2019

Fume Cupboards

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Foreward

A fume cupboard is one of the more expensive items in a science laboratory. As such it is important to choose the right one, have it fitted and commissioned properly and make sure it is well-maintained.

For a good number of years, SSERC has run courses on fume cupboard testing and since 2010 there has been a booklet offering guidance on the testing process: Routine Fume Cupboard Testing.

The time has come to revise this document and we have decided to expand it somewhat. As well as more detailed advice on the testing regime, the guide now contains more information about the design and functioning of the cupboards as well as about installation.

Thanks and acknowledgements must go to CLEAPSS who took on an extensively revised Building Bulletin 88: Fume Cupboards in Schools and then made it available to all. Much of this document is adapted from Building Bulletin 88 and the CLEAPSS revision has been an invaluable guide during the process.

Thanks should also be given to the late Allen Cochrane who, while at SSERC, produced the original 2010 version of this publication.

1

A fume cupboard is intended to minimise exposure to hazardous gases, vapours or dusts. (though they might also act as a safety screen to protect people from minor explosions, splashes etc.

It is an example of Local Exhaust Ventilation (LEV)

What is it for?

The fume cupboard is a common fixture in laboratories used for higher level chemistry (Higher, Advanced Higher and equivalent) and at university.

When working with substances that give off hazardous fumes or vapours, there is a duty of care in Health and Safety law to ensure that exposure to these hazards is kept to a minimum. The fume cupboard is an effective way of doing this.

Not all chemistry teaching requires a fume cupboard. While access to one might be useful for National 4 & 5 work, it is certainly not essential. Even at Higher and Advanced Higher, if there is no suitable fume cupboard, alteration can be made to the practical work, either by leaving out some elements or by using a microscale approach.

Fume cupboards are, however, essential for the safe carrying out of many activities of Laboratory Technicians.

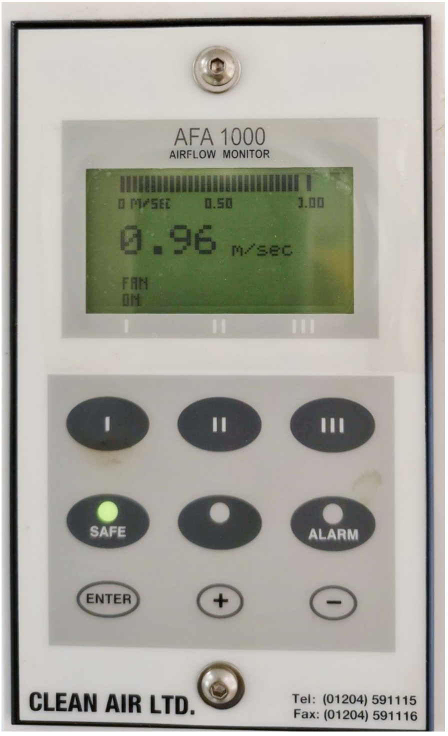
Some definitions

Sash – most though not all fume cupboards have a sash which can be raised to help gain access and lowered to protect the operator from splashes etc. The sash reduces exposure to hazardous gases, etc, by reducing turbulence. Smoothed edges of the cupboard minimise eddies and leakage of contaminated air from the face of the fume cupboard.

Airflow – the rate of airflow is important: too low and hazardous fumes may escape; too high it may extinguish Bunsen burner flames and turbulence can lead to fumes leaking out of the front opening as well as wasting energy and being noisier than need be.

Airflow indicator

Modern fume cupboards usually have a built-in **airflow indicator** with audible and visual alarms to warn the operator of incorrect operation of the fume cupboard – in particular if the face velocity is too low.



Face velocity - is the velocity of air at the plane of the sash when it is set at its maximum working height. The minimum face velocity required for a school fume cupboard to protect the user is 0.3 m s-1. There is no strict figure for a maximum face velocity but values much above 0.5 m s-1 are likely to cause problems. The optimum face velocity is a compromise. There should also not be variation of more than 30% from the mean across the face.

As the sash is lowered, the face velocity may increase and, for example, this increases the risk of de-stabilising a Bunsen burner flame. More modern cupboards have a bypass is to minimise the variation as the sash is lowered and raised.

Working aperture - the opening through which the users can put their arms. If the height of the aperture is too small, it can be difficult to manipulate apparatus; if the opening is too large it is harder to keep the air velocity high enough, and even enough. It also requires a more powerful extraction system and there is less protection from splashes.

For schools, a maximum working height of 400 mm or a little more allows is a suitable compromise.

The sash is usually lowered when in use but it should not be possible for it to go lower than about 50mm.

Ducting

This is the name given to the (usually metal) tubing that carried the contaminated air from the fume cupboard and eventually out of the building.

The fan should be positioned outside or just inside the external wall: in that way the ducting will be under negative pressure.

Negative pressure

In sections of ducting between the fume cupboard and the fan, the movement of the air means that the air inside the duct is at a lower pressure than the still air outside: the system is at negative pressure.

This is important as it means that if there is a small leak in the ductwork then air will flow into the duct rather than out, moving as it does from high pressure to low. So contaminants do not escape.

Stack

The stack is the name given to the ‘chimney’ that carries the contaminated air from the ducting and releases it into the atmosphere. It should be positioned above the highest roof point of the building.

Filters

Some fume cupboards use filters to ‘clean’ the air before returning it to the laboratory. Instead of using ducting to carry it away. In fact these cupboards have two filters:

The **main filter**. This consists of activated carbon suitably treated to react with the hazardous gases which need absorption.

The **pre-filter**. To prevent the main filter from becoming clogged with dust, the contaminated air first passes through a pre-filter which resembles a thin layer of wadding. The pre-filter will also extract smoke particles whose size is 0.5×10^{-6} m or above; finer particles will pass through.

2

Fume cupboards are available in two types: Ducted and filtered (also known as recirculatory fume cupboards).

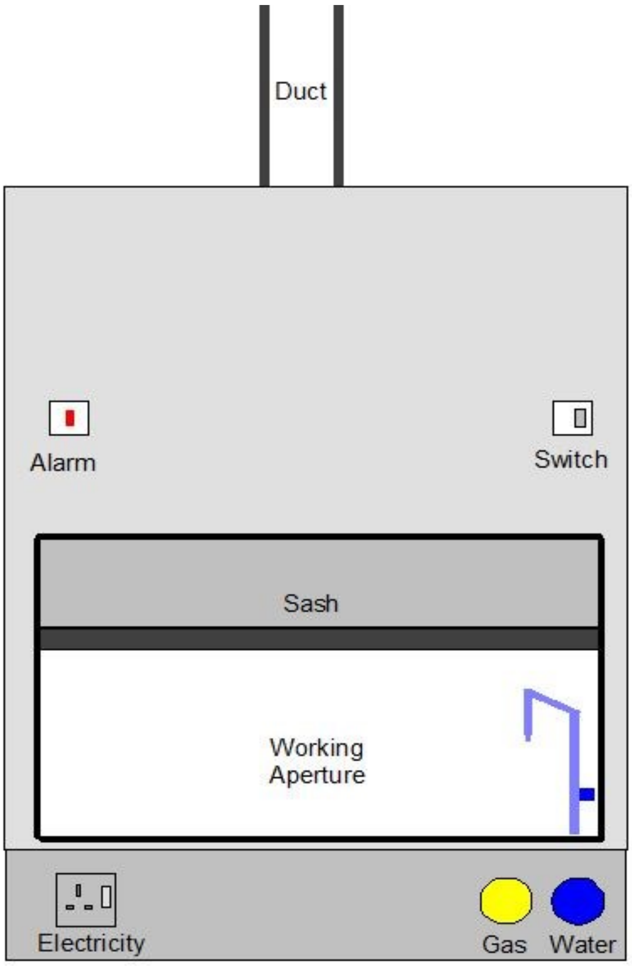
How do they work?

Both types of cupboards have an overall appearance similar to that shown in the diagram. There is an aperture through which it is possible to set up and adjust apparatus.

This usually, but not always, has a sliding sash that can be brought down once the experiment is under way to further decrease the possibility of fumes escaping.

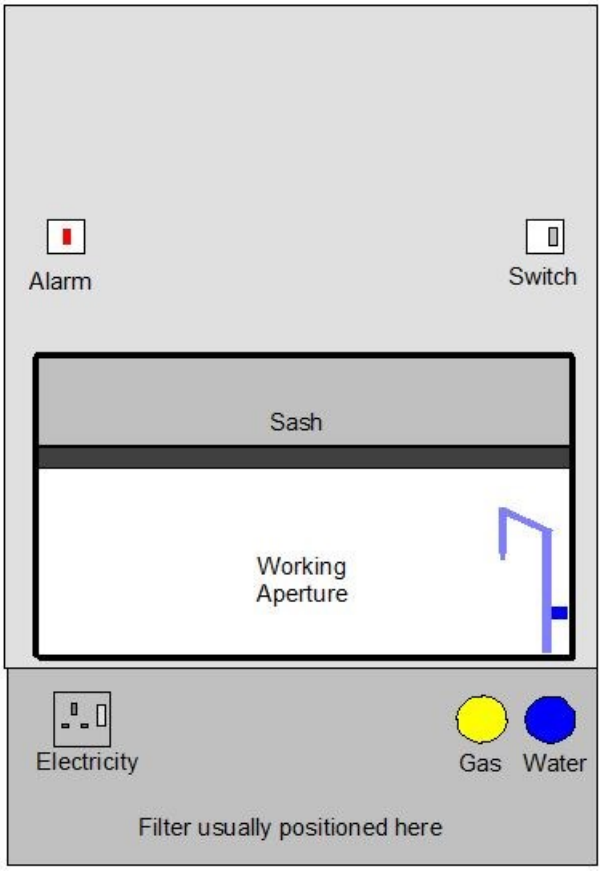
Both types of fume cupboard work in a fundamentally similar way - a fan draws air in through the working aperture. This airflow draws any fumes produced within the chamber along with it

A fixed fume cupboard will usually have services (gas, water and electricity). Many mobile ones do too, connected by specific fixings.



Most modern fume cupboards also have an alarm to warn if the face-velocity drops too low, indicating a problem.

The filtered fume cupboard will, of course, not have the ducting. Instead, it will have a filter usually in the body of the cabinet below the working space.



They are also often smaller, with a smaller working aperture and many do not have a sliding sash at all.

Services, where supplied, are connected by flexible hoses and cables via bespoke connections.

Most, though not all filtered fume cupboards are mobile.

Despite the similarities, here are, however, significant differences in functionality between the two types.

Ducted fume cupboards

These simply remove the contaminants along a duct and discharge them into the atmosphere—having been diluted by mixing with air.

Ducted fume cupboards (DFC) are inherently much safer than filtered fume cupboards and should, wherever possible, always be purchased in preference to the latter.

In the long run the overall cost of a filtered fume cupboard is greater than that of a ducted cupboard when the cost of replacement filters, the tests, testing materials and teacher or technician time is taken into account.

Ducted cupboards are also sometimes available in semi-mobile form with a flexible length of duct connecting the cupboard to the fixed duct in ceiling or wall. These cupboards can be used with all round vision.

Filtered fume cupboards

These have no ducting to the outside air but instead pass the contaminated air through a filter that removes most (**but not all**) of the contaminants before discharging the filtered air back into the room.

More detailed information can be found in SSERC Bulletins 211 [1] and 177 [2].

Essentially the fan pulls the air in the chamber through the 'filter' which removes virtually all of the pollutants and returns the 'cleaned' air to the room. This greatly reduced concentration will be further reduced on being mixed with room air.

The main filter consists of activated carbon suitably treated for the hazardous gases which need absorption. The filters for school fume cupboards usually have three layers :

- for acid gases,
- for alkali gases, mainly ammonia, and
- for hydrogen sulphide.

All three layers will absorb organic gases.

A typical filter has solid plastic sides and a porous top and bottom. It is divided into cells by plastic dividers to keep the carbon granules evenly distributed.

It is more correct to regard these devices not as fume cupboards in the traditional sense, but as devices with low, but definite release rate of the toxic and harmful gases being generated inside.

As a consequence the concentration of those gases will slowly build up in the room atmosphere. However releases in school work are usually low in magnitude (mg s^{-1} or $cm^3\ s^{-1}$) and short-lived, say 5 or10 minutes in duration: thus the room concentration is unlikely to reach anywhere near the WEL. However during the occasional, lengthy release of gas inside at a high rate it is also necessary for the room to be well ventilated.

Although a 'filter' has an enormous surface area, this will eventually become saturated resulting in a decline of the efficiency of capture. Before this point is reached the 'filter' should be replaced. The recognised method of testing is by *challenge tests* described in Section 8 (p21)

Recirculatory fume cupboards are acceptable for handling the relatively small quantities and low rates of release associated with most classroom work.

In SSERC's view they are not suitable for a prep room.

2

Construction

Work surface

Various materials are suitable for this*, including (but not limited to) melamine-surfaced phenolic resin, filled acrylics, solid epoxy, moulded glass-reinforced epoxy laminate and suitably grouted ceramic tiles.

It is important that plastic materials are dark coloured as the stains produced by hot objects and most chemicals tend to be orange-brown.

* Stainless steel can be used but it is prone to blackening, pitting and even having holes created by solutions containing chloride ions, eg, hydrochloric acid or bleach, particularly in the presence of particles of metal. If it is used, it should be grade 316 rather than the grade 304 for domestic use.

The work surface should be slightly concave (dished) or its front should have a lip to prevent spilt liquids running out of the front of the cupboard; the lip should be shaped for easy cleaning. If the work surface is fiat with a lip at the front, it should be sealed round its other edges with a suitable material, for example, silicone rubber mastic. The work surface should be approximately level with other work surfaces in the laboratory', usually about 850mm above the floor.

Illumination

Good lighting helps safety and is essential for demonstration. A steady light level of at least 300 lux at the work surface is required. Suitable lamps should be built into the fume cupboard unless the fume cupboard has extensive glazing and is to be used in a well lit area.

If a fume cupboard is only to be illuminated by general room lighting, then it must be glazed elsewhere besides just the sash.

Light fittings must prevent ingress of gases released within the fume cupboard to reduce the slight risk of igniting flammable vapours and to avoid corrosion.

Lining and construction materials

Materials should be resistant to fire and to chemicals and be non-absorbent. Safety glass, acrylic, polycarbonate, metamine and epoxy-coated or stove enamelled aluminium or steel are suitable.

Wood, plywood, blockboard (suitably veneered and treated), chipboard or medium density fibre board can all be suitable if they are treated with flame-retardant and chemical-resistant coatings or finishes.

Glazing

The sash of a flame cupboard must be glazed and, if it is intended for use for demonstrations, the fume cupboard should have a glazed back and sides. Protective glazing must be used: toughened glass or laminated glass at least 5mm thick; or acrylic, or polycarbonate. Protective glazing is necessary because there is a risk of pupils running into a fume cupboard and, also, a very slight risk of an explosion inside.

Georgian wired glass (clear glass which contains the steel mesh embedded into the actual glass) is not a safety glass. Acrylic is less strong than polycarbonate.

Purchase and installation

3

Putting a fume cupboard in a laboratory is not a simple operation like installing a fridge.

Recirculatory cupboards, as long as you do not need water, gas and electricity, are quite straightforward but adding in services is a more complex process.

Installing a ducted fume cupboard is more complicated still

The advice in this (and other sections) is largely taken from Building Bulletin 88 'Fume Cupboards in Schools' [3] and its successor document, CLEAPSS G9 'Fume Cupboards in Schools'.[4]

What do we need?

A fume cupboard is an expensive purchase. However, for a ducted fume cupboard at least, the duct installation cost is likely to be much greater if it being fitted to an existing building so, if at all possible, the issue of fume cupboard provision should be addressed in the planning stage of a new building or a refurbishment.

While there are a few activities in Biology and Physics that could benefit from a fume cupboard, realistically they are only needed for chemistry work. So fume cupboards should be installed in:

- Any prep room where there is work with chemicals. These should always be ducted models
- All chemistry laboratories. Ducted fume cupboards are preferred but this is not essential.
- If there is a dedicated 6th form laboratory, 2 fume cupboards (or more) is preferable though cost dictates that this rarely happens.

How many fume cupboards do we need?

Most importantly there needs to be a fume cupboard in the technicians' prep room.

Where there is more than one prep room, perhaps for each department, then there is only a requirement for a fume-cupboard in one of them, the chemistry one, but that will mean that dispensing of hazardous chemicals for biology will need to be carried out there. Depending on the geography of the establishment, a risk assessment may show this to be too hazardous in which case provision will be needed in the biology prep room as well.

As for classrooms, every **chemistry** laboratory in a school or college that is used for teaching Higher or Advanced Higher (or equivalent) chemistry should have at least one, ideally 2 fume-cupboards.

If, however, the school or college has a significant number of Advanced Higher students then at least one laboratory should be equipped with more. In such cases, a dedicated Advanced Higher laboratory is often created.

At least some fume cupboards should be designed and positioned so as to be suitable for teacher demonstrations. A demonstration fume cupboard is not needed in every laboratory but there should be enough in the department - roughly a third of the laboratories is a good number.

Where fume-cupboards may be of use in other classes, either a portable cupboard can be purchased and moved as required or the issue can be addressed by swapping rooms.

Fume cupboards for demonstrations

A demonstration fume cupboard should be glazed on all sides and positioned so that the demonstrator can stand at the opening, with the audience around the other three sides. This is most easily managed by having a fume cupboard that can be pulled out from the wall, at least a short distance - although this raises questions about how the services are to be provided.

An easier option might be to have the fume cupboard positioned at the end of the teacher's bench, which will be away from the wall anyway.

What type of fume cupboard?

Wherever possible, it is preferable to install ducted fume-cupboards. They are intrinsically safer in design and, although more expensive to install they are much easier and cheaper to maintain. Over their lifetime, they will save many times the extra money spent on their installation.

That said, SSERC is not against the use of filtered fume cupboards. They are certainly infinitely preferable to not having one at all.

One circumstance where in our view a filtered fume cabinet is **not** suitable though is in the technicians' prep room. The larger volumes and higher concentrations used could easily saturate a filter and impair the functioning of such a cabinet, putting those working there at risk.

Buying a new fume cupboard

... prior to purchasing a fume cupboard, a risk assessment should be performed to assess the risks associated with the substances that are to be manipulated ... [5]

In effect, a fume cupboard designed for school use from a reputable manufacturer will meet all the criteria. The only remaining factor to be considered in the assessment will be whether it is to be used in a classroom or a prep room.

Contractors

Ideally, the same company should supply and install the fume cupboard, and ducting.

If two or more contractors are involved, a clear agreement should be reached and recorded in writing **before work begins** as to who is responsible for which part of the process.

Quotations

When purchasing a new fume cupboard, especially a ducted one, it is wise to obtain at least three quotations.

It could be helpful to get other sources of information: one of the best ways is to ask about other schools the contractor has installed fume cupboards in and contact them for their experience.

Remember that the cupboard is expected to last for 25 years so the cheapest option may not be the best and may not result in any real savings. In particular compare the headline cost with the cost after including things like the ducting, fan, docking stations installation etc.

The most successful projects, as with everything else concerning laboratory provision, always involve senior chemistry teachers and technicians from the outset; otherwise there is the danger that ordering will be done by non-chemists who have little understanding of what is likely to be needed.

Members of SSERC (or CLEAPSS in the rest of the UK) can contact those organisations for advice.

Written specifications should be agreed upon **before** building work begins. Ideally, the school/employer/local authority purchasing the fume cupboard should prepare a specification and choose the successful contractor based on their initial quotation.

> The supplier should test the fume cupboard and provide a report which shows that it performs according to the specification or the agreed quotation.
>
> Commissioning includes checking the effectiveness of the new cupboard.

Installation

Ideally, installation should be done when no pupils are around: before the opening of a new build or outside of term time. Special care will be needed if the work is done during term time, when pupils are around. In all cases, installers should work safely, in cooperation with the school.

Schools need to check that what was specified in the plans and discussions and included in the contractor's quotation matches what has been installed.

How /where should it be positioned?

The following minimum distances, largely taken from BS EN 14175-5: 2006, Fume cupboards – Part 5 [5]: Recommendations for installation and maintenance, should apply to all school or college fume cupboards.

A fume cupboard should be sited at least 1 m away from circulation routes.

Passers-by create eddies, which may cause a release from the fume cupboard. During the brief period of a demonstration, this may not be significant but passers-by can also distract or even knock into its user.

It is important to bear in mind the need for a clear area in front of a fume cupboard in a preparation room.

There should be no opposing wall or other opposing obstruction such as a laboratory bench likely to affect air flow within 1.4 m of the sash.

If more than one operator uses the same bench opposite, this distance may need to be greater

For demonstrations an unobstructed working zone of radius 2 m from the centre of the fume cupboard is recommended

This zone would accommodate 15 to 20 pupils with some sitting and others standing. (In practice 2 m is difficult to achieve even with moveable furniture and the minimum radius of 1.5 m is more realistic).

Ideally, it should be in the middle of a wall, well away from doors and windows (as shown below)

Even if a fume cupboard is not required for demonstration to the whole class, a minimum working zone of radius of 1.5 m is recommended to allow for pupils watching or waiting to use it.

No frequently used doorway should be within 1 m of the sash or within 0.3m (ideally 1 m) of the side of the fume cupboard,

(This does not apply to for doorways exclusively used as emergency exit.)

If an accident occurs in a fume cupboard or if its extraction system fails, it may be necessary to evacuate the room which may be made harder if it is sited near to an exit.

Large isolated obstructions, eg columns, pillars, tall cupboards, etc, at the side of the fume cupboard and projecting beyond the plane of the sash can influence the containment of the fume cupboard

A ceiling height of 3 m is recommended and a height of 2.7 m should be the minimum (any less than this and the fume cupboard may not be able to perform in accordance with the British European Standard against which it was tested).

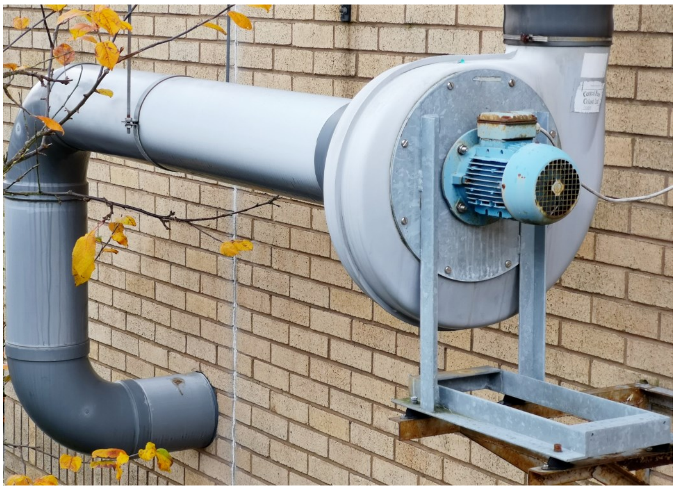
The impact of air inlets (or other vents that are a part of the overall ventilation system) on the performance of the fume cupboard should be carefully considered.

More detailed information on the advantages and disadvantages of various positioning options can be found in Appendix F

Positioning of ducting

In a ducted fume cupboard, the duct exit should be at the top of the fume cupboard, in the middle. This positioning is to reduce variation of the face velocity across the working aperture.

Controlling the face velocity. This can sometimes be done using a damper (installed during commissioning) to adjust the air flow rate. Alternatively, some fume cupboards may have the ability to adjust motor speed. Whichever option is used, once the correct setting(s) are found, the controls should, if at all possible, be locked into position and not altered during normal use.



Ducting and fan– The ducting itself should be rigid (except for any flexible connections to mobile fume cupboards), firmly fixed in position and the joints appropriately sealed.

The fan should be mounted on the outside of the building (or in the roof space as close to the exit point as possible).

This positioning ensures that the ducting inside the building is under negative pressure (compared to atmospheric pressure) so that any holes will result in clean air flowing in to the duct rather than contaminated air flowing out.

To achieve safe dispersion into the atmosphere, the ducting carrying the diluted fumes must be released through a properly designed and sited discharge stack. The design and siting of stacks from fume cupboards is

critical the possibility of fumes from the discharge stack re-entering the building.

The release point should be:

- Above the highest point of the roof
- Well away from any window or inlet vent where fresh air is taken into the building.

The need for the fumes to be released at a high point is the reason why it is preferable for a chemistry department to be located on the top floor of a building, to reduce the length of any ducting.

Commissioning

Once a fume cupboard has been installed, it must be commissioned,

HSE have reported that commissioning is frequently inadequate and that many problems they encounter should have been spotted at this stage. It is therefore essential that commissioning takes place **when members of the science staff are present** and that they are given full instructions of how the fume cupboard works and a copy of the tests and test results carried out at commissioning.

If it is not possible for staff to be present (since work is often carried out during school holidays) the contractor should provide training soon afterwards, as an essential part of the contract.

Further guidance on LEV commissioning is now provided in *Controlling Airborne Contaminants at Work*(HSG258). [6]

Commissioning should cover:

- the details outlined in the customer's specification and included in the contractor's agreed detailed quotation.
- The carrying out of a visual check
- a quantitative test that the performance is at least as good as the minimum laid down in this specification. This should include:
    - ◊ a face velocity test
    - ◊ a smoke test on the ducting, where applicable) and

◊ a challenge test on the filter for filtration fume cupboards. If filters are installed before delivery they can sometimes become dislodged from seating during transport. Also, the seal can be damaged when the filter is inserted and some seals are of poor quality, with small gaps through which leaks can occur

Commissioning Report

A commissioning report needs to be provided to the school and copies retained by all the interested parties such as the school finance department and the science department. It should contain diagrams of the system and the results of the initial tests.

This is important, as it is the standard against which future thorough examinations and tests will be compared.

The report should include:

- diagrams and a description of the LEV, including test points;
- details of the LEV performance specification;
- results, such as pressures, velocities at stated points, and noise levels;
- calculations;
- written descriptions of the commissioning, including the name of the person who made the checks and the company he/she was employed by, the date, the tests undertaken, and the outcome;
- a description of how operators should use the system so it works effectively.

Training

The Health & Safety at Work Act [7] requires adequate safety training; the Control Of Substances Hazardous to Health Regulations (COSHH) [8] specify it for those who might be exposed to hazardous substances.

Therefore, users of school fume cupboards must be instructed and trained to use fume cupboards when the risk assessments provided by the employer require it.

So science staff and any others (such as pupils) using the fume cupboard must be taught how to use the fume cupboard and understand any possible limitations. They should also be taught how to spot when the fume cupboard is failing and what emergency action to take.

This training can be carried out internally within the school or department.

4 Testing Fume Cupboards

Why test?

Under Section 2 of the Health and Safety at Work Act there is a legal requirement for the employer to provide and maintain safe equipment and safe systems of work. Both these requirements are further spelled out in the Provision and Use of Work Equipment Regulations1998 (PUWER) [9] and by the Control of Substances Hazardous to Health COSHH Regulations 2002 (COSHH).[8]

Of particular relevance regarding laboratory fume cupboards is Regulation 9 of COSHH

. .the employer shall ensure that thorough examination and testing of those controls is carried out . . .at least once every 14 months. . .

In effect, this means an annual test.

The 2 months extra time means that in the case of absence of the competent person to carry out the test there is time to make other arrangements without having to take the fume cupboard out of commission.

Every employer shall keep a suitable record of the examinations and tests and of repairs carried out as a result of those examinations and tests, and that record or a suitable summary thereof shall be kept available for at least 5 years from the date on which it was made.

Apart from being a legal requirement the keeping of records makes easier the detection of the beginnings of any gradual decline in performance.

Who should carry out the test?

The regulations merely specify a ‘competent person’.

The testing itself is not especially difficult and in many schools (or Local Authorities) it is carried out by a school technician.

Training is available for this from SSERC.

An alternative is to arrange for an external consultant to do so. This is, however, expensive. SSERC has come across situations where the contractor charges several hundred pounds for each fume cupboard.

In some PPP schools the testing of the fume cupboard is carried out by the building management company. This removes a task from the school but there can be disagreements about the nature of the testing.

What do we test?

SSERC recommends using the standards set by the DfEE document BB88 [3](Now revised as the CLEAPSS document G9 Fume *Cupboards in Schools*—open access availability) rather than the much more onerous ones in the British Standard [4].

Daily check

In the same way that a responsible car owner will periodically check the tyres, oil etc of their vehicle, in addition to the detailed annual MOT, every person using the cupboard should carry out a quick visual check that there is no obvious fault, e.g. that:

- the glazing, sash and structure (work surface, linings), are not showing signs of damage;
- there is an inward air flow as indicated by the airflow meter or small streamers fastened on the bottom of the sash;
- electrical and gas services are not damaged.

Annual check

Ducted cupboards

This consists of:

- making a detailed examination of the sash, structure, and as far as possible, the condition of the fan and ducting.
- measuring the face velocity;
- possibly carrying out a smoke test;

On fixed, ducted cupboards the 13 A socket should have been tested by architectural services or other sub-contractor along with fixed electrical installations in the building.

Filtered cupboards

This consists of:

- making a detailed examination of the sash, and structure.
- measuring the face velocity.
- Possibly carrying out a challenge test of the filter.

Mobile fume cupboards

These are usually filtered but some ducted cupboards have at least a degree of mobility that allows them to be moved away from the wall for improved visibility when carrying out demonstrations

The test should consist of:

- The appropriate testing as outlined above
- A detailed examination of the service connections (gas, water electricity) and particularly the restraining wire
- An appropriate Portable Appliance Test (PAT)

Status of the challenge test

SSERC has sometimes come up against an issue regarding external contractors, in that they will frequently do a face velocity test and a smoke test but not do any testing on the filter.

The companies point out that there is nothing specifically in the regulations that demands this sort of testing.

This is true, though arguments could be made as to whether not testing the filter is sufficient.

However, there may be other reasons why a school does not wish to carry out challenge testing of the filters.

A few years ago, CLEAPSS carried out an extensive survey of fume cupboard use in schools in England and came up with the following guidelines which we would endorse for schools and colleges in Scotland as well.

If the filter is not being challenge tested then it should be replaced regularly **at least:**

- every 4 years for laboratory fume cupboards, or 3 years with heavy use;
- every 2 years for prep room fume cupboards.

More frequent replacement may be necessary if there are unexpected odours or other issues.

5 Fume Cupboards—structural tests

Structural tests

Most of these are common to both types of fume cupboard

Opening stops

Stops should be fitted to prevent the sash being opened beyond positions at which the face velocity is satisfactory. This should be between 400 and 300 mm for the upper stop and a minimum of 50 mm for the lower. They must not be capable of being removed without the aid of a tool, e.g. a screwdriver. (If a by-pass is fitted, the position of sash will not affect the face velocity too much.)

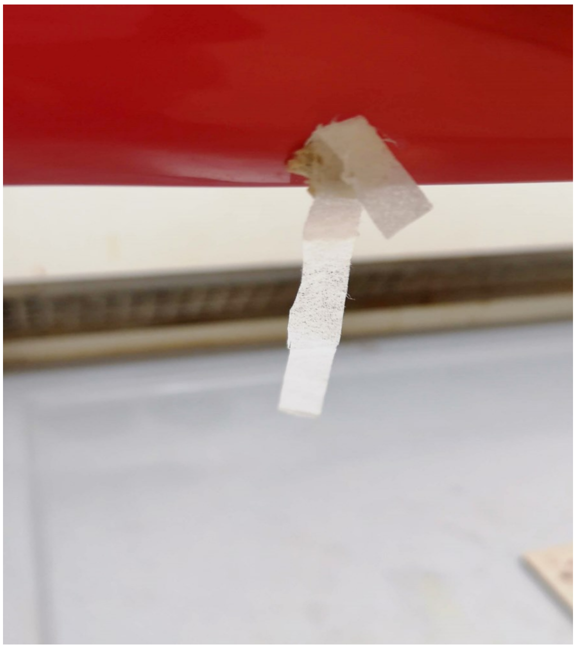
Blocks of wood fixed in place will do for upper and rubber door stops on underside of sash for lower stops.

Glazing

Glass should be undamaged. Safety glass (laminated or toughened of 5mm) is preferred alternatively polycarbonate may be used.

Flow indicator

Some sort of flow indicator should be fitted and working. Newer fume cupboards have anemometers permanently fitted: if not, then a solution may be simple strips of paper or plastic fastened to the underside of the sash.



Structure

This should be sound and metal parts should be free from excessive corrosion.

Sash

The sash should slide freely and yet hold its position. The mechanism (counter weights & cords) or spring should be sound. It must only open to one room (see below).

Openings

Fume cupboard should only have one opening. If there is a double opening, and a second sash opens to an adjacent room, this constitutes a failure and one side **must** be permanently sealed with materials offering > ½ hour fire resistance. Contact the local fire prevention officer for local requirements

Work surface

This should be in good condition (Some very old cupboards might still have a hard asbestos surface. This can be sealed and continue to be used safely, but soft or flaky asbestos is a fail) and must be disposed of.

The work surface should have a lip at front or be slightly concave to contain spillages. The lip can be as simple as a strip of plastic or hardwood glued in place.

Some fume cupboards have the working surface is in the form of a removeable tray which can be easier to clean.

Many newer fume cupboards are being supplied with plastic flooring. In this case, great care needs to be taken with hot objects and with some organic solvents.

Services

Gas. The outlet should be on or above the working surface to side and near the front with controls at the front outside the chamber. The valve should be working smoothly. Ideally it should have a spring loaded off position to prevent the gas supply being accidentally turned on. Pipework should be free of corrosion.

Panel mounted valves are preferred to linked rods control; when link joints wear, it may be difficult to turn the gas off quickly in an emergency.

Water has similar requirements as for gas, apart from the need for a spring loaded off position. It should operate satisfactorily.

Electricity 13 A outlet((s) should be undamaged and have passed the last test on fixed electrical installations test (usually carried out every 5 years by architect's department).

They should be outside the chamber at the front and to one side is safer, but if under the front it will be protected to some extent by an overhang and by a lip. It should be protected by an RCD.

Note – for ducted fume cupboards, the fan motor **must not** be on a circuit sharing an RCD with any other sockets or devices. Otherwise a fault elsewhere could trip the RCD for the fan and cause a dangerous situation.

Note also that recirculatory fume cupboards are classed as portable electrical devices and must be tested as such

Drainage water from the catchpot should go via a bottle trap which feeds onto a dilution trap further downstream. It should be free of leaks.

Connections for mobile cabinets

Most recirculatory fume cupboards are mobile, enabling them to be moved from room to room as required.

Most too have connections for services such as gas, water and electricity. These connect to purpose-built connection pods.

The hoses and cables need to be firmly attached and

there needs to be a cable restraint on the body of the fume cupboard to prevent it being pulled too far from the wall and pulling the connections out.

6

Fume Cupboards—face velocity test

Face velocity check

You will need an anemometer for this. These are precision instruments that need careful looking after and periodic calibration. [See Appendix D]

Even if it has been calibrated recently, do a rough check as follows.

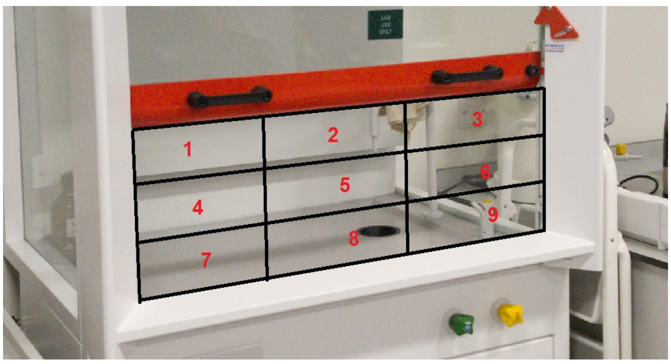
In a closed and draught free room or corridor hold the meter at an arm's length to the side and walk at a speed of about 0.5 m s^{-1}.

(measure the distance and the time of your 'course, then you can easily calculate your speed).

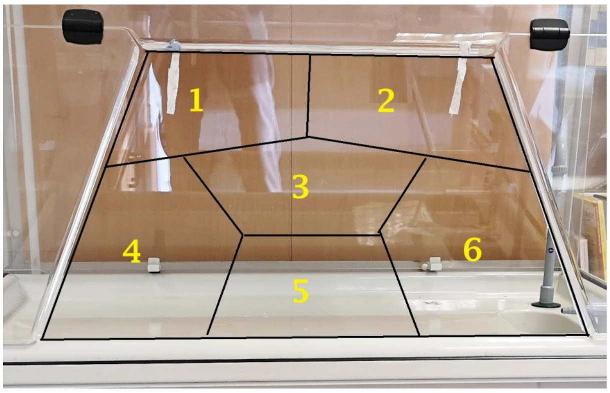
If the reading is not close to the speed you calculated, the meter has obviously been damaged since the last calibration.

Measuring the face velocity

1. Close doors and windows and turn on extractor fans to provide the worst case situation for the fume cupboard fan to have to work against.
2. Empty the fume cupboard of apparatus.
3. Switch on the fan and *ensure that the air flow is inward* by observing tell-tails attached to the bottom of the sash as most anemometers will give a reading for both directions of flow. The air flow direction of axial fans could have become reversed if the polarity of the wiring had been wrong. Centrifugal fans still extract the air even when the direction of rotation of the impeller is reversed, albeit with lower efficiency.
4. Set the sash at the *maximum working opening* (probably 400 mm)
5. 'Divide, the opening into 9 rectangles of equal area. (You can do this roughly by eye—there is no need to mark the areas)



With the recirculatory fume cupboards the opening is generally smaller and it may only be possible to divide it into 6 areas).



7. Measure the face velocity in each of the nine areas for a period of 10 seconds or more and record the results.

   It take a while for the anemometer to get up to speed so the best method is to take several readings and when they have settled down so they are in close proximity, then record the value.

When carrying out the measurements keep your body as far away from the sash opening as possible to minimise interference with the airflow. Some anemometers have the sensor head mounted on a long wand which makes this easier.

The Results

*Calculate the **average** of the nine readings* and ring the highest and the lowest readings.

*Calculate the **% deviation*** of the highest and lowest readings and record them.

$$\%\ deviation\ (h) = \frac{(\text{highest} - \text{average})}{\text{average}} \times 100$$

$$\%\ deviation\ (l) = \frac{(\text{average} - \text{lowest})}{\text{average}} \times 100$$

The easiest way to carry out the calculation is to use a spreadsheet. A suitable spreadsheet can be downloaded from the SSERC website here

A printed version of it can be found in Appendix C

The spreadsheet can be printed off (if needed) and kept as a record of the testing.

The cupboard will fail if:

any one of the 9 readings falls below 0.3 m s^{-1}

or

any of the deviations are greater than 30%.

(or if the deviations are >20% but all on one side)

If it fails

If the average face velocity is only just below 0.3 m s^{-1}, it is allowable to reduce the opening slightly by pulling the sash down a little and repeating the above measurements, but not to lower than 300mm

If it now passes, the upper stops will have to be moved and fastened in the new positions to prevent the sash being raised higher than this new, safe level.

It should be remembered though that although a face velocity of 0.3 m^{-1} can be accepted as a pass, it doesn't stop the fumes from being pulled out backwards through the sash opening if there is a light draught or if someone walks past. It is better to have a face velocity of at least 0.4 m s^{-1}.

It is important that a fume cupboard which fails these tests is no longer used until it is repaired or upgraded so that it meets the standards.

In such a situation, it might be possible to review the activities and, subject to a suitable and sufficient risk-assessment, allow the fume cupboard to be used for certain activities but the onus would be on the employer to ensure that users were adequately protected.

SSERC does not recommend this approach.

A fume cupboard which fails to meet standards should be appropriately labelled as out of use and ideally the power to it should be cut so it cannot be used.

7

Fume Cupboards—smoke test

This is usually used when testing ducted fume cupboards but there are circumstances when it is appropriate for recirculatories.

For checking containment, smoke must be used with extreme caution. Fume cupboards do not contain perfectly: small escapes near the edges of the working aperture must be expected

Ducted fume cupboards

A smoke pellet or two should be released within the body of the fume cupboard.

The smoke release should enough for you to see that there should be no significant escape back out through the open sash into the room.

Smoke may be actually expelled back out through a corner of the sash opening if the face velocity is too high and the cupboard has poor aerodynamics. Reducing the face velocity (perhaps by adjusting the damper) usually cures the problem.

You should also inspect the ducting and joints (as far as possible) for leaks of smoke.

There is no need in a normal test to go poking around in the roof space but a visual inspection of any accessible sections is useful.

Smoke is released into the cabinet and a bright light used to look for any signs of leakage.

If the fan has been positioned correctly and is working properly the ducting should be under negative pressure in relation to the atmosphere so even if there are any holes or cracks, clean air should flow **in** to the ducts rather than contaminated air flowing out.

Recirculatory fume cupboards

You should only do this if there is some doubt about escape of fumes through cracks and seams of the fume cupboard or through the face due to turbulence. Only use a small pellet enough to see that there is no significant escape: too much smoke will clog up the pre-filter so it needs to be changed and may slightly impair the main filter as well.

A percentage of the smoke particles will be fine enough to pass through the 'filter' and form a haze in the room. This is not indicative of a failure.

Fume Cupboards—Filter challenge test

8

Testing filters

More detailed information can be found in SSERC Bulletins 211 [1] and 177 [2], which describe the principle of the filtered fume cupboard and problems that can arise with filters. Essentially the fan pulls the air in the chamber through the 'filter' which removes virtually all of the pollutants from the air, which is then returned to the room. Capture efficiencies are typically in excess of 99% and often as high as 99.9%. A 'filter' with an efficiency of 99% will reduce a steady-state concentration of 2000 ppm inside the fume cupboard to 20 ppm in the air being exhausted back to the room. This greatly reduced concentration will be further reduced on being mixed with room air.

A filter cannot be 100% efficient and the nose is very sensitive. What is smelt may be the small quantity of gas which must pass through and which will present no hazard when dispersed in a normal-sized laboratory with adequate natural ventilation.

It is more correct to regard these devices not as fume cupboards in the traditional sense, but as attenuators of concentration, i.e. as a device with a low, but definite external release rate of the toxic and harmful gases being generated inside. Consequently the concentration of those gases will slowly build up in the room atmosphere. However releases in school work are usually low in magnitude (mg s^{-1} or cm^3 s^{-1}) and short-lived, say 5 or 10 minutes in duration; thus the room concentration is unlikely to reach anywhere near the WEL. However during the occasional, lengthy release of gas inside at a high rate it is also necessary for the room to be well ventilated.

Although a filter has an enormous surface area, this will eventually become saturated resulting in a decline of the efficiency of capture. Before this point is reached the 'filter' should be replaced. The recognised method of testing is by *challenge tests* described below.

The pre-filter will require to be replaced more regularly. A fall in the face velocity usually indicates a partially blocked pre-filter.

Frequency of testing

In addition to measuring the face velocity of the air flow, which is normally done annually in schools for 'ordinary' ducted cupboards, it is also essential to check:

(i) that the main 'filter' still has the capacity to trap a sufficiently high proportion of the pollutants released in the chamber. This is done by the challenge tests on the main 'filter'. The frequency of testing depends on the rate of usage. For the light loading placed on the 'filter' by typical school use (i.e. for not more than one to two hours per week at the usual rates of release), an annual check for the 'acid layer' will suffice. For heavier use, challenge testing may be needed more often, say once a term. If many organic preparations have been carried out or largish quantities of volatile solvents handled in the cupboard, then the 'organic layer' should also be challenged.

Equally if a new 'filter' has just been installed it will be essential to carry out a challenge test to ensure that the 'filter' has been seated properly. Even a small fraction of the pollutants by-passing the 'filter' can make the room unsafe if releases are of lengthy duration.

If experience shows that the 'filter' is failing after 1 or even 2 years the frequency of testing will have to be increased.

(ii) that the pre-filter has not become clogged. The best indicator that this has happened is a fall in face velocity. Then there may be dangers of pollutants escaping back through the sash opening. The large amounts of fumes generated during, for example, the preparation of iron(III) chloride or aluminium chloride can rapidly block a pre-filter. Some cupboards are fitted with small flap anemometers and these are convenient indicators of when the pre-filter needs changing. Pre-filters are much cheaper than the main 'filter' but usually have to be replaced more often.

Safety of the person carrying out the tests

The procedures use hazardous substances, namely sulphur dioxide or trichloroethylene / methylbenzene (this latter is also highly flammable). The solvents should be handled with due care during dispensing, etc to avoid splashes on the skin or eyes and care should be taken to avoid inhalation of the gases or vapours. Please consult the Hazardous Chemicals Database on the SSERC website for more information.

Sulphur dioxide is very toxic above 400 ppm, but even low concentrations can severely irritate the respiratory system. Even a few ppm can severely affect a person suffering from asthma or bronchitis.

For the **solvents** it should be possible to weigh and reweigh them inside the cupboard being tested or in a second cupboard.

In addition it should be remembered that even new 'filters' do not stop 100% of the vapours and old, used 'filters' will almost certainly stop even less. Thus the recirculatory fume cupboards should be regarded only as attenuated sources of the vapours and the room should be ventilated for the challenge tests as for ordinary use of the cupboards.

Many gases can be detected by smell at concentrations below the Workplace Exposure Limit (WEL). Thus smelling one of the challenge gases does not necessarily mean that there exists a significant risk to health. **However whilst smell can be regarded as a useful warning indicator, it is not always a reliable one.** The values for the three substances being offered as possible challenges are given below.

Sensitivity varies from person to person. It also depends on the individual's health at the time and for many gases rapidly falls as the sensory system becomes fatigued. If on starting the release of the gas or vapour it can almost immediately be smelled strongly this may mean that the 'filter' is either badly seated with the pollutants bypassing it or has insufficient adsorptive capacity left in it.

STOP IMMEDIATELY if this happens.

Reseat the 'filter' and try again. If the strong smell is still produced, the 'filter' almost certainly needs to be replaced.

Wear eye protection for the testing procedure.

Workplace exposure limits

These are set by the HSE and are published in the document EH40/2005 Workplace Exposure Limits. [10]

Gas or vapour	Threshold of smell	Workplace exposure limit
sulphur dioxide	0.5 ppm	1 ppm (15 mins)*
methylbenzene	5 ppm	100 ppm (15 mins)
trichloroethene	10 ppm	40 ppm (15 mins)
tetrachloroethene	100 ppm	150 ppm (15 mins)

* For several years, sulphur dioxide was no longer assigned an exposure level by the HSE, but in 2018 they reinstated the WEL at the levels given in the table

Methods for challenging filters

The same general procedures apply to all recirculatory fume cupboards, but the methods given by the manufacturer of a particular cupboard should be used. Otherwise you may be "passing" a cupboard which is just unsafe or you may be "failing" and throwing out a 'filter' which still has sufficient retention capacity left.

The schools 'mixed layer' type of 'filter' has been designed for adsorbing a large variety of chemicals whereas the 'dedicated' 'filter' is designed for one type of vapour or gas only. The latter type might be the used in industrial situations where only one single pollutant is released. Check that the replacement 'filter' ordered is of the correct type. The manufacturer will provide a long list of the chemicals for which the 'school's mixed filter' is suitable. Even with these 'filters', gases of low molecular mass will in general not be absorbed well, e.g. hydrogen, methane, ethene or ammonia. However most manufacturers treat the 'filter' to enable it to adsorb ammonia.

Filter test - acid gases

8

Testing for retention of acidic gases

Theoretically all of the ‘layers’ should be tested, but experience shows that for the practical work used in today’s curriculum the “acid layer” in the ‘filter’ usually becomes saturated long before the organics or solvent layer. Thus the results of an acid challenge can be used as representative of the state of the whole ‘filter’. This assumption would not be valid if large amounts of solvents and only small amounts of acidic fumes had been released in the cupboard. If in any doubt the ‘filter’ should be challenged with a solvent as well. For more details of the equipment needed, [see Appendix D]

Principle

A cylinder of sulphur dioxide is weighed before and after the gas has been released for a known time inside the chamber. During this release the concentration of sulphur dioxide in the effluent or exhaust is measured with a gas detector tube. Measurements for some of the gases can take a long time. For example, one of the Draeger sulphur dioxide tubes tubes requires 100 strokes and this takes about 10-12 minutes as well as possibly causing repetitive strain injury! Other makes of gas detecting pumps operate differently and usually faster. Where a tube is designed for a small number of strokes, they should be spaced out to cover a longer period, say five minutes, so that the readings are more representative of concentration over the whole period of the release.

From the measurements of the rate of release, the time duration of release and the concentration of sulphur dioxide in the exhaust air. it is possible to calculate the *capture efficiency of the ‘filter’*.

Details of this calculation are given in **Appendix C** but many manufacturers offer a simple rule of thumb pass/fail approach. For given release rates of each challenging gas inside they give upper permissible limits for the concentrations of the pollutant found in the exhaust. If the concentration in the exhaust exceeds that stated value, then the capture efficiency of the ‘filter’ has dropped too far and it should be replaced. Estimates of reasonable pass levels for typical schools models for given rates of release are given in Table 1 ***(see page 24).***

A cheaper, though less convenient, source of sulphur dioxide is its generation by burning sulphur. Weighing the sulphur before ignition and at the end of the release allows the rate of release of sulphur dioxide to be calculated.

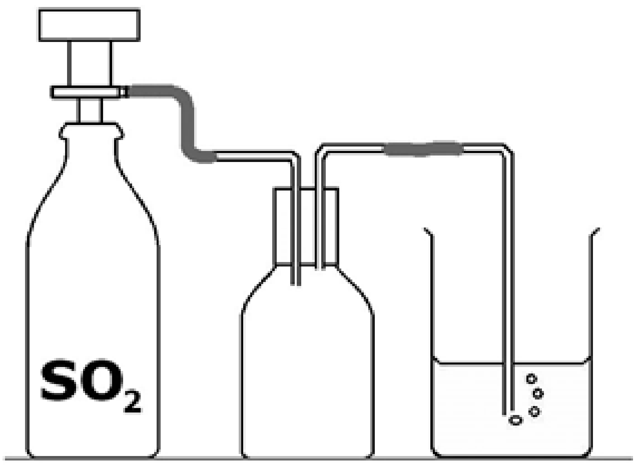
Using sulphur dioxide cylinders

Preparation

- Please consult the SSERC Hazardous Chemicals database on the SSERC website for more information regarding sulphur dioxide.[11]
- Ensure you have
  - ◊ the cylinder and accessories for step 2 below;
  - ◊ stop clock,
  - ◊ balance weighing to 0.01g.
  - ◊ gas detector tube and its pump.
- Check the hand pump for leaks.
- Lock the brakes on the trolley wheels if it is a mobile fume cupboard.

Method

1. Weigh the sulphur dioxide syphon.
2. Connect the syphon via a large trap, e.g. a gas wash bottle in reversed mode or a one litre bottle fitted with a short inlet tube in order to prevent suck back from the delivery tube dipping into water into the syphon. Adjust the flow rate to about 3 or 4 bubbles per second and start the clock



3. Disconnect the syphon from the delivery tube and trap. Without altering the flow rate allow it to continue to leak sulphur dioxide at the same rate in the fume cupboard.
4. After about two minutes, break the sealed ends on the gas detector tube, insert it into the pump, and start measuring the sulphur dioxide levels in the exhaust. (This fitting of the detector tube could have been done earlier provided that the opened gas entry end of the tube were temporarily sealed). Some cupboards are provided with a small port for insertion of the detector tube, but with others you have to climb on top or crawl underneath. To gain access to the top use a suitable step ladder, not a chair or stool.
5. When finished measuring with the gas detector tube, note the time, close the valve of the syphon and reweigh it. The evaporation of the liquid sulphur dioxide during the release cools the syphon and on some days of high humidity condensation may form on the outside. This should be dried off before the final weighing.
6. From the loss of mass and the duration of the release calculate the rate of release of sulphur dioxide in mg s^{-1}.

Pass/fail criteria

If the concentration found in the exhaust is greater than that listed against the calculated rate of release below (see Table 1) then the 'filter' will have to be replaced.

Table 1

Rate of SO_2 release mg s^{-1}	Max concentration of SO_2 permitted in exhaust /ppm
10	0.8
20	1.5
30	2.0
40	3.0
50	3.7
60	4.5
70	5.0
80	6.0

These figures can be used as a reasonable guideline to a pass/fail decision.

However, where available, the manufacturer's advice and instructions should be followed since the calculated efficiency from any pair of the results in the table also depends on the size of the cupboard and on its face velocity. For example, a cupboard with a face velocity of say 0.4 m s-1 and a larger sash opening could, if it produced the figures shown in the table, have an efficiency of 96%, but if it were smaller and had a face velocity of only 0.3 m s-1, the calculated efficiency would rise to 98% or more. **The pass/fail figures can and should be tailored to a particular model of cupboard.** Each manufacturer should have done this for their own particular models

Burning sulphur method

A few years ago when aluminium SO_2 syphons were replaced with the more expensive stainless steel cylinders an alternative method was sought and developed at SSERC This was reported in Bulletin 177 [2] and suggested to fume cupboard manufacturers and to our counterparts south of the Border, who have also adopted it as an alternative.

Basically the method is the same as that using the release from the syphon except that the sulphur dioxide is produced by burning sulphur in a crucible or in a small evaporating basin inside the fume cupboard. Care is needed since burning or molten sulphur can cause a severe burn.

Preparation

- Please consult the SSERC Hazardous Chemicals database on the SSERC website for more information regarding sulphur dioxide.[11]
- Ensure you have:
  - ◊ a shallow, flat-bottomed evaporating basin of diameter 60 to 100 mm (alternatively a small tin can or crucible of similar dimensions may be used);
  - ◊ tongs;
  - ◊ two heatproof mats, one of them small, which is used for extinguishing the burning sulphur;

- ◊ powdered sulphur
- ◊ Bunsen burner
- ◊ stop clock;
- ◊ balance weighing to 0.01 g;
- ◊ gas detector tube and its hand pump. (Check the latter for leaks as per manufacturer's instructions).

- Check the hand pump for leaks.
- Lock the brakes on the trolley wheels if it is a mobile fume cupboard.

Method

1. Weigh the basin, sulphur **and the small heat-resistant mat** which will later be used as a lid (steps 4 & 5 below). 70 to 80 g of sulphur is a suitable quantity.
2. Place the basin on a tripod and gauze inside the cupboard about 10 cm back from the plane of the sash. First gently heat from below until the sulphur just melts. Extreme care is now required not to knock the tripod base with your hands or the Bunsen burner; molten sulphur can cause severe burns.
3. Ignite the molten sulphur by playing the Bunsen flame onto the top. When the sulphur ignites, turn off the Bunsen and start the clock. The flame of the burning sulphur is quite pale so it is easiest to do this with the light off (or dimmed) if possible.
4. A slight smell of sulphur dioxide should be ignored but, if the exhaust gas causes breathing difficulties, stop the test immediately, open the windows, leave and lock the room. This incident should be reported to the line manager as it means that the filtration fume cupboard is not performing adequately and the fume cupboard should be taken out of operation.
5. After 1 to 2 minutes, break the sealed ends on the gas detector tube and insert it into the pump (this step could have been done earlier provided the opened gas entry end were temporarily sealed eg with blutac or parafilm), and start measuring the sulphur dioxide levels in the exhaust. Some cupboards provide a small port for insertion of the detector tube.
6. When finished measuring, extinguish the burning sulphur by placing the small heatproof mat on top of the evaporating basin and stop the clock. Take care with molten sulphur; it can cause a severe burn. Allow it to cool on the tripod.
7. When cool, reweigh the crucible or basin. A small amount of sulphur vapour will condense onto the mat so do this with the mat on top.
8. The mass of sulphur dioxide released is calculated very conveniently by multiplying the loss in mass by 2. [SO_2 / S] = 64/32

   Rate of release in mg of SO_2 per second =

   $$\frac{\text{(Mass of sulphur burned in grams x 2 x 1000)}}{\text{time of burning in seconds}}$$

   As before this can most conveniently be done using a spreadsheet .

8. Consult Table 1 in the previous section and decide if the 'filter' has to be replaced.

Note

The rate of burning and hence the rate of release of sulphur dioxide will vary from cupboard to cupboard. In a faster airflow the sulphur will burn more rapidly. Consequently after a preliminary trial it may be necessary to adjust the rate of burning which can be decreased by moving the dish further back from the sash opening or by using a dish with a smaller surface area. Conversely the rate of combustion can be increased by having a larger surface area of sulphur or by moving the basin of sulphur closer to the front. Here the sulphur is in the stronger draught of air rushing under the bottom of the sash.

8

Filter test - solvents

Hazards

There have been various compounds used for this test:

Formerly 1,1,1-trichloroethane was but its manufacture has ceased many years ago on account of its damage to the ozone layer.

Methylbenzene (toluene), which was the preferred substance in the previous edition, is less toxic but is highly flammable. However, recent research by CLEAPSS suggests that methylbenzene is not good for detecting small leaks.

Trichloroethene has also been used. It is now classed as a Category 2 carcinogen and mutagen. While this is possible -

the preferred option is **Tetrachloroethene**.

This too is a category 2 carcinogen but the tubes can detect a very low concentration

It should be noted that the 15' WELs for the chloroethenes are 40 and 150 for the tetra -and trichloro isomers. The sensitivity of the detector tubes is well below that (0.1 ppm for the Gastec tube) so detection will occur a long way below the WEL , and the measured concentration is that in the exhaust, it will be reduced further by dilution as it mixes with the air in the room. The release will also be for less than 15' so in SSERC's view the risks are extremely low and perfectly acceptable for this usage.

The room should be well ventilated and any release should be kept to a minimum: by weighing out the liquids in a fume cupboard for instance.

Please consult the Hazardous Chemicals Database on the SSERC website for more information [12]

Method

Preparation

Ensure you have:

- stop-clock;
- balance weighing to 0.01g
- small heat resistant mat
- tongs for flask or beaker;
- gas detector tube and its hand pump
- hotplate
- nitrile gloves.

Method

1. In the fume cupboard pour about 50 cm^3 of tetrachloroethylene/methylbenzene into a pyrex 100 cm^3 beaker and add a few anti-bumping granules. Cover the mouth of the beaker with a watch-glass and weigh on a balance, inside the same cupboard if possible. Have beaker tongs handy.
2. Place the hotplate in the fume cupboard about 10 cm back from the front edge. Set the beaker and tetrachloroethylene/methylbenzene on the hotplate.
3. When the solvent vapour begins to escape in quantity from the lip of the beaker, start the stopclock. There is plenty of warning if you watch the moving condensation reflux boundary.
4. Check the pump for leaks. After 1 - 2 minutes after the vapour had started pouring over the lip of the beaker, break the seals on the gas detector tube and fit into the pump. Measure the concentration of the vapour in the exhaust over a period of at least 3 minutes.
5. Then turn off the hotplate and with the tongs lift the beaker (hot) off and onto a mat in the cupboard to cool. After a few seconds it can be held in a large beaker of cold water inside the fume cupboard. Stop the clock when the condensation line falls below the lip of the beaker. When it has cooled a little, remove the vessel, dry the outside, replace the watch-glass lid and weigh it, again inside the cupboard if possible. A second mat can be tared on the balance pan for the initial weighing and left there for the final weighing.
6. Calculate the rate of release of the solvent in mg s^{-1} and compare with the corresponding figure for the permitted concentration in the exhaust given in Table 2. If the concentration found exceeds this value, a new 'filter' is needed. Again remember that these are just guideline figures for a typical cupboard and that, if available, the manufacturer's instructions should be followed.

7. Calculate the rate of release of the solvent in mg s^{-1} and compare with the corresponding figure for the permitted concentration in the exhaust given in Table 2 (next page). If the concentration found exceeds this value, a new 'filter' is needed. Again remember that these are just guideline figures for a typical cupboard and that, if available, the manufacturer's instructions should be followed.

Release rate in fume cupboard / mg s^{-1}	Concentration in exhaust / ppm methylbenzene
20	2
30	3
40	4
50	5
100	10
160	16
200	20
260	26
300	30
360	36
400	40

Table 2

Equipment for challenge testing 'filter' fume cupboards

General

1. Timer or stopwatch.
2. Balance weighing to 0.01 g.
3. Bunsen, tripod, gauze and heat resistant mat for techniques involving the burning of sulphur.
4. Evaporating basin, diameter 60 to 100 mm for burning sulphur method.
5. Second heat resistant mat as lid to extinguish burning sulphur.
6. Tongs for lifting beaker (Fisher pattern VWR Cat. No. 231-0018, £53).
7. 100 cm^3 pyrex beaker or wide-necked flask, ideally spoutless for methylbenzene.
8. Large watch glass as lid for 7.
9. Hotplate for methylbenzene.
10. Antibump granules for solvent, Eye protection and nitrile gloves.

(b) Chemicals

13. Sulphur dioxide syphon OR
14. Sulphur (powder) if using the alternative method.
15. Tetrachloroethene (or trichloroethene).

(c) Specialised equipment

13. Anemometer
14. Gas detection equipment

see Appendix D and SSERC Bulletin 165 [13].

A

Checklist - Ducted Fume Cupboards

AREA	CONDITION NEEDED TO PASS	PASS/ FAIL	COMMENTS
1 Face velocity at opening of- 400 mm	- between 0.3 & 0.5 m s^{-1} and variation < 30% recorded at 9 positions on separate Use **Appendix 1b - Testing ducted cupboards (Record form for face velocity).**	P	Low face velocity may be caused by: • motor underperforming belt slipping • hole in duct between fan and motor- • damper badly adjusted especially if same fan serves more than one cupboard • obstructions in duct. e.g bird's nest.
- at 300 mm (used if face velocity too low at 400 mm)	See note **2.3 Method of measurement** regarding lower stop positions.	Pq	
2 Opening stops	- fitted to prevent the sash being opened beyond positions at which the face velocity is satisfactory. This should be between400 and 300 mm for the upper stop and a minimum of 50 mm for the lower. These must not be capable of being removed without the aid of a tool, e.g. a screwdriver (If a by-pass is fitted, the position of sash will not affect the face velocity too much.)	P	Blocks of wood fixed in place will do for upper and rubber door stops on underside of sash for lower stops.
3 Flow indicator	- fitted and working. Some fume cupboards have vane anemometer permanently fitted.	P	May be simple strips of plastic fastened to the underside of sash.
4 Smoke test	- containment good; no significant escape back through open sash, other parts of structure or back through other cupboard(s) via ductwork if on same extract system.	P	Smoke may be actually expelled back out through a corner of the sash opening if the face velocity is too high and the cupboard has poor aerodynamics. Reducing the face velocity (perhaps by adjusting the damper) usually cures the problem.
5 Two or more cupboards on same extraction system	(i) in *same* room (ii) in *different* rooms and no difficulties have arisen with face velocity or back leakage between cupboards.	P Pq	Dampers may need adjusting to balance the flow rates in the two cupboards
6 Glazing	- undamaged - safety glass (laminated or toughened of 5mm) is preferred alternatively poly carbonate may be used	P	As a temporary measure ordinary glass can be covered with shatter-proof film.
7 Structure	- sound, with metal free from excessive corrosion.	P	

Key P = pass **Pq = qualified pass** **F = fail**

			FAIL	
8	**Sash**	- slides freely and yet holds a position and the mechanism - (counter weights & cords) or spring are sound - only opens to one room.		(See below) Fume cupboard should only have one opening
9	**Double opening**	- a second sash opens to an adjacent room.	F	One side must be permanently sealed with materials offering > ½ hour fire resistance; contact local fire prevention officer for local requirements
10	**Work surface**	- in good condition (Some old cupboards have a hard asbestos surface. This can be sealed, but soft or flaky asbestos is a fail) and must be disposed of - has a lip at front or is dished to contain spillages.	P	Some fume cupboards are being supplied with plastic flooring. In this case, great care needs to be taken with hot objects. Lip can be a strip of plastic or hardwood glued to surface.
11	**Services** **(i) gas**	- outlet on or above working surface to side and near front. - controls at the front outside the chamber. - valve working smoothly. Ideally has a spring loaded off position. Pipework free of corrosion.	P	Panel mounted valves are preferred to linked rods control; when link joints wear, it may be difficult to turn the gas off quickly in an emergency.
	(ii) water	similar requirements as for gas, apart from the need for a spring loaded off position. Operates satisfactorily.	P	
	(iii) electrical 13 A outlet((s) (see 15 for outlet on mobile cupboards)	- undamaged and has passed the last test on fixed electrical installations test (usually carried out every 5 years by architect's department). - outside the chamber at the front and to one side is safer, but if under the front it will be protected to some extent by an overhang and by a lip. It should be protected by an RCD.	P	Note that the fan motor must not be on a circuit sharing an RCD with other outlets Otherwise spurious tripping of the fan could cause a dangerous situation.
	(iv) drain	- water from catchpot goes via a bottle trap which feeds onto a dilution trap further downstream - free of leaks.	P	
12	**Fan and motor**	- runs smoothly without excessive noise and face velocity is adequate. - excessive noise may indicate worn bearings or slipping drive belt or loose mounting - persistent blowing of fuses	P F F	- motor running but no air flow may mean a broken or blocked duct. - see note on RCD protection above.
13	**Duct (if accessible)**	- no obvious signs of damage. (Binoculars can be useful. It is not suggested here that teachers or technicians climb on the roof!) - no leaks of fumes or reports of such; can be checked with a smoke pellet - fire dampers (if fitted) should be free of corrosion. Some can be checked, but others depend on a fusible link and cannot be tested.	P	The fan should be sited near the exit of the duct, so that most of the duct is at negative pressure.

Key **P = pass** **Pq = qualified pass** **F = fail**

Schools who are members of SSERC have permission to reproduce the check lists and record-forms.

A

AREA	CONDITION	PASS/ FAIL	COMMENTS
14 For mobile cup-boards ONLY			
(a) flexible ducting	- in good condition & where fitted, ceiling couplings sound.	P	
(b) if fitted	- umbilicals' for gas, water, drainage & electricity in good condition. - quick release couplings for above also in good condition.	P	
(c) trolley brakes	- trolley cannot be pushed when brakes are engaged.	P	
(d) wire or chain restrainer	- is secure and ensures umbilicals or electrical cord still have some play in them when cupboard is pulled away from an-chorage point the maximum distance permitted by the re-strainer.	P	
15 Mobiles only			
(a) test as portable electrical appliance	PAT tester shows earth resistance on exposed metal parts to be < 0.1 ohm and passes - insulation test	P	**Tests 15 (a) & (b) should only be car-ried out by a person with both the training and competence to carry out electrical safety testing.**
(b) 13 A outlet	- visually undamaged and works satisfactorily & earth lead secure with low path resistance. Details of method are given in **Appendix 3.**	P	

Key P = pass **Pq = qualified pass** **F = fail**

Checklist - Recirculatory Fume Cupboards

A

	AREA	CONDITION	PASS/ FAIL	COMMENTS
1	**Face velocity at designed working opening**	- between 0.3 & 0.5 m s-1 and variation < 30% recorded on separate Form 2.5 at 4 or 6 areas of the sash working opening, but using only4 or 6 of the 9 areas on that form.	P	Low face velocity may be caused by: - fan motor under-performing; - partially blocked pre-filter; replace pre-filter and test again.
2	**Flow indicator**	- fitted and working. (May be simple strips of plastic fastened to the underside of sash. Some fume cupboards have flap anemometer permanently fitted.)	P	
3	**Challenge tests**			
	(i) acid layer with SO_2	(i) concentration in effluent below that for pass (see Table 1 for permitted effluent concentrations).	P	Only the SO_2 test may be needed See 3.1.1.
	(ii) 'solvent' layer with Methylbenzene or dimethylbenzene	(ii) concentration in effluent below that for pass (see Table 2 for permitted effluent concentrations).	P	
4	**Smoke test** (use **only** a small pellet and only if there is some doubt about escape of fumes through cracks and seams.)	- containment good; no significant escape back through open sash, other parts of Structure or back through other cupboard(s) on same extract system or through ductwork.	P	A percentage of the smoke particles will be fine enough to pass through the 'filter' and form a haze in the room. This is not indicative of a failure
5	**Glazing and structure**	- acrylic glazing, frame and any seals undamaged. - no leaks between glazing and frame. - baffle in position.	P	
6	**Work surface**	- is in good condition. - has a lip at front or is dished to contain spillages.	P	Working surface is usually in the form of a removeable tray.
7	**Services -**			
	(i) gas (if fitted)	*outlet* on or above working surface to side and near front. *controls* at front outside plenum chamber. - valve working smoothly & has a spring-loaded off position. - pipework free of corrosion.	P	Panel mounted valves are preferred to linked rods control; when link joints wear, it may be difficult to turn the gas off quickly in an emergency
	(ii) water (if fitted)	similar requirements as for gas, apart from the spring loaded off position.	P	

Key **P = pass** **Pq = qualified pass** **F = fail**

	AREA	CONDITION	PASS/ FAIL	COMMENTS
7	**(iii) electrical 13 A outlet((s)**	ideally fitted outside the plenum chamber at front and to one side. Up the side is safer, but if under the front will be protected to some extent by an overhang and the lip. Ideally protected by an RCD.	P	There are possible problems if the mains socket, to which the fume cupboard is connected, shares an RCD with other outlets. Spurious tripping caused by faults elsewhere could create a dangerous situation by switching off the fan when the cupboard was in use.
	(iv) drain (if fitted)	- water from catchpot goes via a bottle trap which feeds onto a dilution trap further downstream - free of leaks	P	
	(v) 'umbilicals' & quick release couplings if fitted (gas, water & drains)	- are in good condition and couplings operate efficiently.	P	
8	**Fan and motor**	(i) runs smoothly without excessive noise and face velocity is adequate. (excessive noise may indicate worn bearings or loose mounting) (ii) persistent blowing of fuses.	P F	See above note on RCD protection.
9	**Electrical test**			
	(a) visual check	- plug-top, lead and its strain relief in plug top and also at cupboard if lead is wired in directly to the cupboard. - 13 A outlet undamaged.	P	
	(b) test as portable electrical appliance	- an overall pass has been recorded in the last annual PAT test.	P	
	(c) 13 A outlet earth path	- visually undamaged, works satisfactorily and earth lead secure with low path resistance. Details of method are given in Appendix 3. Tests 9 (b) & (c) should only be carried out by a person with both the training and competence to carry out electrical safety testing.	P	
10	**Trolley brakes**	- with brakes applied trolley resists movement.	P	
11	**Restraining wire**	- prevents cupboard from being pulled so far as to strain the gas, water, drainage and electrical supply cable.	P	

Key **P = pass** **Pq = qualified pass** **F = fail**

Schools who are members of SSERC have permission to reproduce the check lists and record-forms.

Electrical testing

Testing the earth path of the 13 A outlet on the mobile fume cupboard

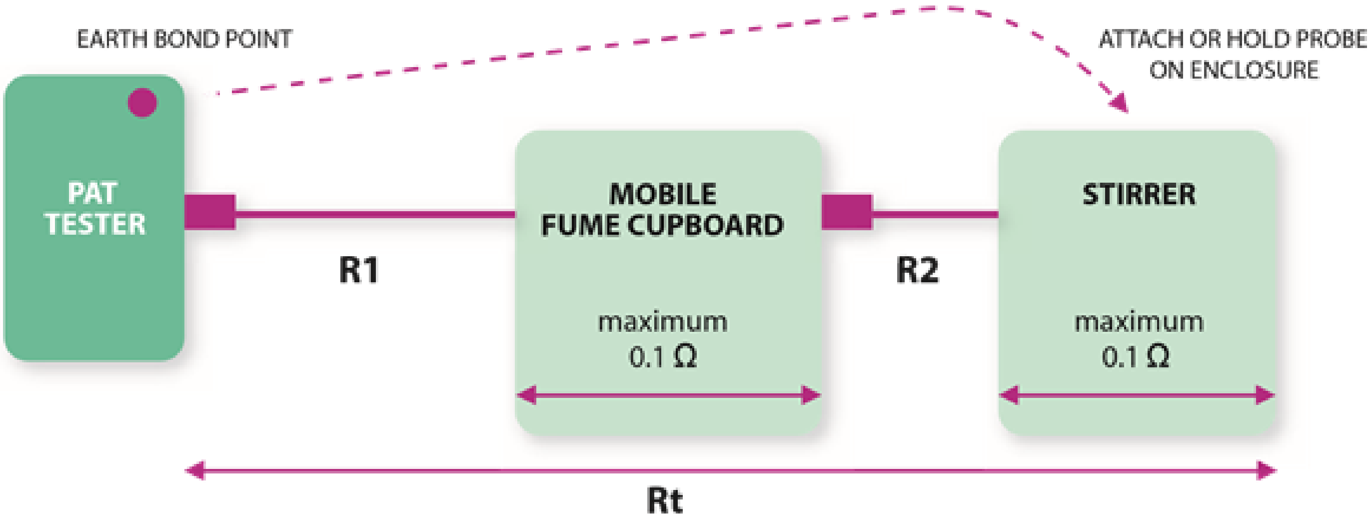
This task should only be carried out by persons who are competent to carry out electrical safety checks on portable electrical equipment.

The cupboard is heavy and often moved around. Thus the lengthy mains cord could easily become strained. This might weaken or even break the earth path not only to the metal frame of the cupboard but also to an appliance, such as a stirrer/hotplate plugged into the 13 A socket on the cupboard. To test the earth continuity of the mobile fume cupboard socket outlet:

i) determine separately R1 (the resistance of the fume cupboard mains cord) and R2 (the resistance of the mains cord of a small mains appliance) by measuring the length of the cables and multiplying by the relevant resistance per unit length of the cable shown in the table below;

Ii) then plug the stirrer into the 13 A socket outlet of the fume cupboard which in turn is plugged into the PAT. Measure the resistance of the total earth path from fume cupboard plug to the exposed casing of the stirrer. The long cord should be uncoiled and gently flexed during the test.

For any one portable appliance on its own, the maximum resistance between the plug and the enclosure should not exceed (R + 0.1) Ω, where R is the resistance of the mains cord.



Thus to be considered electrically satisfactory it is necessary that Ω:

Rt < (R1 + R2 + 0.2) Ω

Values of cord resistance

Cord length	Resistance (mΩ) at 20ºC of protective conductor of size				
	0.5 mm^2	0.75 mm^2	1.0 mm^2	1.25 mm^2	1.5 mm^2
1.0 m	39	26	20	16	13.3

Calculation of capture efficiency of a ‘filter’

This can be done instead of following the pass fail approach referred to in sections 3.4 and 3.5 involves some calculation but has the merit in allowing you to know how much capacity the ‘filter’ has above the pass/fail line.

One additional measurement is needed, namely the area of the sash opening. The steps in the It calculation and an example are tabulated below.

By far the easiest way to do this is using a spreadsheet. A suitable one is shown on the next page and can be downloaded from the SSERC website [14].

Measurement or calculated quantity	Symbol / formula	Example
Measure area of opening	A m^2	0.1647 m^2
Measure face velocity, (V, m s-1)	**V** m s^{-1}	0.44 m s^{-1}
Calculate extract rate (Q, m3 s-1)	**Q** = (V x A) m^3 s^{-1}	0.0725 m^3 s^{-1}
Initial mass of SO2 & time	m1 t1	477.90 g zero
Final mass of SO2 & time	m2 t2	469.43 g 9 m 59s 8.47 g 599 s
Calculate rate of release, i.e. loss in mass per second **(R, mg s^{-1})**	**R** = $\frac{(m1 - m2) \times 1000 \text{ mg s}^{-1}}{\Delta t}$	14.1 mg s^{-1}
Concentration in exhaust. Measure with Gastec or Draeger tube **(Cx, ppm)**	**Cx** ppm	0.125 ppm
Convert concentration to mg m-3 by multiplying by factor, F, the Mol Mass/24 (= 2.67 for SO_2)	**Cx** (mg m^{-3}) = Cex (ppm) x F	(0.125 x 2.67) mg m^{-3} = 0.334 mg m^{-3}
Calculate rate of loss in exhaust **(Rx, mg s^{-1})**	**Rx** = (Cx x Q) mg s^{-1} (mg m^{-3}) x (m3 s^{-1})	(0.334 x 0.0725) mg s^{-1} = 0.0242 mg s^{-1}
Efficiency of capture, (E)	**E** = $\frac{R - Rx}{R}$	$\frac{(14.1 - 0.02)}{14.1}$ = 0.999 or 99.9%

You can use a spreadsheet to carry out the calculations for you. You can download the one(s) below from the SSERC website and customise them. You can then print off or just save the documents as your record of testing.

The yellow boxes are the spaces where you enter information.

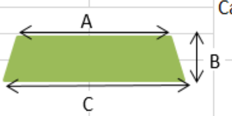
Cells A, B and C are to enter the dimensions of the opening—in cm. In most fume cupboards, A and C (top and bottom width, are the same but some mobile fume cupboards have a trapezoidal opening. You will need to enter both values even if they are the same.

The grid of 9 spaces on the left is for the anemometer readings—in metres per second. If you have less than 9, just leave the cells blank, don't put a zero in—that will mess up the calculations..

If the value is too low (below 0.3 m/s) the cell will be highlighted in red.

The blue cells will be filled automatically with the calculated values.

Again, if any of the values constitute a fail then the cell will be highlighted in red.

Efficiency Tests				**Manufacturer**			**Model:**		**Date**	**Tester**
Cells coloured yellow require a value to be inserted. The values for cells coloured blue will be calculated for you.										
Air Velocity in Sectors (ms^{-1}) Insert all the values measured.			Number of Sectors Sampled	Highest Air Velocity Recorded (ms^{-1})	Lowest Air Velocity Recorded (ms^{-1})		Average Face Velocity (ms^{-1})		Deviation from Average of Highest Air Velocity Recorded (%)	Deviation from Average of Lowest Air Velocity Recorded (%)
					Calculation of opening area - **measurements in cm**		A =		Cupboard fails if either of the deviations above is >30%	
							B =			
The cupboard fails if any of these readings falls below 0.30 ms^{-1} (but see Page 8 of SSERC "Routine fume cupboard testing" 2011)							C =			
							Total (in m^2) =	0.0000		

Use the tick boxes below to indicate a pass/fail. For details see Appendix [..] of the SSERC publication Fume Cupboards

Upper stop		Smoke test	Body		Services	Gas	
Lower stop			Ducting			Water	
Sash		Structure sound				Electricity	
Flow indicator		Work surface OK				Drainage	
Fan		Glass OK					

C

This spreadsheet includes calculations for the challenge test of filter efficiency

The yellow boxes are the spaces where you enter information. The blue cells will be filled automatically with the calculated values.

If any of the values constitute a fail then the cell will be highlighted in red.

The top part of the sheet works in exactly the same way as for the ducted fume cupboard.

For the challenge test(s) there are 5 columns, though you will probably only need one or two.

In the yellow row (16) click on the name box to show a drop-down menu where you can select the gas you are using. This automatically populates the sheet with the correct conversion factors.

In the yellow boxes below, enter

- the mass before and after release (in grammes)
- The time of the release (in seconds)
- The concentration in the exhaust fumes (in ppm—this is the reading you will get from your detector tube.

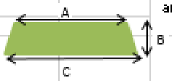
As before, the blue cells will be filled automatically with the calculated values and if any of the values constitutes a fail then the cell will be highlighted in red.

Efficiency Tests	Cells coloured yellow require a value to be inserted. The values for cells coloured blue will be calculated for you.	Manufacturer	Model:	Date	Tester

Select the formula for the chemical being tested for in Row 15.
To convert ppm to mg m^{-3} the concentration in ppm is multiplied by a factor calculated from M.Wt/24.
These factors are automatically inserted for you. For the following gases/vapours they are:

ammonia	0.71
hydrogen chloride	1.52
sulphur dioxide	2.67
methylbenzene	3.83
dimethybenzene	4.41
trichloroethene	5.46
propan-2-ol	2.50

Air Velocity in Sectors (ms^{-1}) Insert all the values measured.			Number of Sectors Sampled	Highest Air Velocity Recorded (ms^{-1})	Lowest Air Velocity Recorded (ms^{-1})		Average Face Velocity (ms^{-1})		Deviation from Average of Highest Air Velocity Recorded (%)	Deviation from Average of Lowest Air Velocity Recorded (%)
			0	0.00	0.00		#DIV/0!		#DIV/0!	#DIV/0!
					Calculation of opening area - **measurements in cm**		A =		Cupboard fails if either of these deviations is >30%	
							B =			
Cupboard fails if any of these readings falls below 0.30 ms^{-1} (but see Page 8 of SSERC "Routine fume cupboard testing" 2011)							C =			
							Total =	0.0000		



Opening area (A)	0.0000 m^2	Face velocity	#DIV/0! m s^{-1}	Extract rate (Q)	#DIV/0! m^3 s^{-1}

rmula of gas/vapour releas	Sulphur Dioxide	Methyl Benzene	Hydrogen chloride	Sulphur Dioxide	trichloroethene
Conversion Factor	2.67	3.83	1.52	2.67	5.46
Extract rate (Q) /m^3 s^{-1}	#DIV/0!	#DIV/0!	#DIV/0!	0.00	#DIV/0!
initial mass / g					
final mass / g					
loss/g *(If you burn S it is d	0.00	0.00	0.00	0.00	0.00
time of release /s					
R (release rate) / mg s^{-1}	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Concn in exhaust (C_x) /					
Conv factor from ppm to mg m^{-3}	2.67	3.83	1.52	2.67	5.46
Concn in exhaust (Cx) /m	0.00	0.00	0.00	0.00	0.00
Rx (Rate of escape) /mg s^{-1} =Q x C_x	#DIV/0!	#DIV/0!	#DIV/0!	0.00	#DIV/0!
Efficiency of capture (%) = ((R-Rx)/R)*100	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
Pass Rate is 97%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Equipment for fume-cupboard testing

D

Anemometer

In order to measure the face velocity you will need an anemometer. To be suitable for these purposes, then need to:

- Have a minimum airflow sensitivity of no more than 0.1 m/s
- Measure to an accuracy of 0.01 m/s

There are various models available but they are not cheap. You can expect to pay around £250 - £300.

(A table of some possible models can be found below. SSERC has not tested these: the table is the result of internet searches and is based purely on the stated specifications).

There are two main types of anemometer:

Rotating Vane — These have a head with a rotor that spins when there is any airflow.

Hot wire — these have a length of wire heated by a precise current. Air flowing over the wire cools it in proportion to the rate of airflow.

Maintenance

These anemometers are precision pieces of equipment and need to be handled carefully. No matter how careful you are, though the anemometer will need to have a regular calibration test, carried out by an accredited body. If the instrument is frequently used then the test should be annual but every 2 to 3 years is acceptable if it only used a few times each year.

You can expect to pay around £75 for the calibration.

Some anemometers that seem to fit the specifications

Make	Model	Type	Guide price (incl VAT)
TMA	21HW	Hot wire	£300
Extech	AN300	Rotating vane	£275
Extech	AN310	Rotating vane	£300
Testo	425	Hot wire	£375
Testo	0560 4251	Hot wire	£425
KIMO	VT110	Hot wire	£500
TSI Airflow	LC301	Rotating vane	£300
Digi-Sense	Hot Wire Thermoanemometer with NIST-Traceable Calibration	Hot wire	£300

Gas detector tubes and pumps

These are hand-powered pumps that draw air through a long thin glass tube filled with the appropriate reagent for the gas being measured.

As the gas is drawn up, it reacts with the reagent in the tube causing it to change colour.

The higher the concentration of the gas, the further up the tube it will manage to permeate. The concentration can be read off from the length of the stain.

There seem currently to be four manufacturers offering suitable pumps and tubes.

Draeger, Gastec, Kitagawa and Uniphos [15]

In each case, you will need to purchase (or at least gain access to) the pump itself.

There are some differences in the mode of action of the pumps. The Draeger* pump, works by squeezing a small bellows in the palm of the hand. This drives out the air and replacement air from the room is then allowed to enter through the gas detector tube. Each gas detector tube has the number of strokes specified on it; often 5 or 10, but occasionally much higher.

The other three pumps work in a similar way: the user pulls out the plunger which draws a measured quantity of air through the tube. As with the Draeger system, each tube requires a specified number of strokes.

Kitigawa tubes are sold for use with the Sabre pump.

Kitigawa state that their tubes will also fit in a Gastec pump.

2018 prices for pumps are:

Draeger	- £299
Gastec	- £220
	- £138*
Kitagawa	- £238
Uniphos	- £220

* This is the Gastec Education Kit. It consists of a pump and various tubes (CO_2, CO, NOx etc for use in scientific experiments. The pump is smaller than the standard one but is still accurate enough.

The gas detection tubes have a typical shelf life of 2 years. The manufacturers of recirculatory fume cupboards often supply anemometers and gas testing kits with the cupboard.

The photos below show Gastec tubes but all makes are similar, though not identical.

The photos on the right show before and after photos of a sulphur dioxide tube.

You can see in the image above that the gas has turned the green solid to a bright yellow. The reading shows 1.0 meaning that the concentration of SO_2 was 1.0 ppm.

Gas	Product code	Sensitivity	Price
Draeger			
sulphur dioxide	6727101	0.1 – 3 ppm	£55.04 (10)
	6728491	0.5 – 5 ppm	£59.19 (10)
methylbenzene	8101661	5 – 300 ppm	£61.13 (10)
tetrachloroethylene	8101501	2 – 40 ppm	£62.47 (10)
	8101551	0.1 – 4 ppm	£176.45 (10)
Gastec			
Sulphur dioxide	GAS5LB	0.5 – 10 ppm	£28.50 (10)
methylbenzene	GAS122L	1 – 100 ppm	£28.50 (10)
tetrachloroethylene	GAS133L	0.1 – 9 ppm	£28.50 (10)
Kitagawa			
Sulphur dioxide	103SE	0.25 – 10 ppm	£28.50 (10)
methylbenzene	124SB	2 – 100 ppm	£28.50 (10)
tetrachloroethylene	135SB	0.2 – 10 ppm	£33.50 (10)
Uniphos			
Sulphur dioxide	SSD-1	0.25 – 5 ppm	£40.00 (10)
methylbenzene	STO-2	1 – 25 ppm	£40.00 (10)
tetrachloroethylene	STE-3	2.5 – 50 ppm	£40.00 (10)

Smoke pellets

Smoke pellets and smoke matches are generally available from plumbers' and builders' merchants, e.g. Screwfix, Plumb.com. One who supplies on-line is given here for convenience of schools distant from such suppliers. Two manufacturers of smoke test materials are ph products and Hayes. We found the latter's products available from AVP supplies to be better priced and to generally have lower delivery charges. For much of the mainland, delivery is free.

For checking the chamber of the fume cupboard those generating the smaller volume of smoke are adequate, but for checking that ducts have not become blocked or leak the larger size of pellet will be needed.

Pellets should be placed on a tin lid or on a watch glass. Matches are best not held by hand, but placed in position in a bung or piece of Blu-tak or Plasticine. Hayes also supply a match holder.

In the absence of the above, the preparation of aluminium chloride by direct combination, even on a small scale, produces large volumes of white fumes. String or cord of natural materials (sisal, cotton or hemp) will smoulder if ignited producing small amounts of smoke.

Smoke pellets can be found from various places.

Avoid the ones that produce coloured smoke as they may cause staining on the inside of the fume cupboard.

A few suppliers are listed in the table below.

Supplier	Manufacturer	Item code	Item	Pk size	Price £	Burn time	Volume of smoke
HVP	Hayes	333003	Classic 3- 3g pellets	10	2.19	45s	$8m^3$
HVP	Hayes	333009	Classic 9 -9g pellets	10	3.72	65s	$25m^3$
HVP	Strikes	333000	Smoke matches	25	1.30	20s	$2m^3$
HVP	Strikes	333000B	Smoke matches	100	4.27	20s	$2m^3$
Toolstation	Hayes	38123	Classic 3- 3g pellets	10	2.19	45s	$8m^3$
Tool station	Strikes	46406	Smoke matches	25	1.46	20s	$2m^3$
Tool station	Strikes	50805	Smoke matches	100	4.26	20s	$2m^3$

Sulphur dioxide cylinders

Using a cylinder is certainly more convenient than generating sulphur dioxide in situ by burning sulphur but convenience comes at a price.

Some suppliers and products are listed in the table below.

Supplier	Item code	Item	Price ex VAT (£)	Charges-delivery etc	Lead Time if appropriate
Sigma	744255	450g Lecture Bottle	474	n/a	Approx. 15-20 days
Sigma	99112	Control Valve - on/off	266	n/a	If in stock 1-2 days
Fisher Scientific	12989534	450g Lecture Bottle	239.09	none	6 days
Scientific and Chemical Supplies	GFT090010	450g Lecture Bottle	305.15 259.38	£45	7-10 days
Scientific and Chemical Supplies	GFT090500	Stainless Steel LB control Valve	300.00 255.00	45	7-10 days
CK Gas	LBSULD30	450g Lecture Bottle	190	56	3-4 days if in stock 2 weeks if not
CK Gas	LBSSVALVE CGA	Control Valve 1/4" tube	49.50	56	3-4 days if in stock 2 weeks if not

a) = price before discount applied valid for 2019-2020
b) = price with current 15% discount applied valid for 2019-2020

E

The following is a list of substances which, in the quantities usual in school experiments, can be released safely in a fume cupboard meeting the recommendations of this bulletin. This claim is based on containment tests.

Absence from the list does not necessarily imply that the gas or vapour is too toxic to be handled in such a fume cupboard or can be handled safely in the open laboratory .

Inclusion in the list does not necessarily imply that the gas or vapour cannot be handled safely in the open laboratory if quantities are sufficiently small.

NB carbon monoxide, hydrogen and methane will not be absorbed by filters (being neutral and low density) nor will mercury vapour.

Inorganic	Organic	Dust etc
aluminium chloride and bromide	acid amides	Dye powders
hydrogen sulphide	acid anhydrides	enzymes
ammonia iodine	acid chlorides	smoke
ammonium chloride fumes	alcohols	
iodine chlorides	aldehydes	
bromine	aliphatic amines and their salts	
lead fumes	aliphatic hydrocarbons but not methane)	
lead bromide fumes	aromatic amines and their salts	
mercury and its compounds	aromatic hydrocarbons	
nitric acid vapour	aromatic nitro compounds	
chlorine	carboxylic acids	
nitrogen oxides	esters	
phosphine	ethers	
phosphorus (white)	ketones	
chromium(VI) dichloride dioxide (chromyl chloride)	nitriles	
hydrogen chloride / hydrochloric acid vapour	organohalogens	
phosphorus chlorides and bromides	phenols	
phosphorus oxides	pyridine	
silicon tetrachloride		
sulphur chlorides		
sulphur dioxide		
thionyl chloride		
tin(IV) chloride		
titanium tetrachloride		
zinc chloride fumes		

Positioning of fume cupboards

F

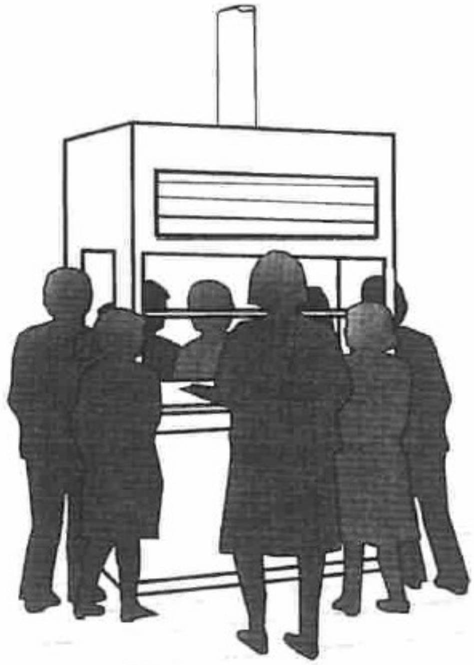
Against a wall (ducted)

Services: Relatively easy to install if services are already available along the perimeter of the room.

Movement Possible: Nil.

Advantages: Does not create an obstruction. Service connections are simple to install and need little maintenance. Can be installed in an existing laboratory by taking the duct out through the wall and up to roof level.

Disadvantages: Limited visibility through the front (and sides if these are glazes). The line of sight of pupils watching a demonstration is limited. Ductwork is expensive.



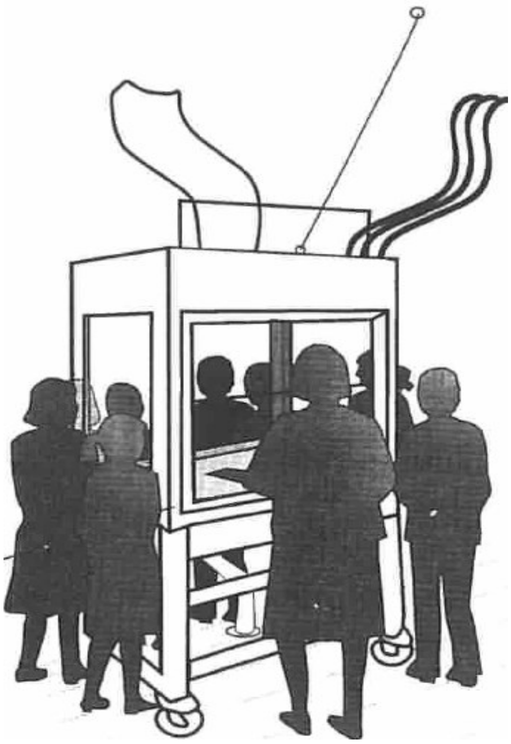
Free standing (ducted)

Services: Easy to connect only when a laboratory is being built.

Movement Possible: Nil.

Advantages: Good visibility on all sides. Maintenance of ducting insignificant, unlike that of a fume cupboard connected by flexible ducting. Service connections need little maintenance.

Disadvantages: May be considered an obstruction. Difficult to install in an existing laboratory unless suitably positioned services are already available. Ductwork is expensive.



Pulled out from against the wall for use (ducted)

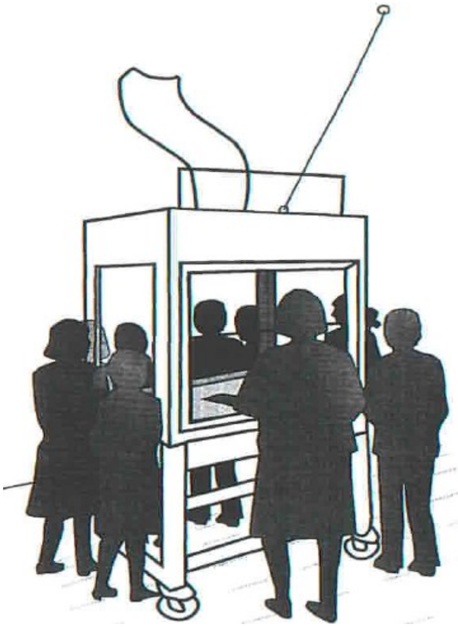
Services: Flexible lines to fixed points.

Movement possible: 1- 2 metres, limited by length of drain connection. A restraining cable protects the ventilation duct and service lines. It is possible to move it to another room if there are special connection points.

Advantages: Good visibility on all sides. Can be moved out of the way when not in use. Can be installed in an existing laboratory by taking the duct out through the wall and up to roof level and by coupling to existing services on perimeter or bollard. Lower maintenance than a filter fume cupboard.

Disadvantages: Movement is limited. Flexible service lines are vulnerable and need care and maintenance, particularly the ventilation and drainage hoses. Location can be limited by trip hazard of low level service lines. Bench height lines can also cause an obstruction. Overhead services are a possibility. Ductwork is expensive.

F



Pulled out from against the wall for use (ducted—no services)

Services: Nil.

Movement possible: 1- 2 metres, limited by restraining cable to protect the ventilation. It is more likely to be moved than a serviced cupboard as there are no services requiring special connections.

Advantages: Visibility on all sides Can be moved out of the way when not in use. Can be installed in an existing laboratory by taking the duct out through the wall and up to roof level. Lower maintenance than a filter fume cupboard.

Disadvantages: Movement limited. Water and drainage not available inside the cupboard. The flexible ventilation duct is vulnerable and needs care and maintenance. Ductwork is expensive. No gas, water or electricity unless these

Mobile (filtered)

Services: Flexible lines to fixed points.

Movement possible: 1- 2 metres, limited by length of drain connection. A restraining cable protects the service lines. It is possible to move to another room if there are special outlets for the service lines.

Advantages: Good visibility on all sides, Can be moved to wherever there are special service outlets. Installation is cheaper than a ducted fume cupboard.

Disadvantages: Filters have finite life and schools find them expensive to replace. Also, they need regular testing for saturation. Mobile fume cupboards are less robust.

Mobile—without services (filtered)

Services: Only mains electricity.

Movement possible: Considerable. It is easy to move to another room provided there is a mains electricity outlet.

Advantages: Good visibility on all sides. Can be moved to wherever there is mains electricity. Installation is less expensive than a ducted fume cupboard.

Disadvantages: Filters have finite life and they are expensive to replace. Also, they need regular testing for saturation. Water and drainage are not available inside the cupboard. No gas or water unless these can be brought as required from standard outlets close by. Mobile fume cupboards are less robust.

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G

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[11] SSERC Hazardous Chemicals Database—Sulphur Dioxide

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According to INDG 408 *A simple guide to buying and using local exhaust ventilation.*

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