________________	No Filter
________________	Reference Filter
________________	No Filter
________________	Filter
________________	No Filter
________________	Filter
________________	No Filter
________________	Filter
________________	HEPA (if not done within last 30 days)
	Oleic Acid Aerosol
________________	No Filter
________________	Filter
________________	No Filter
________________	Filter
________________	No Filter
________________	Filter

ACCEPTANCE CRITERIA FOR TEST CONDITIONS

No-Filter acceptance criteria are:
+/- 10% from 0.3 to 1 um
+/- 25% from 1 to 3 um
+/- 50% from 3 to 10 um

HEPA filter acceptance criteria is: Efficiency > 99% for all sizes.

Acceptable temperature range: 50 - 100 ^{o}F

Acceptable relative humidity (RH) range: < 65%

PSL spheres must show peak in proper OPC channel

PSL sphere diameter and lot #: ___________________________

CHECKLIST FOR UP-TO-DATE CALIBRATIONS

Do not test if any parameters are past due date

Parameter	Required Level	Date Last Performed	Due for re-evaluation
Accuracy of temperature measurement (mercury thermometer)	Measurement accuracy of +/- 2 °F confirmed within past 12 months.		
Accuracy of relative humidity measurement (wet bulb / dry bulb psychrometer)	Measurement accuracy of +/- 10 % RH confirmed within past 12 months.		
Accuracy of pressure drop measurement across the arrestor (fluid manometer)	Readable to within 0.01 in. H_2O with an accuracy of 10% or better confirmed within past 12 months.		
Accuracy of pressure drop measurement across the flow nozzle (fluid manometer)	Readable to within 0.01 in. H_2O with an accuracy of 10% or better confirmed within past 12 months.		
Accuracy of airflow measurement (duct-mounted ASME flow nozzle)	Measurement accuracy within 5% confirmed within past 6 months.		
Precision of airflow measurement (duct-mounted ASME flow nozzle)	Precision within 5% confirmed within past 12 months.		
Resolution of airflow measurement (duct-mounted ASME flow nozzle)	Resolution of airflow measurement system shall not exceed 5% of the set point airflow and confirmed within past 12 months.		
Calibration of OPC	Primary calibration by manufacturer within 6 months for CI-226, within 12 months for CI-500.		
Calibration of laminar flow element	Primary calibration by manufacturer within past 12 months.		
Calibration of Solomat micromanometer	Primary calibration by manufacturer within past 12 months.		
Calibration of Alnor thermo-anemometer	Primary calibration by manufacturer within past 12 months.		
0% Penetration Test	<0.01 and performed within past 30 days.		
Aerosol charge neutralizer	Activity must be detected in radioactive neutralizers. Corona discharge neutralizers must be in balance. Checked within past 30 days.		

EPA METHOD 319 RUN SHEET (Rev. 2/5/99) **Page 3 of 10**

Physical Description of Filter: Date and Time: __________________ Test Operator: ______________

Attach Photographs

	Product Name & Model	Nominal H x W x Thick.	Generic type (flat panel, pleat, bag...)	Media Color	In New Cond.?	ID #
Stage 1						
Stage 2						
Stage 3						

OPC and Manometer: --------- daily checks: "Yes" when performed or **T** if done earlier today ---------

OPC Model	OPC Last Cal.	Check/Set Flow Rate Manometer zero	Check/Set Flow Rate Manometer Level	Check/Set Pressure drop Manometer zero	Check/Set Pressure Drop Manom. Level

---

Correlation Test: Date and Time: _________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge) Attach OPC zero and PSL printout

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total counts / sample		Daily PSL sphere check (Enter PSL sphere size and OPC "peak" channel when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		
				__________ µm Peak in Ch # _____	

Test Conditions: **"No-Filter" Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 /.2ft^3

Efficiency Test: Date and Time: _________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge)

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total / sample		Daily PSL sphere check (Enter size when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		

Test Conditions: **Filter Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 / 0.2ft^3

EPA METHOD 319 RUN SHEET (Rev. 2/5/99) **Page 4 of 10**

Physical Description of Filter: Date and Time: ___________________ Test Operator: ______________

Attach Photographs

	Product Name & Model	Nominal H x W x Thick.	Generic type (flat panel, pleat, bag...)	Media Color	In New Cond.?	ID #
Stage 1						
Stage 2						
Stage 3						

OPC and Manometer: --------- daily checks: “Yes” when performed or **T** if done earlier today ---------

OPC Model	OPC Last Cal.	Check/Set Flow Rate Manometer zero	Check/Set Flow Rate Manometer Level	Check/Set Pressure drop Manometer zero	Check/Set Pressure Drop Manom. Level

Correlation Test: Date and Time: _________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge) Attach OPC zero and PSL printout

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total counts / sample		Daily PSL sphere check (Enter PSL sphere size and OPC “peak” channel when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		
				__________ µm Peak in Ch # _____	

Test Conditions: **“No-Filter” Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 /.2ft^3

Efficiency Test: Date and Time: _________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge)

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total / sample		Daily PSL sphere check (Enter size when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		

Test Conditions: **Filter Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 / 0.2ft^3

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Physical Description of Filter: Date and Time: ___________________ Test Operator: ______________

Attach Photographs

	Product Name & Model	Nominal H x W x Thick.	Generic type (flat panel, pleat, bag...)	Media Color	In New Cond.?	ID #
Stage 1						
Stage 2						
Stage 3						

OPC and Manometer: --------- daily checks: "Yes" when performed or **T** if done earlier today ---------

OPC Model	OPC Last Cal.	Check/Set Flow Rate Manometer zero	Check/Set Flow Rate Manometer Level	Check/Set Pressure drop Manometer zero	Check/Set Pressure Drop Manom. Level

---

Correlation Test: Date and Time: __________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge) Attach OPC zero and PSL printout

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total counts / sample		Daily PSL sphere check (Enter PSL sphere size and OPC "peak" channel when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		
				__________ µm Peak in Ch # _____	

Test Conditions: **"No-Filter" Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 /.2ft^3

Efficiency Test: Date and Time: __________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge)

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total / sample		Daily PSL sphere check (Enter size when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		

Test Conditions: **Filter Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 / 0.2ft^3

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Physical Description of Filter: Date and Time: __________________ Test Operator: ______________

	Product Name & Model	Nominal H x W x Thick.	Generic type (flat panel, pleat, bag...)	Media Color	In New Cond.?	Attach Photographs ID #
Stage 1						
Stage 2						
Stage 3						

OPC and Manometer: --------- daily checks: "Yes" when performed or **T** if done earlier today ---------

OPC Model	OPC Last Cal.	Check/Set Flow Rate Manometer zero	Check/Set Flow Rate Manometer Level	Check/Set Pressure drop Manometer zero	Check/Set Pressure Drop Manom. Level

Correlation Test: Date and Time: _________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge) Attach OPC zero and PSL printout

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total counts / sample		Daily PSL sphere check (Enter PSL sphere size and OPC "peak" channel when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		
				__________ µm Peak in Ch # _____	

Test Conditions: **"No-Filter" Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 /.2ft^3

Efficiency Test: Date and Time: _________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge)

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total / sample		Daily PSL sphere check (Enter size when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		

Test Conditions: **Filter Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 / 0.2ft^3

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Physical Description of Filter: Date and Time: ___________________ Test Operator: ______________

Attach Photographs

	Product Name & Model	Nominal H x W x Thick.	Generic type (flat panel, pleat, bag...)	Media Color	In New Cond.?	ID #
Stage 1						
Stage 2						
Stage 3						

OPC and Manometer: --------- daily checks: "Yes" when performed or **T** if done earlier today ---------

OPC Model	OPC Last Cal.	Check/Set Flow Rate Manometer zero	Check/Set Flow Rate Manometer Level	Check/Set Pressure drop Manometer zero	Check/Set Pressure Drop Manom. Level

Correlation Test: Date and Time: __________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge) Attach OPC zero and PSL printout

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total counts / sample		Daily PSL sphere check (Enter PSL sphere size and OPC "peak" channel when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		
				__________ µm Peak in Ch # _____	

Test Conditions: **"No-Filter" Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 /.2ft^3

Efficiency Test: Date and Time: __________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge)

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total / sample		Daily PSL sphere check (Enter size when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		

Test Conditions: **Filter Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 / 0.2ft^3

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Physical Description of Filter: Date and Time: ___________________ Test Operator: ______________

Attach Photographs

	Product Name & Model	Nominal H x W x Thick.	Generic type (flat panel, pleat, bag...)	Media Color	In New Cond.?	ID #
Stage 1						
Stage 2						
Stage 3						

OPC and Manometer: --------- daily checks: "Yes" when performed or **T** if done earlier today ---------

OPC Model	OPC Last Cal.	Check/Set Flow Rate Manometer zero	Check/Set Flow Rate Manometer Level	Check/Set Pressure drop Manometer zero	Check/Set Pressure Drop Manom. Level

Correlation Test: Date and Time: _________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge) Attach OPC zero and PSL printout

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total counts / sample		Daily PSL sphere check (Enter PSL sphere size and OPC "peak" channel when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		
				__________ µm Peak in Ch # _____	

Test Conditions: **"No-Filter" Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 /.2ft^3

Efficiency Test: Date and Time: _________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge)

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total / sample		Daily PSL sphere check (Enter size when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		

Test Conditions: **Filter Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 / 0.2ft^3

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Physical Description of Filter: Date and Time: ___________________ Test Operator: ______________

Attach Photographs

	Product Name & Model	Nominal H x W x Thick.	Generic type (flat panel, pleat, bag...)	Media Color	In New Cond.?	ID #
Stage 1						
Stage 2						
Stage 3						

OPC and Manometer: --------- daily checks: "Yes" when performed or **T** if done earlier today ---------

OPC Model	OPC Last Cal.	Check/Set Flow Rate Manometer zero	Check/Set Flow Rate Manometer Level	Check/Set Pressure drop Manometer zero	Check/Set Pressure Drop Manom. Level

---

Correlation Test: Date and Time: __________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge) Attach OPC zero and PSL printout

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total counts / sample		Daily PSL sphere check (Enter PSL sphere size and OPC "peak" channel when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		
				__________ µm Peak in Ch # _____	

Test Conditions: **"No-Filter" Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 /.2ft^3

Efficiency Test: Date and Time: __________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge)

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total / sample		Daily PSL sphere check (Enter size when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		

Test Conditions: **Filter Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 / 0.2ft^3

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Physical Description of Filter: Date and Time: ___________________ Test Operator: ______________

Attach Photographs

	Product Name & Model	Nominal H x W x Thick.	Generic type (flat panel, pleat, bag...)	Media Color	In New Cond.?	ID #
Stage 1						
Stage 2						
Stage 3						

OPC and Manometer: --------- daily checks: "Yes" when performed or **T** if done earlier today ---------

OPC Model	OPC Last Cal.	Check/Set Flow Rate Manometer zero	Check/Set Flow Rate Manometer Level	Check/Set Pressure drop Manometer zero	Check/Set Pressure Drop Manom. Level

Correlation Test: Date and Time: __________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge) Attach OPC zero and PSL printout

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total counts / sample		Daily PSL sphere check (Enter PSL sphere size and OPC "peak" channel when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		
				__________ µm Peak in Ch # _____	

Test Conditions: **"No-Filter" Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 /.2ft^3

Efficiency Test: Date and Time: __________________ Test Operator: _______________

OPC: (CI-500, 1/1 - 10/10 - 1/1, 0.2 ft^3 samples with 15 second purge)

20 min warm up	Flow is 0.25cfm	Zero Check < 50 total / sample		Daily PSL sphere check (Enter size when performed or **T** if done earlier today)	File Name
		HEPA capsule	In-duct HEPA		

Test Conditions: **Filter Pressure Drop**

	Flow Rate (cfm)	Flow dP (in. H_2O)	Temp. (°F)	Wet bulb(°F)	RH (%)	Filter dP (in. H2O)	Atm Pressure (in. Hg)
start of test							
end of test							

Aerosol Generator:

KCl or OA	Pump setting	Drying Air	Nozzle air pres. setting (psig)	Nozzle rotameter	> 50 counts per channel	Concentration < 80,000 / 0.2ft^3

Appendix B

Spreadsheet for Calculating Filtration Efficiency

The following three pages show:

- An example printout of the OPC data, efficiency calculations, and DQO assessment as it will appear in the verification report. This represents a portion of the total spreadsheet.
- The entire spreadsheet showing intermediate equations not shown in the standard printout. These include computing the coefficient of variation (CV) of the upstream and downstream counts and computing the particle concentration of each sample and defining the maximum concentration for the data set.
- The formulas associated with Column H; this is the first channel of the OPC (0.3 - 0.4 µm). Similar formulas are applied to each of the other OPC channels (Columns I - V). This shows the formulas used to compute the penetration, the standard deviation of the penetration, check for the minimum required number of counts per channel, and a check on the maximum particle concentration

Test No. 11149703, Arrestor, Solid-Phase

Particle Counts per Indicated OPC Channel (1-Minute Samples @ 7.1 L/min)

OPC Channel Number					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Min. Diam. (um)					0.45	0.59	0.73	0.80	1.02	1.44	1.86	2.28	2.85	3.13	4.25	5.66	7.07	7.77	9.88
Max. Diam. (um)					0.59	0.73	0.80	1.02	1.44	1.86	2.28	2.85	3.13	4.25	5.66	7.07	7.77	9.88	14.10
Geo. Mean Diam (um)					0.52	0.66	0.77	0.90	1.21	1.64	2.06	2.55	2.98	3.65	4.91	6.33	7.41	8.76	11.81
U. Bckgrnd	1	01	11-13-19 08:50:45	01:00	9	0	1	0	2	0	0	0	0	0	0	0	0	0	0
Upstream	1	01	11-13-19 08:58:42	01:00	9671	14480	4592	8113	12220	7580	9732	7318	1596	3806	2727	1183	224	399	269
Upstream	1	01	11-13-19 09:01:12	01:00	9442	14160	4528	8058	12190	7442	9587	7246	1615	3854	2625	1259	230	398	255
Upstream	1	01	11-13-19 09:03:42	01:00	9451	14430	4479	8151	12090	7661	9559	7358	1577	3749	2711	1320	220	411	266
Upstream	1	01	11-13-19 09:06:12	01:00	9434	13840	4581	7961	11980	7324	9564	7377	1668	3642	2673	1272	231	399	261
Upstream	1	01	11-13-19 09:08:42	01:00	9652	14510	4631	8169	12440	7625	9977	7890	1776	4049	2827	1276	230	427	268
Upstream	1	01	11-13-19 09:11:12	01:00	9865	14320	4649	8501	12150	7588	9948	7943	1797	3983	2768	1353	279	438	261
Upstream	1	01	11-13-19 09:13:42	01:00	9561	14180	4456	8102	12280	7510	9920	7755	1707	3896	2720	1226	230	427	293
Upstream	1	01	11-13-19 09:16:12	01:00	9846	14720	4651	8400	12850	7590	10010	7870	1698	3930	2923	1318	236	433	300
Upstream	1	01	11-13-19 09:18:42	01:00	9967	14810	4628	8550	12600	7842	10050	8046	1736	4209	2850	1335	235	396	262
Upstream	1	01	11-13-19 09:21:12	01:00	9829	14760	4719	8500	12600	7938	10060	8346	1745	4166	3021	1308	254	391	288
U. Bckgrnd	1	01	11-13-19 09:31:33	01:00	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Bckgrnd	2	01	11-13-19 08:52:00	01:00	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Downstream	2	01	11-13-19 08:59:57	01:00	8658	13230	4174	7249	10900	6379	7905	5542	1006	1923	855	181	17	22	8
Downstream	2	01	11-13-19 09:02:27	01:00	8984	13390	4113	7522	10990	6402	8133	5718	1063	1923	849	185	18	27	5
Downstream	2	01	11-13-19 09:04:57	01:00	8630	13400	4174	7366	10810	6331	8003	5542	1039	2045	802	194	25	21	10
Downstream	2	01	11-13-19 09:07:27	01:00	9312	14050	4361	7708	11090	6930	8652	6281	1154	2099	894	183	27	29	13
Downstream	2	01	11-13-19 09:09:57	01:00	8997	13800	4203	7386	11050	6442	8242	6050	1080	2071	828	211	28	24	6
Downstream	2	01	11-13-19 09:12:27	01:00	9086	13930	4253	7708	11370	6606	8571	6143	1099	2129	877	185	25	27	5
Downstream	2	01	11-13-19 09:14:57	01:00	9245	13920	4230	7832	11470	6731	8529	6153	1156	2194	943	208	21	25	7
Downstream	2	01	11-13-19 09:17:27	01:00	9169	13770	4247	7717	11400	6639	8488	6188	1118	2145	873	215	22	20	5
Downstream	2	01	11-13-19 09:19:57	01:00	9458	14000	4398	7958	11380	6940	8629	6273	1222	2116	929	191	21	17	11
Downstream	2	01	11-13-19 09:22:27	01:00	9344	13970	4418	7954	11730	6874	8618	6412	1145	2172	920	188	23	28	14
D. Bckgrnd	2	01	11-13-19 09:32:48	01:00	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Meas. Penetration					0.94	0.95	0.93	0.93	0.91	0.87	0.85	0.78	0.66	0.53	0.31	0.15	0.10	0.06	0.03
P100 correction values					1.01	1.00	0.99	1.01	1.00	0.99	0.99	1.01	1.02	1.01	1.03	1.03	1.11	1.06	1.00
Corrected Penetration					0.93	0.95	0.94	0.92	0.91	0.88	0.86	0.77	0.64	0.53	0.31	0.15	0.09	0.05	0.03
Corrected Efficiency (%)					7	5	6	8	9	12	14	23	36	47	69	85	91	95	97

Data Acceptance Criteria:

Total Challenge Counts for Each Channel:	96718	144210	45914	82505	123400	76100	98407	77149	16915	39284	27845	12850	2369	4119	2723
Data Quality Objective:	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500
Does this meet DQO:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard Deviation of Penetration for Each Channel :	0.03	0.03	0.03	0.04	0.03	0.04	0.03	0.06	0.05	0.03	0.02	0.01	0.02	0.01	0.01
Data Quality Objective:	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
Does this meet DQO:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Maximum observed particle concentration (#/cc):	12.5
Data Quality Objective: max. allowable conc. (#/cc):	< 23
Does this meet the DQO:	Yes, (applies to all channels)

Test No. 11149703, Arrestor, Solid-Phase

Particle Counts per Indicated OPC Channel (1-Minute Samples @ 7.1 L/min)

OPC Channel Number					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Min. Diam. (um)					0.45	0.59	0.73	0.80	1.02	1.44	1.86	2.28	2.85	3.13	4.25	5.66	7.07	7.77	9.88	
Max. Diam. (um)					0.59	0.73	0.80	1.02	1.44	1.86	2.28	2.85	3.13	4.25	5.66	7.07	7.77	9.88	14.10	>14.104
Geo. Mean Diam (um)					0.52	0.66	0.77	0.90	1.21	1.64	2.06	2.55	2.98	3.65	4.91	6.33	7.41	8.76	11.81	
U. Bckgrnd	1	01	11-13-19 08:50:45	01:00	9	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0
Upstream	1	01	11-13-19 08:58:42	01:00	9671	14480	4592	8113	12220	7580	9732	7318	1596	3806	2727	1183	224	399	269	168
Upstream	1	01	11-13-19 09:01:12	01:00	9442	14160	4528	8058	12190	7442	9587	7246	1615	3854	2625	1259	230	398	255	174
Upstream	1	01	11-13-19 09:03:42	01:00	9451	14430	4479	8151	12090	7661	9559	7358	1577	3749	2711	1320	220	411	266	200
Upstream	1	01	11-13-19 09:06:12	01:00	9434	13840	4581	7961	11980	7324	9564	7377	1668	3642	2673	1272	231	399	261	190
Upstream	1	01	11-13-19 09:08:42	01:00	9652	14510	4631	8169	12440	7625	9977	7890	1776	4049	2827	1276	230	427	268	201
Upstream	1	01	11-13-19 09:11:12	01:00	9865	14320	4649	8501	12150	7588	9948	7943	1797	3983	2768	1353	279	438	261	195
Upstream	1	01	11-13-19 09:13:42	01:00	9561	14180	4456	8102	12280	7510	9920	7755	1707	3896	2720	1226	230	427	293	175
Upstream	1	01	11-13-19 09:16:12	01:00	9846	14720	4651	8400	12850	7590	10010	7870	1698	3930	2923	1318	236	433	300	215
Upstream	1	01	11-13-19 09:18:42	01:00	9967	14810	4628	8550	12600	7842	10050	8046	1736	4209	2850	1335	235	396	262	193
Upstream	1	01	11-13-19 09:21:12	01:00	9829	14760	4719	8500	12600	7938	10060	8346	1745	4166	3021	1308	254	391	288	214
U. Bckgrnd	1	01	11-13-19 09:31:33	01:00	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Bckgrnd	2	01	11-13-19 08:52:00	01:00	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Downstream	2	01	11-13-19 08:59:57	01:00	8658	13230	4174	7249	10900	6379	7905	5542	1006	1923	855	181	17	22	8	2
Downstream	2	01	11-13-19 09:02:27	01:00	8984	13390	4113	7522	10990	6402	8133	5718	1063	1923	849	185	18	27	5	1
Downstream	2	01	11-13-19 09:04:57	01:00	8630	13400	4174	7366	10810	6331	8003	5542	1039	2045	802	194	25	21	10	4
Downstream	2	01	11-13-19 09:07:27	01:00	9312	14050	4361	7708	11090	6930	8652	6281	1154	2099	894	183	27	29	13	2
Downstream	2	01	11-13-19 09:09:57	01:00	8997	13800	4203	7386	11050	6442	8242	6050	1080	2071	828	211	28	24	6	1
Downstream	2	01	11-13-19 09:12:27	01:00	9086	13930	4253	7708	11370	6606	8571	6143	1099	2129	877	185	25	27	5	3
Downstream	2	01	11-13-19 09:14:57	01:00	9245	13920	4230	7832	11470	6731	8529	6153	1156	2194	943	208	21	25	7	2
Downstream	2	01	11-13-19 09:17:27	01:00	9169	13770	4247	7717	11400	6639	8488	6188	1118	2145	873	215	22	20	5	0
Downstream	2	01	11-13-19 09:19:57	01:00	9458	14000	4398	7958	11380	6940	8629	6273	1222	2116	929	191	21	17	11	5
Downstream	2	01	11-13-19 09:22:27	01:00	9344	13970	4418	7954	11730	6874	8618	6412	1145	2172	920	188	23	28	14	4
D. Bckgrnd	2	01	11-13-19 09:32:48	01:00	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Meas. Penetration					0.94	0.95	0.93	0.93	0.91	0.87	0.85	0.78	0.66	0.53	0.31	0.15	0.10	0.06	0.03	0.01
P100 correction values					1.01	1.00	0.99	1.01	1.00	0.99	0.99	1.01	1.02	1.01	1.03	1.03	1.11	1.06	1.00	
Corrected Penetration					0.93	0.95	0.94	0.92	0.91	0.88	0.86	0.77	0.64	0.53	0.31	0.15	0.09	0.05	0.03	
Corrected Efficiency (%)					7	5	6	8	9	12	14	23	36	47	69	85	91	95	97	

Data Acceptance Criteria:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total Challenge Counts for Each Channel:	96718	144210	45914	82505	123400	76100	98407	77149	16915	39284	27845	12850	2369	4119	2723
Data Quality Objective:	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500	> 500
Does this meet DQO:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standard Deviation of Penetration for Each Channel :	0.03	0.03	0.03	0.04	0.03	0.04	0.03	0.06	0.05	0.03	0.02	0.01	0.02	0.01	0.01
Data Quality Objective:	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
Does this meet DQO:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Maximum observed particle concentration (#/cc): 12.5
Data Quality Objective: max. allowable conc. (#/cc): < 23
Does this meet the DQO: Yes, (applies to all channels)

Note: Intermediate calculations below are not shown on standard print out

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CV Downstream	3.1%	2.2%	2.4%	3.3%	2.6%	3.5%	3.4%	5.2%	5.8%	4.5%	5.2%	6.5%	16.0%	16.3%	40.5%
CV Upstream	2.0%	2.1%	1.8%	2.6%	2.2%	2.3%	2.1%	4.8%	4.5%	4.6%	4.4%	4.1%	7.3%	4.3%	5.7%
Standard Deviation of Penetration	0.035	0.029	0.028	0.039	0.031	0.037	0.034	0.055	0.048	0.034	0.021	0.012	0.017	0.010	0.013

OPC OVERLOAD CHECK:

	Max Cou	Max #/cc	
			'ENTER SAMPLE TIME IN MINUTES BELOW
Maximum particle counts in a sample	88139	12.45	1 minutes
Sum of counts for each sample			
U. Bckgrnd	12		
Upstream	84078		
Upstream	83063		
Upstream	83633		
Upstream	82397		
Upstream	85948		
Upstream	86038		
Upstream	84438		
Upstream	86990		
Upstream	87709		
Upstream	88139		
U. Bckgrnd	13		
D. Bckgrnd	7		
Downstream	68051		
Downstream	69323		
Downstream	68396		
Downstream	72785		
Downstream	70419		
Downstream	72017		
Downstream	72666		
Downstream	72016		
Downstream	73548		
Downstream	73814		
D. Bckgrnd	3		

OPC Channel Nu						1
Min. Diam. (um)						0.451
Max. Diam. (um)						0.592
Geo. Mean Diam						=SQRT(H6*H7)
U. Bckgrnd	1	01	11-13-1997	08:50:45	01:00	9
Upstream	1	01	11-13-1997	08:58:42	01:00	9671
Upstream	1	01	11-13-1997	09:01:12	01:00	9442
Upstream	1	01	11-13-1997	09:03:42	01:00	9451
Upstream	1	01	11-13-1997	09:06:12	01:00	9434
Upstream	1	01	11-13-1997	09:08:42	01:00	9652
Upstream	1	01	11-13-1997	09:11:12	01:00	9865
Upstream	1	01	11-13-1997	09:13:42	01:00	9561
Upstream	1	01	11-13-1997	09:16:12	01:00	9846
Upstream	1	01	11-13-1997	09:18:42	01:00	9967
Upstream	1	01	11-13-1997	09:21:12	01:00	9829
U. Bckgrnd	1	01	11-13-1997	09:31:33	01:00	8
D. Bckgrnd	2	01	11-13-1997	08:52:00	01:00	5
Downstream	2	01	11-13-1997	08:59:57	01:00	8658
Downstream	2	01	11-13-1997	09:02:27	01:00	8984
Downstream	2	01	11-13-1997	09:04:57	01:00	8630
Downstream	2	01	11-13-1997	09:07:27	01:00	9312
Downstream	2	01	11-13-1997	09:09:57	01:00	8997
Downstream	2	01	11-13-1997	09:12:27	01:00	9086
Downstream	2	01	11-13-1997	09:14:57	01:00	9245
Downstream	2	01	11-13-1997	09:17:27	01:00	9169
Downstream	2	01	11-13-1997	09:19:57	01:00	9458
Downstream	2	01	11-13-1997	09:22:27	01:00	9344
D. Bckgrnd	2	01	11-13-1997	09:32:48	01:00	2
Meas. Penetratior						=(AVERAGE(H25:H34)-AVERAGE(H24,H35))/(AVERAGE(H11:H20)-AVERAGE(H10,H21))
P100 correction v						1.01147020322325
Corrected Penetra						=H37/H38
Corrected Efficier						=100*(1-H39)
Data Acceptance						
Total Challenge C						=SUM(H11:H20)
Data Quality Obje						> 500
Does this meet D						=IF(SUM(H11:H20)>=500,"Yes","No")
Standard Deviatic						=H61
Data Quality Obje						<0.10
Does this meet D						=IF(H61<0.1,"Yes","No")
Maximum observe						=I65
Data Quality Obje						< 23
Does this meet th						=IF(I65<23," Yes, (applies to all channels)","No")

Note: Intermediat						
CV Downstream						=STDEV(H25:H34)/AVERAGE(H25:H34)
CV Upstream						=STDEV(H11:H20)/AVERAGE(H11:H20)
Standard Deviatic						=H37*SQRT(H59^2+H60^2)
OPC OVERLOAD						Max Count
Maximum particle						=MAX(H67:H92)
Sum of counts for						
U. Bckgrnd						=SUM(H10:W10)
Upstream						=SUM(H11:W11)
Upstream						=SUM(H12:W12)
Upstream						=SUM(H13:W13)
Upstream						=SUM(H14:W14)
Upstream						=SUM(H15:W15)
Upstream						=SUM(H16:W16)
Upstream						=SUM(H17:W17)
Upstream						=SUM(H18:W18)
Upstream						=SUM(H19:W19)
Upstream						=SUM(H20:W20)
U. Bckgrnd						=SUM(H21:W21)
D. Bckgrnd						=SUM(H24:W24)
Downstream						=SUM(H25:W25)
Downstream						=SUM(H26:W26)
Downstream						=SUM(H27:W27)
Downstream						=SUM(H28:W28)
Downstream						=SUM(H29:W29)
Downstream						=SUM(H30:W30)
Downstream						=SUM(H31:W31)
Downstream						=SUM(H32:W32)
Downstream						=SUM(H33:W33)
Downstream						=SUM(H34:W34)
D. Bckgrnd						=SUM(H35:W35)

Appendix C

Spreadsheet for Summarizing Test Results

The following two pages show:

- An example printout of the summary for the triplicate solid-phase test results, their average, interpolation of the data to the NESHAP specified particle sizes, and associated control tests.
- The formulas associated with the first two data columns of the spreadsheet.

TABLE 2. SUMMARY OF SOLID-PHASE TEST RESULTS

		Filtration Efficiency (%) at Indicated Size Range														
OPC Channel Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Min. Diam. (um)		0.45	0.59	0.73	0.80	1.02	1.44	1.86	2.28	2.85	3.13	4.25	5.66	7.07	7.77	9.88
Max. Diam. (um)		0.59	0.73	0.80	1.02	1.44	1.86	2.28	2.85	3.13	4.25	5.66	7.07	7.77	9.88	14.10
Geo. Mean Diam (um)		0.52	0.66	0.77	0.90	1.21	1.64	2.06	2.55	2.98	3.65	4.91	6.33	7.41	8.76	11.81
Run #1	11139708	5	5	9	6	8	11	14	23	34	47	68	85	92	96	97
Run #2	11139710	6	5	7	7	8	11	15	23	36	46	69	86	92	94	96
Run #3	11149703	7	5	6	8	9	12	14	23	36	47	69	85	91	95	97
Average		6	5	7	7	8	11	14	23	35	47	69	85	92	95	97

Interpolated Efficiency Values (%) for Two-Stage Criteria:

2.60 um (> 10% required):	24
5.00 um (> 50% required):	70
8.10 um (> 90% required):	93

Interpolated Efficiency Values (%) for Three-Stage Criteria:

0.70 um (> 75% required):	6
1.10 um (> 85% required):	8
2.50 um (> 95% required):	22

HEPA Filter Control Test (applicable to both solid and liquid phase conditions)

Run #1	101697-11	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

"No Filter" Control Tests — Penetration For Each Size Range

Run #1	111397-7	1.00	1.00	1.01	1.00	1.01	1.01	1.00	1.01	0.99	1.00	0.99	1.04	1.08	1.05	0.98
Run #2	111397-9	0.98	0.99	1.00	0.99	1.00	1.00	1.00	1.00	0.99	0.99	0.98	1.04	1.02	1.03	0.92
Run #3	111497-2	1.01	1.00	0.99	1.01	1.00	0.99	0.99	1.01	1.02	1.01	1.03	1.03	1.11	1.06	1.00

OPC Channel Nu		1	2
Min. Diam. (um)		0.451	0.592
Max. Diam. (um)		0.592	0.733
Geo. Mean Diam		=SQRT(F8*F9)	=SQRT(G8*G9)
Run #1	11139708	5.388643221311	5.37079592953508
Run #2	11139710	6.490681038163	4.67579434491492
Run #3	11149703	7.052692244666	4.53094799496064
Average		=AVERAGE(F14:	=AVERAGE(G14:G16)

Interpolated Efficiency Values (%) for Two-Stage Criteria:

2.6	um (> 10% required):	=($C20-M10)/(N10-M10)*(N17-M17)+M17
5	um (> 50% required):	=($C21-P10)/(Q10-P10)*(Q17-P17)+P17
8.1	um (> 90% required):	=($C22-R10)/(S10-R10)*(S17-R17)+R17

Interpolated Efficiency Values (%) for Three-Stage Criteria:

0.7	um (> 75% required):	=($C25-G$10)/(H$10-G$10)*(H$17-G$17)+G$17
1.1	um (> 85% required):	=($C26-I$10)/(J$10-I$10)*(J$17-I$17)+I$17
2.5	um (> 95% required):	=($C27-L$10)/(M$10-L$10)*(M$17-L$17)+L$17

HEPA Filter Contr			
Run #1	101697-11	99.92733442181	99.9239044437884
"No Filter" Contro			
Run #1	111397-7	1.00009378773	0.999921324888871
Run #2	111397-9	0.98470453882	0.991813009128495
Run #3	111497-2	1.01147020322	0.998532149505943