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	1	Design Authority	J. D. Dick	5/4/99	74-20	1	1				
		Design Agent				1	1	W. F. White		5/4/99	
1	1	Cog. Eng.	J. D. Dick	5/4/99	74-20	1	1	KARL MELZACK		5/4/99	
1	1	Cog. Mgr.	G. A. Glover	5/4/99	74-20	3		Central Files		5/4/99	
1	1	QA	R. P. Groth	5/4/99	74-15	3		DOE/RL Reading Room		5/4/99	
1	1	Safety	S. E. Nunn	5/4/99	75-11						
1	1	Env.	J. E. Bramson	5/5/99	75-50	1	1				

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Test Plan for N2 HEPA Filters Assembly Shop Stock Used On PFP E4 Exhaust System

JD DICK

B&W Hanford Co., Richland, WA 99352

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Abstract: At Plutonium Finishing Plant (PFP) and Plutonium Reclamation Facility (PRF) Self-contained HEPA filters, encased in wooden frames and boxes, are installed in the E4 Exhaust Ventilation System to provide confinement of radioactive releases to the environment and confinement of radioactive contamination within designated zones inside the facility. Recently during the routine testing in-leakage was discovered downstream of the Self-contained HEPA filters boxes. This Test Plan describes the approach to conduct investigation of the root causes for the in-leakage of HEPA filters.

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Release Approval Date

Approved for Public Release

TEST PLAN FOR N2 HEPA FILTER ASSEMBLY SHOP STOCK
USED ON PFP E4 EXHAUST SYSTEM

April 26, 1999

HNF-4411, Rev. 0

(WORK PACKAGE # 99-725)

PREPARED BY: K. MERZOUK

PROCEDURE APPROVAL:

Test Director

M. K. Ullah

Date 5/3/99

HVAC Design Authority

J. D. Dick

Date 5/3/99

Engr. Manager

G. A. Glover

Date 5/4/99

Safety

J. E. NUNO

Date 5-3-99

Environmental

Date 29 Apr 1999

Quality

Date 4/27/99

TEST EXECUTION

Test Director/BWHC

Quality Control Technician/BWHC

Instrument Technician/BWHC

Vent & Balance Lead/LMHC

TEST APPROVAL AND ACCEPTANCE

Without
Exceptions _____

With Exceptions
Resolved _____

With Exceptions
Outstanding _____

HVAC Design Authority

Environmental

Quality

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1. INTRODUCTION:

Four banks of 12 self-contained HEPA filters each are being used within the PRF building (236-Z), on both E-3 and E-4 exhaust system. These filters are located within the E-3 zone (radiological control area), and provide air cleanup for contaminated exhaust stream prior to discharge to the environment.

During in-place leak testing of newly replaced self-contained filter assemblies in building 236-Z, personnel discovered air in-leakage downstream of the HEPA filter media which allowed for Zone 3 air to effectively by-pass the HEPA filter and discharge directly to the ventilation stack. The in-place leak testing was being performed using electronic sound detection equipment. An NCR has been issued, and the leaks so detected were repaired. Few weeks later, more housing leaks were detected while another field test was being conducted to verify the housing repairs.

The purpose of this work is to test the self-contained spare filters presently in the storage warehouse as follow:

- Repeat the original pressure test conducted by Flanders, at 1" positive pressure, to determine whether the filters still pass this test. Leaks detected during this test would have developed because of handling, storage conditions, or aging while in storage.
- Pressure test the filter housing at the actual field conditions, following ASME N509 and N510 requirements and recommendations, and locate all leaks using the ultrasonic leak detection probe. The results of this test will indicate whether the leaks detected in the field are inherent to the filters, or field developed.
- Conduct a pressure decay test to evaluate filter housing leakage rate. At the same time, the pressure decay test will be an indication on how well the ultrasonic probe works at detecting small leaks.

The results of the test will be analyzed, to determine the proper actions that may be required, regarding these N2 HEPA filters.

2. BACKGROUND:

A typical HEPA filters assembly unit is shown in figure 1. The housing is a 24" X 24" X 30", with a 24" x 24" x 11" deep HEPA filter, rated for 1,000 cfm at 1" wg differential pressure across the filter media. The nipples on both sides are 12" nominal diameter, stainless steel pipe. The filter housing is made of 3/4" plywood.

The filters and housings are supplied as a package from the manufacturer, then stored in a warehouse on the Hanford site, until needed for replacement. These filters are being stored as spare parts, for several years. Table 1 gives a list and year of manufacture of the filters presently in stock.

The filters were purchased in accordance with the Hanford Site Standards, section D1-163-M. The standard required flow test, and penetration test, but not a housing pressure test that reflects the field conditions.

The tests conducted by the manufacturer are described in the Flanders document # FPD-004-109/R01/29/99. A housing pressure test is conducted in the factory, in parallel with the flow test, at the rated flow conditions, therefore at 1" positive pressure, using the bubble method. This pressure is way under the actual operating conditions. Upon reception, the filter assemblies are again tested on site for flow and penetration, but not for leakage.

FIGURE 1: APPLICABLE ASME N509 SCHEME

MODEL #: FLANDER 0-007-C-04-N2-NL-00-23-Z-90477

REFERENCE DRAWING: H-2-29674

3. FIELD CONDITIONS

The installed filters that were recently pressure tested after installation are located in the four banks A, B, C and D inside the PRF building (236-Z), as equipment numbers F-A1 to F-A11, F-B1 to F-B12, F-C1 to F-C12, and F-D1 to F-D11 (drawing H-2-29674, sheet 4).

The filters are installed vertically, with flow downward. They are supported by a steel angles, hanging from the building structure with hanger rods. The 12-3/4" nipples are clamped to the field piping to provide a rigid connection, and taped over to provide a leak free connection. Figure 2 shows the location of the leaks detected during the two field surveys. Under operating conditions, the housing pressure can vary between 0 and about 7" wg negative.

TABLE 1: SPARE PARTS INVENTORY FOR N1 AND N2 SELF CONTAINED FILTERS

Shop Stock No.	Filter Fabrication Dwg./ Flander's Model No.	No. of Filters	Storage Location	Filter Vintage
<i>BUILDING 236-Z, PRF EXHAUST SYSTEM</i>				
6167-4800-1685	H-2-27716, Type I/ 0-007-C-04-N2-NL-00-23-Z-90477 or Flanders # 287613	3	ECP-C03 -A00	4/92
		4	ECP-C06-A00	4/92
		4	ECP-C07-A00	4/92
		4	ECP-C14-A00	4/92
		4	ECP-E02-A00	4/92
		1	ECP-E13-A00	4/92
		8	ECX-I08-000	4/92
		5	ECP-A03-A	4/92
		4	ECP-C01-A	4/92
		4	ECP-E12-A00	2/89
		4	ECP-E16-A00	2/89
		2	ECP-D15-B	2/89
		1	ECP-E11-A00	12/88
		2	ECP-D16-A	12/88
	TOTAL FILTERS:	50

FIGURE 2: PRESSURE TEST

4. APPROACH:

A sample of the filter assemblies being stored for future use will be selected for the test as follow:

- The three filters manufactured in 1988
- Four out of 10 filters manufactured in 1989
- Thirteen out of 37 filters manufactured in 1992

The pressure test includes two parts. The first part of the test consists in conducting a pressure test similar to the pressure test done by the manufacturer. In the event the filters fail this test, the defect could be attributed to handling, storage, aging, etc... During this test, the housing will be pressurized to 1" positive pressure, and the bubble method will be used to detect any leak.

The second test consists in testing the housing for leakage in accordance with ASME and the operating field conditions. The filter housing will be pressurized to an 8" negative pressure, and an ultrasonic leak detection method will be used to find any leaks. A pressure decay method will follow the ultrasonic to quantify the leakage rate.

The filter assembly will be installed on the test bank, with both 12-3/4" OD nipples capped off with steel caps. One cap will be fitted with a pressure indicator PI measuring directly the differential pressure DP across the housing, and temperature indicator TI

measuring the temperature of the air inside the housing. The other cap will be fitted with a smaller vacuum tube and a shut off valve (figure 3).

The details of the instrument connections are shown in figures 4 and 5.

FIG. 3a: POSITIVE PRESSURE TEST

FIG. 3b: NEGATIVE PRESSURE TEST

FIGURE 3: PRESSURE TEST SET UP

FIGURE 4: PRESSURIZATION CAP

FIG. 5: PRESSURE/TEMPERATURE GAUGES CAP

5. PRESSURE DECAY THEORY:

The housing leakage characteristics is given by relation (1):

$$Q = a * (DP)^n \quad (1)$$

Where a is a constant depending on the area on cracks, and the physical characteristics of the housing, and n an exponent depending on the geometry of cracks.

Also, using the ideal gas law, we get the housing leakage rate at the average pressure $(P_i + P_f)/2$ given by relation (2):

$$Q = (P_i/T_i - P_f/T_f) * V/(R * \Delta t * 0.075) \quad (2)$$

Where:

- Q = leakage rate in cfm
- P_i = Initial pressure, at the start of the test, in psf absolute
- T_i = Initial temperature in °R
- P_f = Final pressure in Psf absolute
- T_f = Final temperature, in °R
- V = Volume of the housing being tested, in ft³
- R = Ideal gas constant for air = 53.35 ft/°R
- Δt = time duration between P_i and P_f, in minutes

The leakage rate Q will be compared to the ASME - N510, appendix B allowable leakage rate of 0.2 % of the flow rate, or 2 cfm (based on 1,000 cfm rated capacity for the filters).

6. TEST EQUIPMENT REQUIREMENT:

- The differential pressure gauge PI shall have a range not less than 0 to 10" wg, and graduations of 0.2" wg (Example of make and model: Dwyer Magnehelic model 2010).
- The temperature gauge TI shall have a range of at least 30 °F to 130 °F, with graduations to provide for 1 °F reading (Example of make and model: Trerice model # BX91403 ½ -03).
- The test fan shall have a shut off head not less than 10" wg, to develop the necessary test pressure.

7. EQUIPMENT DATA:

This page needs to be filled only once, during the testing period of the filters, as long as the equipment used is not replaced. Refill this page again, if any of the equipment involved is replaced.

INSTRUMENT:

Measuring instrument used in the test shall be calibrated MT & E equipment. Report the following data:

Pressure gauge PI #: _____ Due date _____

PI range: _____ PI graduations: _____

Temperature gauge TI #: _____ Due date: _____

TI range: _____ TI graduations: _____

OTHER TEST EQUIPMENT:

Valve V-1 (1" quarter turn ball) make/model #: _____

Valve V-2 make/model #: _____ Size: _____

Test Fan make and model: _____ Shut off head (10" min): _____
(Attach fan curve)

Timer make/model: _____

Vent and Balance

Signature and Initials

Date:

QA Representative

Signature and Initials

Date:

Test Director

Signature and Initials

Date:

8. FILTERS TO BE TESTED:

The filters to be tested shall be as follow:

- a. The three filters manufactured in 1988
- b. Five out of 10 filters manufactured in 1989, to be specified below by serial number by the test director.
- c. Twelve out of 37 filters manufactured in 1992, to be specified below by serial number by the test director.

FILTER SERIAL #	YEAR MADE	COMMENTS
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----

_____ Vent and Balance	_____ Signature and Initials	_____ Date:
_____ QA Representative	_____ Signature and Initials	_____ Date:
_____ Test Director	_____ Signature and Initials	_____ Date:

FILTER SERIAL #	YEAR MADE	COMMENTS
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----

Test each filter completely, by performing the positive pressure leak localization test of section 9, followed by the negative pressure leak localization test of section 10, followed by the pressure decay test of section 11, in sequence, before moving to the next filter.

The test director may change the test sequence, if after consideration it was found not to have a negative impact on the conduct of the test.

_____ Vent and Balance	_____ Signature and Initials	_____ Date:
_____ QA Representative	_____ Signature and Initials	_____ Date:
_____ Test Director	_____ Signature and Initials	_____ Date:

Filter Serial Number: _____

Date of Manufacture: _____

NOTE: REPEAT PAGES 12 THROUGH 19 FOR EACH FILTER BEING TESTED. REPORT THE FILTER SERIAL NUMBER AND DATE OF MANUFACTURERE AT THE TOP RIGHT CORNER OF EACH PAGE.

9. POSITIVE PRESSURE LEAK LOCALIZATION TEST:

The purpose of this test is to conduct a housing leak test that is the same as the housing pressure test these filters have passed at the manufacturer's shop. Both vent and balance and quality control to initial each item when completed.

1. _____ Install the filter assembly on the test bank

2. _____ Cap the 12-3/4" nipples as shown in figure 3a, with one cap fitted
_____ with the pressure gauge PI and the temperature gauge TI, and the
other cap fitted with a 1" pipe and valve V-1. Verify that the
direction of test flow specified by the manufacturer is respected, by
checking the direction of the arrow on the filter housing.
3. _____ Connect V-1 to the fan as shown in figure 3a.

4. _____ Close valve V-1

5. _____ Open V-2 fully
6. _____ Start the test fan

7. _____ Open V-1 slowly until PI indicates 1" wg positive pressure inside
_____ the housing.
8. _____ Once PI is stable at 1", survey the filter assembly for leakage using
_____ the bubble soap method.
9. _____ Report leaks by marking the leak location on the attached sketches,
_____ and the leak number next to the mark. Describe leaks in the
following:

Filter Serial Number: _____

Date of Manufacture: _____

LOCATION OF LEAKS AT 1" POSITIVE PRESSURE:

TOP VIEW

RIGHT VIEW

LEFT VIEW

BOTTOM VIEW

INLET SIDE

DISCHARGE SIDE

Vent and Balance_____
Signature and Initials_____
Date:_____
QA Representative_____
Signature and Initials_____
Date:_____
Test Director_____
Signature and Initials_____
Date:

Filter Serial Number: _____

Date of Manufacture: _____

10. NEGATIVE PRESSURE LEAK LOCALIZATION TEST:

The purpose of this test is to determine housing leaks, and quantify the leakage rate, under conditions of operation. Both vent and balance, and quality control to initial each step when completed.

1. _____ Reverse the fan, as shown in figure 3b for negative pressure test.

2. _____ Reverse the location of the instrument caps to maintain the
_____ direction of test flow, and reconnect pressure gauge for negative
pressure configuration.
3. _____ Open V-2 fully

4. _____ Start the test fan

5. _____ Open V-1 slowly

6. _____ Close V-2 slowly until PI indicates 8" wg.

7. _____ Survey the filter assembly for leakage, and verify that PI is stable
_____ at 8"
8. _____ Report leaks by marking the leak location on the attached leak
_____ location sheet, and number each leak next to the mark.

Vent and Balance_____
Signature and Initials_____
Date:_____
QA Representative_____
Signature and Initials_____
Date:_____
Test Director_____
Signature and Initials_____
Date:

Filter Serial Number: _____

Date of Manufacture: _____

TEST PRESSURE: _____

LEAK #	LOCATION AND DESCRIPTION
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----

Vent and Balance_____
Signature and Initials_____
Date:_____
QA Representative_____
Signature and Initials_____
Date:_____
Test Director_____
Signature and Initials_____
Date:

Filter Serial Number: _____
 Date of Manufacture: _____

LOCATION OF LEAKS AT 8" NEGATIVE PRESSURE:

TOP VIEW

RIGHT VIEW

LEFT VIEW

BOTTOM VIEW

INLET SIDE

DISCHARGE SIDE

 Vent and Balance

 Signature and Initials

 Date:

 QA Representative

 Signature and Initials

 Date:

 Test Director

 Signature and Initials

 Date:

Filter Serial Number: _____

Date of Manufacture: _____

11. PRESSURE DECAY TEST:

1. _____ With the PI stable at 8" per steps 7 and 8 of section 10, verify that
_____ the temporary connections between the nipples and the caps are
leak free, using the ultrasonic leak detector.
2. With PI = 8":
 - a. _____ Read initial temperature TI_1 : _____ °F

 - b. _____ Close valve V-1

 - c. _____ Start the time clock as soon as V-1 is closed

 - d. _____ Shut down test fan as soon as V-1 is closed.

3. _____ Report PI and TI every minute in the test data sheet, for 15
_____ minutes, or until PI drops down to 6".

Vent and Balance_____
Signature and Initials_____
Date:_____
QA Representative_____
Signature and Initials_____
Date:_____
Test Director_____
Signature and Initials_____
Date:

Filter Serial Number: _____

Date of Manufacture: _____

TEST DATA SHEET:

Initial temperature at time $t = 0$: $TI_i =$ _____ $^{\circ}\text{F}$ Initial pressure within filter housing at $t = 0$: $PI_i = 8'' \text{ wg}$

Time t , in minutes	PI, inches of H_2O
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Final time $t_f =$ _____ minutesFinal temperature (at $t = t_f$): $TI_f =$ _____ $^{\circ}\text{F}$ _____
Vent and Balance_____
Signature and Initials_____
Date:_____
QA Representative_____
Signature and Initials_____
Date:_____
Test Director_____
Signature and Initials_____
Date:

12. LEAKAGE CALCULATIONS:

$$Q = (P_i/T_i - P_f/T_f) * V/(R*\Delta t*0.075)$$

P_i = initial pressure in psf absolute = PI_i (inches wg) * 5.16 Psf/in + 2,116 Psf

P_f = PI_f (inches wg) * 5.16 Psf/in + 2,116 Psf

Where 2,116 Psf is the atmospheric pressure.

T_i (in °R) = TI_i (in °F) + 459

T_f (in °R) = TI_f (in °F) + 459

R = Ideal gas constant for air = 53.35 ft°R

V = air volume of the filter housing = 7.5 to 8.5 ft³.

$$Q = (P_i/T_i - P_f/T_f) * 2 \text{ with an error of about 12 \%}$$

LEAKAGE RATES:

[illegible]

Engineer

Signature and Initials

Date: _____

Checker

Signature and Initials

Date: _____

Test Director

Signature and Initials

Date: _____