The Energy Consumption of Fume Hoods at the University of Minnesota-Duluth

UMD Sustainability

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Introduction:

Fume hoods are a seemingly unnoticed piece of safety equipment when it comes to energy consumption. For those working in the laboratory for hours, they provide the vital service of removing potentially toxic fumes from the air supply and maintain a standard level of safety. However, they require a substantial amount of energy to do this service. In this report I will focus mainly on the fume hoods located on the UMD campus.

What is a fume hood? A fume hood is a ventilated work enclosure that features epoxy coated steel with a safety glass sash that is between approximately 30-70 inches wide and can be opened to 18 inches high off the waist level workbench or completely shut so that fumes within the hood does not escape into the room and nearby hallways. This sash composed of see-through safety glass that allows an individual to watch what task they are performing within the hood such as pouring of chemicals into containers, observing chemical reactions, and also shielding a blast from accidents in experiments. The air is taken up by an extractor fan and sent to be filtered through open cell foam and then through activated porous charcoal or just purely ducted to the roof to be sent into the atmosphere. Certain fume hoods contain special filters such as HEPA (High Efficiency Particulate Air), filters that are mainly used in the Biology Department and Medical School to prevent the spread of airborne bacteria. These fume hoods are maintained and inspected by a specialized non-university business. Also hoods that contain harmful carcinogens have to maintain constant strong ventilation in order to prevent any chance of it escaping into a lab ("Labconco: Purifier," 2011).

Why is this information important? On average, one fume hood in the United States running 24 hours a day, 365 days a year can use 3.5 times more energy than a house does in a year (“HMS Shut the Sash,”2011). The University of Minnesota-Duluth owns 257 fume hoods, 224 of which are located on campus. This contributes to a very large portion of the energy consumption at the university that in turn creates a large amount of greenhouse gasses to be expelled into the air and a costly energy bill to produce that electricity. Each hood uses approximately 34,871 kWh/year totaling 7,811,104 kWh/year for the fume hoods on campus. This equals out to about 11,873,737 lbs of CO_2 a year generated from those 224 on campus hoods (“Greenhouse Gas Equivalencies”. 2011). A big factor in the energy consumption for the hoods, especially in our northern climate, is the heating and cooling of the air in those laboratories. Since the fume hood is displacing the warm inside air to the outside, the building’s heating system needs to create more heated air to maintain a comfortable room temperature (Mills, Sartor. 2005).

Methods:

From April 25th to May 20th, Andrew Kimball, the Environmental Safety Technician from the Environmental Health and Safety Department at UMD, and I collected data from every lab owned by the university, except Coleraine, Ely, and Grand Rapids labs, with the Shortridge Instruments Inc. Airdata Multimeter ADM-860. This instrument shows how much air the fume hood is taking in from under the hood and in the room and venting it to the outside in feet per minute (*fpm*). Three individual measurements were taken across the hood opening with the sash at 18 inches and the velometer put under the hood parallel with the sash. An average of those three numbers is the final *fpm* measurement for the hood with the sash set at 18 inches serving as the standard of measurement since the velocity of the air increases as you close the sash and decreases when you open it. The standard range should be approximately 90-120 *fpm* but for greater energy efficiency, 100 *fpm* would be ideal. It should be known that large experiments, waste containers, etc. can affect the velocity of the air moving through the hood.

The air pressure in the labs, recorded in *Pascals*, was part of the data collection because it shows if the air in the labs is moving in or out from gaps under the doors. The velometer was used by sliding part of the instrument's tubing under the laboratory doors closest to main hallways to check the pressure of the room in comparison to the outside hallway. This number should be between -1 to -2 *Pascals* because air moves from high pressure areas to low ones and air can come into the room. If a room has a *Pascal* reading that is positive or barely negative such as -0.01, then that room maybe letting out fumes or airborne particles into nearby hallways or classrooms. This negativity is balanced by a building's ventilation system and not by the fume hood itself ("Negative Room Pressure," 2008).

In appendix A there is a list of the problematic hoods located on campus that are above and below the standard operating level. The chosen hoods of this list are functioning below 90 *fpm* because that is considered an unsafe work environment and above 130 *fpm* because that is well above the standard operating level and therefore consuming an unnecessary amount of energy. For figuring out the costs of how much energy the fume hoods are using, I used the Berkley Lab Fume Hood Energy Model. The dollar amount is based off the width of the hood, its average *fpm*, and location is in Duluth, MN. The assumed variables are the HVAC supply for heating and cooling is at 55^{o}F, the hood is operating 24 hours a day, and cost of electricity at 7 cents per kilowatt hour (Mills, Sartor. 2005). In appendix B there is a list of labs with a greater than -1 *Pascal* reading and a list of labs that are less than -5 *Pascal* reading. The greater than -1 *Pascal* reading represents a potential hazard to human health and the less than -5 is well beyond the standard and consuming more energy to over ventilate.

Results:

The *fpm* averages of the past four years in the on campus fume hoods have shown an increase as shown in Figure 1. In 2008 the average *fpm* rating was 113, in 2009 it was 114, in 2010 it was 116, and in 2011 it jumped up to 124. 2011 has been the highest year taking into account that 5 hoods are out of service or not being used at this time in comparison to 3 in 2010, 1 in 2009 and 2 in 2008. Of the 224 hoods located on campus, 68 were over-ventilating in 2011 but 28 feature to low flow technology leaving 40 running 24/7 at their optimum. Figure 2 represents the cost of the 40 over-ventilating hoods on campus and shows the dollar amount for the present velocities at $205,610. If each hood was calibrated down to 120 *fpm*, the cost would drop to $174,577; saving 125,637 kWh/year in electricity, and reduce CO_2 emissions by 190,982 lbs. If calibrated down to 100 *fpm* cost would drop to $145,487, saving 244,361 kWh/year in electricity, and reduce CO_2 emissions by 371,456 lbs. The energy cost saving results would be between $31,033 and $60,123.

The differential pressure in most of the labs was found to have higher than the standard -1 to -2 *Pascal* range. The exception is the Engineering research labs that had a significant negativity due to their larger doorways and have historically been more negative. In a comparison of data collected in 2008, 2009 and 2010, to 2011, the average *Pascal* readings have become higher (or less negative) as shown in Figure 3. Figure 3, also, represents the correlation between room pressure and the average *fpm* of the fume hoods. The graph shows how as the labs have become less negative, the fume hoods work harder increasing the *fpm* and consume more energy.

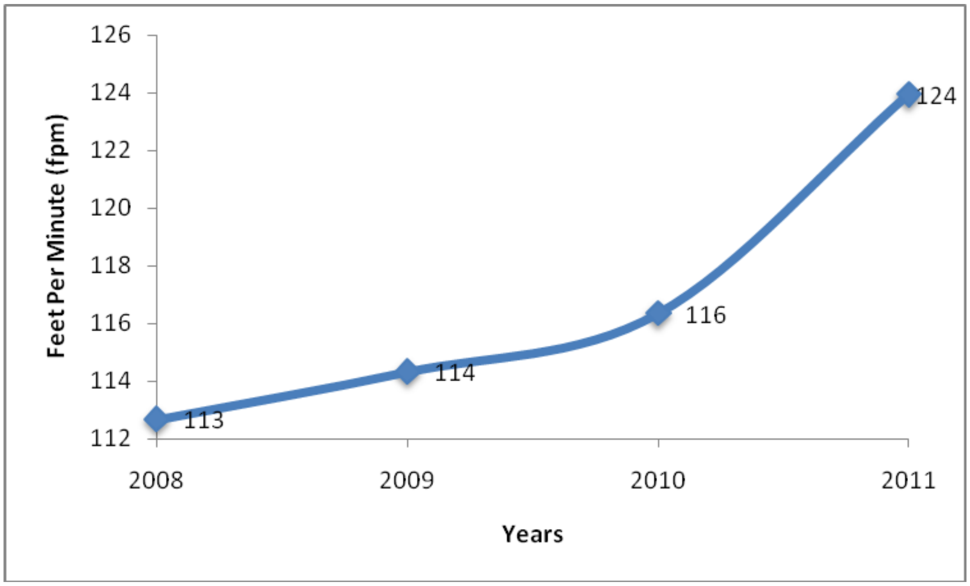

Figure 1: Yearly average of UMD's on campus fume hoods in feet per minute (*fpm*) from 2008 to 2011.

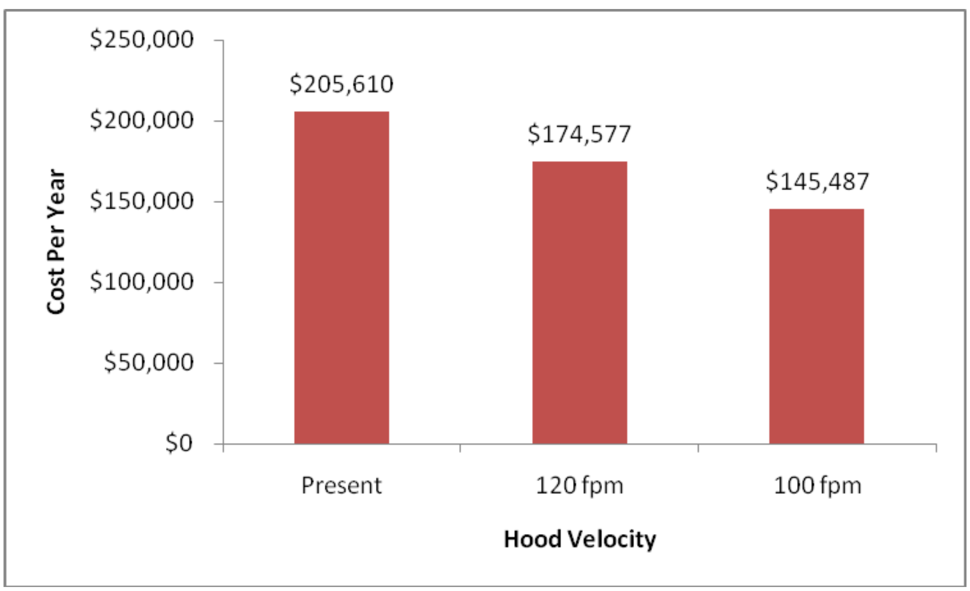

Figure 2: Cost per year of the 40 over-ventilating fume hoods that do not feature the low flow option on the UMD campus. Values represent the cost at the present velocity and if they were calibrated down to 120 fpm and to 100 fpm.

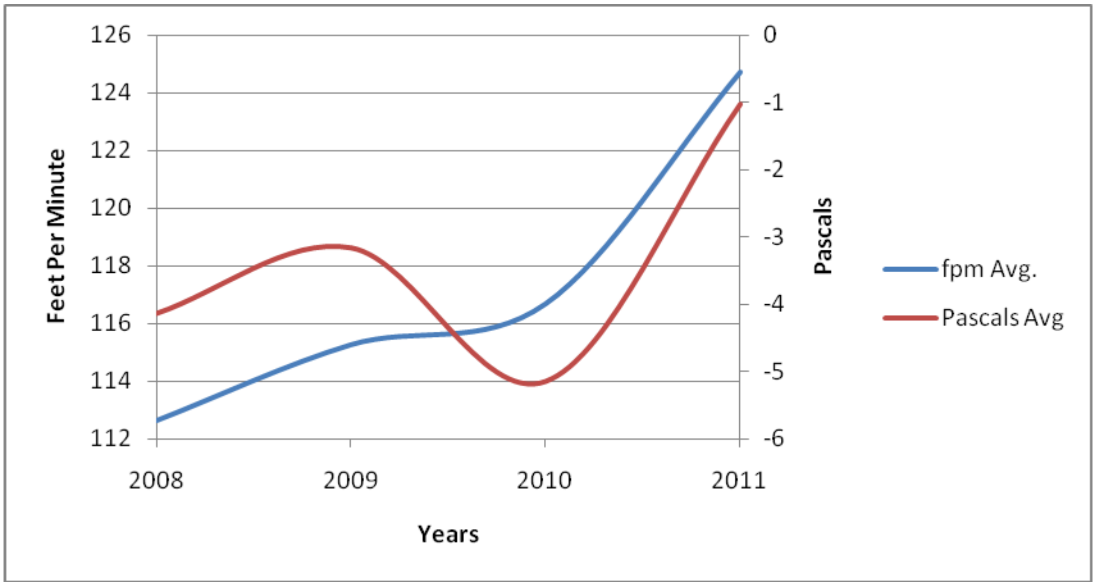

Figure 3: Main campus fume hoods comparison of the average feet per minute and average *Pascals*. Values represent data collection from 2008-2011.

Conclusion:

It was found that many of the fume hoods on campus operate above the maximum standard of 120 *fpm* but the hoods potentially could be lowered by changing the differential pressure within the rooms towards being more negative since the data for an increased room pressure correlates with the increase in the average feet per minute for hoods. An important point to address, relating to room pressure, is many research labs had their doors propped open. This affects the ventilation greatly and is a potential safety hazard in that fumes from experiments going on within the lab could now be moving out into other parts of the building. I would suggest the labs and fume hoods I listed in the appendices be reported to Facilities Management, particularly the individuals who maintain the ventilation on campus, and Mahjoub Labyad in the Environmental Health and Safety Department at UMD to have them corrected for efficiency.

It is important to note that the fume hoods located in the student labs in Swenson have the ability to be turned down to a low flow rate with a switch on the wall. This feature saves on a large amount of energy when the lab is not in use however, when the switch is turned on and the hoods are running at their optimum, there are 28 hoods that are functioning above the standard operating level. I chose not to include these hoods in the appendices because they are in low flow mode for a significant part of the day and are not actually consuming large amounts of energy. When visited, the 80 hoods with a low flow feature in Swenson had the lights turned off and this low flow was in effect. These eighty hoods are for student chemistry the use; however, there are still 45 other hoods in Swenson that are for biology teaching and research that do not have the ability to be turned down. This practical feature should be implemented in the remaining labs in Swenson and other research facilities on the UMD campus.

For a more cost-effective alternative, a good way to reduce energy consumption in the labs is to completely close the sash so the hood is not needlessly removing air in the lab rather than just the area under the hood. The Harvard Medical School implemented a “Shut the Sash” campaign in 2005, where all the labs across campus competed to have the most closed sashes on average for a month. That saved the Harvard Medical School alone $100,000 in energy expenses, and individuals continued to shut the sashes months after the contest ended. The campaign still continues and annually saves Harvard $250,000 in energy costs (“HMS Shut the Sash,” 2011). This could be implemented at UMD as part of a lab’s Standard Operating Procedure. Across campus it can be taught that after completing your work under the hood, the sash should be closed. Once labs are vacated at the end of a day, the sashes could be closed for the night by the individuals primarily working in that lab. Although energy savings would not rival that of

Harvard's, it would still put a noticeable reduction in energy costs and the amount of greenhouse gasses emitted by the university.

Works Cited:

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Appendix:

A. University of Minnesota-Duluth on campus fume hoods under/over ventilating

Below standard operation levels. <90							
Building	Rm#	Hood #	Avg. velocity (*fpm*)				
Chem	347	1	78				
Chem	140	2	82				
Above standard operating levels. >130							
Building	Rm#	Hood #	Velocity (*fpm*)	Width (in.)	Cost/yr	120 *fpm*	100 *fpm*
Med	262	2	146	48	$4,248	$3,289	$2,741
Med	269A		155	48	$4,248	$3,289	$2,741
Lsci	250	2	135	64	$4,933	$4,385	$3,654
VK	227		135	48	$3,700	$3,289	$2,741
ENGR	163	4	135	48	$3,700	$3,289	$2,741
MWAH	55	2	164	60	$5,618	$4,111	$3,426
Chem	140	3	200	72	$8,222	$4,933	$4,111
Chem	140	4	146	72	$6,002	$4,933	$4,111
Chem	212	2	130	60	$4,453	$4,111	$3,426
Chem	224		155	60	$5,310	$4,111	$3,426
Chem	232	2	135	60	$4,625	$4,111	$3,426
Chem	301	1	145	60	$4,967	$4,111	$3,426
Chem	301	2	160	60	$5,481	$4,111	$3,426
Chem	301	5	145	60	$4,967	$4,111	$3,426
Chem	316	2	134	60	$4,590	$4,111	$3,426
Chem	328		132	60	$4,522	$4,111	$3,426
Chem	336		136	48	$3,727	$3,289	$2,741
Chem	402		135	60	$4,625	$4,111	$3,426
Chem	403	2	135	60	$4,625	$4,111	$3,426
Swenson	72A		141	72	$5,796	$4,933	$4,111
Swenson	103	1	140	72	$5,755	$4,933	$4,111
Swenson	105		143	72	$5,878	$4,933	$4,111
Swenson	109A		136	72	$5,591	$4,933	$4,111
Swenson	113	2	142	72	$5,837	$4,933	$4,111
Swenson	160	1	140	72	$5,755	$4,933	$4,111
Swenson	160	2	135	72	$5,550	$4,933	$4,111
Swenson	161	1	131	72	$5,385	$4,933	$4,111
Swenson	169	1	131	72	$5,385	$4,933	$4,111
Swenson	180		131	72	$5,385	$4,933	$4,111
Swenson	181		130	72	$5,344	$4,933	$4,111
Swenson	208		136	72	$5,591	$4,933	$4,111

Swenson	212	2	134	72	$5,509	$4,933	$4,111
Swenson	212B		138	72	$5,673	$4,933	$4,111
Swenson	244	1	131	72	$5,385	$4,933	$4,111
Swenson	244	2	144	72	$5,920	$4,933	$4,111
Swenson	261	2	133	72	$5,467	$4,933	$4,111
Swenson	265	1	165	72	$6,783	$4,933	$4,111
Swenson	280	1	131	72	$5,385	$4,933	$4,111
Swenson	281	1	138	72	$5,673	$4,933	$4,111
Total	**40**				**$205,610**	**$174,577**	**$145,487**

B. University of Minnesota-Duluth campus unbalanced differential pressure labs.

>-1 Pascal Pressure Rooms			<-5 Pascal Pressure Rooms		
Bldg	**RM#**	**Diff. Press. Pascals**	**Bldg**	**RM#**	**Diff. Press. Pascals**
MED	292	-0.39	MED	264	-8.47
MED	338	0.33	MED	269	-8.47
MED	364	6.6	MED	269A	-8.74
MED	366A	0.12	Engr	163	-19.82
MED	368	0.6	Engr	165	-20.23
MED	380	-0.25	Engr	167	-14.02
MED	386	-0.04	Chem	104C	-51.21
MED	394	-0.04			
MED	397	8.68			
LSci	22	-0.02			
LSci	250	0.55			
LSci	302	-0.03			
LSci	306	-0.01			
LSci	326	-0.04			
LSci	328	-0.02			
LSci	330	-0.01			
LSci	340	-0.01			
LSci	354	-0.02			
Heller	105	-0.05			
VK	227	-0.02			
Cina	320	-0.04			
Hum	332	-0.09			
Engr	110	-0.03			
Engr	173	-0.03			

MWAH	53	-0.11
MWAH	55	-0.01
MWAH	373	0
All Labs in Chemistry Bldg except:		
Chem	104	/
All Labs in Swenson except:		
Swenson	54	-2.59
Swenson	64	-2.59
Swenson	72A	-2.59
Swenson	78	-2.59