TITLE: IN-PLACE TESTING SUMMARY (1989)

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PREFACE

This report is another in a series about an on-going in-place testing program of high efficiency filtration and chemical adsorber systems at the Los Alamos National Laboratory. This testing is in support of the Laboratory's airborne waste management programs. Periodic in-place testing, along with Health Physics air sampling will determine whether the air cleaning systems are maintaining acceptable air-cleaning levels. These periodic evaluations help ensure that the plant and surrounding environment are free of any significant radioactive particulates, based on current EPA environmental levels and chemical airborne hazards from processing effluents.

The purpose of this report is to provide an overview of system performance and the testing methods and procedures.

1.0 INTRODUCTION

Periodic evaluation of an air-cleaning system is necessary in order to establish a record of its current operating condition. These evaluations along with Health Physics air sampling determine whether air-cleaning integrity is being maintained. The in-place test is conducted in most instances without disrupting plant operations,¹ and only if the systems failed the test would it become necessary to shut down. Testing is conducted on single and multi-stage filter systems and other filtration devices using optical particle counters.² The testing procedure requires that the filter system be challenged with a test aerosol having a heterodisperse size distribution in the submicrometer diameter range, 0.1 to 1.0 micrometer. This type of testing is not to be confused with tests performed by the Quality Assurance Testing Stations,³ whose purpose is directed at filter efficiency.

In-place testing of adsorber systems is required for several reasons: 1) chemical poisoning of the adsorbers by organic vapors; 2) settling of the charcoal in the bed due to vibration; and 3) installation defects. There are two methods of in-place testing of adsorber systems. The first method uses a fluorocarbon (Freon 11 gas), the second method uses a radioactive gas (Iodine or Methyl Iodide). At Los Alamos, we use the Freon 11 method.⁴

This report presents the results of the 1989 tests, including the methods and procedures used in the testing and calibration of the particle counters and aerosol diluter systems.

2.0 TESTING SCHEDULE

Schedules are sent out to the groups 2 weeks in advance, notifying them of the testing dates. The schedules are normally flexible and our policy is to work around operational conflicts.

3.0 DEFINITIONS

3.1 Penetration (Pen). The measure of quantity of a test agent that leaks through or around an air cleaning system when the system is tested

with an agent of known characteristics under specified conditions. The fractional penetration is expressed as the ratio of the downstream particle counts to the upstream particle counts.

3.2 Diluter. A device used to reduce high aerosol concentrations to concentrations useable by the single-particle-spectrometer. Maximum concentrations are determined by the occurrence of coincidence counting losses when more than one particle occupies the sampling volume of the spectrometer.

3.3 Dilution Ratio (DR). The ratio of the undiluted to diluted aerosol concentrations. Because diluters have inherent particle losses which may vary according to the particle size, the dilution ratio may not be constant for different sizes.

3.4 Single-Particle Spectrometer (SPS). A precision aerosol detector which allows single particle counting and sizing by the amount of light scattered from individual particles. The signals can be grouped into categories corresponding to particle size using pulse height discrimination.

3.5 HEPA. A high efficiency particulate air filter.

3.6 Other. Other terms pertinent to this report are defined in the reference material, more specifically in the Standards ANSI/ASME N-510, and Nuclear Standard F341T.

4.0 POLICY FOR IN-PLACE TESTING

4.1 New Installations. All new filter installations handling toxic materials will be tested before initiating any operations.

4.2 Test Frequency. Each filter system, including entry boxes and adsorbers handling toxic or radioactive materials such as asbestos, beryllium, plutonium, and enriched uranium will be tested annually.

4.3 Filters Changes. All systems containing HEPA or Aerosolve 95 filters will be tested within 2 working days of the filter change, except for glove box in-line filters.

4.4 Other Filtration. Testing of filter systems handling moderately toxic materials such as depleted uranium, lead, etc., will be determined on a case-by-case basis.

4.5 Supply Systems. Supply air systems will be tested only at TA-55 and the new Nuclear Materials Storage Facility.

4.6 Glove Box In-Line Filters. No routine tests will be conducted on these filters except for new installations.

5.0 TEST REQUIREMENTS

5.1 Aerosol or Test Gas Injection Ports. Proper location and installation of injection ports are required in order to properly mix the test agents.

5.2 Sampling Probes. Proper location and installation of sampling probes is required to complete the testing.

5.3 Lighting. Adequate lighting is required both inside and outside the filter system.

5.4 Electrical Power. A minimum of 20 amps, at 120 volts is required.

6.0 TEST METHODS

6.1 HEPA Filters Systems. Figure 1 shows the setup for testing a multi-stage filter system as one unit rather than the stage-by-stage photometer method used in conventional testing. A challenge aerosol is generated upstream of the filter system and allowed to mix thoroughly with

the airstream. Aerosol samples from the airstream through probes both upstream and downstream of the filter system are analyzed with the SPS. With this method the penetration of the filter system can be calculated as a function of particle size. Because of high particle concentration which is required to evaluate the performance of filter systems, it is necessary to dilute the upstream aerosol sample to avoid coincidence counting errors. A schematic of the diluter is shown in Figure 2.

The aerosol should be heterodisperse, spanning the diameter range of 0.1 to 1.0 micrometers. The required upstream concentration is 2×10^6 particles per cubic centimeter, or about 30 micrograms per liter (assuming unit density) to properly evaluate a two-stage HEPA filter system. A schematic of the aerosol generator is shown in Figure 3.

The maximum penetration for one HEPA filter stage is 5×10^{-4} , for two filter stages in series, 2.5×10^{-7} is required. If the filter system fails the tests, then a series of additional tests is required to identify and correct the problem.

6.2 Adsorbers. Adsorber stages are tested individually to establish remaining adsorption capacity and the presence of leaks that may have developed under service conditions. The test method utilizes a refrigerant gas (Freon 11, Fluorotrichloromethane) as the test agent in accordance with procedures of Section 12, ANSI/ASME, N-510. Analysis of the gas both upstream and downstream is accomplished with a gas chromatograph using a detector. The maximum penetration for adsorber systems is 1×10^{-3} .

6.3 Portable Filtered Exhaust. Portable filtered exhaust systems are used primarily for asbestos removal operations. Maximum penetration for these systems is 5×10^{-4} .

7.0 TEST PROCEDURE (HEPA)

7.1 Calibration (SPS). Calibration should be performed periodically (2 times per month), or more frequently if the system encounters rough handling. The calibration consists of testing the SPS with two sizes of

Poly Styrene Latex Spheres (PSLS), 0.1 and 0.3 micrometers traceable to the National Institute of Standards Technology (NIST). One of the calibration aerosols should have a particle size within 0.05 micrometers of the second or third channel boundary of the SPS. If the SPS cannot be adjusted to within the calibration limits, the SPS shall be returned to the manufacturer for repair and calibration. Appendix A describes a procedure for calibration. A schematic diagram of the PSL generator is shown in Figure A-2.

7.1.1 Aerosol Diluter. Calibration of a diluter is very similar to that of the filter penetration test measurement. However, generation of lower particle concentrations is required for the diluter calibration rather than for the actual filter test. If more than one diluter stage is used, each must be calibrated independently. The dilution ratio (DR) for each stage can be calculated by the equation in 7.1.2. The procedure for calibration is described in Appendix B. Figure 4 shows diluter calibration histogram.

7.1.2 DR Calculations.

$$DR = (\text{Sum } C_u) (i) / (C_d (i))$$

where C_u and C_d refer to the concentration of particles of the undiluted to the diluted portion of the aerosol in each of the size intervals. Concentrations are determined by dividing the particle counts in the specified interval by the total sample volume of the SPS.

7.2 Background. Because of the expected low concentrations of test particles penetrating two stages of HEPA filters, it is required to measure the concentration of non-test particles in the airstream as a background sample. With no aerosol generation and no sample dilution, samples are collected with the SPS from downstream of two filter stages. The sampling times may vary depending on the accumulated particle counts; a 20 minute sample is usually sufficient.

7.3 Challenge Aerosol. Generate the test aerosol and accumulate samples from the upstream probe through the diluter and establish the challenge concentration. The concentration is calculated by the equation in 7.4. The required concentration to properly evaluate a two-stage filter system is 2×10^6 particles per cubic centimeter, and for one-stage the concentration is 2.5×10^5 .

7.4 Calculations (Challenge Conc.).

$$\text{Conc} = (C_u)(i) * (DR)(i) / V * T$$

where C_u refers to the particle counts of the challenge aerosol, DR is the dilution ratio, V is the sample volume, T refers to the time, and i refers to the size interval.

7.5 Downstream Sampling. Collect samples of the test aerosol through the downstream probe. Sampling time periods should be selected to yield net particle counts over background of at least 50. At least two samples should be taken to insure representativeness. The difference between counts of two successive samples should not exceed 0.50 of the larger count. With the one-stage system, shorter sampling times may be used than with two-stages because of higher particle concentrations. If coincidence counting is suspected (above 3000 particles per second), the diluter must be used.

7.6 Calculations (PEN).

The Penetration is calculated by:

$$\text{Pen} = [\text{Sum } C_d(i) - B_d(i)] / C_u(i)$$

where $B_d(i)$, $C_d(i)$, and $C_u(i)$ denote the particle concentration in the i th size interval for the background, downstream, and upstream samples, respectively. Figure 5 shows an example of system penetration.

8.0 TEST PROCEDURE (ADSORBERS)

8.1 Challenge Agent. Freon 11 gas is injected into the upstream side of the adsorber system at a rate of 0.50 liters per minute per 1000 CFM of system volume.

8.2 Upstream and Downstream Sampling. Samples are collected in separate mylar bags upstream and at a point downstream where satisfactory mixing of the gas is accomplished or, direct measurements are made with a suitable gas chromatography in place.

8.3 Analysis. The content of each bag is determined by gas chromatography in accordance with ANSI/ASME, N-510, Section 12.

9.0 SUMMARY OF TESTS

Listed below is a summary of all filter systems tested in 1989. The summary includes number of systems that passed the tests, how many failed, and how many were retested.

TABLE I

9.1 Main Exhaust and Supply Filter Systems

9.1.1	Passed Test _____	106
9.1.2	Failed Test _____	11
9.1.3	Retested _____	11

9.2 Adsorber Systems

9.2.1	Passed Test _____	2
9.2.2	Failed Test _____	0
9.2.3	Retested _____	0

9.3 Portable Filtered Exhausters

9.3.1	Passed Test _____	13
9.3.2	Failed Test _____	4
9.3.3	Retested _____	4

10.0 IN-PLACE TEST RESULTS

Listed below are the test results of all in-place tests for 1989. The performance of each filter system is expressed as fractional penetration, across one stage and across both stages as one single unit.

TABLE II

<u>HSE NO</u>	<u>ENG NO</u>	<u>LOCATION</u>	<u>FIL CHG DATE</u>	<u>TEST DATE</u>	<u>PEN 1ST</u>	<u>PEN 1 & 2</u>
100	FE-1	TA-2-1	02/15/89	02/17/89	2.9E-4	
110	FE-2	TA-2-1		02/17/89	5.1E-5	
140	FE-14	TA-3-29	09/20/89	10/02/89	3.1E-5	5.1E-7
150	FE-15	TA-3-29		10/02/89	5.2E-6	1.4E-8
180	FE-19	TA-3-29		10/03/89	3.5E-16	
190	FE-28	TA-3-29		10/04/89	3.6E-5	5.2E-8
200	FE-29	TA-3-29	04/08/88	10/09/89	4.1E-5	2.2E-7
230	FE-32	TA-3-29		06/27/89	4.7E-4	1.7E-7
240	FE-33	TA-3-29	09/29/88	10/10/89	4.2E-5	2.2E-7
250	FE-34	TA-3-29	10/09/89	10/11/89	3.3E-5	
260	FE-35	TA-3-29	10/09/89	10/11/89	2.1E-5	
690	FE-7	TA-21-5	02/20/89	02/24/89	3.6E-4	
820	FE-17	TA-50-1		12/14/89	7.5E-5	
850	FE-3	TA-50-1	03/17/89	03/22/89	1.3E-5	5.5E-9
860	FE-3	TA-50-1		04/14/89	1.0E-5	2.0E-8
890	FE-2	TA-50-1	03/01/89	03/09/89	1.0E-4	5.2E-8
900	FE-1	TA-50-69		02/09/89	3.3E-5	
1120	FE-27	TA-50-1		03/22/89	2.0E-5	
1130	FE-23	TA-50-1		03/30/89	6.0E-5	
1140	FE-1	TA-50-69		03/30/89	2.0E-5	
1150	FE-3	TA-50-69		03/28/89	3.0E-5	1.2E-8
1170	FE-3	TA-53-M	04/13/89	04/14/89	7.1E-4*	
1180	FE-2	TA-53-7	04/17/89	04/17/89	3.2E-5	
1190	FE-1	TA-54-2		07/11/89	6.9E-5	
1210	FA-801	TA-55-4		09/28/89	7.9E-5	1.3E-7
1220	FA-802	TA-55-4		09/27/89	9.5E-5	5.0E-9
1230	FA-803	TA-55-4		10/16/89	5.0E-5	7.3E-8
1240	FA-804	TA-55-4		10/17/89	9.4E-4*	9.7E-7
1240	FA-804	TA-55-4		11/13/89	1.1E-5	
1250	FA-805	TA-55-4		10/10/89	1.8E-5	1.4E-8
1260	FA-806	TA-55-4		10/10/89	3.0E-5	2.1E-8
1270	FA-807	TA-55-4		10/11/89	5.7E-5	6.4E-8
1280	FA-808	TA-55-4		10/11/89	6.8E-6	1.0E-7
1290	FA-809	TA-55-4		10/24/89	6.9E-5	1.7E-7
1300	FA-810	TA-55-4		10/24/89	2.2E-5	1.3E-7
1310	FA-811	TA-55-4		10/18/89	4.7E-4	9.7E-8
1320	FA-812	TA-55-4		10/18/89	4.7E-4	9.7E-8
1330	FA-820	TA-55-4		10/18/89	6.3E-5	7.4E-8

TABLE II (Continued)

<u>HSE NO</u>	<u>ENG NO</u>	<u>LOCATION</u>	<u>FIL CHG DATE</u>	<u>TEST DATE</u>	<u>PEN 1ST</u>	<u>PEN 1 & 2</u>
1340	FA-821	TA-55-4		09/27/89	4.4E-5*	1.6E-6*
1340	FA-821	TA-55-4	09/29/89	10/02/89	3.3E-5	2.8E-8
1350	FA-822	TA-55-4		10/16/89	6.6E-5*	3.3E-7
1350	FA-822	TA-55-4		10/16/89		1.7E-7
1350	FA-822	TA-55-4	12/07/89	12/12/89	4.0E-5	4.6E-8
1360	FA-823	TA-55-4		10/17/89	6.6E-5	1.4E-7
1370	FA-828	TA-55-4		10/20/89	1.0E-5	1.0E-8
1380	FA-829	TA-55-4		10/11/89	3.3E-6	8.5E-8
1390	FA-840	TA-55-4		10/24/89	1.7E-4	
1400	FA-841	TA-55-4	04/15/89	10/24/89	2.3E-4	
1410	FA-850	TA-55-4	03/02/89	03/07/89	1.4E-7	1.2E-8*
1420	FA-851	TA-55-4		03/07/89	1.5E-7	6.6E-8*
1430	FA-852	TA-55-4		03/08/89	5.1E-5	1.5E-8
1440	FA-853	TA-55-4		03/09/89	3.8E-5	6.8E-8
1450	FA-854	TA-55-4		03/09/89	1.0E-5	1.6E-7
1460	FA-855	TA-55-4		01/10/89	3.6E-6	3.7E-7*
1460	FA-855	TA-55-4	01/11/89	01/07/89		7.2E-9
1470	FA-856	TA-55-4		01/08/89	5.0E-6	7.1E-7*
1470	FA-856	TA-55-4	03/02/89	03/03/89	2.6E-6	1.4E-7
1480	FA-857	TA-55-4	10/06/89	10/06/89	6.0E-6	3.0E-7*
1480	FA-857	TA-55-4	10/08/89	10/17/89		1.4E-8
1490	FAS-870A	TA-55-4		11/06/89	5.2E-5	
1500	FAS-870B	TA-55-4		11/06/89	3.3E-5	
1510	FAS-871A	TA-55-4		11/06/89	4.1E-6	
1520	FAS-871B	TA-55-4		11/06/89	2.2E-6	
1530	FAS-872A	TA-55-4		11/07/89	1.6E-6	
1540	FAS-872B	TA-55-4		11/07/89	1.1E-6	
1550	FAS-873A	TA-55-4		11/07/89	3.4E-5	
1560	FAS-873B	TA-55-4		11/07/89	3.6E-6	
1570	XB-103	TA-55-4		03/15/89	3.8E-5	
1580	XB-104	TA-55-4		03/15/89	1.7E-4	
1590	XB-105A	TA-55-4		03/14/89	3.7E-6	
1600	XB-105B	TA-55-4		03/14/89	1.7E-4	
1620	XB-107A	TA-55-4		03/20/89	3.0E-5	

TABLE II (Continued)

<u>HSE NO</u>	<u>ENG NO</u>	<u>LOCATION</u>	<u>FIL CHG DATE</u>	<u>TEST DATE</u>	<u>PEN 1ST</u>	<u>PEN 1 & 2</u>
1630	XB-107B	TA-55-4		03/20/89	3.2E-6	
1640	XB-109	TA-55-4		03/20/89	3.8E-6	
1650	XB-110	TA-55-4		03/20/89	5.5E-5	
1660	XB-111A	TA-55-4		03/20/89	1.1E-5	
1670	XB-111B	TA-55-4		03/20/89	1.8E-6	
1690	XB-221	TA-55-4		03/14/89	2.0E-6	
1710	XB-114	TA-55-4		03/14/89	3.0E-7	
1720	XB-115B	TA-55-4		05/12/89	8.1E-7	
1730	XB-118	TA-55-4		03/16/89	1.0E-7	
1790	XB-223	TA-55-4		03/18/89	2.1E-6	
1840	XB-204A	TA-55-4		03/15/89	9.1E-7	
1850	XB-204B	TA-55-4		03/15/89	4.2E-6	
1860	XB-206A	TA-55-4		03/10/89	5.7E-7	
1870	XB-206B	TA-55-4		03/13/89	3.8E-7	
1880	XB-207	TA-55-4		03/16/89	3.2E-6	
1890	XB-208	TA-55-4		03/15/89	1.5E-5	
1900	XB-209A	TA-55-4		03/14/89	2.0E-6	
1910	XB-209B	TA-55-4		03/14/89	8.3E-7	
1920	XB-215A	TA-55-4		03/15/89	5.8E-6	
1930	XB-215B	TA-55-4		03/15/89	2.0E-6	
1940	XB-216	TA-55-4		03/16/89	3.6E-6	
1950	XB-217	TA-55-4		03/16/89	2.2E-6	
1960	XB-218	TA-55-4		03/14/89	3.6E-6	
1990	XB-220A	TA-55-4		03/14/89	2.2E-6	
2000	XB-220-B	TA-55-4		03/20/89	3.5E-5	
2020	XB-302	TA-55-4		03/21/89	4.7E-5	
2030	XB-304	TA-55-4		03/21/89	9.1E-6	
2040	XB-303A	TA-55-4		03/21/89	1.0E-6	
2050	XB-306A	TA-55-4		03/21/89	1.3E-6	
2070	XB-303B	TA-55-4		03/15/89	4.3E-6	
2090	XB-402	TA-55-4		03/27/89	2.0E-6	
2110	XB-401	TA-55-4		03/27/89	3.2E-6	
2140	XB-412	TA-55-4		03/15/89	3.5E-6	

TABLE II (Continued)

<u>HSE NO</u>	<u>ENG NO</u>	<u>LOCATION</u>	<u>FIL CHG DATE</u>	<u>TEST DATE</u>	<u>PEN 1ST</u>	<u>PEN 1 & 2</u>
2150	XB-478	TA-55-4		03/27/89	6.2E-6	
2220	XB-213	TA-55-4		03/14/89	5.5E-7	
2850	XB-308	TA-55-4		03/22/89	2.4E-5	
2870	FE-37	TA-48-1		12/18/89	2.5E-1&	
2880	FE-40	TA-48-1		12/14/89	1.6E-1&	
2990	BE-EXH	TA-35-213		05/11/89	6.3E-5	
3980	FE-1	TA-50-69	03/30/89	03/30/89	4.2E-4	1.2E-8
3980	FE-2	TA-50-69	04/05/89	0405/89/	1.6E-5	
5870	FA-854SR	TA-55-4		01/11/89	6.2E-6	1.3E-8#
5880	FA-855SR	TA-55-4		01/11/89	8.6E-6	2.5E-8#
6000	XB-390	TA-55-4		03/22/89	2.1E-7	
6010	XB-393	TA-55-4		03/22/89	4.2E-6	
6070	XB-113-A	TA-55-4		03/16/89	2.2E-6	
6080	XB-113-B	TA-55-4		03/16/89	3.1E-6	
6150	FE-1	TA-3-141		12/07/89	6.5E-4*	
6170	FE-3	TA-16-W200		04/18/89	3.7E-4	
6180	FE-1	TA-35-213		04/29/89	2.1E-5	
6210	FE-1	TA-59-OH1		04/05/89	2.2E-6	
6220	FE-2	TA-50-37		12/05/89	3.7E-6	7.1E-10
6230	FE-2	TA-59-37		12/04/89	1.1E-5	1.5E-8
6240	FE-2	TA-50-37		12/05/89	7.1E-6	7.0E-10
6250	FE-2	TA-50-37		12/05/89	2.2E-6	1.1E-9
6770	GB-1472	TA-55-4		12/20/89	2.9E-4	

* Systems Failing Test

Measurements Across Filter Stage 2&3

% Measurements Across Filter Stages 3,4

& Aerosolve 95 Filter Systems

11.0 IN-PLACE TEST RESULTS (ADSORBERS)

TABLE III

<u>HSE-NO</u>	<u>ENG-NO</u>	<u>LOCATION</u>	<u>ADSORB CHG</u>	<u>TEST DATE</u>	<u>PEN</u>
290	FE-66	TA-3-29		06/30/89	2.0E-3*
160	FE-3	TA-50-37		04/25/89	7.2E-4
OMEG-1		TA-2-1	06/06/88	07/21/89	5.0E-4
6210	FE-1	TA-59-OH1	04/04/89	04/04/89	8.0E-3 8.0E-1*

* Systems Failing Tests

12.0 PORTABLE FILTER SYSTEMS

TABLE IV

<u>SYST-NO</u>	<u>ENG-NO</u>	<u>LOCATION</u>	<u>FILTER CHG</u>	<u>TEST DATE</u>	<u>PEN</u>
HSE-7	Demo	TA-52-1	10/11/89	10/12/89	6.6E-5
53125	Pan Am	TA-59-1	06/04/89	06/05/89	3.4E-6
HSE-7	Demo	TA-50-1	06/28/89	06/28/89	1.4E-5
54776	Pan Am	TA-59-1	04/21/89	04/21/89	1.3E-5

13.0 SUMMARY

The penetrations across one or more filter stages did not change significantly from the previous year. In fact, the penetrations were lower in the particle size where you would expect the greatest penetration; i.e., 0.18 μm for one filter stage and 0.15 μm for two stages in series. This was observed, especially when the test was conducted across two filter stages.

We continue to experience some problems in the particle transition processes of the aerosol dilution system. The problem appears

to be in the capillary reaction tube where the diluted aerosol mixes with the clean air, resulting in particle losses that are not consistent with particle size. Improvements have been made to smooth out and streamline the particle sampling contours in the aerosol diluter. This should help reduce the particle losses.

Improvements in our smaller Laskin type aerosol generators have been made by installing a small electric heater at the outlet of the generator to vaporize the large particle, resulting in higher output and uniform aerosol.

14.0 CONCLUSIONS

Although, there were less in-place test failures than the previous year, in most cases, the majority of failures were caused by inadequate sealing of the filters to the filter frame. Acid residue that accumulates on HEPA filter systems will continue to pose problems of filter sealing if this residue is not removed during filter changes. All filter systems that failed the in-place test were repaired and retested with satisfactory results.

REFERENCES

1. In-Place Testing of Multiple-Stage Filter Systems Without Disruption of Plant Operations at the Plutonium Facility at Los Alamos, 18th DOE Nuclear Airborne Waste Management and Air Cleaning Conference, 1984.
2. DOE Nuclear Standard NEF 3-41, In-place Testing of HEPA Filter Systems by the Single-Particle, Particle-Size Spectrometer Method, September 1986.
3. Quality Assurance, Inspection and Testing of HEPA Filters, REF 3-43, 1986.
4. American National Standards Institute/American Society of Mechanical Engineers, N-510, 1989.

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APPENDIX A

SPS Calibration

The calibration procedure uses an aerosol having all particles of one size. An aerosol of PSLs is generated using a compressed-air nebulizer. The nebulizer is contained in a metal box with two chambers for diluting and drying the aerosol, an air pressure regulator, a dilution air control valve, and rotometer to meter the gas flow.

A schematic view of the calibration is shown in Figure A-1. The aerosol generator must be connected to a compressed-air source capable of allowing the generator's pressure regulator to deliver about 15 l/min (STPP of air at 10 psi). The compressed-air source should not deliver any water droplets to the generator. If this is a concern, a water trap should be used ahead of the generator. The generator's output is connected directly to sample inlet of SPS. The nebulizer is a DeVilbiss glass nebulizer that plugs into the rubber stopper in the dilution chamber. The nebulizer has small internal passages for the air jet and the feed tube. These passages can become plugged if the PSL suspension is allowed to dry in the nebulizer. Upon completion of the calibration check, flush out the nebulizer with clean distilled water.

Figure A-1. Schematic diagram of the PSL calibration generator.

APPENDIX B

Diluter Calibration

The calibration of the aerosol diluter is very similar to that of the filter penetration measurement. Generation of lower particle concentration is required for the calibration. It is preferable, but not mandatory, to generate the aerosol in a separate flow system different than the filter system to prevent unnecessary loading of the filters. If more than one diluter is required, each must be calibrated independently. The diluter calibration procedure is as follows:

- B-1. Connect the diluter inlet to the flow system with an absolute filter cartridge between the flow duct and the diluter. With this arrangement and no aerosol generation, accumulate a background sample with the SPS. Background particle counts are most likely due to leaks in the diluter system and must be eliminated before proceeding.
- B-2. Connect the diluter calibrator to the flow system and generate the test aerosol having concentrations below that which is used for the actual filter tests. Open the line between the two absolute filters, and allow the reduced aerosol to enter the upstream side of the diluter and accumulate samples with the SPS from the sample probe. The aerosol concentration should be below that which causes coincidence in the SPS.
- B-3. Change to the downstream position of the diluter and accumulate particles of the diluted aerosol. Note the ΔP across the diluter stage and establish the dilution ratio. The dilution ratio for each size interval can be calculated by the equation in Section 7.1.2.

Figure B-1. Diluter Calibration Histogram.

Figure 1. Typical In-Place Test Arrangement.

Figure 2. Aerosol Diluter.

Figure 3. Aerosol Generator.

Size-um	Size-um	30		1200		1200		Pen 05162	Pen 05162
		System Challenge	Total Challenge	Oil Ratio	1200 05 162	Part Cts	Pen 05162		
0.065	0.0675	1020	2192300		20		340 6.37E-06	0.637258	
0.07	0.0725	1096			13		341 6.61E-06	0.661096	
0.075	0.0775	1306			14		343 5.57E-06	0.556725	
0.08	0.0825	1417			20		400 5.7E-06	0.570484	
0.085	0.0875	1496			18		444 5.93E-06	0.593249	
0.09	0.0925	1693			19		422 6.94E-06	0.496915	
0.095	0.0975	2425			19		514 6.25E-06	0.425250	
0.1	0.105	3307			24		740 4.45E-06	0.445323	
0.11	0.115	4115			19		706 3.00E-06	0.300315	
0.12	0.125	6770			0		716 3.09E-06	0.300707	
0.13	0.135	5490			0		604 2.26E-06	0.22584	
0.14	0.145	6226			10		500 1.64E-06	0.163963	
0.15	0.155	7019			1		467 1.30E-06	0.130315	
0.16	0.165	6506			4		209 9.13E-07	0.091262	
0.17	0.175	6064			1		230 7.2E-07	0.072030	
0.18	0.185	7067			1		183 5.37E-07	0.053683	
0.19	0.195	7272			4		132 3.67E-07	0.03667	
0.2	0.2125	17006			2		160 1.94E-07	0.019306	
0.225	0.2375	13408			1		60 9.12E-08	0.009115	
0.25	0.125	9963			4		12 1.67E-08	0.001675

Figure 4. Example of Filter System Penetration Histogram.

END

**DATE
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