HEPA FILTER USE AT THE HANFORD SITE

J. R. Kriskovich, P.E.
Vista Engineering Technologies LLC
8203 W. Quinault, Bldg. C, Suite 200, Kennewick, WA 99336

ABSTRACT

High Efficiency Particulate Air (HEPA) filters are relied upon at the Hanford site to support several different activities. Each facility relies upon the filters to provide the same function; remove radioactive particulate from various air streams. However, HEPA filters are operated in differing environmental conditions from one facility to another and the constituents in the air streams also differ. In addition, some HEPA filters at the Hanford site have been in service for several years. As a result, an assessment was performed which evaluated the service life and conditions of the HEPA filters at the Hanford site.

INTRODUCTION

Hanford is 586 square miles of shrub steppe, sand, and sagebrush located on the Columbia River in southeastern Washington State. The Hanford Site is managed by the U.S. Department of Energy (DOE), the successor agency to the Atomic Energy Commission. As a plutonium production complex, Hanford played a pivotal role in the nation's defense for more than 50 years beginning in the 1940's with the creation of the site as part of the Manhattan Project. Currently, Hanford is engaged in the world's largest environmental cleanup project, with many challenges to be resolved in the face of overlapping technical, political, regulatory, and cultural interests.

With a workforce of approximately 11,000 and an annual budget of nearly $1.4 billion dollars, Hanford is vigorously pursuing three cleanup outcomes: restoring the Columbia River Corridor, transitioning the central part of the Hanford Site for waste treatment and long-term storage, and putting DOE's assets, including the Pacific Northwest National Laboratory, to work solving regional and global environmental problems.

On March 1, 2000, the Department of Energy directed its field offices to conduct an assessment of potential vulnerabilities due to degraded HEPA filters in nuclear facilities (Ref. 1). The scope of the assessment included all HEPA filters that perform an accident mitigation function (including standby or bypass filter banks) in Hazard Category 2 and 3 Facilities. (There are at present, no Hazard Category 1 facilities on the Hanford Site.) The following facilities have HEPA filter systems, which meet this description.

Waste Management Project

- Waste Encapsulation and Storage facility (WESF)
- 242-A Evaporator

River Corridor Project

- Bldg 324
- Bldg 327

Nuclear Materials Stabilization Project (NMS)

- Plutonium Finishing Plant

The assessment considered possible degradation over time of each filter due to aging and environmental conditions such as wetting, excessive pressure drop, humidity, radiation or chemical exposure, that may result in the inability of the filter to perform its intended safety function during accident conditions. The objective of the assessment was to evaluate the ability of each filter to perform its safety function during accident conditions considering the potential degree of degradation of the filter and possible accident environments. The assessment considered only those accident conditions such as explosions, fires, sprays, high temperatures, high flow rates, etc., corresponding to the accidents for which the filter serves a mitigative function.

The objective was to identify those systems, which may warrant further investigation, such as inspection, testing, or historical research, considering such factors as the facility remaining hazard level and anticipated remaining life. The complete evaluation results can be located in Ref. 2.

METHODOLOGY

The filter vulnerability study consisted of two steps. The first was a screening to identify the applicable filter system. The second was an evaluation of the potential for filter damage during the accidents described in the facility authorization basis (AB) accident consequences.

Filter Screening Criteria

Personnel from each facility initially determined which HEPA filters perform a safety function with respect to one or more accident scenarios. Each safety related HEPA filter was then evaluated with regard to age and past or present service conditions that could lead to degradation of the filter, gaskets, or frame. Where feasible, the filters were visually examined to determine whether any signs of wetting, corrosion, or other signs of degradation were visible. Data was collected through a questionnaire based upon readily available information and interviews with knowledgeable facility personnel, and not necessarily an extensive search of archived records. The following criteria were used to evaluate whether a given HEPA filter was potentially vulnerable to degradation factors.

1) Age of filter. If the date that a filter was placed in service was unknown, it was estimated based on interviews with knowledgeable facility personnel.

2) Wetting. Has the HEPA filter ever been wetted by some type of aerosol or entrained moisture in the air stream, by heavy condensation, or by some other source such as a fire deluge system operation?

3) Temperature. Has the filter been in a high temperature application or been subjected to high temperatures (>120° C) for a period of time?

4) Chemical exposure. Has the filter been in contact with chemicals that could adversely affect the filter components (medium, adhesives, gasket, frame, etc.)? Such chemicals could include solvents, such as acetone, or other corrosive or reactive agents, such as

hydrofluoric acid or sodium chloride. The effects of such chemicals will generally be far greater if coupled with wetting of the filter by condensation, although some agents, such as HF, are corrosive in the gaseous phase.

5) Radiation exposure. Has the filter been exposed to high levels of radiation (generally due to fiber loading) over a long period of time so as to produce a damaging integrated dose?

FILTER SYSTEM EVALUATION CRITERIA

The possible effects of age or service-related degradation on the assumed ability of each filter to withstand the conditions that might challenge the filter during the accident scenarios that the filter was assumed to mitigate were evaluated. If the filter was judged to be liable to fail during the relevant accident scenarios, it was listed as vulnerable. The detailed evaluation criteria used to evaluate the vulnerability of the filters to accident conditions were based on the Lawrence Livermore National Laboratory document *Maximum HEPA Filter Life,* UCRL-AR-134141 (Ref. 3). Information on Radiation damage is shown in Ref. 4.

Aging

- If no other factors applied, the following table (Table I) was used for the aging criteria related to expected filter burst strength (short term loading) differential pressure (ΔP) for this evaluation.
- If more than one question of the five identified under the "Filter Screening Section" above resulted in a "yes", the bounding or most conservative criteria identified in Tables I thru V for each application was used.
- If feasible, visual examination of filters installed was performed. This included examining the filter media to determine if there was any splitting along the crease and if there was sagging.
- If any portion of the gasket material and adhesive was visible, it was examined to determine if there was deterioration such as crumbling, discoloring, or cracking.
- If the case was plywood, it was examined to determine if any tape was applied to stop leakage, etc.

Table I. Filter Aging Criteria

Filter life	Burst Strength ΔP		
NEW	4.3 psi	120 in. w.g.	29.6 KPa
5 years in service	3.9 psi	110 in. w.g.	26.9 KPa
10 years in service	3.6 psi	100 in. w.g.	24.8 KPa
15 years in service	3.2 psi	90 in. w.g.	22.1 KPa
20 years in service	2.8 psi	78 in. w.g.	19.3 KPa
25 years in service	2.4 psi	66 in. w.g.	16.5 KPa
30 years in service	2.0 psi	55 in. w.g.	13.8 KPa

Wetting

If question 2 above, under "Filter Screening Criteria", was answered "yes", either Table II or III was used to determine the acceptable pulse pressure the filters could withstand. If the filters had only been wetted and dried once, Table II was used. If the filters had been wetted and dried more than once, Table III was used.

Table II. Wetted only once

Filter life	Burst Strength ΔP	
New	3.0 psi	20.7 KPa
5 years in service	2.7 psi	18.6 KPa
10 years in service	2.5 psi	17.2 KPa
15 years in service	2.2 psi	15.2 KPa
20 years in service	1.9 psi	13.1 KPa
35 years in service	1.6 psi	11 KPa
30 years in service	1.3 psi	9 KPa

Table III. Wetted more than once

New	0.7 psi	4.8 KPa
5 years in service	0.7 psi	4.8 KPa
10 years in service	0.7 psi	4.8 KPa
15 years in service	0.7 psi	4.8 KPa
20 years in service	0.7 psi	4.8 KPa
35 years in service	0.7 psi	4.8 KPa
30 years in service	0.7 psi	4.8 KPa

Filter life	Burst Strength ΔP

If feasible, a visual examination was performed of the filter to identify discoloration or other signs of wetting to the media or case material.

Temperature

If the answer to question 3, under "Filter Screening Criteria", above was "yes", either Table IV or V was used to determine the acceptable pulse pressure that the filter could withstand. If the filter was exposed to a temperature greater than 120° C but less than 250° C, Table IV was used. If the filter was exposed to a temperature > 250° C, Table V was used.

Table IV. Temperature Range 120 – 250°C

Exposure Time	Non-Wetted Strength ΔP	Wetted Strength (once) ΔP psi/KPa	Wetted Strength (> once) ΔP
New			
1 hr	3.87/26.7	2.7/18.6	0.63/4.3
10 hrs	3.23/22.3	2.25/15.5	0.63/4.3
100 hrs	3.01/20.8	2.1/14.5	0.63/4.3
1000hrs	3.01/20.8	2.1/14.5	0.63/4.3
5 years			
1 hr	3.51/24.2	2.43/16.8	0.63/4.3
10 hrs	2.93/20.2	2.03/14	0.63/4.3
100 hrs	2.73/18.8	1.89/13	0.63/4.3
1000hrs	2.73/18.8	1.89/13	0.63/4.3
10 years			
1 hr	3.24/22.3	2.25/15.5	0.63/4.3
10 hrs	2.7/18.6	1.88/13	0.63/4.3
100 hrs	2.52/17.4	1.75/12.1	0.63/4.3
1000hrs	2.52/17.4	1.75/12.1	0.63/4.3
15 years			
1 hr	2.88/19.9	1.98/13.7	0.63/4.3
10 hrs	2.4/16.5	1.65/11.4	0.63/4.3
100 hrs	2.24/15.4	1.5410.6	0.63/4.3
1000hrs	2,24/15.4	1.54/10.6	0.63/4.3
20 years			
1 hr	2.52/17.4	1.71/11.8	0.63/4.3
10 hrs	2.1/14.5	1.43/9.9	0.63/4.3
100 hrs	1.9/13.5	1.33/9.2	0.63/4.3
1000hrs	1.96/13.5	1.33/9.2	0.63/4.3
25 years			
1 hr	2.16/14.9	1.44/9.9	0.63/4.3
10 hrs	1.8/12.4	1.2/8.3	0.63/4.3
100 hrs	1.68/11.6	1.12/7.7	0.63/4.3
1000hrs	1.68/11.6	1.12/7.7	0.63/4.3
30 years			
1 hr	1.8/12.4	1.17/8.1	0.63/4.3
10hrs	1.5/10.3	0.98/6.8	0.63/4.3
100 hrs	1.4/9.7	0.91/6.3	0.63/4.3
1000hrs	1.4/9.7	0.91/6.3	0.63/4.3

Table V. Temperature Range >250°C

Exposure Time	Non-Wetted Strength ΔP	Wetted Strength (once) ΔP	Wetted Strength (> once) ΔP
New			
1 hr	3.44/23.7	2.4/16.5	0.56/3.9
10 hrs	2.58/17.8	1.8/12.4	0.56/3.9
100	2,15/14.8	1.5/10.3	0.56/3.9
1000	2.15/14.8	1.5/10.3	0.56/3.9
5 years			
1 hr	3.12/21.5	2.16/14.9	0.56/3.9
10 hrs	2.34/16.1	1.62/11.2	0.56/3.9
100	1.95/13.4	1.35/9.3	0.56/3.9
1000	1.95/13.4	1.35/9.3	0.56/3.9
10 years			
1 hr	2.88/19.9	2/13.8	0.56/3.9
10 hrs	2,16/14.9	1.5/10.3	0.56/3.9
100	1.8/12.4	1.25/8.6	0.56/3.9
1000	1.8/12.4	1.25/8.6	0.56/3.9
15 years			
1 hr	2.56/17.7	1.76/12.1	0.56/3.9
10 hrs	1.92/13.2	1.32/9.1	0.56/3.9
100	1.6/11	1.1/7.6	0.56/3.9
1000	1.6/11	1.1/7.6	0.56/3.9
20 years			
1 hr	2.2415.4	1.52/10.5	0.56/3.9
10 hrs	1.68/11.6	1.14/7.9	0.56/3.9
100	1.4/9.7	0.95/6.6	0.56/3.9
1000	1.4/9.7	0.95/6.6	0.56/3.9
25 years			
1 hr	1.92/13.2	1.28/8.8	0.56/3.9
10 hrs	1.44/9.9	0.96/6.6	0.56/3.9
100	1.2/8.3	0.8/5.5	0.56/3.9
1000	1.2/8.3	0.8/5.5	0.56/3.9
30 years			
1 hr	1.6/11	1.04/7.2	0.56/3.9
10 hrs	1.2/8.3	0.78/5.4	0.56/3.9
100	1/6.9	0.65/4.5	0.56/3.9
1000h	1/6.9	0.65/4.5	0.56/3.9

Chemicals

There is no data available to provide a correlation between filter strength or efficiency and chemical exposure. The evaluation, therefore, considered facility-specific experience with solvents and acids, which could affect materials of filter construction. Based upon process history, it was determined whether filter materials had received significant exposure to chemicals that could cause deterioration. Consideration of the specifications of the installed filters (e.g., chemical resistant) and any other available data, such as visual examination described above, was also utilized.

Radiation Exposure

A conservative threshold of $> 5 \times 10^5$ Gray ($5x10^7$ rad) total dose was used for criteria. This equates to 114 rad/hr for 50 years. Since there are no data available relating to the degradation and the reduction in strength, if the filters were exposed to $> 5 \times 10^5$ (5×10^7 rad) total dose, those filters were identified as potentially vulnerable to this factor.

FILTER SYSTEM EVALUATION RESULTS

Waste Encapsulation and Storage Facility (WESF)

The major material of concern in WESF is a quantity of cesium and strontium capsules stored underwater in pool cells. Only one safety related ventilation system (designated K3) is required to ensure confinement of the stored material. The WESF K3 HEPA filters are less than eight years old and have not been subjected to any conditions that would have caused degradation beyond normal aging. The most severe accident that could challenge the filters is a hot cell fire that could result in a high differential pressure (ΔP) due to plugging. It was concluded that the filters would easily maintain their integrity when subjected to the maximum plugging ΔP and would easily fulfill their mitigative function under the most severe accident conditions. See Table VIa.

242-A Evaporator Facility

The 242-A Evaporator is a functioning facility, which typically operates one or two times per year in campaigns lasting approximately one month to reduce waste volumes in the double-shell tanks. Only one filter system services all the contaminated or potentially contaminated areas of the facility. The oldest filters in this system are about 13 years old and may have been wetted once during a steam leak that occurred in 1999. The most severe accident is a small spray leak (0.042 L/min (0.011 gpm) aerosol) in the pump room that would not place any significant added stress on the filters. There are no credible explosion or fire scenarios with the potential to damage the HEPA filters. It was therefore concluded that the filters would not fail under the most severe accident conditions. See Table VIb.

Table VIa. HEPA Filter Status for the 225-B Facility (WESF)

Filter Designator	Age	Visual Inspection?	Filter Wetted?	High Temperatures		Chemical Exposure?	Radiation >50 Mrad?	Comments
				>120 C?	Time			
K-3 East	7 y (9/93)	No	No	No	NA	No	No	
K-3 West	7 y (9/93)	No	No	No	NA	No	No	

Table VIb. HEPA Filter Status for the 242-A Evaporator

Filter Designator	Age	Visual Inspection?	Filter Wetted?	High Temperatures		Chemical Exposure?	Radiation >50 Mrad?	Comments
				>120C?	Time			
Kl-6-1	About 8 y	No	Maybe	No	NA	No	No	7/13/99 steam incident
Kl-6-2	About 8 y	No	Maybe	No	NA	No	No	"
Kl-6-3	About 13 y	No	Maybe	No	NA	No	No	"
Kl-6-4	About 13 y	No	Maybe	No	NA	No	No	"

324 Facility

The 324 Facility consists of laboratory areas, including radiological and non-radiological laboratories, support facilities, and administrative areas. The radiological laboratories include two hot cell facilities and various low-level analytical laboratories. The oldest filters in the facility, one bank of the Zone I filters, are approximately 23 years old. None of the filters have been subjected to any degrading conditions other than age. Soot generation as a result of the fire scenarios has the potential to load HEPA filters resulting in elevated differential pressure across the Zone I filters and to a lesser extent, across the Zone II HEPA filters. Differential pressures associated with soot generation are limited to less than 2.5 KPa (0.36 psig) by system design parameters in conjunctions with limited combustible inventory and would not be expected to exceed filter capacity. The most severe accident scenario is the Explosion in Vault or Hot Cell which could subject the Zone I filters to a pressure pulse of less than 12.4 KPa (1.8 psig), which is considerably below the predicted HEPA filter capacity of 16.5 KPa (2.4 psig) associated with the oldest filter banks. The challenge to the HEPA filters resulting from the analyzed accident scenarios would not exceed the capacity of the existing filters including the effects of degradation due to age. See Table VIc.

Table VIc. HEPA Filter Status for the 324 Facility

Filter Designator	Age	Visual Inspection?	Filter Wetted?	High Temperatures		Chemical Exposure?	Radiation >50 Mrad?	Comments
				>120 C?	Time			
Zone I - Room 9	13 y (7/87)	Yes	No	No	NA	No	No	visual inspection saw no signs of wetting
Zone I—Room 10	23 y (7/77)	Yes	No	No	NA	No	No	visual inspection saw no signs of wetting
Zone I — Room 11 (Process Off-	12 y (1/88)	Yes*	No	No	NA	No	No	visual inspection saw no signs of wetting
Zone II - Room 6	10 y (l/90)	Yes	No	No	NA	No	No	visual inspection saw no signs of wetting
Zone II - Room 7	3 y (5/97)	Yes	No	No	NA	No	No	visual inspection saw no signs of wetting

*0nly the exterior of the self contained housings were inspected. It was not possible to inspect the filter media without

327 Facility

The 327 Facility was a post-irradiation testing facility and was used to perform examinations of irradiated fuel and materials within a number of shielded hot cells. The current mission is the reduction of facility source term in preparation for final deactivation. The new Basis for Interim Operation (BIO) being prepared to support deactivation will demonstrate that the safety significant classification for the 327 HEPA filters is no longer warranted. Under the present Authorization Basis, the only accidents that could stress any safety-credited HEPA filters are an explosion in a hot cell, which was estimated (based on analysis of a similar accident) to produce a peak DP of about 2.1 KPa (0.3 psi), and a fire in a hot cell leading to filter plugging and a maximum DP of about 1.4 KPa (0.2 psi). The maximum age of the filters that could be challenged by this accident is 21 years.

Based on facility records and filter inspections it was determined that no additional degradation beyond aging could be assigned to any of the safety-credited HEPA filters. The assessment results therefore indicate that the 327 Facility HEPA filters will successfully perform their mitigation function in their present state. See Table VId.

Table VId. HEPA Filter Status for the 327 Facility

Filter Designator	Age	Visual Inspection?	Filter Wetted?	High Temperatures		Chemical Exposure?	Radiation >50 Mrad?	Comments
				>120 C?	Time			
AE-17-1	15 y (8/85)	No	No	No	NA	No	No	
AE-20-1	20 y (1980)	yes*	No	No	NA	No	No	age assumed
BE-1 to BE-6	4 y (3/96)	No	No	No	NA	No	No	
BE-6-1	12 y (8/88)	yes*	No	No	NA	No	No	
BE-6-2	12 y (8/88)	yes*	Maybe	No	NA	No	No	filter is located on floor where it could have been wetted.
BE-12-1	7 y (3/93)	yes*	No	No	NA	No	No	
BE-12-2	7 y (3/93)	yes*	Maybe	No	NA	No	No	filter is located on floor where it could have been wetted.
BE-15-1, BE-15-2, BE-15-7, and BE-15-8	21 y (3/79)	yes*	No	No	NA	No	No	
BE-15-3, BE-15-4, BE-15-5, and BE-	21 y (3/79)	yes*	Yes	No	NA	No	No*	water stains visible on exposed plywood
BE-15-6	9 y (11/91)	yes*	No	No	NA	No	No	
BE-A-1	11 y (3/89)	No	No	No	NA	No	No	reads 150 mR/h through 3" lead
BE-A-2	20 y (9/80)	yes*	No	No	NA	No	No	
BE-B-1	15 y (10/85)	yes*	No	No	NA	No	No	
BE-B-2	21 y (5/79)	yes*	No	No	NA	No	No	
BE-C-1	11 y (6/89)	No	No	No	NA	Yes	No	reads 40 mR/h through 3" lead
BE-C-2	24 y (8/76)	yes*	No	No	NA	Yes	No	
BE-D-1	11 y (5/89)	Yes	No	No	NA	No	No	
BE-D-2	8 y (4/92)	Yes	No	No	NA	No	No	

Table VId. HEPA Filter Status for the 327 Facility

Filter Designator	Age	Visual Inspection?	Filter Wetted?	High Temperatures >120 C?	Time	Chemical Exposure?	Radiation >50 Mrad?	Comments
BE-DC-1 and BE-DC-2	30 y (6/70)	Yes	No	No	NA	No	No	
BE-E-1	15 y (10/85)	No	No	No	NA	Yes	No	reads 5 mR/h through 3" lead shielding
BE-E-2	21 y (5/79)	Yes	No	No	NA	Yes	No	
BE-F-1	7 y (11/93)	Yes	No	No	NA	Yes	No	
BE-F-2	8 y (11/92)	Yes	No	No	NA	No	No	
BE-G-1 and BE-G-2	6 y (5/94)	Yes	No	No	NA	yes (pn)	No	covered by portable rolling shielding
BE-H-1 and BE-H-2	20 y (3/80)	Yes	No	No	NA	yes (pn)	No	covered by portable rolling shielding
BE-H2-1	5 y (12/95)	Yes	No	No	NA	Yes	No	
BE-H2-2	5 y (12/95)	Yes	Maybe	No	NA	Yes	No	located on the floor where it could have
BE-H3-1	14 y (10/86)	Yes	No	No	NA	Yes	No	
BE-I-1	17 y (7/83)	Yes	No	No	NA	No	No	
BE-I-2	20 y (7/80)	Yes	No	No	NA	No	No	
BE-N-1	9 y (2/91)	Yes	No	No	NA	No	No	
BE-N-2	9 y (2/91)	Yes	Maybe	No	NA	No	No	located on the floor where it could have
BE-SC-1	14 y (4/86)	No	No	No	NA	No	No	reads 50 mR/h through 3" lead
BE-SC-2	l7 y (5/83)	Yes	No	No	NA	No	No	
CE-1-1 and CE-1-	9 y (2/91)	No	No	No	NA	No	No	
CE-2-1 and CE-2-	1ly (1989)	No	No	No	NA	No	No	
CE-3-1 and CE-3-2	14 y(1986)	No	No	No	NA	No	No	survived SERF cell explosion
CE-4-1 and CE-4-	1l y (1989)	No	No	No	NA	No	No	

Table VId. HEPA Filter Status for the 327 Facility

Filter Designator	Age	Visual Inspection?	Filter Wetted?	High Temperatures		Chemical Exposure?	Radiation >50 Mrad?	Comments
				>120 C?	Time			
CE-5-1 and CE-5-2	14 y (1986)	No	No	No	NA	No	No	survived SERF cell explosion
CE-7-1 and CE-7-	11 y (1989)	No	No	No	NA	No	No	
CE-8-1 and CE-8-	14 y (4/86)	No	No	No	NA	No	No	
CE-9-1 and CE-	4 y (4/96)	No	No	No	NA	No	No	
CE-10-1 and CE-	9 y (2/91)	No	No	No	NA	No	No	
CE-11-1 and CE-	9 y (2/91)	No	No	No	NA	No	No	
CE-13-1 and CE-13-2	14 y (1986)	No	No	No	NA	No	No	survived SERF cell explosion
CE-14-1 and CE-14-2	14y (1986)	No	No	No	NA	No	No	survived SERF cell explosion
CE-15	15 y (10/85)	No	No	No	NA	No	No	
CE-16	5 y (2/95)	Yes*	No	No	NA	No	No	
CE-E-1 and CE-E-2	14 y (1986)	No	No	No	NA	No	No	survived SERF cell explosion
CE-W-1 and CE-	4 y (4/96)	No	No	No	NA	No	No	
CE-S	7 y (3/93)	No	No	No	NA	No	No	

*0nly the exterior of the self-contained housings were inspected. It was not possible to inspect the media without removing

Plutonium Finishing Plant (PFP)

The PFP facility was constructed to purify plutonium nitrate solutions, to reduce plutonium nitrate solutions and to fabricate plutonium parts. The facility is now used to stabilize reactive materials and store in-process materials. The facility contains a large number of safety class filters in the E-3 and E-4 systems. The E-4 system filters air from gloveboxes and cells; the E-3 system filters air from rooms which contain gloveboxes and other Pu processing equipment. The PFP Final Safety Analysis Report (FSAR) (Ref. 5) was reviewed to determine the impact of filter failures on the event consequences.

Most abnormal operations and events described in the FSAR would release only small amounts of material that will not stress the filters. Sensitivity analyses suggest that events such as fires would meet risk guidelines even if failures to filters occur. The fibers are not credited in the FSAR for seismic events, so seismic stresses are not relevant. There are, however, uncertainties associated with filter history and performance. For example, many of the first stage filters in the E4 system have been in service for extended periods, up to twenty years or more. Although the filter specifications provide for chemical resistance and the filters meet operational acceptance criteria, it may be prudent to change some of the filters due to uncertainties created by the combination of chemical exposure, age and dust loading. The assessment results did not indicate that the PFP HEPA filters would fail to perform their mitigation function in their present state. See Table VIe.

Table VIe. HEPA Fitter Status for the Plutonium Finishing Plant (PFP)

Filter Designator	Age	Visual Inspection?	Filter Wetted?	High		Chemical Exposure?	Radiation >50	Comments
				>120 C ?	Time			
HF-1. HF-2. HF-4. HF-	5-10 y	No	No	No	NA	No	No	
HF-3	<5 y	No	No	No	NA	No	No	
EF-C5, EF-C6, EF-D7, EF-D8. EF-D5	15-20 y	No	No	No	NA	Yes	No	
EF-E6	15-20 y	No	No	No	NA	No	No	
FB-l-N	>30 y	Yes	No	No	NA	Yes	No	signs of chemical exposure and aging
FB-l-	5-10 y	Yes	No	No	NA	Yes	No	signs of chemical exposure (crystals)
FB-2	5-10 y	No	No	No	NA	Yes	No	
FB-3. FB-4. FB-5. FB-6	>30 y	No	No	No	NA	Yes	No	
FB-7	5-10 y	Yes	No	No	NA	Yes	No	
FB-8	5-10 y	Yes	No	No	NA	Yes	No	signs of chemical exposure (crystals)
FB-9	>30 y	Yes	Yes	No	NA	Yes	No	signs of chemical exposure. aging. and
FB-10	15-20 y	Yes	No	No	NA	Yes	No	
FB-11	10-15 y	Yes	No	No	NA	Yes	No	
FB-12	>30 y	No	No	No	NA	Yes	No	
FB-13	15-20 y	No	No	No	NA	Yes	No	no temperature info; filter is out of service
FB-14	15-20 y	Yes	No	No	NA	Yes	No	
FB-15	>30 y	No	No	No	NA	Yes	No	
FB-16E and FB-16W	>30 y	Yes	No	No	NA	Yes	No	
FB-17and FB-18	15-20 y	Yes	No	No	NA	Yes	No	
FB-19 and FB-20	5-10 y	Yes	No	No	NA	Yes	No	
FB-21	15-20 y	No	No	No	NA	No	No	

Table VIe. HEPA Fitter Status for the Plutonium Finishing Plant (PFP)

Filter Designator	Age	Visual Inspection?	Filter Wetted?	High >120 C ?	High Time	Chemical Exposure?	Radiation >50	Comments
FB-22	5-10 y	Yes	No	No	NA	No	No	
FB-25	15-20 y	No	No	No	NA	No	No	
FB-26	>30 y	No	No	No	NA	Yes	No	
FB-242-Z	>30 y	Yes	Yes	No	NA	Yes	No	signs of chemical exposure, aging, and
FB-F1-P, FB-F2-S. and FB-F3-P	15-20 y	No	No	No	NA	Yes	No	
FB-F4-S	<5 y	No	No	No	NA	Yes	No	
F-E3-1N, F-E3-1S, F-E3-2N. F-E3-2S	20-25 y	Yes	No	No	NA	No	No	
FR-309andFR-310	5-10 y	Yes	No	No	NA	Yes	No	
FR-311	10-15 y	Yes	No	No	NA	No	No	
FR-312	20-25 y	Yes	No	No	NA	No	No	
FR-313 and FR-314	<5 y	Yes	No	No	NA	No	No	
FR-315. FR-316. and	20-25 y	Yes	No	No	NA	No	No	
F-A1 through F-A 11	<5 y	Yes	Yes	No	NA	No	No	wetting based on filter use: visual inspection of
F-A12	5-10 y	Yes	Yes	No	NA	No	No	visual inspection of exterior (not media)
F-B1 through F-B 12	10-15 y	Yes	No	No	NA	Yes	No	visual inspection of exterior (not media)
FB-10E, FB-10W, and FB-20W	10-15 y	Yes	No	No	NA	Yes	No	signs of chemical exposure
FB-20E	15-20 y	Yes	No	No	NA	Yes	No	signs of chemical
FB-36	10-15 y	Yes	No	No	NA	No	No	visual inspection of exterior (not media)
FB-50	>30 y	Yes	No	No	NA	Yes	No	visual inspection of exterior (not media)

Table VIe. HEPA Fitter Status for the Plutonium Finishing Plant (PFP)

Filter Designator	**Age**	**Visual Inspection?**	**Filter Wetted?**	**High >120 C ?**	**Time**	**Chemical Exposure?**	**Radiation >50**	**Comments**
F-C1 through F-C 12	10-15 y	Yes	No	No	NA	Yes	No	visual inspection of exterior (not media)
F-D1 through F-D 12	<5 y	Yes	No	No	NA	No	No	visual inspection of exterior (not media)
F-D12	10-15 y	Yes	No	No	NA	No	No	visual inspection of exterior (not media)
F-El-25D and F-E3-	10-15 y	No	No	No	NA	Yes	No	
F-W2-25D and F-W4-	15-20y	No	No	No	NA	Yes	No	
ACT-01	5-10 y	No	No	No	NA	No	No	
F-1-1, F-1-2, F-2-2	<5y	No	No	No	NA	No	No	
F-2-1, F-3-1, F-3-2	20-25 y	No	No	No	NA	No	No	
F-14-Pl and F-14-P2, F-15-Pl and F-15-P2, F-17-P1 and F-17-P2	<5y	No	No	No	NA	Yes	No	
F-14-Sl and F.14.S2, F-15-S1 and F-15-S2, F-16-Sl and F-16-S2. F-17-S1 and F-17-S2, F-18-P1 and F-18-P2, F-18-S1 and F-18-82, F- F-19-Sl and F-19-S2, F-20-Pl and F-20-P2, F-20-S1 and F-20-S2, F-21-Pl and F-2l-P2. F-21-Sl and F-21-S2	15-20 y	No	No	No	NA	No	No	
F-16-P1 and F-16-P2	<5y	No	No	No	NA	No	No	
-32	5-10 y	No	No	No	NA	No	No	

CONCLUSIONS

Each facility catalogued and screened the HEPA filters within their own areas according to the criteria given herein. The filters determined as safety related (i.e., credited with mitigating some accident in the facility safety analysis) were evaluated with respect to any possible reduction in effectiveness or strength due to age or service-related degradation. The present state of each filter (or group of fibers), after considering potential effects of any degradation, was then compared with expected conditions due to the most severe accident, which could challenge that filter. *The assessment did not identify any situations where safety-related HEPA filter systems within PHMC facilities would not perform their required safety function due to the predicted degradation caused by aging, wetting, high temperature, radiation or chemical exposure.*

There are, however, some remaining uncertainties, which reflect the limited data used as the basis for the evaluation criteria. In particular, the various degradation factors were applied independently, without any allowance for possible synergistic effects. In addition, the evaluation did not evaluate the potential for releases of lesser magnitude due to accelerated failure under normal operating conditions. Finally, no criteria have been established for reducing the allowable normal operating pressure differential (nominally, 2.5 KPa (10 in. w.g.)), due to the recognized degradation mechanisms. Additional test data would be useful, not only for evaluating system vulnerabilities, but also for establishing filter change-out criteria, especially in cases where filter changes would incur significant effort or radiological risk. In particular, testing of aged or wetted filter assemblies, as opposed to just filter media, could provide an improved basis for decisions on when to change filters.

REFERENCES

1. DOE, 2000, *Action: Assess Potential Vulnerability Due to Degraded High-Efficiency Particulate Air (HEPA) Filters in Nuclear Facilities,* (Memo from T.J. Glauthier, dated 3/1/2000), Department of Energy, Washington, D.C.

2. Himes, D. A., *Degradation Vulnerability Assessment of Safety Related HEPA Filters in WMF, RCP, and NMS Facilities*, HNF-6389, Rev. 0, Fluor Hanford, Richland, Washington.

3. Bergmann, Werner, 1999, *Maximum HEPA-Filter Life,* UCRL-AR-134141, Lawrence Livermore Laboratory, Berkeley, California.

4. Cheever, C. L., 1972, *High Level Gamma Radiation Exposure of HEPA Filters,* CONF-720823, Twelfth Atomic Energy Commission Air Cleaning Conference, August 1972, Oak Ridge, Tennessee.

5. HNF, 1999, *Plutonium Finishing Plant Final Safety Analysis Report,* HNF-SD-CP-SAR-021, Rev, 1, Fluor Hanford, Inc., Richland, Washington.

COMMENT ON HANFORD PAPER
"HEPA FILTER USE AT THE HANFORD SITE" BY KRISKOVICH

Werner Bergman

LLNL

(925) 422-5227

bergman2@llnl.gov

3/12/02

Although I have criticized the specifics of Hanford's paper (1) in my comments, the authors are to be commended for their approach in assessing HEPA filter problems using the limited data available. Their paper can be revised to reflect the comments here and provide a much better assessment of HEPA filter vulnerabilities.

I have reviewed the Hanford report "HEPA Filter Use at the Hanford Site" by Kriskovich(1) in which they use data from my report, Maximum HEPA Filter Life (2) to assess the vulnerability of HEPA filters to accident conditions. I did not generate the burst data but took them from Fretthold's report, "Evaluation of HEPA filter service life"(3). I recommended to Fretthold the use of a burst test because it provided a 2- dimensional strength test instead of a 1- dimensional strength test when tensile strength is specified in filter media standards.

The absolute value of the bust strength data cannot be used to evaluate HEPA filter vulnerability in the manner proposed in the Hanford report. The burst strength data were made on 1 inch diameter samples of the filter medium taken from a 2' x 2' x 1' HEPA filters. A single 1 inch sample would generally not be representative of the 200 square feet of pleated media. The problem lies in the variability in the medium strength and the geometric scale factor for different size HEPA filters. This scale factor is well known (see Figure 3.4 of the Nuclear Air Cleaning Handbook (4)). The Handbook shows that the pressure drop for failure decreases significantly as the depth of the pleats decreases and as the size of the filter increases.

We have not developed a correlation between the burst strength of a 1 inch diameter sample and the full-scale HEPA filter. Any correlation would be tenuous at best because the structural failure mode in the full HEPA filter would begin at a weak point in the pleat (i.e. at one of the creased portions of paper) and then progress. Measuring the burst strength at a crease would be more representative of this failure propagation, but is still subject to large variability. Since the failure at the pleat appears to be random, we do not know if the small sample has the same defect as the failure point in HEPA filters.

There are three problems that must be overcome before one can use the small bust data to represent the structural failure of the entire HEPA filter.(1) A correlation must be made between the burst strength of the small sample and the pressure failure of the entire filter for a single filter. (2) Because of the large variability in the pressure failure in different filters, the correlation obtained for a single filter must be verified in many filters. (3) A correlation between the burst strength of a 1 inch sample and one filter size and design must be verified for other filter sizes and designs. As one can imagine, these correlations would require a large number of tests. I discussed this with Fretthold before he conducted his tests. Alternatively, one could use the large variability in the data directly and scale the 1 inch data to available data sets on full HEPA filters.

We can illustrate some of the problems with the study be Gregory et al [(5)]. Gregory found the structural limit on 4 standard, new HEPA filters ranged from 1.32 to 2.91 psi. The pressure drop data in Bergman's Figure 4 for the 1 inch samples ranged from 0.8 to 7.1 psi for all years, and from 3 to 6 psi for new filters [(2)]. The strength data in Table 1 of the Hanford report appears to be taken from the best-fit linear line through Bergman's age data. The problem with this is that the absolute magnitude of the strength data on the media samples is much higher than what occurs for actual filters. Using the burst data across folds in Figure 5 of Bergman's report shows pressure drops between 0.5-1.5 psi, which is lower than Gregory observed. Since the Gregory data is on actual HEPA filters, a greater weight must be placed on that data than the 1 inch samples. However, the 1 inch data can be used as a relative indicator of the effect of age on HEPA filter strength.

A similar discussion applies for Tables 2 and 3 of the Hanford report which deal with the effect of wetting the filters [(1)]. The Hanford data was taken from the straight line fits in Figure 6 of Bergman's report [(2)].

Another objection to Tables 1-3 of the Hanford report is extrapolating the strength data to 30 years, while the actual data extended to only 15 years.

The effect of temperature was taken from Figure 7 of the report by Bergman et al [6]. Unfortunately, the Hanford authors neither stated the source, nor how they generated Tables 4 and 5. (I had to spend a fair time to figure out these answers.) The original data was obtained from Hamlin et al [7] who measured the tensile and burst strength of media samples at various temperatures and exposure times. As expected, the media tensile and burst strength decreases with increasing temperature and longer exposures. Multiplying the percent residual strength from Bergman's [6] Figure 7 by the burst strength data in Tables 1 and 2 yielded the results shown in Tables 4 and 5 of the Hanford report [1].

Although the approach is reasonable (I had used that in my 23rd Nuclear Air Cleaning Conference report [6]), there are serous problems with using the absolute values of the media strength in tables 4 and 5. In addition, there is no data supporting any values beyond 15 years. Table 5 applies only to temperatures of 250 °C, and not greater than 250 °C. In fact, there is a serious problem when one exceeds 250 -300 °C, because the failure mode of HEPA filters occurs with the sealant and not the media as shown in the study by Bergman, Fretthold and Slawski [8] . The data by Hamlin et al [7] that was used to generate Figure 7 [6] was generated on HEPA media at 120°C and 250°C and is not applicable to HEPA filters at temperatures above 250 °C. The headings of Tables 4 and 5 of the Hanford report should be changed to "less than 120 °C" and "between 120-250°C".

The Hanford report [1] also fails to properly address the significant filter deterioration with age. Because the Hanford report focused only on the average value of media burst strength and not on the tensile strength and actual filter tests in Bergman's age study [2] , the Hanford report did not emphasize the serious loss of strength HEPA filters have after 10 years. Considering all the data, HEPA filters over 10 years old should not be used in safety applications.

However, the most serious problem with all tables 1-5 is the use of 2 or 3 significant figures in prescribing the filter strength for different age, water exposure, and temperature. In reality, the data should be presented with the uncertainty (+/-) values. A better approach would be to present all the data (as done in Bergman's 1999 report) in a graphical format to illustrate the extremely large variability of the data. The false impression created with Tables 1-5 is that we can use age, water exposure and temperature exposure as indicators of filter strength. This can lead to a serious problem by assuming a HEPA filter has sufficient strength to survive accident conditions whereas in reality, it cannot. For example the filters in the 324 facility were judged to be able to survive a smoke loading of 10 in. w.g. (0.36 psig) and an explosion at 49.9 in. w.g. (1.8 psig). Although the smoke loading is border-line , the explosion would unquestionably cause the HEPA filter to fail as shown by actual filter data in Bergman et al [6] and as recommended in accident analysis guidance [9] .

The problem with all of the measurements on burst pressure on filter media and actual DP on filters is the large variability in the data. It is very dangerous to use average data as Hanford is proposing because the filters will fail about 50% of the time at that pressure. This is an unsafe practice. What I have done in my age report [2] and in the previous Air Cleaning report on HEPA efficiencies under accident conditions [6] is to use the minimum failure points since they are most conservative. This will at least provide some confidence that the filter will survive if it is operated at that condition.

REFERENCES

(1) J.R. Kriskovich, "HEPA Filter Use at the Hanford Site" , Waste Management Conference, Feb 24-28, Tucson, AZ 2002.

(2) W. Bergman "Maximum HEPA filter life" LLNL report UCRL-AR-134141, June 1999.

(3) J. Fretthold "Evaluation of HEPA filter service life" RFP-5141, July 14, 1997

(4) C. Burchsted et al, Nuclear Air Cleaning Handbook, Burstead, ERDA-76-21, 1976

(5) W. Gregory et al , "Response of HEPA filters to simulated accident conditions" Proc. 17th DOE Nuclear Air Cleaning Conf, p 1051, CONF-820833, 1983

(6) W. Bergman, M.W. First, W.L. Anderson, H. Gilbert, and J.W. Jacox "Criteria for calculating the efficiency of deep-pleated HEPA filters with aluminum separators

during and after design basis accidents" in Proceedings of the 23rd DOE/NRC Nuclear Air Cleaning and Treatment Conference, Buffalo, N.Y.,July 25-28, 1994, available from NTIS, Springfield, VA, CONF-940738 , pp 563-598, February , 1995

(7) C. Hamblin and P.J. Goodchild, "The effects of temperature on HEPA media" Proceedings of the 22nd DOE/NRC Nuclear Air Cleaning Conf., CONF-9020823, pp. 327-335, 1993.

(8) W. Bergman, J. K. Fretthold and J.W. Slawski, "Potential for HEPA Filter Damage From Water Spray Systems in Filter Plenums" Proceedings of the 24th DOE/NRC Nuclear Air Cleaning and Treatment Conference, CONF-960715, M.W. First, Ed., NTIS, Springfield, VA, pp. 752-777, August, 1997.

(9) NRC, Nuclear Fuel Cycle Facility Accident Analysis Handbook, NUREG/CR-6410, NRC, 1998.