TITLE: IN-PLACE FILTER TESTING SUMMARY

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IN-PLACE FILTER TESTING SUMMARY

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MARCH 1988

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PREFACE

In-place testing of high efficiency filter and chemical adsorber systems at the Los Alamos National Laboratory is in support of the Laboratory's airborne waste management programs. Periodic in-place filter system testing along with Health Physics air sampling will verify that the air cleaning systems are maintaining acceptable air cleaning levels. These periodic evaluations will ensure that the plant and the surrounding environment will be free of any significant radioactive particulates and chemical hazards from processing effluents.

The purpose of this report is to acquaint the reader with the methods and procedures, and provide an overview of system performance and what corrective measures are required when a system fails the in-place test.

1.0 INTRODUCTION

The most common method of identifying particle penetration through a filter or adsorber system is through the performance of a periodic penetration test, i.e., in-place test or leak test using an aerosol or gas vapor to challenge the filter or adsorber system. The aerosol is usually formed by vaporization of a liquid, di-2(ethylhexyl sebacate) (DEHS), and allowed to condense to form liquid particles of a certain size and distribution. The gas vapor is formed by vaporization of Freon 11 liquid. The periodic penetration test, although conducted annually, can and has been demonstrated to show the beginning degradation of a filter or adsorber system. Other evidence of penetration can include detection of radiation downstream of the filter system or the existence of an unusually low pressure drop across the filter, i.e., torn filter, etc. However, these kinds of occurrences show up instantaneously and could release radioactive material to the atmosphere before the systems could be shut down. When a filter system fails the in-place test or is showing evidence of filter or component degradation, corrective measures are put into place in order to return the system back to its best operating condition.

The utilization of a single particle, particle size spectrometer (SPPSS) has improved considerably the capability of evaluating the overall effectiveness [i.e. decontamination factor (DF)], of filter systems consisting of one or more stages of HEPA filters against submicrometer aerosols in distinct particle size ranges. This method has more application for testing of systems with multiple stages, but is also used for single filter and other filter applications.

A policy statement for in-place testing was written and put into practice on December 31, 1987. The statement addresses test frequencies, training requirements for filter changes, and general in-place test practices.

It is the policy of HSE-5 to address, whenever possible, the testability requirements of air cleaning systems during the design stages of a new system. However, there exist some older filter systems with

inadequate equipment factors for in-place testing. These deficiencies invariably add to the time required to perform the tests and are the primary factors that add to the uncertainties of the test results.

This report presents a summary of all tests including the test results of all the filter, adsorber, and portable exhaust systems.

2.0 TESTING SCHEDULE

Schedules are prepared and sent out to involved groups 2 weeks in advance, notifying them of the impending in-place tests. The schedules are normally flexible and our policy has been to work around operational conflicts.

3.0 POLICY FOR IN-PLACE TESTING

A new policy for in-place testing has been established and made effective December 31, 1987. The policy addresses the following:

3.1 TEST FREQUENCY: Each filter system, including entry boxes handling toxic airborne materials, i.e., plutonium, enriched uranium, beryllium, and asbestos will be tested annually.

3.2 NEW INSTALLATIONS: All new filter installations handling toxic materials will be tested before starting any operations.

3.3 FILTER CHANGE: All systems containing HEPA or Aerosolve 95 type filters will be tested within 2 working days of the filter change, except for glove boxes.

3.4 OTHER FILTER SYSTEMS: Testing of filter systems handling less toxic materials, i.e., depleted uranium, lead, etc., will be determined on a case-by-case basis.

3.5 SUPPLY SYSTEMS: Filtered supply air systems will currently be tested only at TA-55 and the new Nuclear Storage Facility.

3.6 GLOVE BOXES: No routine tests will be performed on glove box filters except for new installations, i.e., "cold boxes."

3.7 TRAINING: New policy requires training of individuals whose job is to change filters in filter systems. Previous procedures created problems with handling and replacing of filters. These problems, i.e., damaged or incorrectly installed filters, etc., often caused filter systems to fail the in-place test. The projected cost of filter replacement operations often increased because the change-out crew would have to enter the contaminated area to adjust or install new filters simply to satisfy the requirements of the in-place test.

Three training programs have been evaluated to-date. Pan Am, "HEPA Filter Training Course," Group HSE-7, SRF, "Change-Out HEPA Filters in Bag-In, Bag-Out Systems," and MST-8, "Replacing a HEPA Filter." The conclusions drawn from these evaluations indicate a good start in the implementation of these programs and the planned follow-up of periodic recertification.

4.0 DEFINITIONS

4.1 DECONTAMINATION FACTOR (DF): A measure of air cleaning effectiveness; 100 times the reciprocal of percent penetration.

4.2 DILUTER: A device used to reduce the aerosol concentration below the acceptable limit of the the SPPSS. This limitation is imposed by the occurrence of coincident counting when more than one particle occupies the sampling volume of the SPPSS at a time.

4.3 DILUTION RATIO: The ratio of the undiluted aerosol concentration entering the diluter to the sample drawn after one dilution stage.

4.4 SPPSS: An aerosol spectrometer designed and applied towards counting and sizing particles in size ranges of 0.09-3.0 micrometers. The SPPSS isolates a small volume of particle-laden air to size single

particles in separate storage channels. This provides a quantitative particle size distribution over a measured sample volume.

4.5 OTHER: Other terms pertinent to this report are defined in the reference material, more specifically in the Standard, ANSI/ASME N510¹ and the DOE Standard NEF 3-41T².

5.0 TESTABILITY REQUIREMENTS

Several older air cleaning systems have been identified as lacking proper equipment parameters to conduct a satisfactory in-place test. These parameters include:

5.1 LIGHTING: Insufficient lighting inside or outside the filter system.

5.2 OBSERVATION PORTS: Provisions are needed for communication and observation of activities inside the filter plenum, and/or to monitor the filters and components.

5.3 INJECTION PORTS: Proper location and installation of injection ports is required in order to properly mix the test aerosols.

5.4 ELECTRICAL POWER: A minimum capacity of 20 amperage, 115 volt electrical power is required for operation of aerosol generators.

6.0 TEST METHODS

6.1 HEPA FILTER SYSTEMS (Multiple Stages): Shown in Figure 1 is the arrangement for testing a double stage filter system as one unit using the SPPSS method. Sampling manifolds are permanently installed inside the filter housing, upstream of first stage between the stages and downstream of the second stage before the fan. Testing of these systems does not require disruption of any plant operations³.

6.11 Background Particles: Because of the expected small concentration of test particles that penetrate two stages of filtration, it is necessary to determine the concentration of non-test particles, i.e., dust particles known to occur inside filter housings. This value is ultimately subtracted from the actual test particle concentration.

6.12 Aerosol Generation: Generate test aerosol for approximately 5 minutes before sampling so that the generator can achieve a stable operating level.

6.13 Downstream Of Second Stage: Collect samples in each of the three size ranges of the SPPSS. Sampling times should be selected to yield net counts of at least 100 and at least two sampling runs should be made to ensure representativeness of the samples. Difference between counts of two successive samples should not exceed 50 percent of the larger count. The minimum acceptable DF is $4.0E6$.

6.14 Downstream Of First Stage: Collect samples in each of the three size ranges. Shorter sampling time may be necessary because of the expected higher particle concentration. The minimum acceptable DF for one stage is $2.0E3$.

6.15 Upstream Measurements: Because of the high particle concentrations, it is necessary to dilute the sample. This is accomplished by drawing a upstream sample from the filter housing, through the diluter to establish a dilution factor (ratio of the undiluted to the diluted aerosol, Figure 2). When this factor is determined it is entered into the microprocessor and computed with the rest of the data. Sampling times are relatively short (10 sec) in each of the three size ranges.

6.16 Calibration: The SPPSS is calibrated a least every 6 months or after every use especially if the instrument was subjected to rough handling. The instrument is calibrated with polystyrene latex microspheres (PSL) having geometric mean diameters of 0.220 and 0.312 micrometers and a geometric standard deviation of 1.5. The PSL is traceable to NBS.

6.2 ADSORBERS: Adsorbers are tested to verify the adsorption capacity of the activated charcoal. The test consists of challenging the upstream side of the adsorber with a concentration (20ppm) of Freon 11 (Trichloro-mono Fluoromethane), and then determining the concentration immediately upstream and at a point downstream where satisfactory mixing of the gas vapor with the system air is accomplished. Samples of these locations are collected in mylar bags. The content of each bag is determined by gas chromatography in accordance with procedures (Sect: 12 ANSI/ASME, N-510). Permissible per cent penetration (leak rate) across the adsorber system is 0.1%. The performance of these systems are shown in Table III.

6.3 PORTABLE FILTERED EXHAUST: Portable filtered exhaust systems are used primary for asbestos demolition and removal operations. All of these systems are commercially available from several manufactures⁵. Testing these types of systems is recommended to assure that they perform satisfactory. The air cleaning performance of these systems, shown in Table 1V, will vary from manufacturer to manufacturer.

7.0 SUMMARY

The following is a summary of all the filter systems tested. The summary includes total number tested, how many failed the test, and how many were retested.

Table I

7.1 Main Exhaust and Supply, HEPA Filter Systems

7.11 Filter stages tested.....	175
7.12 Failed test.....	32
7.13 Retested.....	24

7.2 Other Filtration, Aerosolve 95:

7.21 Number tested.....	5
7.22 Failed test.....	4
7.23 Retested.....	1

7.3 Adsorbers:

7.31 Number tested.....	3
7.32 Failed test.....	1
7.33 Retested.....	0

7.4 Portable Filtered Exhaust:

7.41 Number tested.....	7
7.42 Failed test.....	5
7.43 Retested.....	5

8.0 IN-PLACE TEST RESULTS

Table II

System performance will be expressed as DF values, across one stage, and across both stages as one unit.

HSE- NO.	FAN NO.	LOCATION	FILTER CHANGE	TEST DATE	(DF) 1ST	2ND
140	FE-14	TA-3-29		2-13-87	2.1E4	1.3E8
0150	FE-15	"		1-12-87	3.9E3	2.8E6
"	"	"		1-13-87	6.7E3	4.4E6
"	"	"	2-27-87	3-02-87	1.4E4	3.1E7
"	"	"	"	3-04-87	2.5E4	5.5E7
"	"	"	"	"	2.4E4	
160	FE-17	"		4-13-87	2.8E3	
170	FE-18	"		"	3.3E4	
180	FE-19	TA-3-29		2-24-87	3.2E0	
"	"	"		2-24-87	3.4E0	
190	FE-28	TA-3-29		2-23-87	1.3E4	2.0E7
"	"	"		8-05-87	1.2E3	
200	FE-29	"		2-06-87	1.1E4	5.4E5
"	"	"		2-11-87	1.4E4	1.1E7
210	FE-30	"		2-18-87	4.0E5	
220	FE-31	"		2-18-87	1.4E4	
230	FE-32	"		2-24-87	2.4E5	1.2E7
240	FE-33	"		2-6-87	7.1E3	1.0E5
"	"	"		2-11-87	2.3E4	1.1E8
250	FE-34	"		2-25-87	3.8E4	
260	FE-35	"		3-11-87	2.2E5	
270	FE-42-1	"		3-24-87	3.2E4	
280	FE-42-2	"		3-24-87	5.4E4	
290	FE-66	"		1-12-87	5.4E3	
300	FE-42-3	"		3-24-87	2.9E5	

HSE- NO.	FAN NO.	LOCATION	FILTER CHANGE	TEST DATE	(DF) 1ST	2ND
310	FE-41-1	"		"	8.0E4	
320	FE-41-2	"		"	2.1E5	
330	FE-41-3	"		"	1.1E5	
340	FE-40-1	"		"	7.0E4	
350	FE-40-2	"		"	2.7E4	
360	FE-40-3	"		"	4.6E2	
370	FE-40-4	"		"	2.1E3	
380	FE-40-5	"		"	6.2E4	
390	FE-40-6	"		"	1.2E2	
400	FE-40-7	"		"	9.0E0	
410	FE-41-4	"		"	2.3E2	
420	FE-42-4	"		"	2.6E2	
430	FE-42-5	"		"	6.3E3	
440	FE-43	"		3-25-87	2.6E2	
450	FE-44	"		"	1.0E1	
620	FE-10	TA-3-66		5-13-87	9.1E1	
840	FE-25	TA-50-1	9-20-86	5-29-87	2.2E4	
850	FE-3	"	8-5-87	8-17-87	2.1E1	
860	FE-2	"	8-10-87	8-19-87	1.5E3	3.4E6
"	"	"	8-10-87	8-20-87	3.6E3	4.4E6
950	FE-2	"	8-29-87	9-27-87	8.5E3	
960	FE-2	TA-50-37		5-14-87	4.5E4	
1100	FE-20	TA-3-29		9-3-87	1.2E0	
1120	FE-27	TA-50-1		5-29-87	1.0E4	
1140	FE-1	TA-50-69		6-4-87	1.8E3	
"	"	"		"	2.2E4	
1150	FE-3	"	6-2-87	6-4-87	8.2E4	1.2E7
1160	FE-3	TA-53-M	10-23-87	10-28-87	1.6E3	
1170	FE-3	"		5-18-87	4.6E1	
"	"	"		5-19-87	1.8E2	
1180	FE-2	TA-53-7	5-12-87	5-15-87	2.3E3	
1190	FE-1	TA-54-26	3-15-87	3-19-87	3.3E4	
1210	FA-801	TA-55-4		7-27-87	1.2E4	4.0E6
1220	FA-802	"	7-5-87	7-7-87	8.3E3	7.6E7
1230	FA-803	"		7-20-87	4.8E3	6.7E6
1240	FA-804	"		8-1-87	2.2E4	5.1E7
1250	FA-805	"	9-22-87	9-24-87	2.4E4	1.9E8
1260	FA-806	"		8-13-87	2.1E3	4.1E6
1270	FA-807	"		8-7-87	1.1E3	
"	"	"		8-11-87	8.2E2	
"	"	"		8-24-87	1.3E3	
"	"	"	9-7-87	9-9-87	5.6E4	7.6E7
1280	FA-808	"		8-17-87	3.4E3	1.3E7
1290	FA-809	"		2-18-87	1.0E4	
1300	FA-810	"		2-18-87	8.6E3	
1310	FA-811	"		9-25-87	3.2E3	2.0E7
1320	FA-812	"		9-30-87	2.5E3	6.0E6
1330	FA-820	"	9-30-87	10-4-87	1.3E4	2.5E7
1340	FA-821	"	9-21-87	9-23-87	4.7E3	1.9E7
1350	FA-822	"		8-17-87	1.2E3	4.7E6
"	"	"		8-24-87	1.9E3	
"	"	"	9-7-87	9-8-87	2.2E4	6.8E7
1360	FA-823	"	9-10-87	9-23-87	5.4E3	4.0E7

HSE- NO.	FAN NO.	LOCATION	FILTER CHANGE	TEST DATE	(DF) 1ST	2ND
1370	FA-828	"		9-14-87	2.8E5	9.3E6
1380	FA-829	"	10-9-87	10-14-87	2.3E4	1.5E7
1390	FA-840	"		2-18-87	5.8E4	
1400	FA-841	"		2-18-87	4.4E5	
1410	FA-850	"		9-20-87	3.3E4	1.5E7
"	"	"		9-20-87	3.9E4	5.6E7
1420	FA-851	"		9-22-87	2.5E4	4.2E6
"	"	"		"	2.8E4	4.0E6
1430	FA-852	"		9-27-87	4.8E3	1.2E7
"	"	"		9-28-87	4.4E4	
1440	FA-853	"		"	3.3E4	7.4E6
"	"	"		"	1.5E5	
1450	FA-854	"		9-14-87	1.5E4	8.5E6
"	"	"		"	3.4E5	
1460	FA-855	"		9-8-87	3.4E4	5.8E6
"	"	"		"	2.5E4	
1470	FA-856	"		12-1-87	6.4E4	5.5E7
"	"	"		"	2.5E5	
"	"	"	4-14-87	4-15-87	5.1E3	
1480	FA-857	"	4-02-87	4-4-87	1.2E2	
"	"	"		4-13-87	1.7E2	
"	"	"		"	3.3E3	
"	"	"	8-12-87	8-14-87	3.4E3	
"	"	"		8-21-87	6.7E3	
1490	FS-870-A	"		7-18-87	3.4E4	
1500	FS-870-B	"		"	3.2E3	
1510	FS-871-A	"		"	6.5E3	
1520	FS-871-B	"		"	1.4E4	
1530	FS-872-A	"		"	4.3E4	
1540	FS-872-B	"		"	8.7E3	
1550	FS-873-A	"		"	3.8E4	
1560	FS-873-B	"		"	7.8E3	
1700	FE-11	TA-50-37		5-13-87	3.4E4	4.4E6
1720	XB-115-B	TA-55-4		7-27-87	9.3E4	
2900	FE-2	TA-50-1		8-14-87	5.2E0	
2970	XB-4414	TA-55-4		8-1-87	1.4E2	
"	"	"	8-10-87	8-12-87	4.9E4	
2990	BE-EXH	TA-35-213		7-23-87	1.1E4	
3880	FE-3	TA-50-69	1-11-87	1-14-87	1.4E4	
3980	FE-2	"	2-9-87	2-10-87	3.6E4	4.0E5
"	"	"		2-5-87	4.3E4	1.0E5
"	"	"		2-10-87	3.1E4	3.5E7
6000	XB-386-A	TA-55-4		2-4-87	4.7E4	
6010	XB-386-B	"		"	6.6E3	
6020	XB-386-C	"		"	1.0E4	
6030	GB-386	"		2-5-87	3.9E5	
6070	XB-113-A	"	6-30-87	7-27-87	1.5E5	
6080	XB-113-B	"		"	2.4E5	
6090	GB-305	"	7-13-87	7-12-87	5.2E4	
6140	FE-26	TA-3-102	3-9-87	3-11-87	4.6E3	
6150	FE-1	TA-3-141	3-6-87	5-14-87	1.4E3	
"	"	"		"	1.4E3	
6150	FE-3	TA-50-37	2-4-87	8-12-87	3.4E4	5.6E7

9.0 PORTABLE FILTERED EXHAUST

Table III

SYSTEM NO.	LOCATION	TEST DATE	(DF) 1ST
Airmop 2000	TA-59-OH1	5-7-87	8.1E3
CRSI 2000	"	5-7-87	2.3E3
MT-C	"	5-7-87	1.1E3
Quad Air	"	5-12-87	6.5E2
Red Baron	"	5-12-87	4.3E1
Sentry 2000	"	5-13-87	8.6E0
Tri-Dem Accu	"	5-17-87	1.0E4

10.0 ADSORBERS

Table IV

HSE- NO.	FAN NO.	LOCATION	FILTER CHANGE	TEST DATE	(DF) 1ST
290	FE-66	TA-3-29		1-28-87	5.0E1
960	FE-2	TA-50-37		7-20-87	1.2E3
6160	FE-3	TA-50-37	2-4-87	9-8-87	1.0E3

12.0 TEST RESULTS DISCUSSION

The major cause of failures of the in-place test in most of the filter systems was the sealing of filters to the mounting surface. Other causes were damaged filter medium, damaged filter casing, or holes burned in the medium. In a few cases, the filters were incorrectly installed.

The most frequent recommendations made as a corrective measure for the failed filter systems was to remove and replace the existing filters, especially if the filter was dirty. If the filters are relatively clean, excluding fluid seal type, adjustment of the filter components is recommended. These corrective measures are usually effective.

During this testing period an increase of test aerosol penetration across a filter bank was observed in almost every test. This increase contributed to the failure of some filter systems that otherwise would have passed the test with a small margin of the minimum requirements,

i.e., a DF of 2,000; however, the new test indicates a DF of 1950. The incidence of the higher aerosol penetration coincides with a change in the aerosol generator design, more specifically in the liquid-vapor phase. The change of the generator design was made in order to comply with the average particle size of the aerosol as described in the Nuclear Standard NEF 3-41T¹. The standard recommends that the filter systems be challenged with an aerosol having a maximum geometric mean diameter of 0.25 micrometers. The geometric mean diameter that was used previously was 0.32 micrometers.

11.1 AEROSOL DETECTION AND GENERATION: One specific area where improvements were needed was in aerosol dilution. Our current method of making this determination is to utilize the forward light-scattering photometer interfaced with a data logger for measuring the undiluted and diluted aerosol and establishing a dilution factor as the ratio of those two values. Dilution factors by this method, computed with the upstream concentration tend to over estimate the DFs of the filter systems. The problem appears in the inability of the photometer to measure the diluted portion of the concentration within acceptable limits. We are now designing a diluter which will introduce metered clean air directly into the 1st dilution stage. The diluted aerosol will then be collected and measured by the SPPSS. Using this method will improve the accuracy of the measurements and reduce the measurement time by 25%. A schematic of the improved diluter is shown in Figure 3.

Other improvements include the redesign of the aerosol generator vapor core. Particle size diameters of the aerosol of the previously used vapor core which was made of mild steel were above the recommended maximum size of 0.25 micrometers. Also, the generator required up to 1 hour to reach operating temperature. The new vapor core utilizes one and one-half times as many vaporization slots as opposed to the one previously used and the core and the heating jacket are made of aluminum instead of steel. This new design resulted in smaller particle size diameters. The aerosol output was increased and the time to bring the generator to the operating temperature decreased. A schematic the aerosol generator is shown in Figure 4.

12.0 CONCLUSIONS

The test results indicate the procedure for testing HEPA (single and double stage) and other high-efficiency filtration by the SPPSS method has provided acceptable test data to meet the requirements of certifying certain air cleaning systems. However, some of these data suggest that improvements in aerosol dilution is needed to improve the method of establishing dilution factors. We are currently evaluating an improved aerosol air dilution system.

Testing of older filter systems that lack proper test requirements, i.e., proper location of aerosol injection ports, sampling manifolds to verify how well the test aerosol is mixing with the system air, and to collect representative samples of the test aerosol upstream and downstream of the filter system, etc⁶. Until these deficiencies are corrected, the systems will be tested as before.

We have requested that all HEPA filters be replaced if they have been in service for more than 10 years⁴. Currently there are about 12 systems with a total of 480 24" x 24" x 12" filters at the CMR Building. Filter change-out crews have recently replaced all the old filters that were in use for more than 10 years at the Plutonium Facility, TA-55.

Training of individuals who change out filters is progressing satisfactorily. During a recent filter change, no damage to the filters was observed and all the filters were installed correctly.

The percentage of filter systems that failed the in-place test this year increased by 42 per cent compared to last year. This increase of failures was possibly due to the continued deterioration of those HEPA filters that have been in service for more than 10 years. We should see those trends turn around after new filters are installed.

REFERENCES

1. Nuclear Standard NE F 3-41T, "In-place Testing of HEPA Filter Systems by the Single-Particle, Particle-Size Spectrometer Method." Department of Energy Nuclear Standards Programs (December 1981).
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Summary/N/jpo

APPENDIX A

FIGURE 1

SAMPLING MANIFOLD

IN-PLACE TESTING OF MULTISTAGE HEPA FILTER SYSTEM
AS ONE SINGLE UNIT RATHER THAN INDIVIDUAL
TESTING OF EACH STAGE

FIGURE 2

SCHEMATIC DIAGRAM SHOWING AEROSOL DETECTION
INSTRUMENTATION INCLUDING AEROSOL DILUTION

SCHEMATIC DIAGRAM SHOWING THE AEROSOL GENERATOR

FIGURE 4
SCHEMATIC DIAGRAM SHOWING AEROSOL DILUTION SYSTEM