



Interim Status of HEPA Filter 10-Year Lifetime Evaluation

August 2016

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JM Barnett
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Abstract

High efficiency particulate air (HEPA) filters are used to remove a variety of particles from industrial gas streams. HEPA filters remove at least 99.97% of airborne particles 0.3 microns in diameter, while particles smaller or larger than 0.3 microns are removed with an even higher efficiency. The purpose of this study is to draw a relationship between the HEPA filter lifespan and various competing factors that include the differential pressure drop in nuclear grade HEPA filters, the fume hood face velocity, the radiological dose, and the filter efficiency characteristics.

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 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).

Effluent Management (EM) is coordinating a 10-year effort to collect and analyze the lifetime of HEPA filters against the other competing requirements. The study began in 2010, and consists of 49 HEPA filters that are analyzed annually to verify compliance with permit conditions. The data are collected from the Physical Science Facility (PSF) 3410, 3420, and 3430 buildings located at the Pacific Northwest National Laboratory (PNNL). The study suggests the frequency of filter replacement should also be based on the differential pressure, filter efficiency, and/or face velocity of the fume hood, rather than a prescribed filter “lifetime”, which is currently every 10 years from the date of manufacture for filters operating under dry conditions. Over the past six years, only two filters in the study were replaced—one due to high DP 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 (EM) group of the Pacific Northwest National Laboratory (PNNL) performs environmental monitoring of air emissions from laboratories that have the potential to emit radiological particles. Laboratories that have the potential to produce radiological emissions are equipped with nuclear high efficiency particulate air (HEPA) filters. HEPA filters are used to remove a variety of particles from industrial gas streams. They are expected remove at least 99.97% of airborne particles 0.3 microns in diameter, while particles smaller or larger than 0.3 microns are removed with an even higher efficiency. The recommendation for routine HEPA filter replacement is every 10 years. EM is assessing whether filter replacement is typically determined by the lifetime of the filters or other characteristics. The purpose of this study is to draw a relationship between the HEPA filter lifespan and various competing factors that include the differential pressure drop in nuclear grade HEPA filters, the fume hood face velocity, the radiological dose, and the filter efficiency characteristics.

The 10-year evaluation period extends from 2010–2020; annual fume hood and HEPA filter exhaust preventative maintenances (PM) for nuclear HEPA filters located in the Physical Science Facility (PSF) are collected annually. The PMs to date were analyzed in order to determine the cause of HEPA replacement and failure. PMs are used to decide whether HEPA filters require replacement, by measuring the differential pressure (DP), filter efficiency, and fume hood face velocity. The 49 HEPA filters in the study have two PMs performed on them annually, totaling 980 PMs during the 10-year period. The PMs are analyzed in order to determine the cause of HEPA filter failure and replacement.

The HEPA filter exhaust preventative maintenance measures the DP and the efficiency of the HEPA filters. At PNNL facilities, the DP must remain under 4.0 inches water gauge (in. wg); once the DP of the filter is 4.0 in. wg or greater, the HEPA filter is replaced. The PM also measures the efficiency of the HEPA filter. Regulatory standards require the efficiency level to be 99.00% or greater. At PNNL, efficiency standards are 99.95% or greater, and limited operations begin when the filter efficiencies range between 99.90% and 99.95%. When the efficiency test is below 99.90%, the HEPA filter is replaced. The fume hood face velocity PM measures the velocity across the inlet face of the fume hood (ft/min). PNNL requires the fume hood velocity be 100 ft/min or greater; fume hoods that fall below the 100 ft/min are placed out of service. To date, HEPA filters were not replaced due to low velocity unless they were also accompanied by a high DP or low efficiency.

During the six-year span of the study, to date, two HEPA filters were replaced. The first HEPA filter replaced was in 2010 at the 3430 Building. Efficiency of the filter was 99.90%, causing the filter to be replaced. The next HEPA filter to be replaced was in 2013 at the 3410 Building; the filter's DP was 4.0 in. wg. Thus, the HEPA filters were not replaced due to lifetime considerations, but were replaced due to DP and efficiency.

2.0 Equipment

HEPA filters are designed to remove at least 99.97% of airborne particles 0.3 microns in diameter from the filtered air stream. HEPA filters carry an American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 52.2 minimum efficiency reporting values (MERV) of 17–19 (ASHRAE 2012). 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. The DP is also measured as part of the PM. (Colby 2013)

In order to test the efficiency of filters, an in-place aerosol test is performed. The in service leak test is 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 PM (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 the average face velocity entering the fume hood is within the design parameters. Measurements of face hood velocities are performed using various types of airflow instruments that are calibrated and traceable to the National Institute of Standards and Technology (NIST) (Rohrig 2016).

3.0 Procedure

Annually, two PMs are performed on the PSF (3410, 3420, and 3430) buildings' HEPA filters. The PMs consist of the "HEPA Exhaust Filter Testing" and "Fume Hood" tests. Forty-nine nuclear grade HEPA filters were selected and analyzed in this study from the various HEPA filters available at the PSF buildings: Seven HEPA filters from 3410, 27 HEPA filters from 3420, and 15 HEPA filters from 3430 were analyzed, totaling 49 HEPA filters. Each filter has two PMs performed on them annually; this is a total of 980 PMs during the 10-year period. The PMs are analyzed in this study in order to determine the cause of HEPA filter failure and replacement.

The "HEPA Exhaust Filter Testing" and "Fume Hood" PMs are performed on each nuclear grade HEPA filter in the PSF buildings. The HEPA Exhaust PM measures the DP and efficiency of HEPA filters, while the Fume Hood PM measured the face velocity (ft/min) of the fume hood. The PMs are individually evaluated to determine if filters meet the following criteria: DP under 4.0 inches water gauge (in. wg), filter efficiency of 99.95% or greater, and fume hood face velocity of 100 ft/min or greater. HEPA filters were replaced when the DP was 4.0 in. wg or greater and/or the efficiency was less than 99.95%; limited operations can be used when filter efficiency range between 99.90% and 99.95%. For the safety of researchers, the face velocity of fume hoods must remain 100 ft/min or greater. When the face velocity falls below 100 ft/min, the fume hood is placed out of service and/or the velocity is as adjusted; unless the low velocity is also accompanied by a high DP or low efficiency, the HEPA filter is not replaced.

PMs are collected annually from the Facilities and Operations (F&O) Vault. Data regarding the DP, filter efficiency, and fume hood face velocity was collected from the PMs and entered into an ExcelTM spreadsheet. The spreadsheet is used to evaluate whether filters have been changed and the cause of filter failure.

4.0 Discussion

The study is ongoing and will not be completed until year 2020. Over the last 5 years (2010–2015), 2 of 49 (4.08%) HEPA filters had been changed due to other factors than the filter lifetime (Table 1). The first HEPA filter to be changed was located at PSF 3430 in 2010. This HEPA filter (3430-HVEF-HEPA-1507) failed the filter efficiency test with an efficiency of 99.90. The next filter to fail was located in PSF 3410 in 2013. The filter (3410-HVEF-HEPA-1404-3) failed the DP and fume hood face velocity criteria, with a DP of 4.0 in. wg and face velocity of 68 ft/min. 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 – 2015

3410					
Year	HEPA	DP	Efficiency	FH	Velocity
2013	3410-HVEF-HEPA-1404-3	4.0	99.98	3410-HVE-FH-1404	68
3430					
Year	HEPA	DP	Efficiency	FH	Velocity
2010	3430-HVEF-HEPA-1507	0.8	99.90	3430-HVEF-FH-1505	111

5.0 Conclusion

At this point in the study, it appears that HEPA filter lifetime is augmented by evaluating the DP, filter efficiency, and fume hood face velocity. Due to the low rate of filter changes (4.08% over the interim 5-year period), the filters seem adequate to withstand use over the prescribed lifetime of 10 years. Filters should be evaluated on a case-by-case basis before they are removed.

6.0 References

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U.S. Department of Energy. 2003. *DOE Handbook: Nuclear Air Cleaning Handbook*. DOE-HDBK-1169-2003, Washington, District of Columbia.

Appendix A

Raw Data

Raw Data

DP = Differential Pressure measured in inches.

Face Velocity measured in feet per minute.

PSF 3410

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			
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			
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			
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			
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			

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

PSF 3420

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			
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			
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			
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			
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			
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			
3420-HVEF-HEPA-1707E			7/26/2010	N/A	N/A			3420-HVEF-FH-1707-6	10/31/2010	115			
			10/18/2011	N/A	N/A				9/9/2011	121			
			11/15/2012	N/A	N/A				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			

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			
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			
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			
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			
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			
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			
3420-HVEF-HEPA-1707E			7/26/2010	N/A	N/A			3420-HVEF-FH-1707-6	10/31/2010	115			
			10/18/2011	N/A	N/A				9/9/2011	121			
			11/15/2012	N/A	N/A				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			

3420-HVEF-HEPA-1702-2/ 1702-3	7/29/2010	0.30 0.30	99.98 99.98		3420-HVEF-FH-1702-1/ 1702-2/ 1702-3	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 0.35	99.98 99.98			11/12/2012	120 110 122	
	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	
3420-HVEF-HEPA-1702/ 1702-1	7/29/2010	0.60 0.60	99.98 99.98		3420-HVEF-FH-1702-4/ 1702-5	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	
	7/29/2010	0.60 0.60	99.98 99.98		3420-HVEF-FH-1703A-1/ 1703A-2/ 1703A-3	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	
	7/29/2010	0.60 0.60	99.98 99.98		3420-HVEF-HEPA-1703/ 1703-1	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	
	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	

	7/29/2010	0.40	99.98				10/31/2010	115		
		0.40	99.98					110		
								115		
	10/18/2011	0.70	99.98				11/30/2011	115		
		0.80	99.98					120		
								125		
3420-HVEF-HEPA-1705/ 1705-1	11/19/2012	1.00	99.98			3420-HVEF-FH-1703C-1/ 1705-3/ 1705-4	11/12/2012	101		
		1.00	99.98					125		
	11/19/2013	1.00	99.98				11/19/2013	116		
		1.10	99.98					117		
	11/21/2014	1.60	99.98				11/17/2014	123		
		1.60	99.98					107		
3420-HVEF-HEPA-1703-2/ 1703-3	7/29/2010	0.60	99.98			3420-HVEF-FH-1703C-2/ 1703C-3	10/31/2010	111		
		0.55	99.98					125		
	10/18/2011	0.60	99.98				11/30/2011	110		
		0.60	99.98					107		
	11/19/2012	0.50	99.98				11/12/2012	114		
		0.60	99.98					110		
3420-HVEF-HEPA-1704-2/ 1704-3	11/19/2013	0.50	99.98			3420-HVEF-FH-1704-1/ 1704-2/ 1704-3	11/19/2013	125		
		0.50	99.98					110		
	11/21/2014	0.90	99.98				11/17/2014	124	Adjusted, found 131	
		1.00	99.98					110		
	11/30/2015	0.60	99.98				11/1/2015	123		
		0.65	99.98					106		
3420-HVEF-HEPA-1704-2/ 1704-3	7/29/2010	0.60	99.98			3420-HVEF-FH-1704-1/ 1704-2/ 1704-3	10/31/2010	120		
		0.60	99.98					123		
	10/18/2011	0.75	99.98				11/30/2011	118		
		0.75	99.98					124		
	11/19/2012	0.70	99.98				11/12/2012	123		
		0.70	99.98					109		
3420-HVEF-HEPA-1704-2/ 1704-3	11/19/2013	0.70	99.98			3420-HVEF-FH-1704-1/ 1704-2/ 1704-3	11/19/2013	107		
		0.70	99.98					110		
	11/21/2014	2.00	99.98				11/17/2014	110		
		2.00	99.98					113		
	11/30/2015	1.20	99.98				11/30/2015	109		
		1.10	99.98					121		
								115		
								112		
								113		

3420-HVEF-HEPA-1704-1704-1	7/29/2010	0.30 0.20	99.98 99.98		3420-HVEF-FH-1704-4/1704-5	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	
	7/29/2010	0.25	99.98			10/31/2010	125 118 121 115	
		0.25	99.98					
	10/18/2011	0.40 0.50	99.98 99.98			11/30/2011	111 115 120 112	
3420-HVEF-HEPA-1705-2/1705-3	11/19/2012	0.40 0.40	99.98 99.98		3420-HVEF-FH-1705-1/1705-2/1705-7/1705-8	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	
3420-HVEF-HEPA-1706-2/1706-3	7/29/2010	0.30 0.30	99.98 99.98		3420-HVEF-FH-1706-1/1706-2/1706-3	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	0.90 0.90	99.98 99.98			11/19/2013	118 112 122	
	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

	7/29/2010	0.30	99.98				10/31/2010	105		
		0.30	99.98					115		
								109		
	10/18/2011	0.50	99.98				11/30/2011	101		
		0.50	99.98					112		
								122		
3420-HVEF-HEPA-1706/ 1706-1	11/19/2012	0.80	99.98			3420-HVEF-FH-1706-4/ 1706-5/ 1706-6	11/12/2012	111		
		0.80	99.98					121		
	11/19/2013	0.60	99.98				11/19/2013	109		
		0.60	99.98					125		
	11/21/2014	0.70	99.98				11/17/2014	54	Adjusted to 124	
		0.70	99.98					108		
	11/30/2015	1.40	99.98				11/30/2015	114		
		1.40	99.98					113		
								N/A		
								N/A	Under construction	
3420-HVEF-HEPA-1707/ 1707-1	7/29/2010	0.40	99.98			3420-HVEF-FH-1707-1/ 1709	10/31/2010	N/A		
		0.35	99.98					108		
	10/18/2011	0.50	99.98				11/30/2011	115		
		0.50	99.98					88	Out of Service	
	11/19/2012	0.50	99.98				11/12/2012	110		
		0.50	99.98					125		
	11/19/2013	0.55	99.98				11/19/2013	115		
		0.50	99.98					119		
	11/21/2014	0.60	99.98				11/17/2014	74	WR# Written by BE	
		0.55	99.98					119		
	11/30/2015	0.65	99.98					122		
		0.60	99.98					111		
								123		

PSF 3430

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	
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	
3430-HVEF-HEPA-1507		6/11/2010	0.80	99.90	Failed DO: HEPA Replaced	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		
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		
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	

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			11/28/2011	100		
		5/26/2011	1.00	99.98			11/9/2012	100		
			0.20	99.98			10/28/2013	103		
		5/31/2012	0.50	99.98			10/27/2014	109		
			0.50	99.98			11/9/2015	101		
		5/28/2013	0.50	99.98						
			0.60	99.98						
		5/28/2014	0.40	99.98						
3430-HVEF-HEPA-1301B/1301C			0.50	99.98		3430-HVEF-FH-1310-2				
		6/2/2015	0.18	99.98						
			0.20	99.98						
		6/11/2010	N/A	N/A			10/31/2010	105		
			N/A	N/A			11/28/2011	103		
		5/26/2011	N/A	N/A			11/9/2012	104		
			N/A	N/A			10/28/2013	107		
		5/31/2012	N/A	N/A			10/27/2014	106		
			N/A	N/A			11/9/2015	109		
		5/28/2013	N/A	N/A						
			N/A	N/A						
		5/28/2014	N/A	N/A						
			N/A	N/A						
		6/2/2015	N/A	N/A						
			N/A	N/A						

Multiple HEPA : Multiple Fume Hoods														
HEPA			Date	DP	Efficiency	Remarks		Fume Hood	Date	Velocity	Remarks			
3430-HVEF-HEPA-1300A/ 1300B			6/11/2010	0.45 0.45	99.98 99.98			3430-HVEF-FH-1300-1/ 1302-3/ 1306-2/ 1306-4	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			
3430-HVEF-HEPA-1305-1/ 1305-2/ 1406-1/ 1406-2			6/11/2010	0.70	99.98	Listed as 3501		3430-HVEF-FH-1305/ 1406	10/31/2010	N/A N/A				
				0.60	99.98	Listed as 3502								
				0.60	99.98	Listed as 3503								
				0.70	99.98	Listed as 3504								
			5/26/2011	0.75	99.98				11/28/2011	N/A N/A				
				0.65	99.98									
				N/A	N/A									
				N/A	N/A									
			5/31/2012	0.70	99.98				11/9/2012	108 120	Found 94, Adjusted			
				0.65	99.98									
				0.80	99.98									
				0.90	99.98									
			5/28/2013	0.70	99.98				10/28/2013	101 122				
				0.75	99.98									
				0.80	99.98									
				0.90	99.98									
			5/28/2014	0.85	99.98				10/27/2014	102 108				
				0.90	99.98									
				0.90	99.98									
				1.00	99.98									
			5/1/2015	0.66	99.98				10/1/2015	104 109				
				0.69	99.98									
				0.71	99.98									
				0.71	99.98									
3430-HVEF-HEPA-1310/ 1310A			6/11/2010	0.20 0.25	99.98 99.98			3430-HVEF-FH-1310-3/ 1310-4/ 1310-5	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			

	6/11/2010						10/31/2010	100		
		0.70	99.98					112		
		0.15	99.98							
	5/26/2011	N/A	N/A				11/28/2011	N/A	Out of service	
3430-HVEF-HEPA-1500/ 1500A	5/31/2012					3430-HVEF-FH-1501-1/ 1501-2/ 1501-3	11/9/2012	110		
		0.60	99.98					121		
	5/28/2013						10/28/2013	111		
		1.60	99.98					112		
		0.02	99.98					105		
	5/28/2014						10/27/2014	112		
		1.50	99.98					105		
	5/1/2015						10/1/2015	102		
		1.40	99.98					111		
								108		
3430-HVEF-HEPA-1503/ 1503A	6/11/2010					3430-HVEF-FH-1503-1/ 1503-2	10/31/2010	117		
		1.64	99.98					113		
	5/26/2011						11/28/2011	109		
		0.65	99.98					103		
	5/31/2012						11/9/2012	N/A	Out of service	
		0.50	99.98					123		
	5/28/2013						10/28/2013	111		
		0.60	99.98					116		
	5/28/2014						10/27/2014	102		
		0.55	99.98					106		
	5/1/2015						10/1/2015	104		
		0.60	99.98					105		
								101		
		0.63	99.98					100		
		0.55	99.98							



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