Topic 7: Fume cupboards

This *Topic* (dated July 2015) is an updated version of *Topic 7*, which appeared in the 3rd edition of *Topics in Safety* (ASE, 2001). It has been completely revised and rewritten to reflect the replacement of *Building Bulletin 88, Fume Cupboards in Schools* (DfEE Architects & Building Branch, 1998) by guide *G9 Fume Cupboards in Schools* (CLEAPSS, 2014). In effect, this *Topic* is a summary of important issues and the key points in that document, which, unlike most CLEAPSS publications, is freely available to non-members at http://www.cleapss.org.uk/attachments/article/0/G9.pdf.

As with any summary, some of the details are omitted and, in cases of doubt, readers should refer to the original. The *Topic* also takes into account advice from the HSE[1].

7.1 Introduction

Fume cupboards are safety devices, used to minimise exposure to hazardous fumes, gases or dusts. They are examples of 'local exhaust ventilation' (LEV) and operate by using a fan to draw air from the laboratory through an opening at the front (usually of variable area by means of a sash) and then either discharging it at roof level to the atmosphere (ducted fume cupboards) or by passing it through a pre-filter and filter which remove most (but not all) of the hazardous materials before discharging back to the laboratory (re-circulatory filtration fume cupboards). A subsidiary function can be to act as a safety screen, giving protection from splashes, minor explosions, etc.

7.2 When fume cupboards are needed

Before any activity involving hazardous chemicals – either using or making them – the employer[2] must carry out a risk assessment and identify control measures to reduce the risk from those chemicals. In many cases, control measures may involve carrying out the activity in a fume cupboard to minimise the exposure of employees (eg, teachers, technicians) and others who may be affected (eg, students) to hazardous fumes, gases or dusts. In practice, most school-level employers do not have sufficient in-house expertise to carry out suitable risk assessments and instead rely on national providers, such as ASE, CLEAPSS or (in Scotland) SSERC who publish Model (or General) Risk Assessments. For many hazardous substances, the HSE publishes Workplace Exposure Limits (WELs), which may relate to short-term (15-minute) or long-term (8-hour) exposure. Those carrying out risk assessments then consider how much of the substance might be released in a typical school activity or a worst-case scenario and hence determine whether a fume cupboard is needed and, if so, to what standard it should be performing. Exposure limits have changed over time as more evidence about the risks from the hazard becomes available, and hence activities once considered acceptable on the open bench may now require a fume cupboard of satisfactory quality.

Employees have a duty to cooperate with their employer on health & safety matters. Hence if the risk assessment provided by the employer requires the use of a fume cupboard, employees must use one. If the employer has not provided a fume cupboard, or if the fume cupboard is not working

1 *Controlling Airborne Contaminants at Work, HSG 258*, 2nd edition, Health & Safety Executive, 2011. ISBN 978 0 7176 6415 3.

2 The employer is the body with which an employee has a contract of employment. For those working in schools, this is usually the local authority or governing body but may be a trust, a chain of academies or the proprietor.

to a satisfactory standard, then the proposed activity must not take place. In some circumstances it may be possible to contact whoever carried out the risk assessment (eg, CLEAPSS or SSERC) for a Special Risk Assessment, which might involve some other method of containing the hazardous fumes or perhaps working on a smaller scale.

7.3 How many fume cupboards are needed?

It would not be possible to deliver the science curricula across the UK at secondary level without access to one or more fume cupboards. The number required depends upon the type of school.

Technicians working in prep. rooms may need a fume cupboard for dispensing volatile chemicals, diluting concentrated solutions, preparing gases, dealing with hazardous waste, etc. They may be working on a larger scale than teachers or students and hence at greater risk. It is unsafe to expect technicians to use fume cupboards in teaching laboratories – they are reluctant to do so because it would disrupt any teaching taking place and they would be at risk of being jostled. As a result, they may be tempted to carry out on the open bench in the prep. room activities for which their employers' risk assessments require a fume cupboard.

Any laboratory used for teaching chemistry at post-16 level (ie A-level or equivalent) would need at least 2 fume cupboards and a 3rd cupboard if classes are likely to exceed 15. One of these should also be suitable for demonstrations by teachers. Below the age of 16, students will rarely need personal access to a fume cupboard except for dispensing hazardous chemicals. However, their teachers will need access for the purposes of demonstration, so it would be necessary for 30 or so observers to gather around the cupboard with a clear view. This is most easily achieved if the fume cupboard can be moved away from the wall. Ideally, every laboratory in which chemistry is taught to GCSE level or equivalent needs a fume cupboard. However, if a school chooses to teach chemistry in all its laboratories it would be unrealistic to expect a fume cupboard in every science laboratory. In that situation, there should be fume cupboards in one third of the laboratories and classes will then need to move when the risk assessment requires it.

It is sometimes suggested that the number of fume cupboards required can be reduced by providing mobile fume cupboards (these are usually re-circulatory filtration fume cupboards, but can be ducted – see Section 7.5). However, experience shows that such cupboards are very rarely moved - it is too demanding on technician time to uncouple the services, move stools out of the way, get a 2nd technician to hold open the door, find a time when corridors are empty of children and then reverse the previous process in the destination laboratory.

At lower secondary level, one cupboard for use by technicians in the prep. room and one in a teaching laboratory may suffice. The latter would be mainly used for demonstrations by the teacher.

7.4 Buying and installing new fume cupboards

Fume cupboards are an expensive investment and schools should always obtain at least 3 quotations, not just for the cupboard but for any necessary ducting, service connections, etc. A pricey installation may have cheaper running costs but if these are paid for from different budgets it may prove difficult to get agreement. There are many different fume cupboards on the market, some quite unsuitable for schools. Do not be misled by claims that a high air-flow rate means greater safety or that a supplier has fitted out university or research laboratories. Such laboratories rarely use Bunsen burners but a high air-flow rate may well destabilise a Bunsen-burner flame, perhaps even extinguishing it. When contacting possible suppliers, it is worth asking them for the names of (local) schools which have been supplied with their fume cupboards.

For ducted fume cupboards (see Section 7.5), complications can arise if the fume cupboard supplier is not the same company that installs the ducting or commissions the fume cupboard once

installed. The windows and doors in modern laboratories are much better sealed than in the past and this can lead to problems in replacing the air which is extracted. Often the contractor who is building new laboratories, or refurbishing existing ones, will have a fume cupboard supplier with whom there is a special arrangement but the cupboards may not be the most suitable. It is important that teachers and technicians insist that they are involved in the choice of fume cupboards and that they are kept informed as the project develops, so that, for example, the specification is not changed at the last minute without their approval. Some new-builds or refurbishments are almost entirely in the hands of bursars or others, with science departments scarcely consulted.

The siting of a fume cupboard within the laboratory is important, both to achieve good visibility and to prevent draughts causing leakage of fumes. Two or more fume cupboards should not share the same extraction system unless the cupboards are in the same room. The motor driving the fan of a fume cupboard should not be wired from a residual-current device (RCD) that protects socket outlets in the laboratory; a fault elsewhere could cause the RCD to trip, switching off the extraction system and thus allowing fumes to escape. There may be an assumption that experts, such as architects, know what they are doing but, in specialist areas such as science laboratories, this is an unwise assumption. There is plenty of sound advice available, eg from CLEAPSS or SSERC, but architects and others may be unaware of its existence.

There is a European Standard, adopted as a British Standard[3], for fume cupboards, BS EN 14175. (replacing an earlier British Standard, BS 7258). (There is a separate British Standard for re-circulatory filtration fume cupboards, BS7989, which is likely to be replaced by a European Standard soon.)

BS EN 14175 is relatively permissive, allowing a wide range of specifications to be agreed between supplier and purchaser. As schools rarely acquire new fume cupboards and most teachers and technicians (or indeed architects) will have little experience of the process, they will find it difficult to draw up a suitable specification. The original *Building Bulletin 88, Fume Cupboards in Schools* and its successor CLEAPSS guide G9 *Fume Cupboards in Schools* both include a specification (ie, a standard) for school fume cupboards. This is, in effect, a sub-set of BS EN 14175. In producing the model risk assessments (see section 7.2), assumptions will have been made that a fume cupboard at least meets the requirements of this specification.

The specification includes materials of construction, dimensions, services (gas, electricity, water, drainage), sash design and labelling. However, the most important part is the rate of air flow through the sash opening. It must be a minimum of 0.3 m s^{-1} and not vary by more than a certain amount across the opening (otherwise, eddy currents can carry fumes out of the cupboard). As the sash is lowered, the rate of air flow should not increase by too much, otherwise there is a risk of de-stabilising Bunsen-burner flames.

For a ducted cupboard, the fan should be at or near roof level, so that almost all the ducting is under negative pressure to avoid hazardous fumes leaking out. The discharge should be above roof level, which may cause problems with local planning authorities. However, if not properly designed, there is a risk of fumes coming back into the school via windows, ventilation inlets, or accumulating in outdoor areas where people congregate.

If the fume cupboard relies on filters then these must be specifically designed for school use. Most filters are good at absorbing organic solvents but, in schools, the main challenge is acidic gases (HCl, Br_2, SO_2, etc) and some alkaline gases (NH_3 and some amines). The usual carbon filters have to be specially treated to achieve their absorption. Some filters are not well designed or manufactured, with small gaps in the seal – even a gap of 1 mm can lead to significant leaks.

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[3] Note: the European Standard, EN 14175 can be bought more cheaply than the British Standard, BS EN 14175, but the former lacks the British (National) Foreword which is particularly relevant for schools.

Some existing fume cupboards are very noisy, making it difficult to teach and resulting in a risk that the extraction system may be switched off too soon. The CLEAPSS guide G9 has a more-stringent specification in this respect than its predecessor.

All of the above points are discussed much more fully in the CLEAPSS guide and it would be sensible to make sure that the bursar and architect are given copies.

Once installed, the fume cupboard must then be commissioned, ie, tested to make sure it is working in accordance with the specification. This may happen during school holidays but it is important to insist that somebody from the science department is present, to be given the User Manual and Log Book, to be shown how to use the cupboard and to make sure that the department has a copy of the commissioning report. The report will be the benchmark against which performance is measured in subsequent years.

7.5 Ducted versus re-circulatory filtration fume cupboards

Schools often equate mobile fume cupboards with filtration fume cupboards but, in fact, ducted fume cupboards can also be mobile. Clearly, a mobile cupboard needs flexible connections to the gas, electricity, water, drainage and ducting (if any). This can introduce safety issues (especially for gas) and the need for portable electrical-appliance testing but a semi-mobile cupboard that can be pulled 1 m or so from the wall does allow much better visibility for demonstrations.

A filter fume cupboard is an attenuation device. It never removes all the hazardous fumes, it simply removes most of them; as the active sites on the filter become used up, a gradually smaller proportion is removed. Because a small proportion of fumes will get through the filter, the human nose may be able to detect these and staff may become concerned, even if the concentration is significantly below the WEL. A filter will not remove hydrogen, methane, carbon monoxide or mercury vapour and such cupboards must not be used for these gases. Some procedures (eg, the ‘Howling Jelly Baby’) cannot be safely carried out in a filter fume cupboard because there is a risk of igniting the pre-filter.

Filter fume cupboards are not fail-safe devices. If the filter is not replaced soon enough, teachers, technicians and students may be exposed to hazardous fumes. Filters may not be replaced because the school can’t afford to do so or because nobody realised it was necessary (eg, because of staff changes or a failure to carry out regular testing). Filters are usually supplied sealed in plastic. In this state they may have an indefinite shelf life although manufacturers do not give any guarantee. However, once opened and exposed to air (and especially moisture), manufacturers usually state they have a shelf-life of 5 years – even if they have not been used to absorb any chemical fumes.

Filters and pre-filters will need to be replaced from time to time so this adds to the running costs. Filters may be replaced only when a test shows they are almost saturated or replaced on a regular basis, well short of saturation. Testing for saturation is time-consuming and thus expensive but replacing a filter early obviously wastes part of the filter capacity. There are electronic sensors available for testing filter capacity but these have not yet been shown to be reliable for the gases used in schools. Filters are heavy (typically, 20 kg) and replacing them may not be easy, depending on the design of the cupboard. There is a risk of damaging the seal, leading to hazardous gases by-passing the filter.

Used filters need disposal. In most cases these are not currently regarded as hazardous waste, and do not need expensive disposal by appropriately-licensed contractors, but this may not be true in the future.

A ducted fume cupboard is much more expensive to install than a re-circulatory filtration cupboard because the ducting may cost 2, 3 or even 4 times the price of the cupboard itself. It is also

sometimes claimed that a ducted cupboard is wasteful of energy because it discharges heated air to the outside but school fume cupboards are switched on for such short periods of time that this is negligible. However, the flow of air through ducted fume cupboards may well interfere with air-conditioning and room ventilation systems, so the system needs careful design.

Claims that filter fume cupboards are cheaper because a single cupboard can be purchased which is then moved from laboratory to laboratory fail to take account of the cost of technician time. In practice, schools do not move them around very often.

Filter fume cupboards are sometimes the best solution, for example in temporary laboratories where the cost of the ductwork could not be justified. They may also be useful when refurbishing existing buildings (especially listed buildings) where it may not be practical to install ductwork. It is a moot point as to whether the life-time cost (say, over 25 years) of a ducted or filter fume cupboard is the greater but there is no doubt that a ducted cupboard is safer.

7.6 Testing fume cupboards

Fume cupboards require routine maintenance and testing. In addition, UK law requires LEV devices to have a 'thorough examination and test' at regular intervals. For fume cupboards this is at least once every 14 months, but schools are more likely to remember if it is done on an annual cycle. The thorough examination and test, in effect, compares current performance against the performance during commissioning. Full details of what to do are given in the CLEAPSS guide G9 or, or in Scotland, the SSERC publication *Routine Fume Cupboard Testing* but the most important aspect is testing the air-flow rate. It is necessary to use a sufficiently accurate meter for this, which will probably cost over £250. (This will need occasional re-calibration or checking.) In addition, for filter fume cupboards, filter saturation will need to be tested unless a decision has been made to replace the filters at regular intervals.

Many schools employ outside contractors to carry out the thorough examination and test, sometimes using the original supplier. However, carrying out the thorough examination and test is well within the capabilities of most school technicians, especially if they have attended a suitable training course, run for example by CLEAPSS or SSERC. A school can recover the cost of training and the necessary equipment very quickly.

If problems are found or suspected, it will usually be necessary to call in a specialist fume cupboard contractor. Modern fume cupboards are much better than those installed even 20 years ago and you cannot expect old fume cupboards to comply fully with a modern standard. In UK law there is no requirement to do so as long as the cupboard is fit for purpose. It is usually worthwhile, however, to attach a simple swing-vane anemometer (cost about £35). Whilst not sufficiently accurate for the thorough examination and test, it will indicate whether there is an air flow of about the right magnitude in the right direction.

7.7 How to use fume cupboards

Unless a particular cupboard can be devoted exclusively to storage, fume cupboards should not be used to store chemicals. It reduces the space for activities that need fume cupboards and increases the risk of an accident.

Most people would probably think that it is obvious how to use a fume cupboard but, in fact, training will be required on the idiosyncrasies (eg, alarms, testing, filter replacement, etc) of any particular fume cupboard. Heads of department need to be sure that all teachers (including non-chemists) and technicians (including the recently-appointed unqualified part-timer) know and would implement everything in the list on the next page. Schools might find it useful to copy it.

Checklist when using a fume cupboard

- Carry out a quick visual check of the fume cupboard. Look for:
  - signs of damage to any ducting, especially if flexible;
  - signs of any damage to the services;
  - ease of movement of the sash;
  - signs of damage to the cupboard itself;
  - evidence that the fume cupboard has been tested within the last 14 months and, if a filter is fitted, it is not past its use-by date.
- If there is a sink in the fume cupboard, check that there is water in the U-bend or trap so that fumes cannot leak out.
- Switch on the extraction system.
  - Does the sensor, if fitted, indicate a satisfactory air flow?
  - If a sensor is not fitted, unless the fume cupboard has been used recently, use a simple hand-held device (eg, a swing-vane anemometer) to check for satisfactory air flow.
  - Does the extraction system make any unusual noises?
- Place any apparatus in the fume cupboard, raising the sash as necessary, perhaps even raising it above the maximum working height stop.
- Lower the sash as far down as possible, but in any case below the maximum working height stop, to improve containment.
- Keep the sash as far down as possible throughout the procedure, raising it briefly as necessary to manipulate apparatus or chemicals, but never higher than the maximum working height stop.
- When the procedure is complete, keep the extraction system running until you are sure that there are no hazardous contaminants being generated and those generated have been removed.
- Clear away and, where necessary, safely dispose of any chemicals.
- Clear away the equipment.
- Check whether the glazing, especially inside, has become obscured by deposits and needs to be wiped clean.
- Leave the fume cupboard ready for immediate use by somebody else.