Ventilation best practice

BE SUSTAINABLE case study

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 2015.

This document describes a number of actions and the potential savings.

Page	Action	Saving
1	**VAV fume cupboards**	£1000/year
2	**Optimising face velocities**	£800/year
2	**Replacing old plant**	Variable
3	**Demand Based Ventilation**	40-65%/year
3	**Shut the Sash**	25%/year
4	**Set-back of ventilation rates**	25%/year
4	**Low flow fume cupboards**	40%/year

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 air which is being drawn into the fume cupboard has a large amount of embodied energy (and financial value) as it comes from the room air which then 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 and associated financial resources.

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 air handling systems to fume cupboards allows the flow to be reduced 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 s**avings 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].

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 a standard speed constant volume fume cupboard 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

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 0.5m/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].

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

Replace old with new

The problem

The plant which is used to treat air (heating, cooling and humidifying) is some of the highest energy using individual items of equipment across the whole of the University of Edinburgh. Where equipment is old the energy consumption may be excessively high.

The solution

Assess the age of plant across the University of Edinburgh and replace old with new where an adequate payback period can be achieved. For example, the Gurdon Institute at the University of Cambridge replaced their old electric humidifiers with new gas fired humidifiers and realised savings of £345,000 in 6 months[17].

16 Wiles, M., (2015), Personal communication.

17 Hilton, K., (2015), Presentation at ECCI on 30/4/2015

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 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 required, and yet if there is a release of fumes outwith 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.

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. 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**[18]) and University of Cambridge (**41% gas energy saving**[19]). 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 installing DBV in 2007, resulting in $1M/yr savings.[20]

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 instantaneous energy consumption by 50-70%**[21]. 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, Chancellor's and SynthSys labs.

18 http://www.ehs.uci.edu/programs/energy/SafelyCutYourLaboratoryEnergyUseinHalf.pdf

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

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

21 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 to standardised 9-5 hours 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 solutions

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[22] changed from 8/4 (day/night) to 6/3 ACH and reduced costs from $1.2m to $900k (25% saving) while maintaining required safety levels.

Low flow fume cupboards

The problem

Standard constant air volume 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%**[23 24 25] 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.

22 http://www1.eere.energy.gov/buildings/commercial/pdfs/bba_air_change_rates_highlights.pdf

23 http://www.fumair.co.uk/wp-content/uploads/2012/04/Low-Velocity-Energy-Saving.pdf

24 http://www.cleanairltd.co.uk/low-volume-fume-cupboard/

25 http://www.eventlink.org.uk/uploads/DOCS2/90-S-Labs_Workshop__-_Chemistry_Labs_refurbishment_-_David_Josey.pdf

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Andrew Arnott, October 2015

Please get in touch with us if you're interested in implementing any of these recommendations.

More information is available at **www.ed.ac.uk/sustainability/labs**

This publication is available online at www.ed.ac.uk/sustainability.

It can also be made available in alternative formats on request.

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