Revision No. 3
Date: August 24, 1999

**GENERIC VERIFICATION PROTOCOL FOR
PAINT OVERSPRAY ARRESTORS**

EPA Cooperative Agreement No. CR 826152-01-0
RTI Project No. 93U-7012-20

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APCT	Air Pollution Control Technology
DQO	data quality objective
EPA	Environmental Protection Agency
ETV	environmental technology verification
NESHAP	National Emission Standard for Hazardous Air Pollutants
POA	paint overspray arrestor
QA	quality assurance
QC	quality control
QMP	quality management plan
RTI	Research Triangle Institute
SOP	standard operating procedure

1. INTRODUCTION

1.1 Environmental Technology Verification

The U.S. Environmental Protection Agency (EPA) has instituted the Environmental Technology Verification (ETV) Program to verify the performance of innovative technical solutions to problems that threaten human health or the environment. EPA created ETV to substantially accelerate the entrance of new environmental technologies into the domestic and international marketplace.

ETV supplies technology buyers and developers, consulting engineers, states, and U.S. EPA regions with high-quality, objective data on the performance of new technologies. This encourages more rapid protection of the environment with better and less expensive approaches.

ETV has established verification efforts in 12 pilot areas. In these pilot programs, EPA utilizes the expertise of partner organizations to design efficient processes for conducting performance tests of new technologies. EPA selects its partners from the non-profit public and private sector, including federal laboratories, states, universities, and private sector facilities. Verification organizations oversee and report verification activities based on testing and quality assurance protocols developed with input from all major stakeholder/customer groups associated with the technology area.

The ETV goal is to verify the environmental performance characteristics of commercial-ready technologies through the evaluation of objective and quality assured data so that potential purchasers and permitters are provided with an independent and credible assessment of what they are buying and permitting.

1.2 Air Pollution Control Technology Program

One of the 12 ETV pilot programs is the Air Pollution Control Technology (APCT) program. The U.S. EPA's partner in the APCT program is Research Triangle Institute (RTI), a non-profit contract research organization with headquarters in Research Triangle Park, NC. The APCT program will verify the performance of commercial-ready technologies used to control air pollutant emissions. The initial emphasis of the APCT program is on technologies for controlling particulate matter, volatile organic compounds, nitrogen oxides, and hazardous air pollutants. As the program matures, more technologies will be added.

RTI will cooperatively organize and develop the APCT program for verification testing of air pollution control technologies. The focus is on commercial-ready technologies. The APCT program will not evaluate technologies that are at the pilot or bench scale.

The APCT program will develop standardized verification protocols and test plans, conduct independent testing of technologies, and prepare verification test reports for broad dissemination. A goal of the APCT program is to ultimately become self-sustaining, or "privatized," by operating on project-generated income (user fees) and other resources.

The APCT program has selected paint overspray arrestors (POAs) as a technology to be verified.

1.3 The Paint Overspray Arrestor Program

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 and presents the test method to be used to make these filtration efficiency determinations (Method 319, “Determination of Filtration Efficiency for Paint Overspray Arrestors”).

Testing within the POA program will be performed by RTI and by other laboratories that elect, and qualify, to participate in the POA program. In addition to RTI, it is anticipated that from one to three other laboratories will be available for testing. Regardless of where the testing is performed, all verification reports and statements will be reviewed by the APCT program for compliance with this test protocol and associated quality assurance (QA) documents. The APCT program will resolve any issues with the testing laboratory and, once all issues are resolved, send the verification report and statement to EPA for review and approval. (Laboratory participation is discussed further in Sections 12 through 14.)

1.4 Quality Management Documents

Management and testing within the POA program is 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, 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.

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.)

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 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). The document herein is the generic verification protocol for paint overspray arrestors and was written by RTI, with input from the POA Technical Panel, 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 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.

2. OBJECTIVE, SCOPE, AND VERIFICATION PARAMETERS

2.1 Objective

The objective of the Paint Overspray Arrestor program is to verify the filtration efficiency performance of arrestors using Method 319, "Determination of Filtration Efficiency for Paint Overspray Arrestors" (*Code of Federal Regulations*, Volume 40, Part 63, Appendix A and attached as Appendix A of this protocol) and to produce verification statements for dissemination to the public.

2.2 Scope

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 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 1 - 4.)

2.3 Verification Parameters

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 1 - 4), and the pressure drop across the arrestor at the test flow rate.

2.4 Data Quality Objectives (DQOs)

The data quality objectives (Table 5) combine those specified in Method 319 with added requirements on airflow and particle measurement to ensure comparability between testing laboratories. The DQOs include the zero and sizing accuracy of the optical particle counter (OPC), the minimum and maximum particle concentrations to be used during testing, the standard deviation of the measured penetration, the acceptable range of penetration measured during 0% and 100% penetration control tests, the accuracy of the airflow measurement, and the operation of the aerosol charge neutralizer. These DQOs are fully compliant with Method 319 and are believed adequate to provide accurate, reproducible test results.

In addition to the daily calibration check of the optical particle counter using a calibration aerosol (polystyrene latex (PSL) spheres), reference filters will be used to check for shifts in OPC calibration. Each participating laboratory will maintain a set of at least three reference filters. These filters will provide a filtration efficiency that passes through 50% efficiency within in the 0.7 - 5 µm particle diameter range. Prior to each Method 319 test, the filtration efficiency of one of the reference filter will be measured. The measured efficiency must fall within +/- 10% of previous measurements of that reference filter (i.e., within a 10% shift in particle size and/or filtration efficiency). If the measurement falls outside this range, and the other reference filters also fall outside this range, corrective action must be taken (such as recalibration of the OPC) prior to performing the Method 319 test.

Static charge is often a natural results of the aerosol generation process. If left uncontrolled, variations in the degree of charging could affect the repeatability of the efficiency measurement. Method 319 requires that a charge neutralizer be used to neutralize electrostatic charge on the aerosol. In addition to this, the DQOs include a monthly check of the operation of the charge neutralizer.

TABLE 1. EXISTING SOURCES*
LIQUID-PHASE CHALLENGE AEROSOL PARTICLES

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

TABLE 2. EXISTING SOURCES*
SOLID-PHASE CHALLENGE AEROSOL PARTICLES

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

TABLE 3. NEW SOURCES*
LIQUID-PHASE CHALLENGE AEROSOL PARTICLES

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

TABLE 4. NEW SOURCES*
SOLID-PHASE CHALLENGE AEROSOL PARTICLES

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

* A new source is any affected source that commenced construction after October 29, 1996. An existing source is any affected source that is not new.

TABLE 5. 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 as part of each run.	50 - 100 ºF acceptable test condition range. Measurement accuracy of +/- 2 ºF
Relative Humidity	The test duct relative humidity measured as part of 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: 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.

Airflow accuracy will be checked monthly by comparing the test duct's airflow reading to a calibrated reference device temporarily installed in series with the duct's flow measurement device. The reference device will be a calibrated laminar flow element, calibrated flow nozzle, or calibrated orifice plate. The reference flow device must have received a primary calibration by the manufacturer within the manufacturer's recommended recalibration period.

3. TEST METHOD

Method 319

The Aerospace NESHAP includes Test Method 319 "Determination of Filtration Efficiency for Paint Overspray Arrestors" and requires that this method be used for determining the filtration efficiency for paint overspray arrestors. The NESHAP specifies the minimum filtration efficiency required for various aerodynamic particle sizes. Therefore, Method 319 will be used to verify arrestor performance. A brief overview of the method is given below; the complete method is presented in Appendix A.

Many of the issues related to a verification protocol are addressed in Method 319 including: (1) scope and application; (2) summary of the method; (3) definitions; (4) interferences; (5) safety; (6) equipment and supplies; (7) reagents and standards; (8) sample collection, preservation, and storage; (9) quality control; (10) calibration and standardization; (11) procedures; (12) data analysis and calculation; (13) pollution prevention; and (14) waste management.

Where appropriate and necessary, this protocol expands, clarifies and adds to Method 319. This protocol addresses several issues that Method 319 does not cover, including periodic testing, acquisition of paint overspray arrestors for testing, and product definition.

Computation of Filtration Efficiency

Filtration efficiency is computed from aerosol concentrations measured upstream and downstream of an arrestor installed in a laboratory test rig that is documented to meet the requirements listed in Table 5. The aerosol concentrations upstream and downstream of the arrestors are measured with an aerosol analyzer that simultaneously counts and sizes the particles in the sample aerosol stream. The aerosol analyzer covers the particle diameter size range from 0.3 to 10 µm in a series of contiguous sizing channels. Each sizing channel covers a narrow range of particle diameters. For example, Channel 1 may cover from 0.3 to 0.4 µm, Channel 2 from 0.4 to 0.5 µm, ... and Channel 15 from 7 - 10 µm. By taking the ratio of the downstream to upstream counts on a channel by channel basis, the efficiency is computed for each of the sizing channels:

$$Filtration\ Efficiency\ @\ 0.35\ \mu m = 100\ x\ \left(1 - \frac{Channel\ 1\ downstream\ concentration}{Channel\ 1\ upstream\ concentration}\right)$$

$$Filtration\ Efficiency\ @\ 0.45\ \mu m = 100\ x\ \left(1 - \frac{Channel\ 2\ downstream\ concentration}{Channel\ 2\ upstream\ concentration}\right)$$

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$$Filtration\ Efficiency\ @\ 8.4\ \mu m = 100\ x\ \left(1 - \frac{Channel\ 15\ downstream\ concentration}{Channel\ 15\ upstream\ concentration}\right)$$

The upstream and downstream aerosol measurements are made while injecting a test aerosol into the air stream upstream of the arrestor. (Ambient aerosol is removed with HEPA filters on the inlet of the test rig.) This test aerosol spans the particle size range from 0.3 to 10 µm and provides a sufficient upstream concentration in each of the sizing channels to allow accurate calculation of filtration efficiencies up to 99%.

The efficiency measurements are performed with both solid-phase particles and liquid-phase particles. Solid-phase particles (simulating dry oversprays) penetrate some arrestors at a higher level than liquid-phase particles (i.e., wet oversprays). The higher penetration of solid particles is due to “particle bounce” (i.e., the particles strike the fiber of the filter but, rather than being captured, bounce off and are reentrained in the airflow). Under normal filtration air velocities, particle bounce is a solid particle phenomenon often associated with flat panel type filters; particle bounce is less likely with filters of extended surface area (e.g., pleated and bag filters) for which the air flow rate through the media is reduced, and does not occur with liquid-phase particles which readily adhere to the fibers of the filter.

Method 319 Test Series

A Method 319 test performed under this protocol consists of a total of 15 filtration efficiency runs consisting of:

- One reference filter check
- Triplicate tests using a liquid-phase aerosol challenge
- Triplicate tests using a solid-phase aerosol challenge

- "No-filter" control tests (one performed prior to each arrestor test and the reference filter test)
- One HEPA filter control test.

Table 6 illustrates one acceptable testing sequence. All the tests are performed at a face velocity of 120 feet per minute with the arrestors in their initial (i.e., clean) condition.

TABLE 6. EXAMPLE RUN SEQUENCE FOR METHOD 319 TESTING UNDER THIS PROTOCOL

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		

4. REPORTING REQUIREMENTS

There will be two types of reports prepared for products tested under this protocol: Verification Statements and Verification Reports.

The Verification Statement will be a two- to three-page summary report. The Verification Statement will include the arrestor manufacturer, model number, a physical description of the arrestor, and the filtration efficiencies corresponding to the particle sizes specified in the aerospace NESHAP. A manufacturer, upon review of test results, may request that a Verification Statement not be issued.

The Verification Report is a fully documented report and contains a complete description of the test method and equipment, results of all measurements, and raw data. The Verification Report will include:

- testing date
- test laboratory
- arrestor manufacturer, arrestor model number
- acquisition procedures used to obtain the tested arrestors
- physical description of the arrestor
- filtration efficiency curves from each test and their averages
- tabulated efficiency data
- interpolated efficiencies at particle sizes corresponding to NESHAP
- results of control tests
- raw upstream/downstream particle counts
- pressure drop across the arrestor
- an overview of the test method and facilities/equipment used for the tests
- a copy of the annual calibration certificate for the optical particle counter
- any deviations from Method 319
- any deviations from this test protocol
- a note that the test protocol (i.e., this document) is available on the APCT web site.

The measurement data are to be presented in a format that allows a reviewer to easily determine whether the testing has met the data quality objectives. Verification Reports will be prepared and issued for all products tested.

Verification Statements and Verification Reports will be reviewed and approved by the APCT program and EPA prior to release.

The Verification Statements and Verification Reports will follow fixed formats. The formats will be consistent with prior POA Verification Statements and Verification Reports (available on EPA's ETV web site at http://www.epa.gov/etv).

5. DISSEMINATION OF VERIFICATION REPORTS AND VERIFICATION STATEMENTS

After a product has been tested, the APCT program will send a draft verification statement and report to the manufacturer for review prior to submission to EPA and release to the public. The purpose of this draft review is to give the manufacturer an opportunity to review the results, test methodology, and report terminology. The manufacturer may submit comments and revisions on the draft statement and report to the APCT program. The APCT program will consider these comments and suggested revisions when preparing the final verification statement and report for submission to EPA. Also, upon review of the draft results, the manufacturer may request that a Verification Statement not be issued.

Verification Statements will be posted on the ETV web site for public access without restriction. A copy of the signed statement will be provided to the manufacturer of the paint overspray arrestor.

Verification Reports will be provided to the manufacturer and made available to the public upon request. Further distribution, if desired, is at the manufacturer's discretion and is the manufacturer's responsibility.

6. MANUFACTURER'S OPTIONS IF A PRODUCT PERFORMS BELOW EXPECTATIONS

In the event that a product fails to meet the manufacturer's expectations, the manufacturer may request that a Verification Statement not be issued. The manufacturer may improve the product and resubmit it under a new model number for verification testing. Verification Statements for tests of the new product will be issued as they are processed by the APCT program and EPA.

Note that Verification Reports will always be available from EPA for review by the public regardless of a request not to issue a Verification Statement.

7. LIMITATIONS ON TESTING AND REPORTING

To avoid having multiple ETV reports for the same product and to maintain the verification testing as a cooperative effort with manufacturers, the following restrictions apply to verification testing under this protocol:

- Manufacturers may submit only their own products for testing; manufacturers may not submit arrestors from other manufacturers for verification testing.

- ! For a given product (e.g., brand and model number) only one ETV Verification Report and Statement will be issued during the 1-year period the report and statement are valid.

- ! Verification Statements will not be issued for products that fail to meet the NESHAP filtration efficiency requirements for either new or existing facilities.

8. ACQUISITION OF PAINT ARRESTORS FOR TESTING

The test arrestors will be supplied to the test laboratory directly from the manufacturer with a letter signed by the manufacturer's chief executive officer, president, or other responsible corporate representative, attesting that all components of the products being submitted for testing comply with what is specified in the manufacturer's Bill of Materials for each arrestor. No additional inspection was performed for these arrestors beyond that which is specified in the manufacturer's normal manufacturing procedures. The manufacturer will supply the test laboratory with 12 arrestors; from these 12, the test laboratory will randomly select six for testing.

The test laboratory will retain the six tested arrestors for a minimum of 6 months after testing. The untested arrestors may be disposed of per agreement between the test laboratory and the manufacturer.

9. REQUIREMENTS FOR PRODUCT LABELING

For purposes of product identification (by, for example, the test laboratory, auditors, end-user, and local inspectors), the manufacturer must label or tag the arrestors in a reasonably permanent manner to show the name of the manufacturer, model number, and date (year and month) of manufacture.

For arrestors that are impractical to label directly (for example, it is often not practical to directly label unframed loose fibrous or expanded paper pads that are frequently used as the first stage of a multi-staged system), the manufacturer must label the smallest unit of packaging of the product with this information.

If the arrestors are not labeled in the above manner, the test laboratory will reject the arrestors for testing.

This labeling must be present on all products that the manufacturer claims to be covered by the verification test; products that are not labeled in the above manner are not covered by the verification test.

10. PRODUCT CHANGE

Anytime a manufacturer changes a product, including process changes in production of raw materials or arrestor assembly, the verification statement is no longer valid (for the new product), and a new verification test is required if verification of the new product is desired. In the case of paint overspray arrestors, there is a reasonable probability of an unintentional product change occurring over a 12-month production cycle due to variations in assembly lines, media, and/or components. To address this product variability, it is assumed that sufficient changes could occur over a 12-month period that a new verification test is warranted. Therefore, a new verification test will be required every 12 months for paint overspray arrestors bearing the same model number as a previously verified manufacturer's product.

11. PRODUCT DEFINITION

Manufacturers often offer paint overspray arrestors in several standard sizes (e.g. nominal face dimensions of 20" x 20" and 24" x 24") as well as in roll stock. Arrestors of different size may be considered the same product when they have:

- the same media velocity (within 20%) for a 120 fpm face velocity
- the same media composition and structure

In multi-staged systems, the above requirements apply to each stage.

If the manufacturer knowingly changes the product, such as changing the filtration media composition, media density, or media area, the changed product is defined as a new product. As such, a verification test is required to verify the performance of the new product. The new product must be given a new model number to distinguish it from the prior model.

12. TEST LABORATORIES

The APCT ETV program is open to multiple test laboratory participation. In addition to RTI, it is anticipated that from one to three other laboratories will be available for testing. All participating laboratories must meet the ETV program's QA requirements and accept on-site audits by EPA and/or APCT personnel. The audits may include running one or more efficiency tests on a reference filter(s) provided by the APCT program.

Test laboratory qualifications include:

- Possession of the equipment and facilities required to perform Method 319 tests
- Independence from manufacturers
- ISO 9000 registration or ANSI/ASQ E4 compliance with specifications and guidelines for Quality Systems for Environmental Data collection and Environmental Technology Programs
- EPA or APCT Approved Quality Management Plan (QMP)
- EPA or APCT Approved Test/QA Plan

- Successful completion of on-site audit by APCT
- Capability and agreement to conduct testing in accordance with APCT program-approved protocol.

13. INITIATION OF VERIFICATION TESTING

To provide an orderly and controlled start to the ETV testing program, testing will begin in a staged manner with two "rounds," a round being a group of arrestors that will go through the ETV verification testing and reporting process as one batch. The first round (Round 1) of testing will include one arrestor model from each manufacturer that chooses to participate. For Round 1, the arrestors will be those intended to meet the NESHAP filtration efficiency requirements for new facilities (i.e., Tables 1-4 presented earlier). To facilitate conducting these first tests and working through the ETV process, the Round 1 tests will be performed at RTI. The Verification Statements and Reports resulting from all the Round 1 tests will be released simultaneously.

For Round 2, the arrestors may be either those intended to meet the NESHAP filtration efficiency requirements for existing or new sources (Tables 1 through 4 presented earlier). To facilitate conducting these first tests and working through the ETV process, the Round 1 tests will be performed at RTI. Again the statements and reports from all Round 2 tests will be issued simultaneously.

To facilitate conducting these first rounds of testing and working through the ETV process, testing for Rounds 1 and 2 tests will be performed at RTI. It is anticipated that after Round 2, all participating test laboratories that meet the requirements of Section 12 will be eligible to perform testing.

After Round 2, verification testing will proceed based on market demands (i.e., based on manufacturer's requests for testing and the test laboratory's testing schedule). After Round 2, to have an arrestor tested under this protocol, manufacturers must contact one of the approved testing laboratories to arrange for testing. Each test laboratory is responsible for establishing its own price and testing schedule for conducting an ETV verification test under this protocol. The APCT program will maintain a list of approved testing laboratories that will be available on request and on the ETV web site. Verification Statements and Reports will be released as they are completed. When more than one product is evaluated within a round of tests, the Verification Statements and Reports for all products tested in that round will be released simultaneously.

14. TEST LABORATORY SUBMITTAL OF RESULTS TO THE APCT PROGRAM

Upon completion of a verification test, the test laboratory will prepare a draft Verification Statement and a draft Verification Report for the product following the format shown in Appendices B and C, respectively. The test laboratory will submit the draft Verification Statement and draft Verification Report to the APCT Test QA Officer. The submittal will be in both hard copy and electronic format (either Word or WordPerfect). Example reports will be available in electronic form to participating laboratories to facilitate consistent formatting. The APCT program will review the draft Verification Statement and Report, interact with the testing laboratory as needed to resolve any questions or comments, and then forward the (revised) documents to EPA for their review, and signature.

Test laboratories will retain all applicable testing data for a period of seven years in accordance with the APCT QMP and Part B, Section 5.3 of EPA's quality and management plan. Among the electronic and printed records that are covered in this section are the following items: test/QA plans; verification reports, verification statements, raw data (including relevant calibration data), and internal and external reviews and audit reports.

15. REQUIREMENT FOR TEST/QA PLAN

15.1 Quality Management

It is required that all laboratories participating in the paint overspray arrestor verification testing program meet the QA/QC requirements defined below and have an adequate quality system to manage the quality of work performed. Documentation and records management must be performed in accordance with the EPA's QMP. Laboratories must also perform assessments and allow audits by APCT program (headed by the APCT QA Officer) and EPA corresponding to those specified in Section 16.

All participating laboratories must have an ISO 9000-accredited or ANSI E4-1994-compliant quality system and an EPA- or APCT-approved QMP. EPA will approve RTI's APCT QMP; the APCT program will approve the QMP from other participating test laboratories.

15.2 Quality Assurance

All verification testing will be carried out under approved Test/QA Plans that meet the requirements of *EPA Requirements for Quality Assurance Project Plans*, EPA Publication No. EPA QA/R-5, Draft, 1997 and Part B, Section 2.2.2 of EPA's quality and management plan. These documents establish the requirements for Test/QA Plans and the companion guidance document, EPA QA/G-5, provides guidance on how to meet these requirements. The Test/QA Plan describes how Method 319 will be implemented at the individual laboratory and the steps the laboratory will take to ensure acceptable data quality in the test results. RTI's Test/QA Plan, under preparation, will be available to other laboratories for information purposes; however, each laboratory will need to tailor its plan to its specific laboratory, equipment, instrumentation, and procedures.

Each participating test laboratory must prepare a Test/QA Plan and submit it for approval. RTI's

Test/QA Plan will be approved by EPA. Test/QA Plans for other participating laboratories will be approved by the APCT program. The Test/QA Plan must be approved before the test laboratory may begin verification testing.

A Test/QA Plan contains the following required elements. Not all elements listed are appropriate to every test. Each Test/QA Plan will note and explain those elements that are not applicable.

- Title and approval sheet
- Table of contents, distribution list
- Test description, test objectives
- Identification of the critical measurements, data quality objectives, data quality indicators, test schedule, and milestones
- Test (including QA) organization and responsibilities
- Documentation and records
- Experimental design
- Sampling procedures
- Sample handling and custody
- Analytical procedures
- Test-specific procedures for assessing data quality indicators
- Instrument calibration and its frequency
- Data acquisition and data management procedures
- Internal systems audits
- Internal performance audits (where applicable)
- Corrective action procedures (response actions to audit findings)
- Assessment reports to EPA
- Data reduction, data review, data validation, data reporting
- Reporting of data quality indicators for critical measurements
- Limitations of the data
- Any deviations from Method 319 or this Test Protocol

The verification protocol is incorporated by reference into the Test/QA Plan. In addition to the APCT QMP, a reference document available for writing test/QA plans is EPA/QA G-5, *Guidance for Quality Assurance Project Plans.*

15.3 Standard Operating Procedures

If a level of detail beyond that of the Test/QA Plan is required for describing test activities (for example operation of an instrument), a standard operating procedure may be written and attached to the Test/QA Plan. The following topics, from EPA QA/G-6, *Guidance for Development of Standard Operating Procedures (SOPs),* may be included (or a reference provided) in the standard operating procedure:

- Scope and applicability

- Summary of procedures
- Definitions (acronyms, abbreviations, etc.)
- Personnel qualifications
- Health and safety warnings (Warn of activities which could result in possible personal injury.)
- Cautions (Warn of activities which could damage equipment, degrade samples, or invalidate results.)
- Apparatus and materials
- Calibration
- Sample collection, sample labeling, sample tracking
- Handling and preservation of samples
- Interferences
- Sample preparation and analysis
- Data acquisition, calculations and data reduction
- Requirements for computer hardware and software used in data reduction and reporting
- Data management and records management

16 ASSESSMENT AND RESPONSE

The APCT program and/or EPA will conduct assessments to determine testing laboratory's compliance with its Test/QA Plan. The requirement to conduct assessments is specified in EPA's *Quality Management Plan for the Pilot Period (1995 - 2000)*, and in RTI QMP. EPA will assess RTI's compliance to RTI's Test/QA Plan. RTI will assess the compliance of other participating laboratories to their Test/QA Plans. The assessments will be conducted in accordance to *Guidance on Technical Assessments for Environmental Data Operations*, EPA Publication No. EPA QA/G-7, August 1998, working draft.

16.1 Assessment types

Management system review - Audit of a quality system for conformance to a quality management plan

Technical systems audit - Qualitative onsite audit of the physical setup of the test. The auditors determine the compliance of testing personnel with the Test/QA Plan.

Performance evaluation audit - Quantitative audit in which measurement data are independently obtained and compared with routinely obtained data to evaluate the accuracy (bias and precision) of a measurement system.

Audit of data quality - Qualitative and quantitative audit in which data and data handling are reviewed and data quality and data usability are assessed.

16.2 Assessment frequency

Activities performed during technology verification performance operations that affect the quality of the data shall be assessed regularly, and the findings reported to management to ensure that the requirements stated in the generic verification protocols and the test/QA plans are being implemented as prescribed.

The types and minimum frequency of assessments for the ETV program are listed in Part A Section 9.0 of EPA's *Quality Management Plan for the Pilot Period (1995 - 2000)*. The pilot tests will have at minimum the following types and numbers of assessments:

- management systems review - one independent assessment, as provided in the pilot quality management plan
- technical systems audits - self-assessments for each test as provided for in the test/QA plan and independent assessments, twice per pilot
- performance evaluation audits - self-assessments, as applicable, for each test as provided in the test/QA and independent assessments, as applicable for each pilot
- audits of data quality - self-assessments of at least 10% of all the verification data; and independent assessment, as applicable for each pilot

The independent assessments of RTI's tests will be performed by EPA. The independent assessments of other participating laboratories will be by the APCT program.

16.3 Response to assessment

Appropriate corrective actions shall be taken and their adequacy verified and documented in response to the findings of the assessments. Data found to have been taken from non-conforming equipment shall be evaluated to determine its impact on the quality of the data. The impact and the action taken shall be documented. Assessments are conducted according to procedures contained in the APCT QMP. Findings are provided in audit reports. Responses to adverse findings are required within 10 working days of receiving the audit report. Follow-up by the auditors and documentation of response are required.

17. REFERENCES

Method 319: Determination of Filtration Efficiency for Paint Overspray Arrestors. *Code of Federal Regulations*, Volume 40, Part 63, Appendix A.

National Emission Standards for Hazardous Air Pollutants Aerospace Manufacturing and Rework Facilities. Federal Register, 40 CFR Part 63.

U.S. EPA, Environmental Technology Verification Program: Quality and Management

Plan for the Pilot Period (1995-2000), May 1998.

U.S. EPA, EPA Requirements for Quality Management Plans, EPA QA/R-2. Draft interim final, August 1994.

U.S. EPA, EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5. Draft, October 1997.

U.S. EPA, Guidance on Quality Assurance Project Plans, EPA QA/G-5. EPA/600/R98/018. February 1998.

U.S. EPA *Guidance on Technical Assessments for Environmental Data Operations*, EPA Publication No. EPA QA/G-7, August 1998, working draft.

U.S. EPA *EPA Requirements for Quality Assurance Project Plans*, EPA Publication No. EPA QA/R-5, Draft, 1997.

ANSI/ASQC. Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Program; ANSI/ASQC E4. American Society for Quality Control, Milwaukee, Wisc., 1994.

ANSI/ASQC. Quality Systems—Model for Quality Assurance in Designing, Development, Protection, Installing and Servicing; ANSI/ASQC Q9001-1994, American Society for Quality Control, Milwaukee, Wisc., 1994. This is the most recent U.S. version of the International Organization for Standards ISO 9001 standard.

Revision No. 3
Date: August 24, 1999

APPENDIX A

METHOD 319

Elevated-temperature Skydrol-resistant commercial primer—A primer applied primarily to commercial aircraft (or commercial aircraft adapted for military use) that must withstand immersion in phosphate-ester (PE) hydraulic fluid (Skydrol 500b or equivalent) at the elevated temperature of 150°F for 1,000 hours.

Epoxy polyamide topcoat—A coating used where harder films are required or in some areas where engraving is accomplished in camouflage colors.

Fire-resistant (interior) coating—For civilian aircraft, fire-resistant interior coatings are used on passenger cabin interior parts that are subject to the FAA fireworthiness requirements. For military aircraft, fire-resistant interior coatings are used on parts subject to the flammability requirements of MIL–STD–1630A and MIL–A–87721. For space applications, these coatings are used on parts subject to the flammability requirements of SE–R–0006 and SSP 30233.

Flexible primer—A primer that meets flexibility requirements such as those needed for adhesive bond primed fastener heads or on surfaces expected to contain fuel. The flexible coating is required because it provides a compatible, flexible substrate over bonded sheet rubber and rubber-type coatings as well as a flexible bridge between the fasteners, skin, and skin-to-skin joints on outer aircraft skins. This flexible bridge allows more topcoat flexibility around fasteners and decreases the chance of the topcoat cracking around the fasteners. The result is better corrosion resistance.

Flight test coating—A coating applied to aircraft other than missiles or single-use aircraft prior to flight testing to protect the aircraft from corrosion and to provide required marking during flight test evaluation.

Fuel tank adhesive—An adhesive used to bond components exposed to fuel and that must be compatible with fuel tank coatings.

Fuel tank coating—A coating applied to fuel tank components to inhibit corrosion and/or bacterial growth and to assure sealant adhesion in extreme environmental conditions.

High temperature coating—A coating designed to withstand temperatures of more than 350 °F.

Insulation covering—Material that is applied to foam insulation to protect the insulation from mechanical or environmental damage.

Intermediate release coating—A thin coating applied beneath topcoats to assist in removing the topcoat in depainting operations and generally to allow the use of less hazardous depainting methods.

Lacquer—A clear or pigmented coating formulated with a nitrocellulose or synthetic resin to dry by evaporation without a chemical reaction. Lacquers are resoluble in their original solvent.

Metalized epoxy coating—A coating that contains relatively large quantities of metallic pigmentation for appearance and/or added protection.

Mold release—A coating applied to a mold surface to prevent the molded piece from sticking to the mold as it is removed.

Nonstructural adhesive—An adhesive that bonds nonload bearing aerospace components in noncritical applications and is not covered in any other specialty adhesive categories.

Optical anti-reflection coating—A coating with a low reflectance in the infrared and visible wavelength ranges, which is used for anti-reflection on or near optical and laser hardware.

Part marking coating—Coatings or inks used to make identifying markings on materials, components, and/or assemblies. These markings may be either permanent or temporary.

Pretreatment coating—An organic coating that contains at least 0.5 percent acids by weight and is applied directly to metal or composite surfaces to provide surface etching, corrosion resistance, adhesion, and ease of stripping.

Rain erosion-resistant coating—A coating or coating system used to protect the leading edges of parts such as flaps, stabilizers, radomes, engine inlet nacelles, etc. against erosion caused by rain impact during flight.

Rocket motor bonding adhesive—An adhesive used in rocket motor bonding applications.

Rocket motor nozzle coating—A catalyzed epoxy coating system used in elevated temperature applications on rocket motor nozzles.

Rubber-based adhesive—Quick setting contact cements that provide a strong, yet flexible, bond between two mating surfaces that may be of dissimilar materials.

Scale inhibitor—A coating that is applied to the surface of a part prior to thermal processing to inhibit the formation of scale.

Screen print ink—Inks used in screen printing processes during fabrication of decorative laminates and decals.

Seal coat maskant—An overcoat applied over a maskant to improve abrasion and chemical resistance during production operations.

Sealant—A material used to prevent the intrusion of water, fuel, air, or other liquids or solids from certain areas of aerospace vehicles or components. There are two categories of sealants: extrudable/rollable/brushable sealants and sprayable sealants.

Silicone insulation material—Insulating material applied to exterior metal surfaces for protection from high temperatures caused by atmospheric friction or engine exhaust. These materials differ from ablative coatings in that they are not ''sacrificial.''

Solid film lubricant—A very thin coating consisting of a binder system containing as its chief pigment material one or more of the following: molybdenum, graphite, polytetrafluoroethylene (PTFE), or other solids that act as a dry lubricant between faying surfaces.

Specialized function coatings—Coatings that fulfill extremely specific engineering requirements that are limited in application and are characterized by low volume usage. This category excludes coatings covered in other Specialty Coating categories.

Structural autoclavable adhesive—An adhesive used to bond load-carrying aerospace components that is cured by heat and pressure in an autoclave.

Structural nonautoclavable adhesive—An adhesive cured under ambient conditions that is used to bond load-carrying aerospace components or for other critical functions, such as nonstructural bonding in the proximity of engines.

Temporary protective coating—A coating applied to provide scratch or corrosion protection during manufacturing, storage, or transportation. Two types include peelable protective coatings and alkaline removable coatings. These materials are not intended to protect against strong acid or alkaline solutions. Coatings that provide this type of protection from chemical processing are not included in this category.

Thermal control coating—Coatings formulated with specific thermal conductive or radiative properties to permit temperature control of the substrate.

Touch-up and Repair Coating—A coating used to cover minor coating imperfections appearing after the main coating operation.

Wet fastener installation coating—A primer or sealant applied by dipping, brushing, or daubing to fasteners that are installed before the coating is cured.

Wing coating—A corrosion-resistant topcoat that is resilient enough to withstand the flexing of the wings.

18. Appendix A to Part 63 is amended by adding method 319 in numerical order to read as follows:

Appendix A to Part 63—Test Methods

* * * * *

Method 319: Determination of Filtration Efficiency for Paint Overspray Arrestors

1.0 Scope and Application.

1.1 This method applies to the determination of the initial, particle size dependent, filtration efficiency for paint arrestors over the particle diameter range from 0.3 to 10 µm. The method applies to single and multiple stage paint arrestors or paint arrestor media. The method is applicable to efficiency determinations from 0 to 99 percent. Two test aerosols are used—one liquid phase and one solid phase. Oleic acid, a low-volatility liquid (CAS Number 112–80–1), is used to simulate the behavior of wet paint overspray. The solid-phase aerosol is potassium chloride salt (KCl, CAS Number 7447–40–7) and is used to simulate the behavior of a dry overspray. The method is limited to determination of the initial, clean filtration efficiency of the arrestor. Changes in efficiency (either increase or decrease) due to the accumulation of paint overspray on and within the arrestor are not evaluated.

1.2 Efficiency is defined as 1—Penetration (e.g., 70 percent efficiency is equal to 0.30 penetration). Penetration is based on the ratio of the downstream particle concentration to the upstream concentration. It is often more useful, from a mathematical or statistical point of view, to discuss the upstream and downstream counts in terms of penetration rather than the derived efficiency value. Thus, this document uses both penetration and efficiency as appropriate.

1.3 For a paint arrestor system or subsystem which has been tested by this method, adding additional filtration devices to the system or subsystem shall be assumed to result in an efficiency of at least that of the original system without the requirement for additional testing. (For example, if the final stage of a three-stage paint arrestor system has been tested by itself, then the addition of the other two stages shall be assumed to maintain, as a minimum, the filtration efficiency provided by the final stage alone. Thus, in this example, if the final stage has been shown to meet the filtration requirements of Table 1 of § 63.745 of subpart GG, then the final stage in combination with any additional paint arrestor stages also passes the filtration requirements.)

2.0 Summary of Method.

2.1 This method applies to the determination of the fractional (i.e., particle-size dependent) aerosol penetration of several types of paint arrestors. Fractional penetration is computed from aerosol concentrations measured upstream and downstream of an arrestor installed in a laboratory test rig. The aerosol concentrations upstream and downstream of the arrestors are measured with an aerosol analyzer that simultaneously counts and sizes the particles in the aerosol stream. The aerosol analyzer covers the particle diameter size range from 0.3 to 10 µm in a minimum of 12 contiguous sizing channels. Each sizing channel covers a narrow range of particle diameters. For example, Channel 1 may cover from 0.3 to 0.4 µm, Channel 2 from 0.4 to 0.5 µm, * * * By taking the ratio of the downstream to upstream counts on a channel by channel basis, the penetration is computed for each of the sizing channels.

2.2 The upstream and downstream aerosol measurements are made while injecting the test aerosol into the air stream upstream of the arrestor (ambient aerosol is removed with HEPA filters on the inlet of the test rig). This test aerosol spans the particle size range from 0.3 to 10 µm and provides sufficient upstream concentration in each of the optical particle counter (OPC) sizing channels to allow accurate calculation of penetration, down to penetrations of approximately 0.01 (i.e., 1 percent penetration; 99 percent efficiency). Results are presented as a graph and a data table showing the aerodynamic particle diameter and the corresponding fractional efficiency.

3.0 Definitions.

Aerodynamic Diameter—diameter of a unit density sphere having the same aerodynamic properties as the particle in question.

Efficiency is defined as equal to 1—Penetration.

Optical Particle Counter (OPC)—an instrument that counts particles by size using light scattering. An OPC gives particle diameters based on size, index of refraction, and shape.

Penetration—the fraction of the aerosol that penetrates the filter at a given particle diameter. Penetration equals the downstream concentration divided by the upstream concentration.

4.0 Interferences.

4.1 The influence of the known interferences (particle losses) are negated by correction of the data using blanks.

5.0 Safety.

5.1 There are no specific safety precautions for this method above those of good laboratory practice. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

6.0 Equipment and Supplies.

6.1 Test Facility. A schematic diagram of a test duct used in the development of the method is shown in Figure 319–1.

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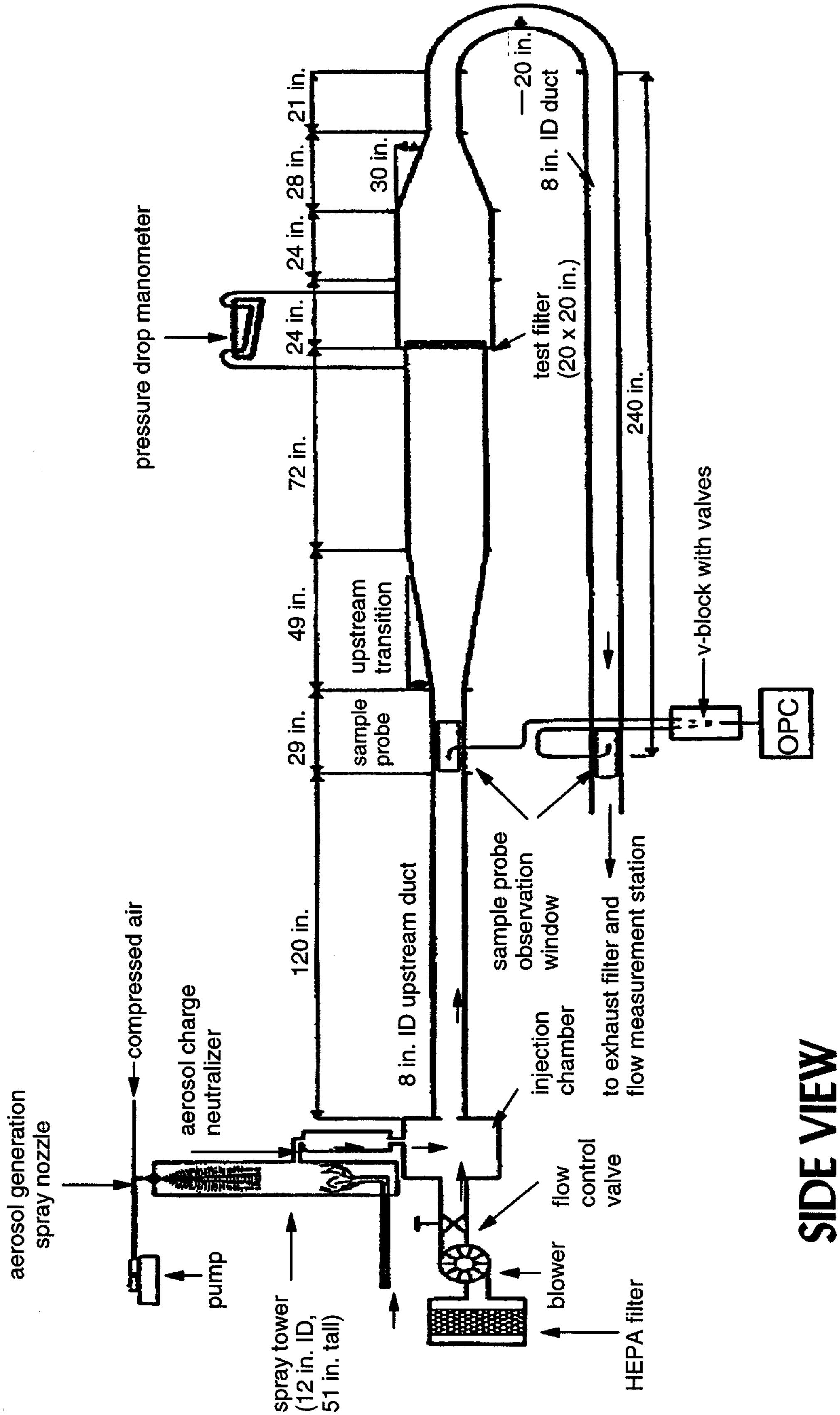

Figure 319-1. Schematic illustration of the fractional efficiency test rig.

BILLING CODE 6560–50–C

6.1.1 The test section, paint spray section, and attached transitions are constructed of stainless and galvanized steel. The upstream and downstream ducting is 20 cm diameter polyvinyl chloride (PVC). The upstream transition provides a 7° angle of expansion to provide a uniform air flow distribution to the paint arrestors. Aerosol concentration is measured upstream and downstream of the test section to obtain the challenge and penetrating aerosol concentrations, respectively. Because the downstream ducting runs back under the test section, the challenge and penetrating aerosol taps are located physically near each other, thereby facilitating aerosol sampling and reducing sample-line length. The inlet nozzles of the upstream and downstream aerosol probes are designed to yield isokinetic sampling conditions.

6.1.2 The configuration and dimensions of the test duct can deviate from those of Figure 319–1 provided that the following key elements are maintained: the test duct must meet the criteria specified in Table 319–1; the inlet air is HEPA filtered; the blower is on the upstream side of the duct thereby creating a positive pressure in the duct relative to the surrounding room; the challenge air has a temperature between 50° and 100°F and a relative humidity of less than 65 percent; the angle of the upstream transition (if used) to the paint arrestor must not exceed 7°; the angle of the downstream transition (if used) from the paint arrestor must not exceed 30°; the test duct must provide a means for mixing the challenge aerosol with the upstream flow (in lieu of any mixing device, a duct length of 15 duct diameters fulfills this requirement); the test duct must provide a means for mixing any penetrating aerosol with the downstream flow (in lieu of any mixing device, a duct length of 15 duct diameters fulfills this requirement); the test section must provide a secure and leak-free mounting for single and multiple stage arrestors; and the test duct may utilize a 180° bend in the downstream duct.

TABLE 319–1.—QC CONTROL LIMITS

	Frequency and description	Control limits
OPC zero count	Each Test. OPC samples HEPA-filtered air	<50 counts per minute.
OPC sizing accuracy check	Daily. Sample aerosolized PSL spheres	Peak of distribution should be in correct OPC channel.
Minimum counts per channel for challenge aerosol.	Each Test	Minimum total of 500 particle counts per channel.
Maximum particle concentration	Each 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 test based on the 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—KCl	Triplicate tests performed immediately before, during, or after triplicate arrestor tests.	0.3 to 1 μm: 0.90 to 1.10. 1 to 3 μm: 0.75 to 1.25. 3 to 10 μm: 0.50 to 1.50.
100% Penetration—Oleic Acid	Triplicate tests performed immediately before, during, or after triplicate arrestor tests.	0.3 to 1 μm: 0.90 to 1.10. 1 to 3 μm: 0.75 to 1.25. 3 to 10 μm: 0.50 to 1.50.

6.2 Aerosol Generator. The aerosol generator is used to produce a stable aerosol covering the particle size range from 0.3 to 10 μm diameter. The generator used in the development of this method consists of an air atomizing nozzle positioned at the top of a 0.30–m (12-in.) diameter, 1.3–m (51-in.) tall, acrylic, transparent, spray tower. This tower allows larger sized particles, which would otherwise foul the test duct and sample lines, to fall out of the aerosol. It also adds drying air to ensure that the KCl droplets dry to solid salt particles. After generation, the aerosol passes through an aerosol neutralizer (Kr85 radioactive source) to neutralize any electrostatic charge on the aerosol (electrostatic charge is an unavoidable consequence of most aerosol generation methods). To improve the mixing of the aerosol with the air stream, the aerosol is injected counter to the airflow. Generators of other designs may be used, but they must produce a stable aerosol concentration over the 0.3 to 10 μm diameter size range; provide a means of ensuring the complete drying of the KCl aerosol; and utilize a charge neutralizer to neutralize any electrostatic charge on the aerosol. The resultant challenge aerosol must meet the minimum count per channel and maximum concentration criteria of Table 319–1.

6.3 Installation of Paint Arrestor. The paint arrestor is to be installed in the test duct in a manner that precludes air bypassing the arrestor. Since arrestor media are often sold unmounted, a mounting frame may be used to provide back support for the media in addition to sealing it into the duct. The mounting frame for 20 in. x 20 in. arrestors will have minimum open internal dimensions of 18 in. square. Mounting frames for 24 in. x 24 in. arrestors will have minimum open internal dimensions of 22 in. square. The open internal dimensions of the mounting frame shall not be less than 75 percent of the approach duct dimensions.

6.4 Optical Particle Counter. The upstream and downstream aerosol concentrations are measured with a high-resolution optical particle counter (OPC). To ensure comparability of test results, the OPC shall utilize an optical design based on wide-angle light scattering and provided a minimum of 12 contiguous particle sizing channels from 0.3 to 10μm diameter (based on response to PSL) where, for each channel, the ratio of the diameter corresponding to the upper channel bound to the lower channel bound must not exceed 1.5.

6.5 Aerosol Sampling System. The upstream and downstream sample lines must be made of rigid electrically-grounded metallic tubing having a smooth inside surface, and they must be rigidly secured to prevent movement during testing. The upstream and downstream sample lines are to be nominally identical in geometry. The use of a short length (100 mm maximum) of straight flexible tubing to make the final connection to the OPC is acceptable. The inlet nozzles of the upstream and downstream probes must be sharp-edged and of appropriate entrance diameter to maintain isokinetic sampling within 20 percent of the air velocity.

6.5.1 The sampling system may be designed to acquire the upstream and downstream samples using (a) sequential upstream-downstream sampling with a single OPC, (b) simultaneous upstream and downstream sampling with two OPC's, or (c) sequential upstream-downstream sampling with two OPC's.

6.5.2 When two particle counters are used to acquire the upstream and downstream counts, they must be closely matched in flowrate and optical design.

6.6 Airflow Monitor. The volumetric airflow through the system shall be measured with a calibrated orifice plate, flow nozzle, or laminar flow element. The measurement device must have an accuracy of 5 percent or better.

7.0 Reagents and Standards.

7.1 The liquid test aerosol is reagent grade, 98 percent pure, oleic acid (Table 319–2). The solid test aerosol is KCl aerosolized from a solution of KCl in water. In addition to the test aerosol, a calibration aerosol of monodisperse polystyrene latex (PSL) spheres is used to verify the calibration of the OPC.

TABLE 319–2.—PROPERTIES OF THE TEST AND CALIBRATION AEROSOLS

	Refractive index	Density, g/cm^3	Shape
Oleic Acid (liquid-phase challenge aerosol)	1.46 nonabsorbing	0.89	Spherical.
KCl (solid-phase challenge aerosol)	1.49	1.98	Cubic or agglomerated cubes.
PSL (calibration aerosol)	1.59 nonabsorbing	1.05	Spherical.

8.0 Sample Collection, Preservation, and Storage.

8.1 In this test, all sampling occurs in real-time, thus no samples are collected that require preservation or storage during the test. The paint arrestors are shipped and stored to avoid structural damage or soiling. Each arrestor may be shipped in its original box from the manufacturer or similar cardboard box. Arrestors are stored at the test site in a location that keeps them clean and dry. Each arrestor is clearly labeled for tracking purposes.

9.0 Quality Control.

9.1 Table 319–1 lists the QC control limits.

9.2 The standard deviation (σ) of the 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 upstream and downstream measurements as:

$$\sigma_P = P\sqrt{\left(CV_{upstream}^2 + CV_{downstream}^2\right)} \qquad \text{(Eq. 319-1)}$$

For a properly operating system, the standard deviation of the penetration is < 0.10 at particle diameters from 0.3 to 3 µm and less than 0.30 at diameters > 3 µm.

9.3 Data Quality Objectives (DQO).

9.3.1 Fractional Penetration. From the triplicate tests of each paint arrestor model, the standard deviation for the penetration measurements at each particle size (i.e., for each sizing channel of the OPC) is computed as:

$$s = \left[\sum\left(P_i - \overline{P}\right)^2 / (n-1)\right]^{\frac{1}{2}} \qquad \text{(Eq. 319-2)}$$

where P_i represents an individual penetration measurement, and P the average of the 3 (n = 3) individual measurements.

9.3.2 Bias of the fractional penetration values is determined from triplicate no-filter and HEPA filter tests. These tests determine the measurement bias at 100 percent penetration and 0 percent penetration, respectively.

9.3.3 PSL-Equivalent Light Scattering Diameter. The precision and bias of the OPC sizing determination are based on sampling a known diameter of PSL and noting whether the particle counts peak in the correct channel of the OPC. This is a pass/fail measurement with no calculations involved.

9.3.4 Airflow. The precision of the measurement must be within 5 percent of the set point.

10.0 Calibration and Standardization.

10.1 Optical Particle Counter. The OPC must have an up-to-date factory calibration. Check the OPC zero at the beginning and end of each test by sampling HEPA-filtered air. Verify the sizing accuracy on a daily basis (for days when tests are performed) with 1-size PSL spheres.

10.2 Airflow Measurement. Airflow measurement devices must have an accuracy of 5 percent or better. Manometers used in conjunction with the orifice plate must be inspected prior to use for proper level, zero, and mechanical integrity. Tubing connections to the manometer must be free from kinks and have secure connections.

10.3 Pressure Drop. Measure pressure drop across the paint arrestor with an inclined manometer readable to within 0.01 in. H_2O. Prior to use, the level and zero of the manometer, and all tubing connections, must be inspected and adjusted as needed.

11.0 Procedure.

11.1 Filtration Efficiency. For both the oleic acid and KCl challenges, this procedure is performed in triplicate using a new arrestor for each test.

11.1.1 General Information and Test Duct Preparation

11.1.1.1 Use the ''Test Run Sheet'' form (Figure 319–2) to record the test information.

Run Sheet

Part 1. General Information

Date and Time: ______________________

Test Operator: ______________________

Test #: ______________________

Paint Arrestor:

Brand/Model ______________________

Arrestor Assigned ID # ______________

Condition of arrestor (i.e., is there any damage? Must be new condition to proceed):

____

Manometer zero and level confirmed?

____

Part 2. Clean Efficiency Test

Date and Time: ______________________

Optical Particle Counter:

20 min. warm up ______________________

Zero count (< 50 counts/min) __________

Daily PSL check ______________________

PSL Diam: ______ µm

File name for OPC data: ______________

Test Conditions:

Air Flow: ______

Temp & RH: Temp ______ °F RH ______ %

Atm. Pressure: ______in. Hg (From mercury barometer)

Aerosol Generator: (record all operating parameters)

____

____

____

____

Test Aerosol:

(Oleic acid or KCl) ______________________

Arrestor:

Pressure drop: at start ______ in. H_2O

at end ______ in. H_2O

Condition of arrestor at end of test (note any physical deterioration):

____

____

Figure 319–2. Test Run Sheet

Other report formats which contain the same information are acceptable.

11.1.1.2 Record the date, time, test operator, Test #, paint arrestor brand/model and its assigned ID number. For tests with no arrestor, record none.

11.1.1.3 Ensure that the arrestor is undamaged and is in ''new'' condition.

11.1.1.4 Mount the arrestor in the appropriate frame. Inspect for any airflow leak paths.

11.1.1.5 Install frame-mounted arrestor in the test duct. Examine the installed arrestor to verify that it is sealed in the duct. For tests with no arrestor, install the empty frame.

11.1.1.6 Visually confirm the manometer zero and level. Adjust as needed.

11.1.2 Clean Efficiency Test.

11.1.2.1 Record the date and time upon beginning this section.

11.1.2.2 Optical Particle Counter.

11.1.2.2.1 General: Operate the OPC per the manufacturer's instructions allowing a minimum of 20 minutes warm up before making any measurements.

11.1.2.2.2 Overload: The OPC will yield inaccurate data if the aerosol concentration it is attempting to measure exceeds its operating limit. To ensure reliable measurements, the maximum aerosol concentration will not exceed 10 percent of the manufacturer's claimed upper concentration limit corresponding to a 10 percent count error. If this value is exceeded, reduce the aerosol concentration until the acceptable conditions are met.

11.1.2.2.3 Zero Count: Connect a HEPA capsule to the inlet of the OPC and obtain printouts for three samples (each a minimum of 1-minute each). Record maximum cumulative zero count. If the count rate exceeds 50 counts per minute, the OPC requires servicing before continuing.

11.1.2.2.4 PSL Check of OPC Calibration: Confirm the calibration of the OPC by sampling a known size PSL aerosol. Aerosolize the PSL using an appropriate nebulizer. Record whether the peak count is observed in the proper channel. If the peak is not seen in the appropriate channel, have the OPC recalibrated.

11.1.2.3 Test Conditions:

11.1.2.3.1 Airflow: The test airflow corresponds to a nominal face velocity of 120 FPM through the arrestor. For arrestors having nominal 20 in. x 20 in. face dimensions, this measurement corresponds to an airflow of 333 cfm. For arrestors having nominal face dimensions of 24 in. x 24 in., this measurement corresponds to an airflow of 480 cfm.

11.1.2.3.2 Temperature and Relative Humidity: The temperature and relative humidity of the challenge air stream will be measured to within an accuracy of +/−2°F and +/−10 percent RH. To protect the probe from fouling, it may be removed during periods of aerosol generation.

11.1.2.3.3 Barometric Pressure: Use a mercury barometer. Record the atmospheric pressure.

11.1.2.4 Upstream and Downstream Background Counts.

11.1.2.4.1 With the arrestor installed in the test duct and the airflow set at the proper value, turn on the data acquisition computer and bring up the data acquisition program.

11.1.2.4.2 Set the OPC settings for the appropriate test sample duration with output for both printer and computer data collection.

11.1.2.4.3 Obtain one set of upstream-downstream background measurements.

11.1.2.4.4 After obtaining the upstream-downstream measurements, stop data acquisition.

11.1.2.5 Efficiency Measurements:

11.1.2.5.1 Record the arrestor pressure drop.

11.1.2.5.2 Turn on the Aerosol Generator. Begin aerosol generation and record the operating parameters.

11.1.2.5.3 Monitor the particle counts. Allow a minimum of 5 minutes for the generator to stabilize.

11.1.2.5.4 Confirm that the total particle count does not exceed the predetermined upper limit. Adjust generator as needed.

11.1.2.5.5 Confirm that a minimum of 50 particle counts are measured in the upstream sample in each of the OPC channels per sample. (A minimum of 50 counts per channel per sample will yield the required minimum 500 counts per channel total for the 10 upstream samples as specified in Table 319–1.) Adjust generator or sample time as needed.

11.1.2.5.6 If you are unable to obtain a stable concentration within the concentration limit and with the 50 count minimum per channel, adjust the aerosol generator.

11.1.2.5.7 When the counts are stable, perform repeated upstream-downstream sampling until 10 upstream-downstream measurements are obtained.

11.1.2.5.8 After collection of the 10 upstream-downstream samples, stop data acquisition and allow 2 more minutes for final purging of generator.

11.1.2.5.9 Obtain one additional set of upstream-downstream background samples.

11.1.2.5.10 After obtaining the upstream-downstream background samples, stop data acquisition.

11.1.2.5.11 Record the arrestor pressure drop.

11.1.2.5.12 Turn off blower.

11.1.2.5.13 Remove the paint arrestor assembly from the test duct. Note any signs of physical deterioration.

11.1.2.5.14 Remove the arrestor from the frame and place the arrestor in an appropriate storage bag.

11.2 Control Test: 100 Percent Penetration Test. A 100 percent penetration test must be performed immediately before each individual paint arrestor test using the same challenge aerosol substance (i.e., oleic acid or KCl) as to be used in the arrestor test. These tests are performed with no arrestor installed in the test housing. This test is a relatively stringent test of the adequacy of the overall duct, sampling, measurement, and aerosol generation system. The test is performed as a normal penetration test except the paint arrestor is not used. A perfect system would yield a measured penetration of 1 at all particle sizes. Deviations from 1 can 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.

11.3 Control Test: 0 Percent Penetration. One 0 percent penetration test must be performed at least monthly during testing. The test is performed by using a HEPA filter rather than a paint arrestor. This test assesses the adequacy of the instrument response time and sample line lag.

12.0 Data Analysis and Calculations.

12.1 Analysis. The analytical procedures for the fractional penetration and flow velocity measurements are described in Section 11. Note that the primary measurements, those of the upstream and downstream aerosol concentrations, are performed with the OPC which acquires the sample and analyzes it in real time. Because all the test data are collected in real time, there are no analytical procedures performed subsequent to the actual test, only data analysis.

12.2 Calculations.

12.2.1 Penetration.

Nomenclature

U = Upstream particle count

D = Downstream particle count

U_b = Upstream background count

D_b = Downstream background count

P_{100} = 100 percent penetration value determined immediately prior to the arrestor test computed for each channel as:

$$P_{100} = \frac{\left(\overline{D} - \overline{D_b}\right)}{\left(\overline{U} - \overline{U_b}\right)}$$

P = Penetration of the arrestor corrected for P_{100}

ó = Sample standard deviation

CV = Coefficient of variation = ó/mean

E = Efficiency.

Overbar denotes arithmetic mean of quantity.

Analysis of each test involves the following quantities:

- P_{100} value for each sizing channel from the 100 percent penetration control test,
- 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 is calculated as:

$$P = \left\{\frac{\left(\overline{D} - \overline{D}_b\right)}{\left(\overline{U} - \overline{U}_b\right)}\right\} / P_{100} \qquad \text{(Eq. 319-3)}$$

$$E = 1 - P \qquad \text{(Eq. 319-4)}$$

Most often, the background levels are small compared to the values when the aerosol generator is on.

12.3 The relationship between the physical diameter ($D_{Physical}$) as measured by the OPC to the aerodynamic diameter (D_{Aero}) is given by:

$$D_{Aero} = D_{Physical} \sqrt{\frac{\rho_{Particle}}{\rho_o} \frac{CCF_{Physical}}{CCF_{Aero}}} \qquad \text{(Eq. 319-5)}$$

Where:

ρ_O = unit density of 1 g/cm^3.
$\rho_{Particle}$ = the density of the particle, 0.89 g/cm^3 for oleic acid.
$CCF_{Physical}$ = the Cunningham Correction Factor at $D_{Physical}$.
CCF_{Aero} = the Cunningham Correction Factor at D^{Aero}.

12.4 Presentation of Results. For a given arrestor, results will be presented for:

- Triplicate arrestor tests with the liquid-phase challenge aerosol,
- Triplicate arrestor tests with the solid-phase challenge aerosol,
- Triplicate 100 percent penetration tests with the liquid-phase challenge aerosol,
- Triplicate 100 percent penetration tests with the solid-phase challenge aerosol, and
- One 0 percent filter test (using either the liquid-phase or solid-phase aerosol and performed at least monthly).

12.4.1 Results for the paint arrestor test must be presented in both graphical and tabular form. The X-axis of the graph will be a logarithmic scale of aerodynamic diameter from 0.1 to 100 µm. The Y-axis will be efficiency (%) on a linear scale from 0 to 100. Plots for each individual run and a plot of the average of triplicate solid-phase and of the average triplicate liquid-phase tests must be prepared. All plots are to be based on point-to-point plotting (i.e., no curve fitting is to be used). The data are to be plotted based on the geometric mean diameter of each of the OPC's sizing channels.

12.4.2 Tabulated data from each test must be provided. The data must include the upper and lower diameter bound and geometric mean diameter of each of the OPC sizing channels, the background particle counts for each channel for each sample, the upstream particle counts for each channel for each sample, the downstream particle counts for each channel for each sample, the 100 percent penetration values computed for each channel, and the 0 percent penetration values computed for each channel.

13.0 Pollution Prevention.

13.1 The quantities of materials to be aerosolized should be prepared in accord with the amount needed for the current tests so as to prevent wasteful excess.

14.0 Waste Management.

14.1 Paint arrestors may be returned to originator, if requested, or disposed of with regular laboratory waste.

15.0 References.

1. Hanley, J.T., D.D. Smith and L. Cox. ''Fractional Penetration of Paint Overspray Arrestors, Draft Final Report,'' EPA Cooperative Agreement CR–817083–01–0, January 1994.

2. Hanley, J.T., D.D. Smith, and D.S. Ensor. ''Define a Fractional Efficiency Test Method that is Compatible with Particulate Removal Air Cleaners Used in General Ventilation,'' Final Report, 671–RP, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., December 1993.

3. ''Project Work and Quality Assurance Plan: Fractional Penetration of Paint Overspray Arrestors, Category II,'' EPA Cooperative Agreement No. CR–817083, July 1994.

[FR Doc. 98–6999 Filed 3–26–98; 8:45 am]
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