RPP-RPT-32842, Rev. 0

222-S Laboratory Fume Hood Testing Study

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U.S. Department of Energy Contract DE-AC27-99RL14047

EDT/ECN: DRF

UC:

Cost Center: 7S900

Charge Code: 502052

B&R Code:

Total Pages: 54

Key Words: 222-S Laboratory, fume hood, testing, study, plan, face velocity, profile, room, hood, arm port, open face, airflow, safe operation, containment, smoke (visualization), vapors, turbulence, results, evaluations, analytical equipment, as-used, ANSI/ASHRAE 110-1995, recommendations, conclusions, Maintenance Procedure 2S99003, properties, characteristics, sash, readings

Abstract: The 222-S Laboratory contains 155 active fume hoods that are used to support analytical work with radioactive and/or toxic materials. The performance of a fume hood was brought into question after employees detected odors in the work area while mixing chemicals within the subject fume hood. Following the event, testing of the fume hood was conducted to assess the performance of the fume hood. Based on observations from the testing, it was deemed appropriate to conduct performance evaluations of other fume hoods within the laboratory.

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Jamie Asadul 03/26/07
Release Approval Date

Release Stamp

Approved For Public Release

A-6002-767 (REV 1)

RPP-RPT-32842
Revision 0

222-S LABORATORY FUME HOOD TESTING STUDY

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Date Published
March 2007

CH2MHILL
Hanford Group, Inc.

Prepared for the U.S. Department of Energy
Office of River Protection

Contract No. DE-AC27-99RL14047

Approved for public release; distribution is unlimited

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EXECUTIVE SUMMARY

On October, 26, 2006, the performance of fume hood 2 in Room 1K of the 222-S Laboratory was brought into question after employees detected odors in the room while mixing chemicals within the subject fume hood. Room 1K and fume hood 2 were placed on restricted access until testing could be performed to assess the performance of the fume hood.

Face velocity and smoke (flow visualization) testing of fume hood 2 was conducted on November 15, 2006, to rate the performance of the fume hood under varying conditions. Face velocity of the subject fume hood was found to be within normal operating parameters. Flow visualization testing revealed that airflow turbulence within the fume hood resulted in periodic reversal of vapors towards the front of the fume hood. Some of these vapors would then actually break the sash plane of the fume hood, reverse direction, and then flow back into the fume hood.

Based on testing observations, it was deemed appropriate to conduct further evaluations of other 222-S Laboratory fume hoods. Thirty-four fume hoods were identified as candidates for performance testing. Of the 34 candidate fume hoods, 13 were configured with arm port sashes while the remaining 21 had open face sashes. The majority of these fume hoods contained large pieces of analytical equipment or exhibited "as-used" conditions similar to fume hood 2 in Room 1K.

Based on performance testing results, an engineering evaluation was conducted for each of the candidate fume hoods. This evaluation established an initial performance rating for each fume hood based on a combination of the air velocity profile and flow visualization assessment.

Of the 13 arm port fume hoods tested, seven were rated as "Good" and the remaining six rated as "Fair." All fume hoods rated as "Fair" contained a significant amount of equipment or materials that caused a significant increase in turbulence that was normally observed in all the arm port fume hoods tested.

Of the 21 open-face fume hoods initially tested, 15 were rated as "Good," three rated as "Fair," and three rated as "Poor." All three of the fume hoods rated as "Fair" received their rating due to localized air turbulence caused by instruments positioned within 6 in. of the sash face. Each of the three fume hoods rated as "Poor" received their rating due to turbulence, slow clearing time, and the potential for airflow reversal caused by large solid objects placed close to the fume hood sash plane.

Improvements to fume hood performance ratings can be achieved by the repositioning of instrumentation or materials contained within the fume hood. For example, fume hood 2 in Room 1K received an improved performance rating by removing excess laboratory items and positioning the remaining materials at least 6 in. back from the fume hood sash plane.

Flow characteristics can be improved by modifying support equipment features. The performance ratings for fume hoods 3 and 5 in Room 4B were raised from "Poor" to "Fair" by cutting openings in the lower section of the splash shields that were positioned just inside the fume hood sash planes. Other candidate fume hoods could show similar improved performance ratings with minor modifications.

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1. INTRODUCTION

The 222-S Laboratory contains 155 active fume hoods that are used to support analytical work with radioactive and/or toxic materials. Face velocities for these fume hoods are set and maintained based on many years of operating experience and guidance from the American Conference of Governmental Industrial Hygienists (ACGIH®) *Industrial Ventilation: A Manual of Recommended Practice*. Monthly testing is performed and documented to ensure that the face velocity of each fume hood remains within established parameters. In addition to this, laboratory personnel conduct all analytical activities using approved work practices to ensure safe fume hood operation.

On October 26, 2006, the performance of fume hood 2 in Room 1K of the 222-S Laboratory was brought into question after employees detected odors in the room while mixing chemicals within the subject fume hood. Following this event, performance testing was conducted on fume hood 2. Results of the testing indicated that the large quantity of analytical equipment and materials contained within the fume hood caused airflow turbulence that led to periodic release of vapors into the surrounding area.

Based on the observations from the testing of fume hood 2 in Room 1K, a selected group of candidate fume hoods was identified for performance testing. These fume hoods contained large pieces of analytical equipment or congested work surfaces that could contribute to reduced fume hood performance.

2. TEST METHODOLOGY

The selected testing methods were adopted from ANSI/ASHRAE 110-1995, *Method of Testing Performance of Laboratory Fume Hoods*. The test methods used provided for a qualitative and quantitative evaluation of fume hood performance.

The quantitative evaluation consisted of air velocity measurements. These measurements were taken across the face of each fume hood utilizing a grid pattern established in accordance with Analytical Technical Services Maintenance Procedure 2S99003, "Open Face/Arm Port Hood Airflow Test, 222-S." The average of the velocity measurements was calculated, the highest and lowest readings noted, and a velocity profile generated.

The qualitative portion of the evaluation consisted of general, local, and large volume flow visualization testing. A mixture of dry ice and hot water was used to generate a visible "challenge vapor" for these tests. Direct observation as well as recording of digital video was utilized to render a determination on the ability of each fume hood to contain vapors in its "as-used" state.

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Based on flow visualization test results, performance ratings were established for each of the candidate fume hoods. These ratings and criteria are as follows:

Good

Challenge vapors are adequately captured at the face of the fume hood and are drawn into the fume hood and exhausted. Quick clearance times are observed. Limited fume hood roll vortex. No visible escape of vapors at any time. Turbulence and eddying will be observed in arm port fume hoods between the arm port openings.

Fair

Some challenge vapors reverse flow and migrate toward the fume hood face but are recaptured and exhausted. Dead air spaces are present that would result in a slow migration of vapors toward the fume hood face but are again recaptured and exhausted. Limited turbulent vortex is observed. No visible escape of vapors at any time.

Poor

Challenge vapors reverse flow near the fume hood face. Dead air spaces are present that result in slow migration of vapors toward the fume hood face. Slow capture and clearance of challenge vapors. There is an observed potential for escape of vapors from the fume hood.

Failure

Challenge vapors migrate directly to the fume hood face and escape from the interior of the fume hood into the surrounding area.

3. TEST RESULTS

The data presented in Table 1 shows the average and minimum/maximum readings for face velocities, flow visualization test rating, and general comments applicable to each of the candidate arm port fume hoods.

Of the 13 arm port fume hoods tested, seven of these fume hoods received a "Good" performance rating. The remaining six arm port fume hoods received a "Fair" performance rating. It was noted during flow visualization testing that all arm port fume hoods exhibited varying degrees of turbulence between the arm ports and on either side of the arm ports next to the hood walls. Five of the six fume hoods rated as "Fair" contained a significant amount of equipment that was positioned in such a manner as to accentuate the inherent turbulence problem. Fume hood 1 in Room 2H received a "Fair" rating due to turbulence in the front section of the fume hood caused by poor housekeeping and less than adequate work practices within the fume hood (materials and equipment very close to the hood face). Fume hood 6 in Room 4D was found cluttered with numerous bagged items that were placed between and on top

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of analytical equipment. Despite the poor housekeeping, this fume hood received a performance rating of "Good."

Table 1. Arm Port Fume Hood Test Results.

Room	Hood	Average Face Velocity ^a	Maximum/Minimum Face Velocity	Performance Rating ^b	Comments
4D	6	133	135 / 130	Good	Needs housekeeping.
4P	10	130	137 / 125	Good	Clean work area.
1B	9	133	137 / 129	Good	Equipment well placed.
1GA	4	134	136 / 133	Good	Hood is well kept.
4C	1	134	141 / 130	Good	Equipment well placed.
4A	4	134	140 / 130	Good	Minor turbulence in right corner.
4A	5	135	142 / 131	Good	Minor turbulence in right corner.
4D	5	134	139 / 128	Fair	Excessive equipment for this type of hood.
1D	4	131	132 / 130	Fair	Excessive equipment for this type of hood.
1D	7	134	138 / 132	Fair	Excessive equipment for this type of hood.
1D	8	134	145 / 126	Fair	Excessive equipment for this type of hood.
4J	11	133	134 / 131	Fair	Equipment position causing turbulence.
2H	1	135	141 / 132	Fair	Very cluttered. Materials too close to sash plane.

^a The average face velocity for 222-S Laboratory fume hoods is required to be 125 to 140 feet per minute (FPM).

^b Performance rating from test plan.

Note: All values listed are in FPM.

The data presented in Table 2 show the average and minimum/maximum readings for face velocities, flow visualization test rating, and general comments applicable to each of the candidate open face fume hoods.

Of the 21 open face fume hoods initially tested, 15 fume hoods received a performance rating of "Good." Three fume hoods received a performance rating of "Fair" and three fume hoods received a performance rating of "Poor." All three of the fume hoods rated as "Fair" received this rating due to some localized turbulence and swirling of vapors caused by instruments positioned within 6 in. of the sash face.

Fume hoods 3 and 5 in Room 4B received "Poor" ratings due to splash shields that were positioned just inside the sash faces (within 2 to 3 in.). Velocity profiles for these two fume hoods show a significant decrease in face velocities at the splash shield locations. A very slow clearing time of vapors was observed for both of these fume hoods during flow visualization testing. Following initial performance testing, the splash shields were modified by cutting circular openings in the lower portion of each shield. Velocity and flow visualization testing was again performed for these two fume hoods. This time, a significant improvement in airflow

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around and through the shields was observed with some expected turbulence. These two fume hoods received a revised performance rating of "Fair."

Hood 4 in Room 1K was rated "Poor" due to a large solid support platform that was positioned in the center front section of this fume hood. Flow visualization testing indicated that a potential for escape of vapors from this fume hood might occur if personnel attempted to utilize the limited work surface directly in front of the solid support platform. Following initial performance testing, the solid support platform contained within this fume hood was replaced by an open support platform. Velocity and flow visualization testing was repeated for this hood. The performance rating for this fume hood remained at "Poor" due to some turbulence and reversal of airflow at the fume hood face between the new platform and some containers providing secondary containment for bottled chemicals. This fume hood has been removed from service until such time as the observed performance issues can be corrected.

Finally, fume hood 2 in Room 1K was retested after excess materials and items had been either removed or moved back at least 6 in. from the fume hood face plane. Some swirling on the left side wall of the fume hood was observed. This could be attributed to a couple of bottled chemicals and the tight fit of an instrument located against the left wall. Based on the results of the retest, this fume hood would now be performance rated as "Fair."

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Table 2. Open Face Fume Hood Test Results.

Room	Hood	Average Face Velocity ^a	Maximum/Minimum Face Velocity	Performance Rating ^b	Comments
4K	3	130	170 / 91	Good	Large equipment is raised.
4K	4	134	185 / 90	Good	Large equipment is raised.
4K	7	131	180 / 91	Good	Large equipment is raised.
4K	9	135	169 / 114	Good	Large equipment is raised.
4P	3	132	153 / 98	Good	Large equipment is raised.
4P	4	132	150 / 113	Good	Equipment is well placed.
4P	11	132	143 / 124	Good	Equipment is well placed.
1L	6	134	153 / 124	Good	Modified open face.
4H	12	135	195 / 61	Good	Very slight amount of swirling on left side in front of instrument.
4S	3	135	150 / 109	Good	Connected to hood 4.
4S	10	133	143 / 122	Good	Connected to hood 11.
4S	11	134	145 / 128	Good	Equipment well placed.
4M	2	135	150 / 120	Good	Good airflow pattern.
4M	3	132	147 / 108	Good	Good airflow pattern.
2B	3	132	190 / 51	Good	Strong airflow pattern.
4M	1	133	165 / 70	Fair	Some swirling directly in front of instrument.
4M	4	130	162 / 110	Fair	Some turbulence on right side in front of instrument.
4S	4	130	153 / 115	Fair	Turbulence in front of "Caliper" unit. Some reverse flow observed.
1K	4	134	155 / 46	Poor	Large solid platform causing turbulence and reverse airflow towards hood face.
4B	3	132	183 / 21	Poor	Splash shield blocking inlet flow. Slow clearing time between shield and hot plate.
4B	5	135	177 / 54	Poor	Splash shield blocking inlet flow. Slow clearing time between shield and hot plate.
4B	3	134	183 / 42	Fair	RETEST- Splash shield modified. Airflow pattern improved through, around, and behind shield.
4B	5	128	190 / 52	Fair	RETEST - Splash shield modified. Airflow pattern improved through, around, and behind shield.
1K	2	138	148 / 131	Fair	RETEST - Good airflow distribution in hood, some swirling observed on left side near wall of hood.
1K	4	133	146 / 121	Poor	RETEST - Turbulence and reverse airflow still observed near fume hood face.

^aThe average face velocity for 222-S Laboratory fume hoods is required to be 125 to 140 feet per minute (FPM).

^bPerformance rating from test plan.

Note: All values listed are in FPM.

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Figures 1 through 38 provide a comparison of fume hood face velocity profiles with photographs of the corresponding hoods showing the position of equipment and materials that were contained within each hood at the time of testing.

4. RECOMMENDATIONS

Equipment should always be placed as deep into the hood as possible and at least 6 in. back from the sash plane.

Whenever possible, large equipment should be elevated 2 to 3 in. above the work surface to allow airflow under and around the equipment.

The amount of equipment and materials in a hood should be limited. No more than 50% of the work surface should be taken up by equipment, apparatus, or large obstructions.

Sufficient space should be provided on the sides of equipment and laboratory materials placed in fume hoods. This will improve airflow patterns by reducing turbulence and swirling next to the fume hood wall.

On open face hoods, the sash height should be lowered, when possible, to improve capture of vapors. Some fume hoods in Room 4S are operated with a reduced sash opening.

Adjustment of rear baffles on some of the hoods should be considered to improve the flow characteristics of the hood. Fume hoods 2 and 4 in Room 1K might be candidates for baffle adjustment to obtain an increased flow across the working surfaces.

5. CONCLUSIONS

The "dry ice vapor challenge" test proved to be very effective in visualizing hood flow characteristics while minimizing waste generation and disruption of analytical processes. It was demonstrated to be the method of choice for flow visualization testing within fume hoods containing sensitive analytical instrumentation.

Prior to placement of large analytical equipment into a hood, face velocity and flow visualization testing should be performed to determine the performance characteristics of the hood in the "as-installed" condition. All testing should be repeated after placement of the equipment into the hood to ensure that hood performance has not deteriorated significantly in the "as-used" state.

Some correlation was observed between the fume hood face velocity profiles and flow visualization performance testing, particularly with fume hoods 3 and 5 in Room 4B. Because this correlation was not consistent, there is justifiable argument for performing flow visualization testing for all questionable situations.

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Arm port fume hoods should not be used for analytical work that requires the use of large instruments or results in congested working surfaces. The inherent turbulence observed in all arm port fume hoods tested is increased significantly by these conditions. The reduced performance ratings for all three arm port fume hoods in Room 1D can be attributed to these conditions.

Regardless of fume hood performance rating, consideration must be made with regard to the toxicological properties of the materials being handled or are anticipated to be handled within any fume hood. A facility safety representative should be consulted to evaluate fume hood conditions and all proposed operations.

6. REFERENCES

222-S Maintenance Procedure 2S99003, Rev. 4-0, "Open Face/Arm Port Hood Airflow Test, 222-S," Analytical Technical Services, CH2M HILL Hanford Group, Inc., Richland, Washington.

ACGIH®, 1988, *Industrial Ventilation: A Manual of Recommended Practice*, 20th Edition, American Conference of Governmental Hygienists, Cincinnati, Ohio.

ANSI/ASHRAE 110-1995, "Method of Testing Performance of Laboratory Fume Hoods," American National Standards Institute, New York, New York.

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Figure 1. Room 4K, Hood 3.

SASH				
	128	125	146	170
	91	103	137	130
	105	150	135	122
	146	118	140	140

Face Velocity Profile (values are in FPM)

ROOM NO. 4KHOOD NO. 3**PERFORMANCE RATING: GOOD**

Note: Flanders Bag Out Housing is a product of Flanders Corporation, St. Petersburg, Florida.

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Figure 2. Room 4K, Hood 4.

SASH				
185	146	146	170	
160	170	92	95	
150	122	90	125	
150	120	110	125	

Face Velocity Profile (values are in FPM)

ROOM NO. 4KHOOD NO. 4PERFORMANCE RATING: GOOD

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Figure 3. Room 4K, Hood 7.

SASH				
180	136	122	155	
167	145	103	132	
142	131	91	113	
129	126	112	117	

Face Velocity Profile (values are in FPM)

ROOM NO. 4KHOOD NO. 7**PERFORMANCE RATING: GOOD**

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Figure 4. Room 4K, Hood 9.

SASH				
169	133	124	120	
158	132	130	130	
154	114	127	129	
162	122	126	126	

Face Velocity Profile (values are in FPM)

ROOM NO. 4KHOOD NO. 9**PERFORMANCE RATING: GOOD**

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Figure 5. Room 4D, Hood 5.

Face Velocity Profile (values are in FPM)

ROOM NO. 4D

HOOD NO. 5

PERFORMANCE RATING: FAIR

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Figure 6. Room 4D, Hood 6.

Face Velocity Profile (values are in FPM)

ROOM NO. 4D

HOOD NO. 6

PERFORMANCE RATING: GOOD

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Figure 7. Room 4P, Hood 3.

SASH				
145	140	147	127	
150	130	145	105	
150	143	120	98	
145	153	90	122	

Face Velocity Profile (values are in FPM)

ROOM NO. 4PHOOD NO. 3**PERFORMANCE RATING: GOOD**

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Figure 8. Room 4P, Hood 4.

SASH				
	140	130	123	126
	142	115	126	136
	148	122	113	136
	150	145	135	132

Face Velocity Profile (values are in FPM)

ROOM NO. 4PHOOD NO. 4PERFORMANCE RATING: **GOOD**

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Figure 9. Room 4P, Hood 10.

Face Velocity Profile (values are in FPM)

ROOM NO. 4PHOOD NO. 10**PERFORMANCE RATING: GOOD**

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Figure 10. Room 4P, Hood 11.

SASH				
134	128	127	143	
130	124	129	128	
135	128	126	136	
136	140	130	135	

Face Velocity Profile (values are in FPM)

ROOM NO. 4PHOOD NO. 11**PERFORMANCE RATING: GOOD**

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Figure 11. Room 1K, Hood 4.

SASH				
150	130	120	136	
143	131	122	136	
123	146	145	160	
154	155	150	46	

Face Velocity Profile (values are in FPM)

ROOM NO. 1KHOOD NO. 4**PERFORMANCE RATING: GOOD**

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Figure 12. Room 1D, Hood 4.

Face Velocity Profile (values are in FPM)

ROOM NO. 1DHOOD NO. 4**PERFORMANCE RATING: FAIR**

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Figure 13. Room 1D, Hood 7.

Face Velocity Profile (values are in FPM)

ROOM NO. 1D

HOOD NO. 7

PERFORMANCE RATING: FAIR

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Figure 14. Room 1D, Hood 8.

Face Velocity Profile (values are in FPM)

ROOM NO. 1D

HOOD NO. 8

PERFORMANCE RATING: FAIR

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Figure 15. Room 1B, Hood 9.

Face Velocity Profile (values are in FPM)

ROOM NO. 1B

HOOD NO. 9

PERFORMANCE RATING: GOOD

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Figure 16. Room 1GA, Hood 4.

Face Velocity Profile (values are in FPM)

ROOM NO. 1GAHOOD NO. 4**PERFORMANCE RATING: GOOD**

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Figure 17. Room 1L, Hood 6.

SASH				
		125	125	137
		130	125	125
	150	150	124	130

Face Velocity Profile (values are in FPM)

ROOM NO. 1LHOOD NO. 6**PERFORMANCE RATING: GOOD**

Note: PQ ExCell is a product of PQ Energy Services, Inc., Easton, Pennsylvania.

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Figure 18. Room 4H, Hood 12.

SASH				
150	118	152	195	
142	100	136	194	
128	78	120	192	
108	61	112	174	

Face Velocity Profile (values are in FPM)

ROOM NO. 4HHOOD NO. 12**PERFORMANCE RATING: GOOD**

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Figure 19. Room 4S, Hood 3.

SASH				
149	109	140	150	
144	126	135	149	
132	120	126	138	
130	122	143	150	

Face Velocity Profile (values are in FPM)

ROOM NO. 4SHOOD NO. 3PERFORMANCE RATING: GOOD

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Figure 20. Room 4S, Hood 4.

SASH				
145	122	125	153	
145	126	123	150	
140	123	121	132	
140	120	115	99	

Face Velocity Profile (values are in FPM)

ROOM NO. 4SHOOD NO. 4**PERFORMANCE RATING: FAIR**

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Figure 21. Room 4S, Hood 10.

SASH				
132	138	143	122	
135	135	133	131	
131	132	139	132	
130	131	129	127	

Face Velocity Profile (values are in FPM)

ROOM NO. 4SHOOD NO. 10**PERFORMANCE RATING: GOOD**

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Figure 22. Room 4S, Hood 11.

SASH				
134	132	134	132	
133	129	132	133	
145	131	135	136	
140	133	128	134	

Face Velocity Profile (values are in FPM)

ROOM NO. 4SHOOD NO. 11PERFORMANCE RATING: GOOD

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Figure 23. Room 4A, Hood 4.

Face Velocity Profile (values are in FPM)

ROOM NO. 4A

HOOD NO. 4

PERFORMANCE RATING: GOOD

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Figure 24. Room 4A, Hood 5.

Face Velocity Profile (values are in FPM)

ROOM NO. 4A

HOOD NO. 5

PERFORMANCE RATING: GOOD

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Figure 25. Room 4B, Hood 3.

SASH				
150	42	152	175	
160	21	150	165	
155	33	151	175	
158	60	183	180	

Face Velocity Profile (values are in FPM)

ROOM NO. 4BHOOD NO. 3**PERFORMANCE RATING: POOR**

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Figure 26. Room 4B, Hood 5.

SASH				
158	90	137	156	
154	54	137	150	
140	54	150	155	
165	110	177	165	

Face Velocity Profile (values are in FPM)

ROOM NO. 4B

HOOD NO. 5

PERFORMANCE RATING: POOR

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Figure 27. Room 4C, Hood 1.

Face Velocity Profile (values are in FPM)

ROOM NO. 4CHOOD NO. 1**PERFORMANCE RATING: GOOD**

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Figure 28. Room 4M, Hood 1.

SASH

	164	102	133	155
	164	87	130	154
	154	71	135	150
	151	70	165	143

Face Velocity Profile (values are in FPM)

ROOM NO. 4MHOOD NO. 1**PERFORMANCE RATING: FAIR**

Note: Safeaire® Hamilton is a product of Hamilton, a part of Thermo Fisher Scientific, Two Rivers, Wisconsin.

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Figure 29. Room 4M, Hood 2.

SASH				
150	120	131	142	
136	122	129	135	
133	123	138	136	
141	130	131	140	

Face Velocity Profile (values are in FPM)

ROOM NO. 4MHOOD NO. 2PERFORMANCE RATING: GOOD

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Figure 30. Room 4M, Hood 3.

SASH				
133	130	133	143	
128	110	130	146	
125	108	141	145	
125	119	144	147	

Face Velocity Profile (values are in FPM)

ROOM NO. 4MHOOD NO. 3PERFORMANCE RATING: GOOD

RPP-RPT-32842, Rev. 0

Figure 31. Room 4M, Hood 4.

SASH				
144	123	130	141	
162	127	122	127	
145	130	120	115	
142	126	123	110	

Face Velocity Profile (values are in FPM)

ROOM NO. 4MHOOD NO. 4**PERFORMANCE RATING: FAIR**

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Figure 32. Room 4J, Hood 11.

Face Velocity Profile (values are in FPM)

ROOM NO. 4J

HOOD NO. 11

PERFORMANCE RATING: FAIR

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Figure 33. Room 2H, Hood 1.

Face Velocity Profile (values are in FPM)

ROOM NO. 2H

HOOD NO. 1

PERFORMANCE RATING: FAIR

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Figure 34. Room 2B, Hood 3.

SASH				
181	190	185	190	
150	138	94	130	
130	112	51	100	
140	130	90	102	

Face Velocity Profile (values are in FPM)

ROOM NO. 2BHOOD NO. 3PERFORMANCE RATING: GOOD

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Figure 35. Room 4B, Hood 3 (RETEST).

HORIZONTAL SASH				
151	55	138	170	
143	53	140	167	
141	32	138	172	
163	115	180	183	

Face Velocity Profile (values are in FPM)

ROOM NO. 4BHOOD NO. 3**PERFORMANCE RATING: FAIR**

RPP-RPT-32842, Rev. 0

Figure 36. Room 4B, Hood 5 (RETEST).

HORIZONTAL SASH				
	149	60	130	153
	134	52	135	154
	142	75	111	144
	150	96	169	190

Face Velocity Profile (values are in FPM)

ROOM NO. 4BHOOD NO. 5**PERFORMANCE RATING: FAIR**

RPP-RPT-32842, Rev. 0

Figure 37. Room 1K Hood 2 (RETEST).

HORIZONTAL SASH				
143	140	134	148	
134	134	141	143	
135	131	134	139	
140	135	142	133	

Face Velocity Profile (values are in FPM)

ROOM NO. 1KHOOD NO. 2**PERFORMANCE RATING: FAIR**

RPP-RPT-32842, Rev. 0

Figure 38. Room 1K, Hood 4 (RETEST).

HORIZONTAL SASH				
151	133	137	13	
130	129	130	136	
121	132	138	146	
123	131	139	145	

Face Velocity Profile (values are in FPM)

ROOM NO. 1KHOOD NO. 4**PERFORMANCE RATING: POOR**

Note: GBC SDS-270 is a product of GBC Scientific Equipment, Dandenong, Victoria, Australia.

RPP-RPT-32842, Rev. 0

**APPENDIX:
LABORATORY FUME HOOD PERFORMANCE TESTING PLAN**

Introduction

Selected fume hoods within the 222-S Laboratory will be tested to ensure acceptable containment exists in their "as-used" state. Based on the test results, an engineering evaluation will be performed. This evaluation will establish initial performance ratings for the hoods tested. Recommendations will be made to improve fume hood performance ratings through operator work practices, equipment placement, and reduction in sash height.

The selected testing methods are adopted from the ANSI/ASHRAE 110-1995, *Method of Testing Performance of Laboratory Fume Hoods*. The methods used will provide for a qualitative and quantitative evaluation of hood performance. The testing methods and their associated steps described in this plan may be completed in any order.

General Test Conditions

1. Fume hoods sashes will be in the normal operating position.
2. Testing shall be conducted with normal hood apparatus in place.
3. Entry doors to the rooms containing fume hoods to be tested will be in their normal configuration (in most cases open).

Preliminary Data

1. A sketch or drawing of each room shall be provided to indicate test hood location, other hoods, the location of significant equipment nearby, and door configurations.
2. The fume hood type, size, and sash configuration shall be noted.
3. The location of material storage and amount of work surface space occupied by materials and/or equipment within the fume hood shall be noted.

Flow Visualization Test

The purpose of this test is to visualize the capacity of a fume hood to contain vapors and render an observation of hood performance as it is typically used. In the following tests, it is expected that all vapors shall be carried to the rear of the fume hood and exhausted. Any movement of vapor towards the face of the fume hood will be defined as negative characteristic airflow, and any lack of movement will be defined as dead air space. Any vapor escaping the fume hood face during any of the tests will result in a "FAILURE" rating for the fume hood.

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Testing will be conducted as follows:

1. General Visualization Test –

Using a container of dry ice and water, conduct a complete traverse of the fume hood face to determine that a positive flow of air into the hood is being maintained over the entire fume hood face. No reverse flow should be evident (however, some initial turbulence at the vapor challenge receptacle is acceptable).

2. Local Visualization Test –

- a. Using a container of dry ice and water, challenge vapor test along each side and across the working surface of the fume hood, in a line parallel to the fume hood face and 6 in. back into the fume hood. Note airflow patterns.
- b. Move the challenge media to the rear of the fume hood. Note airflow patterns and clearing time.
- c. Move the challenge media to the upper portion of the fume hood. Note airflow patterns and clearing time.
- d. Move the challenge media around any equipment/material in the fume hood. Note airflow patterns and clearing time.

3. Large Volume Visualization Test –

Place a container of dry ice and water in the center of the fume hood sash opening on the work surface 6 in. back from the rear edge of the sash. Note airflow patterns. No reverse flow of vapor should be evident into the work area.

Face Velocity Measurements

The purpose of this test is to quantitatively measure air velocity at the fume hood face.

Measurement locations will be established at the hood face in accordance with Analytical Technical Services Maintenance Procedure 2S99003, "Open Face/Arm Port Hood Airflow Test, 222-S."

Air velocity measurements will be taken using a thermal anemometer. Flow rates in feet per minute (FPM) will be obtained at established locations and recorded.

An average face velocity of 125 to 140 FPM shall be established for each hood.

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Performance Classifications

Following review of the testing data, performance ratings will be established for each fume hood tested. The ratings and criteria are as follows:

1. Good

Challenge vapors are adequately captured at the face of the fume hood and are drawn into the fume hood and exhausted. Quick clearance times are observed. Limited fume hood roll vortex. No visible escape of vapors during any testing phase. Turbulence and eddying will be observed in arm ported fume hoods between arm port openings.

2. Fair

Some challenge vapors reverse flow and migrate toward the fume hood face but are recaptured and exhausted, or dead air spaces are present that would result in a slow migration of vapors toward the fume hood face but are again recaptured and exhausted. Limited turbulent vortex is observed. No visible escape of vapors during any testing phase.

3. Poor

Challenge vapors reverse flow near fume hood face. Dead air spaces are present that result in slow migration of vapors toward the fume hood face. Slow capture and clearance of challenge vapors. There is an observed potential for escape of vapors from the fume hood.

4. Failure

Challenge vapors migrate directly to the fume hood face and escape from the interior of the hood into the surrounding area.

Discussion

Regardless of fume hood performance rating, consideration must be made with regard to the toxicological properties of the materials being handled or anticipated to be handled within any fume hood. A facility safety representative should be contacted to evaluate fume hood conditions and proposed operations.

It is strongly recommended that any fume hood that fails flow visualization testing be temporarily removed from service. Additional testing should be conducted as soon as possible to identify the source(s) affecting performance. Once corrective actions have been completed, fume hood performance testing should be repeated to validate any rating change.