THE UNIVERSITY *of* EDINBURGH
Social Responsibility & Sustainability

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Ventilation best practice

Executive summary

This paper summarises the findings of research undertaken by the Social Responsibility and Sustainability Department of University of Edinburgh into best practice in ventilation management. It incorporates international best practice as published on the websites of various universities, as well as information gained through judging applications for the Edinburgh Sustainability Awards and good practice across the University of Edinburgh laboratories.

University of Edinburgh lab users should also familiarise themselves with the sustainable lab ventilation policy and guidance.

This document describes a number of actions and the potential savings, including:

VAV fume cupboards (up to £1000/year saving per fume cupboard)

Separate ventilated storage (variable savings, up to over £1200/year saving per fume cupboard)

Optimising face velocities (variable savings, up to £800/year saving per fume cupboard)

Replace old plant with new (savings site specific)

Sensor Controlled Demand Based Ventilation (40-65% energy saving on main air handling units)

Shut the sash (energy savings up to 25%)

Night set-back of ventilation rates (savings of 25% can realistically be achieved)

Low flow fume cupboards (energy savings up to 40% per fume cupboard)

Variable air volume (VAV) fume cupboards

The problem:

Currently many older (and some newer) fume cupboards are Constant Air Volume (i.e. regardless of the sash position, the same volume of air will be drawn through the fume cupboard). The room air which is being expelled through the fume cupboard needs to be replaced with more air (known as make-up air). This make-up air has to be heated (or sometimes cooled), and in some scenarios also needs to have humidity controlled - all of which consumes a large amount of energy (with associated cost and carbon impacts).

In chemistry labs ventilation costs can account for **60%[1] of the total energy** consumed by the lab. Fume cupboard use in biological labs is lower but still has a significant impact. Individual fume cupboard energy costs can amount to **up to £2,000 annually**[2].

The solution:

Installing variable volume controls to fume cupboards allows the flow to be reduced (but the face velocity maintained) when the sash is down. Reducing the flow reduces the demand for make-up air, and thus reduces the demand on the room air ventilation system. Savings depend on the relative amounts of time the sash is open or closed, and whether there is any current set-back (i.e. lower air flow at night), but it is reasonable to expect **savings of up to £1,000 per fume cupboard**.

VAV fume cupboards are a mature and well-established technology which can be found in a wide range of locations across the University of Edinburgh (although there are still a lot of constant volume units). A great many other universities are also using VAV fume cupboards, including the University of Glasgow[3] and the University of Cambridge[4].

Separate storage

The problem:

In some instances, lab users keep a fume cupboard switched on purely for the purpose of ventilating volatile chemicals or waste. Fume cupboards should not be used for this purpose, their ventilation rate is far higher than required.

The solution:

Separate ventilated chemical stores use just 1% of the energy of a fume cupboard, and provide safe ventilation for volatile chemicals. If your lab doesn't have ventilated chemical stores, controlled separately from the fume cupboard, and you consequently have to run your fume cupboard for many hours per week longer than your experimental work would require, please get in touch with SRS or Estates to arrange for a feasibility assessment. It's possible that funds from the Sustainable Campus Fund could be used to support this. Savings will vary depending on the exact difference in operational hours from chemical storage requirements down to purely experimental requirements, but could easily exceed £1,200 annually.

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[1] http://www.goodcampus.org/uploads/DOCS/147-Briefing_Paper_2_-_lab_energy_audits_final.pdf
[2] http://www.goodcampus.org/uploads/DOCS/106-case_6_-_Nottingham_-_fume_cupboard_reporting_final_2.pdf
[3] http://www.gla.ac.uk/media/media_297054_en.pdf
[4] http://www.environment.admin.cam.ac.uk/resource-bank/case-studies/energy-and-carbon-reduction/fume-cupboards-air-flow-management

Faster isn't necessarily safer…

The problem:

Typically fume cupboards are 'tested' once per year to determine if they are safe and effective. The main measurement in this test is the face velocity (i.e. the speed at which air is drawn into the fume cupboard). For most fume cupboards the face velocity would have to be over 0.5m/s in order to be deemed safe. Thus, a measurement of 0.6 or 0.7m/s would also be deemed safe. However, studies have shown that higher face velocities (0.6m/s or above) can cause turbulence and actually reduce user safety.[5] [6] [7] [8] [9] [10]

In fact, in broader terms, face velocity is not a particularly good proxy for user safety as many other environmental factors can influence the movement of air through the lab and into the fume cupboard, and thus the safety of lab users[11] [12] [13] [14] [15].

The solution:

Request Estates to commission a suitably qualified and experienced individual to undertake containment testing of your fume cupboards to determine the optimum face velocity required for safety at each individual fume cupboard (based on the activities going on in and around the fume cupboard). This may result in some fume cupboards being operated at 0.6m/s, while others may be found to safely operate at 0.3m/s.

The University of Bristol has undertaken containment testing for their fume cupboards and subsequently has managed to safely reduce face velocities (and thus reduce costly make-up air demand)[16].

Ventilation which reacts to your needs

The problem:

Ventilation in lab spaces is typically operated at a constant level of 8-12 air changes per hour (ACH). This level does not fluctuate regardless of whether the lab is occupied or unoccupied, and whether the air is clean or contaminated. The chosen air change rate is not backed up by evidence, but is rather historic and a compromise between the competing demands of energy efficiency and safety. Modern lab work practices require that actions which may release fumes into the air take place with appropriate local ventilation (i.e. fume cupboards, biological safety cabinets, local exhaust ventilation) rather than on the bench and so the air quality of the general lab space is far better than in the past. Thus, for most of the time 8-12 ACH is more than is

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[5] http://www.escoglobal.com/resources/pdf/guide-fumehoods.pdf
[6] http://ehs.colorado.edu/wp-content/uploads/2014/11/Fume-Hood-QandA.pdf
[7] http://www.research.northwestern.edu/ors/forms/chemical-fume-hood-handbook.pdf
8 Sustainable Design of Research Laboratories: Planning, Design, and Operation By Kling Stubbins, 2011, p135
[9] ASHRAE Report Number 2438 RP 70, K.J. Caplan and G.W. Knutson, 1978 http://www.forensic-applications.com/hoods/face.html#2
[10] Laboratory Fume Hood Standards Recommendations for the USEPA, R.I. Chamberlin and J.E. Leahy, 1/15/78. Contract No. 68-01-4661 http://www.forensic-applications.com/hoods/face.html#5
[11] http://ateam.lbl.gov/hightech/fumehood/students/su00/Fox/FHFace_velocity.htm
[12] http://www.fumehoodtesters.com/hoodmyth.pdf
[13] http://www.sefalabs.com/i4a/pages/index.cfm?pageid=3396
[14] Hitchings Associates, PC, 5320 W. 79th St., Indianapolis, Indiana. Copyright graphics were used with kind permission. http://www.forensic-applications.com/hoods/face.html#1
[15] A New Method for Quantitative, In-Use Testing of Laboratory Fume Hoods, R.E. Ivany, First, M.W., Diberardinis, Am. Ind. Hyg. Assoc. J. (50)5:275-280 (1989) http://www.forensic-applications.com/hoods/face.html#3
[16] Wiles, M., (2015), Personal communication.

required, and yet if there is a release of fumes out with the local ventilation containment (i.e. from a spill in the main lab area) the air change rate is not adjusted to remove the contaminants more quickly so the lab must be evacuated as the 8-12 ACH is inadequate to maintain air quality in the event of a spill. The existing common setting of 8-12 ACH is therefore inappropriate for either normal operation or emergency operation.

The solution:

Sensor-controlled demand-based ventilation (DBV) uses multi-sensors located within the extract ducting of the lab air handling system to search for the presence of certain contaminants. When no contaminants are identified the baseline air change rate can safely be reduced to as low as 2 or 3 ACH. When a contaminant is sensed the air change rate is dramatically increased to 16 ACH. This means that the contaminant concentration in the event of a spill is reduced more quickly with DBV than under standard conditions of 8-12 ACH, while still achieving substantial savings.

Savings will vary from lab to lab depending on the proportion of time the air is 'clean' but other Higher Education Institutions have seen substantial energy savings through this system, e.g. UC Irvine (**58% energy saving**[17]) and University of Cambridge (**41% gas energy saving**[18]). Arizona State University Biodesign Building achieved LEED Platinum in 2006 and was awarded the "R&D Lab of the Year", but still achieved a further **65% energy reduction** by subsequently retrofitting DBV in 2007, resulting in $1M/yr savings.[19]

Shut the sash!

The problem:

Variable air volume fume cupboards only save energy (by reducing air exhausted, and therefore reducing the demand for heated or cooled make-up air) when the sash is lowered. If lab users do not lower the sash when they leave the fume cupboard the air flow will remain high. An unattended fume cupboard with an open sash is also a health and safety concern.

The solution:

When leaving a fume cupboard (whether briefly or for an extended period of time) ensure the sash is lowered. With a VAV fume cupboard this will **reduce the energy consumption by 50-70%**[20]. University of Nottingham measured overall annual savings from a 'shut the sash' campaign of between 5% and 25%. Regular spot checks are undertaken at Chemistry, Roslin, Chancellors' and SynthSys labs.

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[17] http://www.ehs.uci.edu/programs/energy/SafelyCutYourLaboratoryEnergyUseinHalf.pdf

[18] http://www.environment.admin.cam.ac.uk/resource-bank/case-studies/energy-and-carbon-reduction/star-department-case-study-hutchisonmrc

[19] http://www.e2singapore.gov.sg/DATA/0/docs/NEEC%20&%20EENP%20Award%20Ceremony/07%20Gordon%20Sharp_neeconf.pdf

[20] http://www.environment.admin.cam.ac.uk/resource-bank/case-studies/energy-and-carbon-reduction/fume-cupboards-air-flow-management

Set back and relax at night…

The problem:

Although lab users rarely work just 9-5 there are still substantial periods of time when the lab is unoccupied. Despite this the air change rate may still be operating at the same rate at 3am as it would at 3pm, with the resultant energy and cost implications.

The solution:

Labs can make significant energy savings by setting a lower air change rate at night. As an example, setting the overnight (12 hours) air change rate to 50% of daytime (12 hours) rate would **reduce the energy consumption of lab ventilation by around 25%.** The Roslin Institute has successfully adopted this approach and realised substantial energy savings without compromising safety. Cornell University[21] changed from 8/4 (day/night) to 6/3 ACH and reduced costs from $1.2m to $900k (25% saving).

Low flow fume cupboards

The problem:

Standard fume cupboards operate at 0.5m/s face velocity in order to achieve the desired level of user safety. This consumes a substantial amount of energy, equating to around £2,000 annually.

The solution:

Low flow fume cupboards are more aerodynamically designed than standard models and can achieve the same level of user safety at 0.3m/s face velocity, **saving 40%** [22] [23] [24] on energy consumption and costs. A number of new or refurbished laboratories have installed low flow fume cupboards, including School of Chemistry at Joseph Black.

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[21] http://www1.eere.energy.gov/buildings/commercial/pdfs/bba_air_change_rates_highlights.pdf
[22] http://www.fumair.co.uk/wp-content/uploads/2012/04/Low-Velocity-Energy-Saving.pdf
[23] http://www.cleanairltd.co.uk/low-volume-fume-cupboard/
[24] http://www.eventlink.org.uk/uploads/DOCS2/90-S-Labs_Workshop_-_Chemistry_Labs_refurbishment_-_David_Josey.pdf

Appendix

Lab contacts who can help you with these projects:

David Brown, School of Chemistry, David.Brown@ed.ac.uk

Brian McTeir, Roslin Institute, brian.mcteir@roslin.ed.ac.uk

Heather Anderson, Chancellors' Building, Heather.Anderson@ed.ac.uk

Eliane Salvo-Chirnside, SynthSys labs, Eliane.Chirnside@ed.ac.uk

Andrew Arnott, Department for Social Responsibility and Sustainability andrew.arnott@ed.ac.uk

Your building or premises manager can also help:

Useful links and resources

Faster face velocity isn't necessarily safer:

http://ehs.colorado.edu/wp-content/uploads/2014/11/Fume-Hood-QandA.pdf

Sustainable Design of Research Laboratories: Planning, Design, and Operation By Kling Stubbins, 2011, p135

ASHRAE Report Number 2438 RP 70, K.J. Caplan and G.W. Knutson, 1978 http://www.forensic-applications.com/hoods/face.html#2

Laboratory Fume Hood Standards Recommendations for the USEPA, R.I. Chamberlin and J.E. Leahy, 1/15/78. Contract No. 68-01-4661 http://www.forensic-applications.com/hoods/face.html#5

Lack of correlation between face velocity and occupant safety

http://ateam.lbl.gov/hightech/fumehood/students/su00/Fox/FHFace_velocity.htm

http://www.fumehoodtesters.com/hoodmyth.pdf

http://www.forensic-applications.com/hoods/face.html#1

A New Method for Quantitative, In-Use Testing of Laboratory Fume Hoods, R.E. Ivany, First, M.W., Diberardinis, Am. Ind. Hyg. Assoc. J. (50)5:275-280 (1989) http://www.forensic-applications.com/hoods/face.html#3