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Interim Status of HEPA Filter 10-Year Lifetime Evaluation

August 2017

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JM Barnett
VA Sabandith
CL Ensign

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99352

Abstract

High efficiency particulate air (HEPA) filters are widely employed by nuclear facilities to remove used to remove radiological particulate matter from their effluent gas streams. The purpose of this study is to draw a relationship between the HEPA filter lifespan and its performance indicators. The 10 year-long endeavor to collect and analyze data regarding the lifetime of HEPA filters at the Pacific Northwest National Laboratory (PNNL) began in 2010. Forty-nine filters were surveyed and analyzed at least annually to verify compliance with permit conditions. The study suggests the frequency of filter replacement should be based on the actual statistics of the filter and its fume hood instead of on the prescribed filter "age limit" of 10 years from the date of manufacture when operating under dry conditions. Over the past six years, only two filters in the study were replaced—one due to high pressure differential and low fume hood face velocity, and the other due to low filter efficiency results.

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1.0 Introduction

The Effluent Management group of the Pacific Northwest National Laboratory (PNNL) performs environmental surveillance of air emissions from facilities that could potentially emit radiological particles. These facilities are equipped with nuclear high efficiency particulate air (HEPA) filters, which are defined by their "minimum efficiency of 99.97% when tested with an aerosol of essentially monodispersed 0.3 micrometer diameter test aerosol particles" (ASME AG-1). Particles larger or smaller are removed with an even higher efficiency.

The Department of Energy (DOE) uses a conservative interpretation of data to set the age limit of HEPA filters at 10 years (DOE-HDBK-1169-2003). The lifetime was determined by an analysis of multiple HEPA filter research studies, performed by Werner Bergman at the Lawrence Livermore National Laboratory (LLNL). Analysis of data from Robinson et al. suggests that unfolded media tensile strength fails at 13 years. Folded media do not have the required 2.5 pound/inch tensile strength, even when new, and the tensile strength is reported to be extremely low at 7 years. Therefore, the data displayed failed tensile strength and low burst strengths at an average of 10 years. Although filter life was difficult to estimate using the data, based on the relationship between HEPA filter and age, the recommended lifetime was set at 10 years under dry conditions (Bergman 1999).

Because HEPA filters are used in nuclear facilities, they are heavily regulated and standardized. The American Society of Mechanical Engineers publishes the Code on Nuclear Air and Gas Treatment (ASME AG-1) provides a robust standard for the performance, design, construction, acceptance, and testing of HEPA filters. Once in use, the Department of Energy provides the recommendations and standards for HEPA filters, which are considered "throwaway" and "disposable." (ASME AG-1 p. 391; DOE-HDBK-1169-2003, 3-1). Their recommendation for routine HEPA filter replacement is every 10 years. The purpose of this study is to draw a relationship between the HEPA filter lifespan and the following indications of performance: the differential pressure drop (ΔP) in the filters, the fume hood face velocity, the radiological dose, and the filter efficiency.

The 10-year evaluation period from 2010–2020 consists of annual collection of two preventative maintenances (PMs) for HEPA filters located within the Physical Science Facility (PSF). The PMs measure the ΔP, filter efficiency, and fume hood face velocity, which is used to determine if the filter has failed or needs replacing.

At PNNL facilities, the ΔP must remain under 4.0 inches water gauge (in. wg), and exceeding this is a basis for replacement. Regulatory standards (40 CFR Part 61, Appendix D) require the efficiency level to be 99.00% or greater, a reading below which is a basis for replacement. At PNNL, efficiency standards are 99.95% or greater, and limited operations begin when the filter efficiencies range between 99.90% and 99.95%. The velocity across the inlet face of the fume hood is required to be at least 100 feet/min for the safety of the researchers, but falling below this threshold alone is not a basis for replacement. The fume hood could be placed out of order, or the velocity could be adjusted. HEPA filters with a low velocity are replaced when also accompanied by a high ΔP or low efficiency, but that condition has not occurred to date. Radiological dose is measured in mrem/hr and is reported in surveys conducted by PNNL's

Radiation Protection Division. A dose reading that exceeds 20 mrem/hr (the minimum detectable activity) is a basis for replacement.

2.0 Equipment

HEPA filters carry a range of minimum efficiency reporting values (MERV) from 17–19 (ASHRAE 2012). MERV are set by the American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 52.2 as a rating of efficiency on a scale from 1 (lowest) to 20 (highest) (EPA 2009). Each new filter is independently tested at the DOE-sanctioned Filter Test Facility prior to being placed into service. Annual testing of HEPA filters are performed to confirm the filtration has not degraded (Colby 2013).

An in-place aerosol test measures the efficiency of the filters, performed in accordance with ASME/ANSI N511-2007, *In-Service Testing of Nuclear Air Treatment, Heating, Ventilation, and Air-Conditioning Systems.* A compressed gas source is connected to an aerosol generator, which is injected upstream from the filter bank. A photometer is then used to measure the upstream and downstream aerosol background concentrations; readings are taken until at least three of the readings are stable (within ±0.01 gage reading). The final sets of efficiency readings are recorded on the preventative maintenance (PM) worksheet (Colby 2013).

Laboratory fume hoods are tested periodically for adequate airflow. The inspections of laboratory fume hoods are based on ANSI/AIHA Z9.5, *American National Standard for Laboratory Ventilation*, and ASHRAE Standard 110, *Method of Testing Performance of Laboratory Fume Hoods*. Fume hood air flow is tested by verifying that the average face velocity entering the fume hood is within the design parameters. Airflow instruments are calibrated and traceable to the National Institute of Standards and Technology (NIST) (Rohrig 2016).

3.0 Procedure

Forty-nine nuclear grade HEPA filters were selected and analyzed in this study from those available at the PNNL Physical Science Facility (PSF) buildings: 7 from 3410, 27 from 3420, and 15 from 3430. The "HEPA Exhaust Filter Testing" and "Fume Hood" PMs are performed annually on each filter and the results are stored electronically in the Facilities and Operations (F&O) Vault online database. The "HEPA Exhaust Filter Testing" PM contains the efficiency and pressure data; its identification numbers are PSF5501, PSF1083, and PSF5503 for 3410, 3420, and 3430, respectively. The "Fume Hood" PM contains the velocities; its identification numbers are PSF1368, PSF1339, and PSF1215. Note, in 2017, the "Fume Hood" PMs for the tests performed the previous year were published as PSF51368, PSF51339, and PSF51215.

Radiological data was collected from PNNL's Radiation Protection Division. The facilities were new in 2011, so surveys were only conducted once that year. Surveys became semiannual beginning in 2012. Surveying the filters did not commence until 2012 for the 3430 Building due to building occupancy, but the semi-annual pattern is continued in 2013.

The PM data for the forty-nine filters were collected and entered into a spreadsheet to graphically evaluate whether filters were replaced and the cause for the replacement. Figure 3.1 is a sample graph of the PM data for a filter that has not needed to be replaced. The graph is annotated with green and purple lines such that any plot points that are placed out of the first quadrant obviously indicate that the filter underperformed. To indicate a radiological dose above MDA or an efficiency below 99.90%, the descriptor for the plot point is recolored.

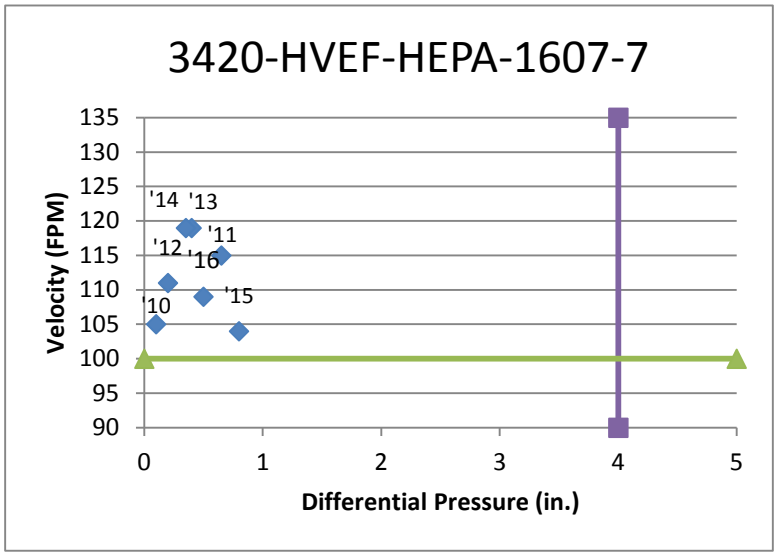

Figure 3.1 PM data for HEPA filter 1607-7 in the 3420 Building.

4.0 Discussion

The HEPA filter study is a 10-year study, beginning in 2010 and continuing through 2020. Over the last six years (2010–20166), only two of the HEPA filters have been changed (Table 1). The first changed was in 2010 due to failing the filter efficiency test with an efficiency of 99.90%. The other filter was in 2013 for not meeting the ΔP and fume hood face velocity criteria, with a ΔP of 4.0 in. wg and face velocity of 68 ft/min. Figure 4.1 (a) and (b) are the graphical analyses for these two filters. The red data point for 2010 in (a) visually indicates either that the radiological dose was above MDA or that the efficiency was below 99.90%, either of which would require the filter to be replaced. That the 2013 data point in (b) is not in the first quadrant visually indicates that the filter needed to be replaced.

Lifetime considerations had no effect on the decision to replace the filters. Laboratory exhaust systems at PNNL are incapable of generating sufficient pressure or flow that could damage filters, and the exhaust's tepid temperature and low humidity renders the ten year filter life cycle conservative (Colby 2013). See Appendix A for the raw data.

Table 1. HEPA Filters Changed 2010 – 2016

Year	Location	Filter Asset	ΔP (in. wg)	Efficiency	Fume Hood Asset	Velocity (ft/min)	Standard Broken
2010	3430	HVEF-HEPA-1507	0.8	99.90	HVEF-FH-1505	111	efficiency > 99.90%
2013	3410	HVEF-HEPA-1404-3	4.0	99.98	HVE-FG-1404	68	ΔP < 4.0 in. wg; velocity >= 100 ft/min

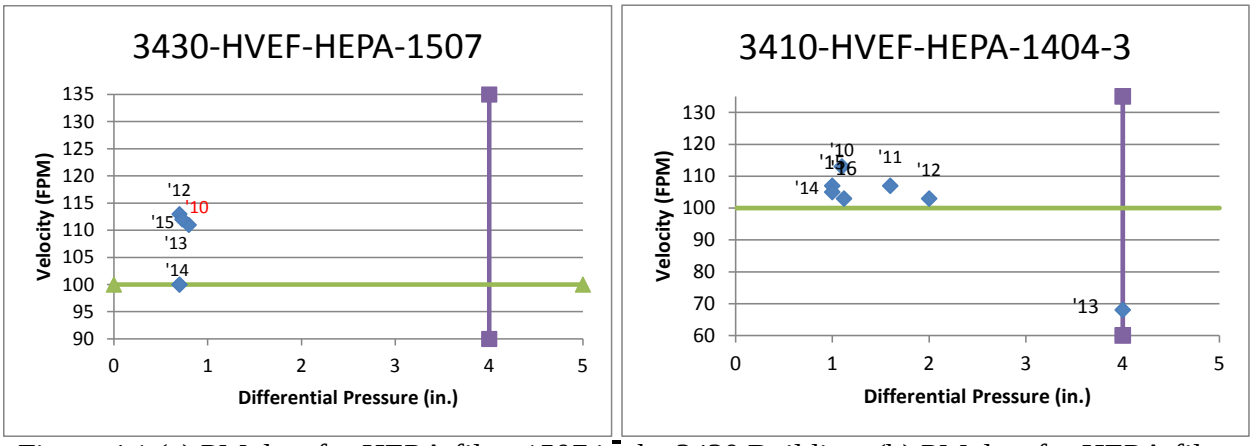

Figure 4.1 (a) PM data for HEPA filter 1507 in the 3430 Building. (b) PM data for HEPA filter 1404-3 in the 3410 Building.

5.0 Conclusion

Regular evaluations of the pressure differential (ΔP), filter efficiency, radiological dose, and fume hood face velocity indicate that the HEPA filter lifetime is longer than the 10 years presently recommended; however, this excludes the tensile strength of the HEPA filter. The low rate of filter changes (4.1% over the interim six-year period) were due to arbitrary failures of filter performance, not deterioration due to old age. At this point in the study, the filters used in the PSF buildings seem adequate to withstand use beyond the DOE 10-year-recommended age limit, which the EPA admits was set conservatively to ensure appropriate tensile strength in the filters since "extrapolated… data suggests [it] fails at 13 years" (EPA 2009). Because there is so little data suggesting the age limit should be increased or decreased, filters should instead be evaluated on a case-by-case basis before removal.

6.0 References

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Appendix A: Raw Data

DP = Differential Pressure measured in inches.
Face Velocity measured in feet per minute.

MDA = 20 mrem/hr

PSF 3410 (2 pages)

1 HEPA : 1 Fume Hood

HEPA	Date	DP	Efficiency	Remarks	Fume Hood	Date	Velocity	Remarks
3410-HVEF-HEPA-1402	6/16/2010	0.70	99.98		3410-HVE-FH-1402	10/31/2010	120	
	6/30/2011	0.60	99.98			11/28/2011	117	
	6/27/2012	1.40	99.98			10/29/2012	122	
	6/19/2013	1.30	99.98			12/17/2013	116	
	6/27/2014	1.30	99.98			12/19/2014	107	
	7/1/2015	0.90	99.98			12/7/2015	107	
	6/1/2016	0.76	99.98			12/1/2016	n/a	unlisted
3410-HVEF-HEPA-1403-3	6/16/2010	0.70	99.98	Written as 1403B	3410-HVE-FH-1403-2	10/31/2010	119	
	6/30/2011	0.40	99.98			11/28/2011	188	Found as 188; out of service
	6/27/2012	N/A	99.98	Δp across damper		10/29/2012	144	Found 144 fpm. SR; written for controller
	6/19/2013	1.00	99.98			12/17/2013	119	
	6/27/2014	N/A	99.98	Δp across damper		12/19/2014	104	
	7/1/2015	N/A	99.98	Δp across damper		12/7/2015	109	
	6/1/2016	n/a	99.98	Δp across damper		12/1/2016	95	
3410-HVEF-HEPA-1404-3	6/16/2010	1.10	99.98	Written as 1404B	3410-HVE-FH-1404	10/31/2010	113	
	6/30/2011	1.60	99.98			11/28/2011	107	
	6/27/2012	2.00	99.98			10/29/2012	103	
	6/16/2013	4.00	99.98	Filter Changed; 5707050		12/17/2013	68	Out of service
	6/27/2014	1.00	99.98			12/19/2014	107	
	7/1/2015	1.00	99.98			12/7/2015	105	
	6/1/2016	1.12	99.98			12/1/2016	103	
3410-HVEF-HEPA-1407-1	6/16/2010	0.70	99.98	Written as 1407	3410-HVE-FH-1407	10/31/2010	125	
	6/30/2011	0.20	99.98			10/1/2011	109	
	6/27/2012	0.60	99.98			10/29/2012	116	
	6/19/2013	0.30	99.98			12/17/2013	116	
	6/27/2014	0.30	99.98			12/19/2014	106	
	7/1/2015	0.20	99.98			12/7/2015	107	
	6/1/2016	0.69	99.98			12/1/2016	103	
3410-HVEF-HEPA-1607	6/16/2010	1.00	99.98		3410-HVEF-FH-1607	10/31/2010	N/A	Out of service
	6/30/2011	1.00	99.98			10/1/2011	41	Out of service
	6/27/2012	0.90	99.98			10/29/2012	113	
	6/19/2013	1.20	99.98			12/17/2013	105	
	6/27/2014	0.45	99.98			12/19/2014	98	
	7/1/2015	0.30	99.98			12/7/2015	102	
	6/1/2016	0.37	99.98			12/1/2016	100	

2 HEPA : 1 Fume Hood

HEPA	Date	DP	Efficiency	Remarks	Fume Hood	Date	Velocity	Remarks
3410-HVEF-HEPA-1403-1/ 1403-2		0.40	99.98	Listed as 1403	3410-HVE-FH-1403-1			
	6/16/2010	0.40	99.98	Listed as 1403A		10/31/2010	125	
		0.50	99.98			11/28/2011		
	6/30/2011	0.20	99.98				121	
		0.60	99.98					
	6/27/2012	0.60	99.98			10/29/2012	118	
		1.50	99.98					
	6/19/2013	1.60	99.98			12/17/2013	118	
		0.80	99.98					
	6/27/2014	0.85	99.98			12/19/2014	119	
		0.30	99.98					
	7/1/2015	0.30	99.98			12/7/2015	120	
		0.50	99.98					
	6/1/2016	0.52	99.98			12/1/2016	99	
3410-HVEF-HEPA-1600/ 1602A		0.60	99.98	Listed as 1602	3410-HVEF-FH-1602		N/A	
	6/16/2010	0.60	99.98	Listed as 1602-2		10/31/2010		
		0.80	99.98	Listed as 1602-1			110	
	6/30/2011	0.90	99.98	Listed as 1602-2		11/28/2011		
		0.80	99.98	Listed as 1602			116	
	6/27/2012	0.80	99.98	Listed as 1602A		10/29/2012		
		1.25	99.97	Listed as 1602-1			111	
	6/19/2013	1.10	99.97	Listed as 1602-2		12/17/2013		
		0.95	99.98	Listed as 1602			105	
	6/27/2014	1.00	99.98	Listed as 1603		12/19/2014		
		0.80	99.98	Listed as 1602			117	
	7/1/2015	N/A	99.98	Listed as 1603		12/7/2015		
		1.22	99.98	both are listed as 1602 maols asset corrections			110	
	6/1/2016	1.22	99.98			12/1/2016		

3410 Contamination Measurements

MDA: minimum detectable activity

Date	Location	β-γ	α	Date	Location	B-γ	α
12/14/2011	HEPA Units South (1400 hall)	< MDA	<	9/26/2014	HEPA Units South (1400 hall)	<	<
	HEPA Units North (1600 hall)	<	<		HEPA Units North (1600 hall)	<	<
1/18/2012	HEPA Units North (1600 hall)	<	<	2/3/2015	HEPA Units South (1400 hall)	<	<
1/25/2012	HEPA Units South (1400 hall)	<	<	2/23/2015	HEPA Units North (1600 hall)	<	<
11/8/2012	HEPA Units South (1400 hall)	<	<	12/15/2015	HEPA Units South (1400 hall)	<	<
	HEPA Units North (1600 hall)	<	<		HEPA Units North (1600 hall)	<	<
2/5/2013	HEPA Units South (1400 hall)	<	<	1/12/2016	HEPA Units South (1400 hall)	<	<
2/6/2013	HEPA Units North (1600 hall)	<	<		HEPA Units North (1600 hall)	<	<
9/17/2013	HEPA Units South (1400 hall)	<	<	7/28/2016	HEPA Units South (1400 hall)	<	<
	HEPA Units North (1600 hall)	<	<		HEPA Units North (1600 hall)	<	<
1/30/2014	HEPA Units South (1400 hall)	<	<	2/28/2017	HEPA Units South (1400 hall)	<	<
	HEPA Units North (1600 hall)	<	<		HEPA Units North (1600 hall)	<	<

PSF 3420 (9 pages)

1 HEPA : 1 Fume Hood

HEPA	Date	DP	Efficiency	Remarks	Fume Hood	Date	Velocity	Remarks
3420-HVEF-HEPA-1607-7	7/26/2010	0.10	99.98		3420-HVEF-FH-1607-3	10/31/2010	105	
	10/18/2011	0.65	99.98			10/1/2011	115	
	11/15/2012	0.20	99.98			11/12/2012	111	
	10/8/2013	0.40	99.98			10/8/2013	119	
	11/12/2014	0.35	99.98			10/10/2014	119	
	11/30/2015	0.80	99.98			11/30/2015	104	
	11/1/2016	0.50	99.98			11/1/2016	117	
3420-HVEF-HEPA-1700-4	7/26/2010	0.60	99.98		3420-HVEF-FH-1700-5	10/31/2010	110	
	10/18/2011	0.65	99.98			10/1/2011	109	P.O. to start
	11/15/2012	N/A	N/A	Perch. Hood		11/12/2012	109	
	10/8/2013	0.70	99.98			10/8/2013	117	
	11/12/2014	0.80	99.98			10/10/2014	113	
	11/30/2015	0.60	99.98			11/30/2015	114	
	11/1/2016	0.53	99.98			11/1/6016	105	
3420-HVEF-HEPA-1705-5	7/26/2010	0.15	99.98		3420-HVEF-FH-1705-5	10/31/2010	115	
	10/18/2011	0.20	99.98			10/1/2011	116	
	11/15/2012	0.15	99.98			11/12/2012	111	
	10/8/2013	0.20	99.98			10/8/2013	121	
	11/12/2014	0.60	99.98			10/10/2014	119	
	11/30/2015	0.65	99.98			11/30/2015	107	
	11/1/2016	0.64	99.98			11/1/2016	n/a	room 1705 under construction, no access to room
3420-HVEF-HEPA-1705-4	7/26/2010	0.20	99.98		3420-HVEF-FH-1705-6	10/31/2010	120	
	10/18/2011	0.50	99.98			10/1/2011	121	
	11/15/2012	0.40	99.98			11/12/2012	114	
	10/8/2013	0.55	99.98			10/8/2013	121	
	11/12/2014	0.60	99.98			10/10/2014	116	
	11/30/2015	0.60	99.98			11/30/2015	113	
	11/1/2016	0.57	99.98			11/1/2016	n/a	room 1705 under construction, no access to room
3420-HVEF-HEPA-1707-4	7/26/2010	0.20	99.98		3420-HVEF-FH-1707-5	10/31/2010	115	
	10/18/2011	0.25	99.98			10/1/2011	122	
	11/15/2012	0.25	99.98			11/12/2012	108	
	10/8/2013	0.85	99.98			10/8/2013	116	
	11/12/2014	0.70	99.98			10/10/2014	104	
	11/30/2015	0.75	99.98			11/30/2015	113	
	11/1/2016	n/a	n/a	under const. not to be tested per B.E.		11/1/2016	n/a	room 1707 under construction, no access to room
3420-HVEF-HEPA-1707-5	7/26/2010	0.20	99.98		3420-HVEF-FH-1707-4	10/31/2010	115	
	10/18/2011	0.30	99.98			10/1/2011	101	
	11/15/2012	0.60	99.98			11/12/2012	108	Found 96 Adjusted
	10/8/2013	0.85	99.98			10/8/2013	124	
	11/12/2014	0.70	99.98			10/10/2014	104	
	11/30/2015	0.80	99.98			11/30/2015	108	
	11/1/2016	n/a	n/a	under const. not to be tested per B.E.		11/1/2016	n/a	room 1707 under construction, no access to room
3420-HVEF-	7/26/2010	N/A	N/A			10/31/2010	115	
	10/18/2011	N/A	N/A			9/9/2011	121	

HEPA-1707E	11/15/2012	N/A	N/A		3420-HVEF-FH-1707-6	11/12/2012	110	
	10/8/2013	N/A	N/A			10/8/2013	113	
	11/12/2014	N/A	N/A			10/10/2014	132	
	11/30/2015	N/A	N/A			11/30/2015	118	
	11/1/2016	n/a	n/a	not listed		11/1/2016	n/a	room 1707 under construction, no access to room

2 HEPA : 1 Fume Hood

HEPA	Date	DP	Efficiency	Remarks	Fume Hood	Date	Velocity	Remarks
3420-HVEF-HEPA-2500/	7/26/2010	0.90 1.00	99.98 99.98		3420-HVE-FH-1600	10/31/2010	N/A	
	10/18/2011	1.30 1.35	99.98 99.98			10/1/2011	N/A	
	11/15/2012	1.40 1.20	99.98 99.98			11/12/2012	103	
	10/8/2013	1.45 1.50	99.98 99.98			10/8/2013	110	
	11/12/2014	1.50 1.60	99.98 99.98			10/10/2014	106	
	11/30/2015	1.40 1.50	99.98 99.98			11/30/2015	105	
	11/1/2016	4.20 4.20	99.98 99.98			11/1/2016	104	
3420-HVEF-HEPA-1607/	7/26/2010	1.00 0.90	99.98 99.98		3420-HVEF-FH-1603-1	10/31/2010	110	
	10/18/2011	1.30 1.20	99.98 99.98			10/1/2011	104	
	11/15/2012	1.30 1.20	99.98 99.98			11/12/2012	103	
	10/8/2013	1.40 1.30	99.98 99.98			10/8/2013	110	
	11/12/2014	2.00 1.90	99.98 99.98			10/10/2014	101	
	11/30/2015	1.30 1.20	99.98 99.98			11/30/2015	120	
	11/1/2016	2.23 1.62	99.98 99.98			11/1/2016	106	
3420-HVEF-HEPA-1601/	7/26/2010	0.35 0.40	99.98 99.98		3420-HVEF-FH-1603-4	10/31/2010	123	
	10/18/2011	0.75 0.85	99.98 99.98			10/1/2011	103	
	11/15/2012	0.50 0.50	99.98 99.98			11/12/2012	108	
	10/8/2013	0.90 1.00	99.98 99.98			10/8/2013	112	
	11/12/2014	0.90 1.00	99.98 99.98			10/10/2014	115	
	11/30/2015	1.20 1.20	99.98 99.98			11/30/2015	104	
	11/1/2016	1.68 1.75	99.98 99.98			11/1/2016	106	

3420-HVEF-HEPA-1607-4/	7/26/2010	0.10 0.10	99.98 99.98		3420-HVEF-FH-1607-1	10/31/2010	123	
	10/18/2011	0.60 0.60	99.98 99.98			10/1/2011	129	
	11/15/2012	0.50 0.50	99.98 99.98			11/12/2012	115	
	10/8/2013	0.40 0.40	99.98 99.98			10/8/2013	122	
	11/12/2014	0.50 0.50	99.98 99.98			10/10/2014	115	
	11/30/2015	0.60 0.50	99.98 99.98			11/30/2015	112	
	11/1/2016	0.67 1.71	99.98 99.98			11/1/2016	121	
3420-HVEF-HEPA-1707-2/	7/26/2010	0.10 0.10	99.98 99.98		3420-HVEF-FH-1707-3	10/31/2010	121	
	10/18/2011	0.15 0.20	99.98 99.98			10/1/2011	117 120	both sides open, read both sides
	11/15/2012	0.60 0.60	99.98 99.98			11/12/2012	104 125	both sides open, read both sides
	10/8/2013	0.20 0.20	99.98 99.98			10/8/2013	123	
	11/12/2014	0.40 0.40	99.98 99.98			10/10/2014	150	
	11/30/2015	0.20 0.20	99.98 99.98			11/30/2015	108	both sides open, read both sides
	11/1/2016	n/a	n/a	under const. not to be tested per B.E.		11/1/2016	n/a	room 1707 under construction, no access to room

2 HEPA : Multiple Fume Hoods

HEPA	Date	DP	Efficiency	Remarks	Fume Hood	Date	Velocity	Remarks
3420-HVEF-HEPA-1603/	7/29/2010	0.20 0.20	99.98 99.98		3420-HVEF-FH-1603-2/	10/31/2010	118 115	
	10/18/2011	0.20 0.20	99.98 99.98			11/30/2011	103 110	
	11/19/2012	0.20 0.20	99.98 99.98			11/12/2012	103 111	
	11/19/2013	0.20 0.20	99.98 99.98			11/19/2013	108 114	
	11/21/2014	0.70 0.70	99.98 99.98			11/17/2014	123 125	
	11/30/2015	0.80 0.80	99.98 99.98			11/30/2015	112 116	
	11/1/2016	0.73 1.02	99.98 99.98			11/1/2016	103 109	
3420-HVEF-HEPA-1607-2/	7/29/2010	0.10 0.10	99.98 99.98		3420-HVEF-FH-1607-2/	10/31/2010	114 N/A	
	10/18/2011	0.30 0.30	99.98 99.98			11/30/2011	118 N/A	
	11/19/2012	0.90 1.00	99.98 99.98			11/12/2012	113 106	

	11/19/2013	0.80 0.90	99.98 99.98			11/19/2013	118 N/A	
	11/21/2014	0.90 1.00	99.98 99.98			11/17/2014	118 N/A	
	11/30/2015	1.00 1.10	99.98 99.98			11/30/2015	113 108	
	11/1/2016	0.58 2.89	99.98 99.98			11/1/2016	107 117	
3420-HVEF-HEPA-1700/	7/29/2010	0.30 0.30	99.98 99.98		3420-HVEF-FH-1700-1/	10/31/2010	125 120 123	
	10/18/2011	0.40 0.40	99.98 99.98			11/30/2011	116 122 113	
	11/19/2012	0.40 0.40	99.98 99.98			11/12/2012	125 122 108	
	11/19/2013	0.40 0.40	99.98 99.98			11/19/2013	112 118 111	
	11/21/2014	0.65 0.65	99.98 99.98			11/17/2014	120 120 117	
	11/30/2015	0.70 0.80	99.98 99.98			11/30/2015	124 120 109	
	11/1/2016	1.18 1.32	99.98 99.98			11/1/2016	110 117 107	
3420-HVEF-HEPA-1700-2/	7/29/2010	0.30 0.30	99.98 99.98		3420-HVEF-FH-1700-4/	10/31/2010	120 115	
	10/18/2011	0.30 0.30	99.98 99.98			11/30/2011	125 116	
	11/19/2012	0.20 0.20	99.98 99.98			11/12/2012	125 117	
	11/19/2013	0.80 0.80	99.98 99.98			11/19/2013	122 113	
	11/21/2014	1.00 1.00	99.98 99.98			11/17/2014	119 124	
	11/30/2015	1.10 0.90	99.98 99.98			11/30/2015	111 110	
	11/1/2016	0.74 0.60	99.98 99.98			11/1/2016	119 105	
3420-HVEF-HEPA-1702-2/	7/29/2010	0.30 0.30	99.98 99.98		3420-HVEF-FH-1702-1/	10/31/2010	120 115 124	
	10/18/2011	0.30 0.30	99.98 99.98			11/30/2011	119 106 115	
	11/19/2012	0.30	99.98			11/12/2012	120 110	

		0.35	99.98				122	
	11/19/2013	0.40 0.65	99.98 99.98			11/19/2013	121 111 123	
	11/21/2014	0.40 0.45	99.98 99.98			11/17/2014	119 114 123	
	11/30/2015	0.40 0.40	99.98 99.98			11/30/2015	114 105 107	
	11/1/2016	1.08 1.27	99.98 99.98			11/1/2016	100 108 111	all are constant volume
3420-HVEF-HEPA-1702/	7/29/2010	0.60 0.60	99.98 99.98		3420-HVEF-FH-1702-4/	10/31/2010	118 110	
	10/18/2011	0.40 0.50	99.98 99.98			11/30/2011	108 121	
	11/19/2012	0.40 0.40	99.98 99.98			11/12/2012	117 116	
	11/19/2013	0.80 0.80	99.98 99.98			11/19/2013	123 106	
	11/21/2014	1.50 1.50	99.98 99.98			11/17/2014	120 119	
	11/30/2015	1.40 1.30	99.98 99.98			11/30/2015	107 113	
	11/1/2016	0.83 0.95	99.98 99.98			11/1/2016	108 107	
3420-HVEF-HEPA-1703/	7/29/2010	0.60 0.60	99.98 99.98		3420-HVEF-FH-1703A-1/	10/31/2010	124 108 105	
	10/18/2011	0.30 0.30	99.98 99.98			11/30/2011	105 108 116	
	11/19/2012	0.60 0.70	99.98 99.98			11/12/2012	123 104 116	Found 131 Adjusted
	11/19/2013	0.65 0.60	99.98 99.98			11/19/2013	120 125 115	
	11/21/2014	0.70 0.80	99.98 99.98			11/17/2014	113 108 125	
	11/30/2015	0.20 0.20	99.98 99.98			11/30/2015	117 106 105	
	11/1/2016	1.94 1.98	99.98 99.98	Δp across damper Δp across damper		11/1/2016	103 124 116	
3420-HVEF-HEPA-1705/	7/29/2010	0.40 0.40	99.98 99.98		3420-HVEF-FH-1703C-1/	10/31/2010	115 110 115	

	10/18/2011	0.70 0.80	99.98 99.98			11/30/2011	115 120 125	
	11/19/2012	1.00 1.00	99.98 99.98			11/12/2012	101 125 125	
	11/19/2013	1.00 1.10	99.98 99.98			11/19/2013	116 117 123	
	11/21/2014	1.60 1.60	99.98 99.98			11/17/2014	107 125 111	
	11/30/2015	1.02 1.50	99.98 99.98			11/1/2015	111 120 120	
	11/1/2016	0.86 1.22	99.98 99.98			11/1/2016	116	unlisted unlisted
3420-HVEF-HEPA-1703-2/	7/29/2010	0.60 0.55	99.98 99.98		3420-HVEF-FH-1703C-2/	10/31/2010	110 115	
	10/18/2011	0.60 0.60	99.98 99.98			11/30/2011	107 114	
	11/19/2012	0.50 0.60	99.98 99.98			11/12/2012	110 125	
	11/19/2013	0.50 0.50	99.98 99.98			11/19/2013	110 124	Adjusted, found 131
	11/21/2014	0.90 1.00	99.98 99.98			11/17/2014	110 123	
	11/30/2015	0.60 0.65	99.98 99.98			11/1/2015	106 120	
	11/1/2016	1.87 1.91	99.98 99.98	Δp across damper Δp across damper		11/1/2016	107 107	
3420-HVEF-HEPA-1704-2/	7/29/2010	0.60 0.60	99.98 99.98		3420-HVEF-FH-1704-1/	10/31/2010	125 120 123	
	10/18/2011	0.75 0.75	99.98 99.98			11/30/2011	118 124 123	
	11/19/2012	0.70 0.70	99.98 99.98			11/12/2012	109 107 106	
	11/19/2013	0.70 0.70	99.98 99.98			11/19/2013	110 110 113	
	11/21/2014	2.00 2.00	99.98 99.98			11/17/2014	109 121 115	
	11/30/2015	1.20 1.10	99.98 99.98			11/30/2015	112 112 113	
		1.52	99.98				n/a	removed

		1.08	99.98					
3420-HVEF-HEPA-1704/	7/29/2010	0.30 0.20	99.98 99.98		3420-HVEF-FH-1704-4/	10/31/2010	123 125	
	10/18/2011	0.30 0.25	99.98 99.98			11/30/2011	116 121	
	11/19/2012	0.30 0.30	99.98 99.98			11/12/2012	113 125	
	11/19/2013	0.35 0.40	99.98 99.98			11/19/2013	121 124	
	11/21/2014	0.50 0.50	99.98 99.98			11/17/2014	115 118	
	11/30/2015	0.60 0.60	99.98 99.98			11/30/2015	112 122	
	11/1/2016	1.02 1.04	99.98 99.98			11/1/2016	100 112	renamed 1704-6 renamed 1704-7
3420-HVEF-HEPA-1705-2/	7/29/2010	0.25 0.25	99.98 99.98		3420-HVEF-FH-1705-1/	10/31/2010	125 118 121 115	
	10/18/2011	0.40 0.50	99.98 99.98			11/30/2011	111 115 120 112	
	11/19/2012	0.40 0.40	99.98 99.98			11/12/2012	116 121 119 120	Found 127 Adjusted
	11/19/2013	0.30 0.30	99.98 99.98			11/19/2013	129 115 108 133	Adjusted 107 Adjusted to 119
	11/21/2014	1.10 1.10	99.98 99.98			11/17/2014	105 112 114 108	
	11/30/2015	1.35 1.20	99.98 99.98			11/30/2015	108 106 105 117	
	11/1/2016	1.44 1.60	99.98 99.98			11/1/2016	n/a	room 1705 under construction no access to room
3420-HVEF-HEPA-1706-2/	7/29/2010	0.30 0.30	99.98 99.98		3420-HVEF-FH-1706-1/	10/31/2010	120 115 122	
	10/18/2011	1.20 1.20	99.98 99.98			11/30/2011	115 111 125	
	11/19/2012	1.20 1.20	99.98 99.98			11/12/2012	114 113 113	
	11/19/2013					11/19/2013	118	

		0.90 0.90	99.98 99.98				112 122	
	11/21/2014	0.75 0.75	99.98 99.98			11/17/2014	121 115 116	
	11/30/2015	1.00 1.40	99.98 99.98			11/30/2015	N/A N/A N/A	Under construction
	11/1/2016	1.14 1.21	99.98 99.98			11/1/2016	108 110 111	
3420-HVEF-HEPA-1706/	7/29/2010	0.30 0.30	99.98 99.98		3420-HVEF-FH-1706-4/	10/31/2010	105 115 109	
	10/18/2011	0.50 0.50	99.98 99.98			11/30/2011	101 112 122	
	11/19/2012	0.80 0.80	99.98 99.98			11/12/2012	111 121 120	
	11/19/2013	0.60 0.60	99.98 99.98			11/19/2013	109 125 54	Adjusted to 124
	11/21/2014	0.70 0.70	99.98 99.98			11/17/2014	108 114 113	
	11/30/2015	1.40 1.40	99.98 99.98			11/30/2015	N/A N/A N/A	Under construction
	11/1/2016	1.43 1.47	99.98 99.98			11/1/2016	107 120 116	
3420-HVEF-HEPA-1707/	7/29/2010	0.40 0.35	99.98 99.98		3420-HVEF-FH-1707-1/	10/31/2010	108 115	
	10/18/2011	0.50 0.50	99.98 99.98			11/30/2011	88 110	Out of Service
	11/19/2012	0.50 0.50	99.98 99.98			11/12/2012	125 115	
	11/19/2013	0.55 0.50	99.98 99.98			11/19/2013	119 74	WR# Written by BE
	11/21/2014	0.60 0.55	99.98 99.98			11/17/2014	119 122	
	11/30/2015	0.65 0.60	99.98 99.98			11/30/2015	111 123	
	11/1/2016	n/a	n/a	under const. not to be tested per B.E.		11/1/12016	n/a	room 1707 under construction; no access to room

3420 Contamination Measurements

MDA: minimum detectable activity

Date	Location	β-γ	α
12/7/2011	floors	<	<
2/29/2012	2nd floor open areas	<	<
	floor inside 2500-2508	<	<
3/13/2013	1703 (4)	<	<
	1705 (6)	<	<
	1707 (7)	<	<
	1709	<	<
	1800	<	<
	1706 (4)	<	<
	1704 (4)	<	<
	1702 (4)	<	<
	1700 (5)	<	<
	1601 (2)	<	<
	1603 (2)	<	<
	1607 (8)	<	<
	2500 (2)	<	<
10/21/2013	1703 (4)	<	<
	1705 (6)	<	<
	1707 (7)	<	<
	1709	<	<
	1800	<	<
	1706 (4)	<	<
	1704 (4)	<	<
	1702 (4)	<	<
	1700 (5)	<	<
	1601 (2)	<	<
	1603 (2)	<	<
	1607 (8)	<	<
	2500 (2)	<	<
5/8/2014	1703 (4)	<	<
	1705 (6)	<	<
	1707 (7)	<	<
	1709	<	<
	1800	<	<
	1706 (4)	<	<
	1704 (4)	<	<
	1702 (4)	<	<
	1700 (5)	<	<
	1601 (2)	<	<
	1603 (2)	<	<
	1607 (8)	<	<
	2500 (2)	<	<
12/16/2014	1703 (4)	<	<
	1705 (6)	<	<
	1707 (7)	<	<
	1709	<	<
	1800	<	<
	1706 (4)	<	<
	1704 (4)	<	<
	1702 (4)	<	<
	1700 (5)	<	<
	1601 (2)	<	<
	1603 (2)	<	<
	1607 (8)	<	<
	2500 (2)	<	<
6/10/2015	1703 (4)	<	<
	1705 (6)	<	<
	1707 (7)	<	<
	1709	<	<
	1800	<	<
	1706 (4)	<	<
	1704 (4)	<	<
	1702 (4)	<	<
	1700 (5)	<	<
	1601 (2)	<	<
	1603 (2)	<	<
	1607 (8)	<	<
	2500 (2)	<	<
12/11/2015	1703 (4)	<	<
	1705 (6)	<	<
	1707 (7)	<	<
	1709	<	<
	1800	<	<
	1706 (4)	<	<
	1704 (4)	<	<
	1702 (4)	<	<
	1700 (5)	<	<
	1601 (2)	<	<
	1603 (2)	<	<
	1607 (8)	<	<
	2500 (2)	<	<
3/4/2016	1703 (4)	<	<
	1705 (6)	<	<
	1707 (7)	<	<
	1709	<	<
	1800	<	<
	1706 (4)	<	<
	1704 (4)	<	<
	1702 (4)	<	<
	1700 (5)	<	<
	1601 (2)	<	<
	1603 (2)	<	<
	1607 (8)	<	<
	2500 (2)	<	<
7/29/2016	1703 (4)	<	<
	1705 (6)	<	<
	1707 (7)	<	<
	1709	<	<
	1800	<	<
	1706 (4)	<	<
	1704 (4)	<	<
	1702 (4)	<	<
	1700 (5)	<	<
	1601 (2)	<	<
	1603 (2)	<	<
	1607 (8)	<	<
	2500 (2)	<	<
5/19/2017	1703 (4)	<	<
	1705 (6)	<	<
	1707 (7)	<	<
	1709	<	<
	1800	<	<
	1706 (4)	<	<
	1704 (4)	<	<
	1702 (4)	<	<
	1700 (5)	<	<
	1601 (2)	<	<
	1603 (2)	<	<
	1607 (8)	<	<
	2500 (2)	<	<

PSF 3430 (5 pages)

1 HEPA : 1 Fume Hood

HEPA	Date	DP	Efficiency	Remarks	Fume Hood	Date	Velocity	Remarks
3430-HVEF-HEPA-1310D	6/11/2010	0.50	99.98		3430-HVEF-FH-1310-1	10/31/2010	103	
	5/26/2011	N/A	N/A	Not Listed		11/28/2011	112	
	5/31/2012	0.35	99.98			11/9/2012	116	
	5/28/2013	0.41	99.97			10/28/2013	109	
	5/28/2014	0.30	99.98			10/27/2014	101	
	6/2/2015	0.20	99.98			11/9/2015	102	Found 94, Adjusted
	5/1/2016	n/a	99.98	Δp across damper		10/4/2016	105	
3430-HVEF-HEPA-1310E	6/11/2010	N/A	N/A	Perc. Hood, Out of Service	3430-HVEF-FH-1310-6	10/31/2010	N/A	Out of Service
	5/26/2011	N/A	N/A	Not Listed		11/28/2011	N/A	Out of Service
	5/31/2012	0.40	99.98	Perc. Hood		11/9/2012	115	Found 126, Adjusted
	5/28/2013	0.40	99.98			10/28/2013	123	
	5/28/2014	0.40	99.98			10/27/2014	125	
	6/2/2015	0.42	99.98			11/9/2015	116	Constant Volume
	5/1/2016	0.45	99.98	perc. hood		10/4/2016	122	
3430-HVEF-HEPA-1507	6/11/2010	0.80	99.90	Failed DOS Test	3430-HVEF-FH-1505	10/31/2010	111	
	5/26/2011	N/A	N/A			11/28/2011	100	Ovens in hood
	5/31/2012	0.70	99.98			11/9/2012	113	
	5/28/2013	0.70	99.98			10/28/2013	100	
	5/28/2014	0.70	99.98			10/27/2014	100	
	6/2/2015	0.73	99.98			11/9/2015	117	
	5/1/2016	n/a	99.98	Δp across damper		10/4/2016	101	sash can't be lowered due to equip
3430-HVEF-HEPA-1507A	6/11/2010	0.60	99.98		3430-HVEF-FH-1507	10/31/2010	103	
	5/26/2011	N/A	N/A	Not Listed		11/28/2011	107	
	5/31/2012	0.80	99.98			11/9/2012	110	
	5/28/2013	0.95	99.98			10/28/2013	111	
	5/28/2014	0.90	99.98			10/27/2014	108	
	6/2/2015	0.97	99.98			11/9/2015	112	
	5/1/2016	n/a	99.98	Δp across damper		10/4/2016	125	
3430-HVEF-HEPA-1601-4	6/11/2010	0.50	99.98	Listed as 1601-C	3430-HVEF-FH-1601-1	10/31/2010	N/A	Not Listed
	5/26/2011	N/A	N/A			11/28/2011	N/A	
	5/31/2012	0.20	99.98			11/9/2012	105	Listed as 1601
	5/28/2013	0.60	99.98			10/28/2013	114	Listed as 1601
	5/28/2014	0.10	99.98			10/1/2014	117	Listed as 1601
	6/2/2015	0.05	99.98			11/9/2015	85	Adjusted # not listed
	5/1/2016	n/a	99.98	Δp across damper		10/4/2016	116	

2 HEPA : 1 Fume Hood

HEPA	Date	DP	Efficiency	Remarks	Fume Hood	Date	Velocity	Remarks
3430-HVEF-HEPA-1306/1306A	6/11/2010	0.20	99.98		3430-HVEF-FH-1306-3	10/31/2010	104	
		0.10	99.98					
	5/26/2011	1.00	99.98			11/28/2011	100	
		0.20	99.98					
	5/31/2012	0.50	99.98			11/9/2012	100	
		0.50	99.98					

	5/28/2013	0.50 0.60	99.98 99.98			10/28/2013	103	
	5/28/2014	0.40 0.50	99.98 99.98			10/27/2014	109	
	6/2/2015	0.18 0.20	99.98 99.98			11/9/2015	94	
	5/1/2016	1.20 1.10	99.98 99.98			10/4/2016	122	
3430-HVEF-HEPA-1301B/ 1301C	6/11/2010	N/A N/A	N/A N/A		3430-HVEF-FH-1310-2	10/31/2010	105	
	5/26/2011	N/A N/A	N/A N/A			11/28/2011	103	
	5/31/2012	N/A N/A	N/A N/A			11/9/2012	104	
	5/28/2013	N/A N/A	N/A N/A			10/28/2013	107	
	5/28/2014	N/A N/A	N/A N/A			10/27/2014	106	
	6/2/2015	N/A N/A	N/A N/A			11/9/2015	109	
	5/1/2016	1.40 1.50	99.98 99.98			10/4/2016	112	

1 HEPA : 2 Fume Hoods

HEPA	Date	DP	Efficiency	Remarks	Fume Hood	Date	Velocity	Remarks
3430-HVEF-HEPA-1300	6/11/2010	0.20	99.98		3430-HVEF-FH-1300-2/	10/31/2010	108	
	5/26/2011	0.70	99.98			11/28/2011	105	
	5/31/2012	1.10	99.98			11/9/2012	106	
	5/28/2013	0.70	99.98			10/28/2013	106	
	5/28/2014	0.70	99.98			10/27/2014	103	Out of Service, 5727927
	6/2/2015	0.93	99.98			11/9/2015	108	Found 85, Adjusted
	5/1/2016	n/a	99.98	Δp across damper		10/4/2016	103	
3430-HVEF-HEPA-1302	6/11/2010	0.20	99.98		3430-HVEF-FH-1302-1/	10/31/2010	123	
	5/26/2011	0.20	99.98			11/28/2011	112	
	5/31/2012	0.50	99.98			11/9/2012	110	
	5/28/2013	0.30	99.98			10/28/2013	111	
	5/28/2014	0.45	99.98			10/27/2014	105	
	6/2/2015	0.39	99.98			11/9/2015	111	
	5/1/2016	n/a	99.98	Δp across damper		10/4/2016	103	
3430-HVEF-HEPA-1308	6/11/2010	0.40	99.98		3430-HVEF-FH-1308-1/	10/31/2010	104	
	5/26/2011	0.70	99.98			11/28/2011	115	
	5/31/2012	1.15	99.98			11/9/2012	113	
	5/28/2013	1.30	99.98			10/28/2013	112	
	5/28/2014	1.25	99.98			10/27/2014	115	
	6/2/2015	1.08	99.98			11/9/2015	106	
	5/1/2016	2.00	99.98	fix test port @100%		10/4/2016	111	

Multiple HEPA : Multiple Fume Hoods								
HEPA	**Date**	**DP**	**Efficiency**	**Remarks**	**Fume Hood**	**Date**	**Velocity**	**Remarks**
3430-HVEF-HEPA-1300A/	6/11/2010	0.45 0.45	99.98 99.98		3430-HVEF-FH-1300-1/	10/31/2010	107 103 122 100	
	5/26/2011	0.40 0.50	99.98 99.98			11/28/2011	103 108 107 106	
	5/31/2012	0.60 0.60	99.98 99.98			11/9/2012	101 113 104 100	
	5/28/2013	0.70 0.70	99.98 99.98			10/28/2013	111 111 104 108	
	5/28/2014	0.70 0.75	99.98 99.98			10/27/2014	110 113 101 110	
	5/1/2015	0.59 0.70	99.98 99.98			10/1/2015	111 114 107 106	 Found 96, Adjusted Found 94, Adjusted
	5/1/2016	n/a n/a	99.98 99.98	Δp across damper Δp across damper		10/4/2016	103 103 107 n/a	 unlisted
3430-HVEF-HEPA-1305-1/	6/11/2010	0.70 0.60 0.60 0.70	99.98 99.98 99.98 99.98	Listed as 3501 Listed as 3502 Listed as 3503 Listed as 3504	3430-HVEF-FH-1305/	10/31/2010	N/A N/A	
	5/26/2011	0.75 0.65 N/A N/A	99.98 99.98 N/A N/A			11/28/2011	N/A N/A	
	5/31/2012	0.70 0.65 0.80 0.90	99.98 99.98 99.98 99.98			11/9/2012	108 120	 Found 94, Adjusted
	5/28/2013	0.70 0.75 0.80 0.90	99.98 99.98 99.98 99.98			10/28/2013	101 122	
	5/28/2014	0.85 0.90 0.90 1.00	99.98 99.98 99.98 99.98			10/27/2014	102 108	

	5/1/2015	0.66 0.69 0.71 0.71	99.98 99.98 99.98 99.98			10/1/2015	104 109	
	5/1/2016	0.60 0.60 0.65 0.70	99.98 99.98 99.98 99.98			10/4/2016	108 104	
3430-HVEF-HEPA-1310/	6/11/2010	0.20 0.25	99.98 99.98		3430-HVEF-FH-1310-3/	10/31/2010	105 102 105	
	5/26/2011	0.50 0.50	99.98 99.98			11/28/2011	114 107 105	
	5/31/2012	0.70 0.65	99.97 99.98			11/9/2012	115 100 102	
	5/28/2013	0.70 0.70	99.98 99.98			10/28/2013	105 106 107	
	5/28/2014	0.70 0.70	99.98 99.98			10/27/2014	112 103 123	
	5/1/2015	0.79 0.82	99.98 99.98			10/1/2015	105 102 114	Found 94, Adjusted
	5/1/2016	1.30 1.30	99.98 99.98			10/4/2016	109 113 122	
3430-HVEF-HEPA-1500/	6/11/2010	0.70 0.15	99.98 99.98		3430-HVEF-FH-1501-1/	10/31/2010	100 112	
	5/26/2011	N/A N/A	N/A N/A			11/28/2011	N/A 119 110	Out of service
	5/31/2012	0.60 0.60	99.98 99.98			11/9/2012	110 121 111	
	5/28/2013	1.60 0.02	99.98 99.98			10/28/2013	112 105 112	
	5/28/2014	1.50 1.40	99.98 99.98			10/27/2014	105 102 111	
	5/1/2015	1.64 1.48	99.98 99.98			10/1/2015	108 117 113	
	5/1/2016	n/a n/a	99.98 99.98	Δp across damper renamed 1501		10/4/2016	109 109 106	
	6/11/2010	0.65	99.98			10/31/2010	109	

3430-HVEF-HEPA-1503/		0.50	99.98		3430-HVEF-FH-1503-1/		103	
	5/26/2011	N/A N/A	N/A N/A			11/28/2011	N/A 123	Out of service
	5/31/2012	0.65 0.60	99.98 99.98			11/9/2012	111 116	
	5/28/2013	0.60 0.55	99.98 99.98			10/28/2013	102 106	
	5/28/2014	0.60 0.50	99.98 99.98			10/27/2014	104 105	
	5/1/2015	0.63 0.55	99.98 99.98			10/1/2015	101 100	
	5/1/2016	n/a n/a	99.98 99.98	Δp across damper		10/4/2916	113 103	

3430 Contamination Measurements

Date	Location	β-γ	α	Date	Location	B-γ	α
2/15/2012	1310: A - E	< MDA	<	5/14/2013	HEPA's	<	<
	1308: A - C	<	<	10/13/2013	HEPA Units	<	<
	1304: A, B	<	<		HEPA Units	<	<
	1300: A, B	<	<	5/30/2014	HEPA Units	<	<
	1406: 1, 2	<	<	11/7/2014	HEPA Units	<	<
	2506	<	<	2/27/2015	HEPA Units	<	<
	1280	<	<	9/4/2015	HEPA Units	<	<
	1500 A	<	<	6/22/2016	HEPA Units	<	<
	1503 A	<	<	10/28/2016	HEPA Units	<	<
	1601: 1 - 6	<	<				
10/29/2012	HEPA filters	<	<				
	HEPA filters	<	<				

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