SSERC

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Routine fume cupboard testing

Contents

Introduction

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Ducted fume cupboards (DFC) are inherently much safer than recirculatory fume cupboards and should always be purchased in preference to the latter. With recirculatories there is uncertainty about the filter condition and they are really only suitable for handling small quantities and with low rates of release inside the cupboard.

Recirculatories should be seen only as a stop gap, temporary solution and new builds or refurbishments should **always** avoid them. In the long run the overall cost of a recirculatory is often 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 available in 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.

1.1 Reasons for testing

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 Work Equipment Regulations 1992 and by the COSHH Regulations 2002. The latter legislation in particular requires all LEVs (local exhaust ventilation devices of which fume cupboards are a subset) to be tested at least once every 14 months and records kept. Apart from being a legal requirement the keeping of records makes easier the detection of the beginnings of any gradual decline in performance.

In practice, the employer often appoints a competent person in the school to carry out this annual task or arranges for an external consultant to do so.

1.2 Annual check for ducted cupboards

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

These checks are listed in the tabulated **2.1 Check list for ducted cupboards** where it recommends pass/fail conditions and comments on the likely causes of a failure. This should be used in conjunction with the blank equivalent **Appendix 1a - Testing ducted fume cupboards (RFC)** to record details of your own fume cupboards. **Appendix 1b - Testing ducted fume cupboards (Record form face velocity)** should be used to record the face velocities in each area of the sash opening. It is prudent to measure the face velocity immediately after installation of a new cupboard or refurbishment of an older one, in order to provide a reference or datum. Then, any observed decline in performance between successive years may be useful in diagnosing a fault in the condition of the fan or duct.

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.

1.3 Mobile ducted cupboards

Where a cupboard is connected to the fixed ducting by a short length of a flexible duct, extra attention must be paid to checking the earth resistance of any electrical supply for lighting or for a 13 A outlet socket. It is vitally important that the electrical supply cord is protected from being strained by fitting a suitably short restraining wire or chain. In addition the whole cupboard should be tested as a portable electrical appliance. **The resistance of the earth path from the 13 A socket outlet should be measured by a person competent to carry out the testing of portable electrical appliances.** See **Appendix 3** for a simple method.

The standards set by the DfEE document BB88 (a revision of DN 29) [1] are used here rather than the much more onerous ones in the British Standard [2].

CPD for Technicians course at SSERC where they learn about the use of recirculatory fume cupboards as part of a Chemical Handling workshop.
For more information see the science3-18.org website at http://tinyurl.com/Technicians-CPD.

1.4 Daily check

In addition to the detailed annual check by the apponted specialist 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 small streamers fastened on the bottom of the sash;
- electrical and gas services are not damaged.

This short visual check is similar to what is done before using any other item of equipment.

1.5 Recirculatory fume cupboards

In addition to checks on *face velocity*, structure and services as required for a fixed, ducted cupboard, it will be necessary to carry out a *challenge test*, probably annually, on the 'filter' to ensure that it still has sufficient adsorptive capacity left. Three to four years is a typical life of a 'filter' given normal school usage. The pre-filter which removes dust will probably have to be replaced more often. See **Chapter 3** for details.

Most recirculatory fume cupboards are mobile and require the following tests which should only be carried only by persons with the competence and training to test portable electrical appliances;

- as for any other portable electrical appliance particular attention being given to the condition of the mains supply cable and its cable grips;
- the 13 A socket outlets fitted, especially the resistance of the path to earth. The method is described in **Appendix 3**;
- the restraining wire and its ability to prevent the electrical cable from being strained.

Obviously several of the tests needed for recirculatory fume cupboards are different from those for ducted cupboards. The check lists and record forms for tests on recirculatory fume cupboards are in **3.1 Check list for recirculatory fume cupboards** (to be used in conjunction with **Appendix 2 - Record form (RFC)**).

Measuring face velocity in a ducted fume cupboard with the sash window set at 400 mm.

Testing ducted fume cupboards (DFC)

2

2.1 Check list for ducted cupboards (use in conjunction with **Appendix 1a - Record form (DFC)**)

AREA	CONDITION	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 between 400 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 will do for upper and rubber door stops on underside of sash for lower stops.
3 **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	
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 by adjusting the damper usually cures the problem.
5 **Two or more cupboards on same extract system**	(i) in *same* room	P	Dampers may need adjusting to balance the flow rates in the two cupboards.
	(ii) in *different* rooms and no difficulties have arisen with face velocity or back leakage between cupboards.	Pq	
6 **Glazing**	- undamaged - safety glass (laminated or toughened of 5mm) preferred alternatively poly carbonate may be used.	P	As a temporary measure ordinary glass can be covered with shatterproof film.
7 **Structure**	- sound, with metal free from excessive corrosion.	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.

AREA	CONDITION	PASS/ FAIL	COMMENTS
8 Sash	- slides freely and yet holds a position and the mechanism - (counter weights & cords) or spring are sound - only opens to one room.		
9 Double opening	- second sash opening is to 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 (hard asbestos can be sealed, but soft or flaky asbestos is a fail) and - has a lip at front or is dished to contain spillages.	P	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 front outside plenum 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 elecrical installations test (usually carried out every 5 years by architect's department). - outside the plenum at front and to one side is safer, but if under the front will be protected to some extent by an overhang and by a lip. Ideally 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 down stream - 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 loose mounting - persistent blowing of fuses	P F F	- motor running but no air flow may mean a broken or slipping drive belt 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 is preferably sited near the exit of the duct, so that most of the duct is at negative pressure.

AREA	CONDITION	PASS/ FAIL	COMMENTS
14 For mobile cupboards 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 anchorage point the maximum distance permitted by the restrainer.	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 carried 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**

2.2 Annual face velocity check

See **Appendix 1b - Testing ducted fume cupboards (Record form face velocity)**.

Choice of anemometer
Preferred is the rotating vane type. Any model from the older Airflow LCA6000 series or their successors, the LCA 301 and LCA 501 is suitable and will sample over any time period chosen. Both these replacements operate in a similar way, but the more expensive variant, the LCA 501, is more sophisticated.

The anemometer must have passed a calibration test, renewed annually if the instrument is frequently used and every 2 to 3 years if only used a few times each year. Even if it has been calibrated recently, do a rough check as follows. In a closed and draught free room hold the meter at an arm's length to the side and walk at a speed of 0.5 m s^{-1}. (with the aid of a meter stick and a timer this is easily achieved with a little practice). If the reading is not in this region the meter has obviously been damaged since the last calibration.

2.3 Method of measurement

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. Empty the fume cupboard of apparatus.

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.

Set the sash at the *maximum working opening* (probably 400 mm) and "divide" the opening into 9 rectangles of equal area.
(With the recirculatory fume cupboards the opening is generally smaller and it may only be possible to divide it into 6 areas).

Measure the face velocity in each of the nine areas for a period of 10 seconds or more and record the results in the appropriate boxes in the record form. The person carrying out the measurements must keep their body as far away from the sash opening as possible. Some anemometers have the sensor head mounted on a long wand.

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.

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

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

The cupboard will fail if:

- **any one of the 9 readings falls below 0.3 m s^{-1} or if**
- **any of the deviations are greater than 30%.**

If the average face velocity falls to just below 0.3 m s^{-1}, it is permissible to reduce the opening slightly by pulling the sash down a little and repeating the above measurements. The upper stops will have to be fastened in the new positions to prevent the sash being raised higher than this. Although a face velocity of 0.3 m^{-1} can be accepted as a bare 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}.

Testing recirculatory fume cupboards (RFC)

3

3.1 Check list for recirculatory fume cupboards (use in conjunction with **Appendix 2** - Record form (RFC))

	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 only 4 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 **(ii) 'solvent' layer** with Methylbenzene or dimethyl-benzene	(i) concentration in effluent below that for pass (see Table 1 for permitted effluent concentrations). (ii) concentration in effluent below that for pass (see Table 2 for for permitted effluent concentrations).	P P	Only the SO_2 test may be needed. See 3.1.1.
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 structureor 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)** **(ii) water (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. similar requirements as for gas, apart from the spring loaded off position.	 P 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

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

AREA	CONDITION	PASS/ FAIL	COMMENTS
7 continued...			
(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 down stream - free of leaks.	P	
(v) 'umbilicals' & quick release couplings if fitted (gas, water & drains)	- and 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).	P	See above note on RCD protection.
	(ii) persistent blowing of fuses.	F	
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 leadsecure 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**

Testing recirculatory fume cupboards

Obviously several of the tests for ducted cupboards are not needed here, but others peculiar to the 'filter' and to the type of construction require their own procedures. These are given in **3.1 Check list for recirculatory fume cupboards** (to be used in conjunction with **Appendix 2 - Record form (RFC)**).

3.2 Challenge testing of recirculatory fume cupboards

This part should be read in conjunction with SSERC Bulletins 211 [3] and 177 [4], which describe the principle of the recirculatory 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.

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 (of the order of mg s^{-1} or cm^3 s^{-1}) and usually short-lived, say 5 or 10 minutes in duration and 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* decribed below in 3.3, 3.4 and 3.5 below.

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

3.2.1 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.

3.3 Safety of the person carrying out the tests

The procedures use hazardous substances, namely sulphur dioxide or methylbenzene (this 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 section of SafetyNet [5] 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 by-passing it or has insufficient adsorptive capacity left in it.

Immediately discontinue the release 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.

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)
dimethylbenzenes	4 ppm	100 ppm (15 mins)

* Sulphur dioxide is no longer assigned an exposure level by the HSE, but they now recommend that the level of the gas should be kept as low as reasonably practicable and if possible below 1 ppm for both short term and long term exposures. Other authorities recommend a guideline figure of 0.5 ppm.

3.4 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.

Theoretically all of the 'layers' should be tested, but experience shows that for the practical work used in to-day'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 operating the Draeger see their websites listed in part (b) of **Appendix 5**.

3.5 Testing for retention of acidic gases

3.5.1 Principle

A syphon of sulphur dioxide is weighed before and after the gas has been released for a known time inside the plenum 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 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 4** but most 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 14)*.

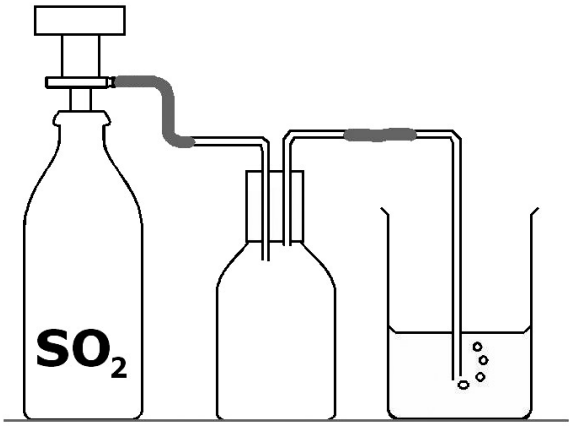
A cheaper, though less convenient, source of sulphur dioxide is its generation by burning sulphur. Weighing the sulphur before ignition and at the end of the release allows the rate of release of sulphur dioxide to be calculated.

3.5.2 Method using sulphur dioxide syphons

1) Collect the syphon and accessories for step 3 below; stop clock, balance weighing to 10 mg, gas detector tube (if Draeger, use tube 6727101 for concentrations 0.1 to 3 ppm or tube 6728491 for 0.5 to 25 ppm) and its pump. Check hand pump for leaks. Lock the brakes on the trolley wheels. Gastec and other piston pumps can also be used.

2) Weigh the sulphur dioxide syphon.

3) 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.



4) 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.

5) 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 (most undignified!). To gain access to the top use a suitable step ladder, not a chair or stool.

6) 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.

7) 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.

3.5.3 Method burning sulphur

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 in the Centre. This was reported in Bulletin 177 [4] and suggested to fume cupboard manufacturers and to our counterparts south of the Border, who have also adopted it as an alternative. Please consult the Hazardous Chemicals part of SafetyNet [5] on the SSERC website for more information regarding sulphur dioxide.

Basically the method is the same as that using the release from the syphon except that the SO_2 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. The steps are:

1) Collect:
   - 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 heat-resistant mats, one of them small and which is used for extinguishing the burning sulphur;
   - powdered sulphur and accessories for 3 below;
   - stop clock;
   - balance weighing to 10 mg;
   - gas detector tube and its hand pump. (Check the latter for leaks as per manufacturer's instructions).

2) Weigh the basin, sulphur and small heat-resistant mat which will later be used as a lid (steps 5 & 6 below). 70 to 80 g of sulphur is a suitable quantity.

3) 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 and then ignite by playing the bunsen flame onto the top. When the sulphur ignites, turn off the bunsen and start the clock.

4) 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), and start measuring the sulphur dioxide levels in the exhaust. Some cupboards provide a small port for insertion of the detector tube.

5) When finished measuring, extinguish the burning sulphur by placing the small heat resisting 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.

6) When cool, reweigh the crucible or basin. Do this with the mat on top.

7) 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 =

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

8) Consult Table 1 in the previous section (3.4.2) 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.

3.6 Testing for solvent retention using methylbenzene

3.6.1 Hazards
Formerly 1,1,1-trichloroethane was used as the challenge solvent, but its manufacture has ceased on account of its ozone layer unfriendliness. Trichloroethene has also been used. It is now classed as a Category 2 carcinogen and we would recommend it is now longer used for this application, since a poorly performing filter would release the vapour into the room.
Methylbenzene is less toxic but is highly flammable, has also been used. IF METHYLBENZENE IS USED TAKE ALL PRECAUTIONS TO AVOID ACCIDENTAL IGNITION. KEEP FIRE EXTINGUISHER HANDY.

The room should be well ventilated and if possible the balance used inside another or even the same fume cupboard. Please consult the Hazardous Chemicals part of SafetyNet [5] on the SSERC website for more information regarding methylbenzene.

3.6.2 Method
1) Collect:
- stop-clock;
- balance weighing to 10 mg;
- small heat resistant mat
- tongs for flask or beaker;
- gas detector tube (e.g. Draeger tube 8101661 for methylbenzene;
- its hand pump and other accessories for 3 below;
- hotplate
- nitrile gloves.

2) In the fume cupboard pour about 50 cm^3 of 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.

3) Place the hotplate in the fume cupboard about 10 cm back from the front edge. Set the beaker and methylbenzene on the hotplate.

4) 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.

5) 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.

6) 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.

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. 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.

Table 2

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

3.6.3 Ancillary equipment for challenge testing 'filter' fume cupboard

(a) General

1) Timer or stopwatch.

2) Balance weighing to 10 mg.

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, ideally spoutless for methylbenzene.

8) Large watch glass as lid for 9.

9) Hotplate for methylbenzene.

10) Antibump granules for solvent, (methylbenzene or possibly dimethylbenzene).

11) Eye protection and nitrile gloves.

(b) Chemicals

Sulphur dioxide syphons are available from:

12) **Fluka**
- 100 cm^3 liquefied gas cylinder (Cat. No. 84693-1EH) £67.40 + vat
- valve (Cat. No. 83547) £77.40 + vat

Griffin
- 500 g liquefied gas cylinder (Cat. No. S/9081) £204.72 + vat
- valve insert (for above) £138.14 + vat

VWR (Merck)
- cylinder price is £287 + vat
- valve (Cat. No. 602851K) £122.75 + vat

13) Sulphur (powder) if using the alternative method.

14) Methylbenzene.

(c) Specialised equipment

For anemometers and gas detection equipment see **Appendix 5** and SSERC Bulletin 165 [6].

Appendix 1a - Testing ducted fume cupboards (Record form)

4

To be used in conjunction with **2.1 Check list for ducted fume cupboards.** It may be photocopied.

School **Room/lab no** **Cupboard no** **Flow meter used**

AREA	CONDITION	PASS/ FAIL	COMMENTS
1 **Face velocity at opening of - 400 mm** **- at 300 mm** (used if face velocity too low at 400 mm)	Use **Appendix 1b - Testing ducted fume cupboards (Record form for face velocity).** See note **2.3 Method of measurement** regarding lower stop positions.		
2 **Opening stops**			
3 **Flow indicator**			
4 **Smoke test**			
5 **Two or more cupboards on same extract system**			
6 **Glazing**			
7 **Structure**			

AREA	CONDITION	PASS/ FAIL	COMMENTS
8 Sash			
9 Double opening			
10 Work surface			
11 Services - (i) gas			
(ii) water			
(iii) electrical 13 A outlet(s) (see 15 for outlet on mobile cupboards)			
(iv) drain			
12 Fan and motor			
13 Duct (if accessible)			

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

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

AREA	CONDITION	PASS/ FAIL	COMMENTS
14 For mobile cupboards ONLY **(a) flexible ducting** **(b) if fitted** **(c) trolley brakes** **(d) wire or chain restrainer**			
15 Mobiles only **(a) test as portable electrical appliance** **(b) 13 A outlet**			

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

* The record for test 1 in the table on page 19 only indicates whether a pass or fail is recorded. See **Appendix 1b - Testing ducted fume cupboards (Record form for face velocity)** for recording the actual velocities. Tests 15a & 15 b should only be carried out by a person competent and trained and to carry out electrical safety testing.

4 Appendix 1b - Testing ducted fume cupboards (Record form face velocity)

To be used in conjunction with **2.1 Check list for ducted fume cupboards**. It may be photocopied.

School **Room** **Meter used**

Height of sash opening during measurements _____ **mm**

Date	Air velocity in sectors (m s^{-1})			Average face velocity (m s^{-1})	Change from last year	Variations		Signature of tester
						Highest	Lowest	
						abs %	abs %	
						abs %	abs %	
						abs %	abs %	
						abs %	abs %	
						abs %	abs %	
						abs %	abs %	
						abs %	abs %	
						abs %	abs %	
						abs %	abs %	

Appendix 2 - Testing recirculatory fume cupboards (Record form)

5

To be used in conjunction with **3.1 Check list for recirculatory fume cupboards**. It may be photocopied.

School **Room/lab no** **Cupboard no** **Flow meter used**

AREA	CONDITION	PASS/ FAIL	COMMENTS
1 **Face velocity at designed working opening**			
2 **Flow indicator**			
3 **Challenge tests (i) acid layer** with SO_2			
(ii) 'solvent' layer with Methylbenzene or dimethyl-benzene			
4 **Smoke test** (use **only** a small pellet and only if there is some doubt about escape of fumes through cracks and seams.)			
5 **Glazing and structure**			
6 **Work surface**			
7 **Services - (i) gas (if fitted)**			
(ii) water (if fitted)			

AREA	CONDITION	PASS/ FAIL	COMMENTS
7 continued... (iii) electrical 13 A outlet((s)			
(iv) drain (if fitted)			
(v) 'umbilicals' & quick release couplings if fitted (gas, water & drains)			
8 Fan and motor			
9 Electrical test (a) visual check			
(b) test as portable electrical appliance			
(c) 13 A outlet earth path			
10 Trolley brakes			
11 Restraining wire			

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

* The record in the above form for test 1 only indicates whether a pass or fail is recorded. The opening on recirculatory fume cupboards is smaller than on ducted cupboards and it is not realistic to divide the smaller opening into 9 areas. 6 or even 4 areas is more likely.

Appendix 3

6

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

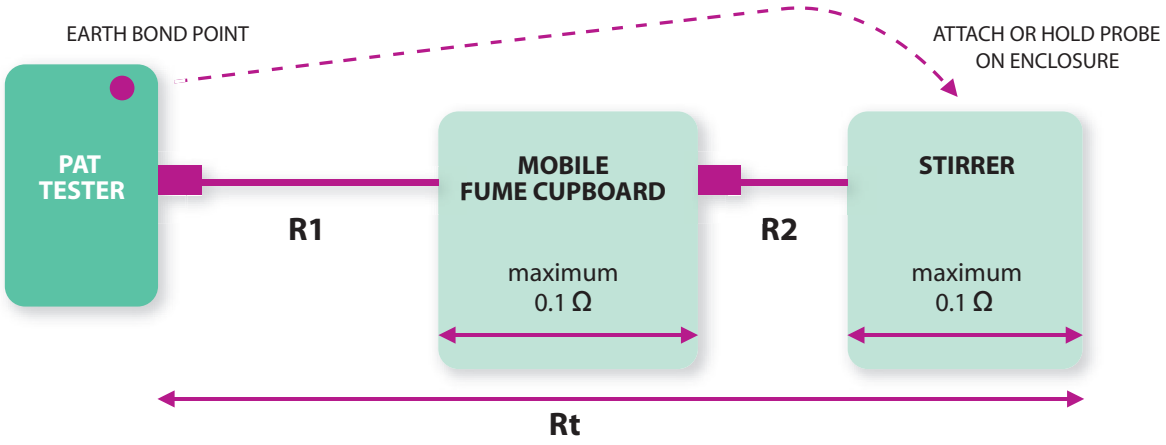
This task should only be carried out by persons who are competent to carry out electrical safety checks on portable electrical equipment.

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

Cord length	Resistance (mΩ) at 20°C of protective conductor of size				
	0.5 mm²	0.75 mm²	1.0 mm²	1.25 mm²	1.5 mm²
1.0 m	39	26	20	16	13.3

Values of cord resistance.

Appendix 4

Calculation of capture efficiency of a 'filter'

This can be done instead of following the pass or fail approach referred to in sections 3.4 and 3.5. It 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 calculation and an example are tabulated below.

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, m^3 s^{-1})	**Q** = (V x A) m^3 s^{-1}	0.0725 m^3 s^{-1}
Initial mass of SO_2 & time	m_1 t_1	477.90 g zero
Final mass of SO_2 & time	m_2 t_2	469.43 g 9 m 59 s 8.47 g 599 s
Calculate rate of release, i.e. loss in mass per second **(R, mg s^{-1})**	$R = \frac{(m^1 - m^2) \times 1000}{\Delta t}$ mg s^{-1}	14.1 mg s^{-1}
Concentration in exhaust. Measure with Gastec or Draeger tube **(C_x, ppm)**	C_x ppm	0.125 ppm
Convert concentration to mg m^{-3} by multiplying by factor, F, the Mol Mass/24 (= 2.67 for SO_2)	C_x (mg m^{-3}) = C_{ex} (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})**	R_x = (C_x x Q) mg s^{-1} (mg m^{-3}) x (m^3 s^{-1})	(0.334 x 0.0725) mg s^{-1} = 0.0242 mg s^{-1}
Efficiency of capture, (E)	$E = \frac{R - R_x}{R}$	$\frac{(14.1 - 0.02)}{14.1}$ = 0.999 or 99.9%

Appendix 5

8

Specialised equipment

(a) Rotating vane anemometer

Manufacturer	Model	Range (/m s^{-1})	Averaging time	Price (/£)
TSI Airflow Instruments	LCA 301 (formerly the LCA 6000VT)	0.25 - 30	Variable up to 12 mins	275
	LCA 501 (formerly the LCA 6000RVT)	0.25 - 30	Variable up to 12 mins	450

The LCA 501 has some advantages over the simpler LCA 301, but the extra cost is hardly worthwhile.

It has:
(i) a telescopic handle which makes it easier for the operator to keep clear of the sash opening and hence not impede the in-flowing air and
(ii) a facility for datalogging, recalling and downloading to a computer.

For testing purposes the first feature might be useful, but is not necessary and is probably not worth the extra cost. Even the cheaper LCA 301 has a "hold" function. It will take measurements as long as you hold the trigger button. When the trigger is released recording stops and the average values are shown on the screen.

The Lownes anemometer is now discontinued, but some of you may still have one. Cherish it. It is a precision instrument, easily used and because of the light mica vanes and jewelled bearings is more accurate at low air flows. If only a few persons are to use the anemometer and there is a certainty of it being handled with care the 1000/L might be the preferred choice.

Calibration of these carried out at a later time typically costs £50 to £60.

SSERC possesses an LCA6000VT for which the current hiring rate is £20 per day plus postage.

(b) Gas detector tubes and pumps

(i) Hand pumps and gas detection tubes

Manufacturer	Model	Range	Price
Gastec	Hand pump & kit (GASGV-100S)		£208.95
Gastec tubes	SO_2 (5Lb) methylbenzene (122L)	0.05 to 10 ppm 1 to 100 ppm	£33.00 (pk of 10) £33.00 (pk of 10)
Sabre	APS Pump & kit		£225.00
Kitagawa tubes*	SO_2 (103SE) methylbenzene tubes (124SB)	0.25 to 10 ppm 2 to 100 ppm	£31.14 (pk of 10) £31.14 (pk of 10)
Draeger	gas detector hand bellows pump (Accuro)		£257.04
Draeger tubes	SO_2 (no Accuro 6400000) SO_2 (part no CH31701) methylbenzene(toluene) 8101661	0.1 to 3 ppm 1 to 25 ppm 5 to 300 ppm	£33.90 (pk of 10) £29.60 (pk of 10) £38.70 (pk of 10)

** Kitigawa tubes are sold for use with the Sabre pump. Kitigawa state that their tubes will also fit in a Gastec pump.*

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.

(ii) Pump modes of action

These hand-powered pumps draw air through a long thin glass tube filled with the appropriate reagent for the gas being measured, the concentration being read off from the length of the stain. There are however differences in the mode of action. With the Draeger* pump, squeezing a small bellows in the palm of the hand drives out the air (100 cm^3), and room air is then allowed to re-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 *Sabre*, *Kitigawa* and the *Gastec*** pumps consist of *precision metal syringes*. These are evacuated by pulling out the plunger and locking it either in the half or in the full volume *100* cm^3 position. Then the room air slowly leaks back in through the gas detector tube. These pumps commonly require only one stroke, sometimes 5 and, very occasionally, more.

All three are simple to use, but the two syringe types will be much easier on the wrist, especially in those few applications where the Draeger model requires a large number of strokes, 100 in the case of sulphur dioxide! However this feature of the Draeger SO_2 tube can sometimes prove to be an advantage. If the concentration of the gas happened to be higher than the maximum for the chosen tube, the reading on the syringe types will almost certainly go off the end of the scale. With the Draeger it is possible to stop when the stain is, say three quarters way along, and still obtain an answer by multiplying the reading by the appropriate factor, i.e..

(no of strokes recommended for the tube) / (no of strokes actually taken).

(c) 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.

SSERC sell pellets separately at 40 & 50 p for small and large pellets respectively. These cannot be sent by post and must be collected or sent by carrier.

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 producing small amounts of smoke.

Gasafe

Type	Code	Qty in tube	Price	Burn time	Vol smoke
Classic 3 - pellets , 3 g	33003	Tube (10)	£2.50	45 s	8 m^3
Classic 9 - pellets, 9 g	33009	Tube (10)	£3.70	65 s	25 m^3
Strikes smoke matches	33000	Tube (25)	£0.92	20 s	2 m^3
Strikes smoke matches	33001	Tube (100)	£3.20	20 s	2 m^3

* and ** More detail of the operation and maintenance of the Draeger and Gastec pumps can be found at:
http://www.draeger.com/media/10/01/87/10018750/tubeshandbook_br_9092086_en.pdf
Gastec handbook at:
http://www.a1-safetech.com/assets/articles/assets/1700413290_Gastec_Pump_Manual.pdf

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[2] BS EN 14175, Fume Cupboards (5 parts), *British Standards Institution*

[3] Recirculatory Fume Cupboards, *SSERC Bulletin 211*
- Problems with filters - http://tinyurl.com/RFC-problems

[4] Recirculatory Fume Cupboards
- Review and test summaries
- Monitoring recirculatory filters, *SSERC Bulletin 177*

[5] Hazardous Chemicals - part of SafetyNet on the SSERC website and SafetyNet CD.
- Hazardous chemicals - http://tinyurl.com/Hazardous-Chemicals
- Sulphur dioxide - http://tinyurl.com/sulphur-dioxide
- Methylbenzene - http://tinyurl.com/methylbenzene

[6] Anemometers for fume cupboard monitoring, *SSERC Bulletin 165*

Addresses

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High Wycombe, Buckinghamshire, HP12 3QP
Telephone: 01494 459200
Fax: 01494 459700
E-mail: info@airflowinstruments.co.uk
Web: www.airflowinstruments.co.uk

Draeger Safety Ltd
Blyth Riverside Business Park
Blyth, Northumberland, NE24 4RG
Telephone: 01670 352891

Draeger Safety Limited (Scottish agents)
(i) Cosalt Seadog, 4 Albert Road
Edinburgh, EH6 7DP
Telephone: 0131 554 8531

(ii) Cosalt Seadog, 18 Palmerston Road
Aberdeen, AB11 5QN
Telephone: 01224 588 327

Fluka Chemicals (Sigma Aldrich)
The Old Brickyard, New Road
Gillingham, Dorset, SP8 4XT
Telephone: 0800 26 23 00
E-mail: UKOrders@vms.sial.com

HVP Supplies
Eagle Industrial Estate
Brookes Road
Billinghurst, Sussex, RH14 9RZ
Web: www.hvpsupplies.com

Gastec agents
(i) KAD Detection Systems Ltd
Unit 4/6, Barrmill Road
Galston Ayrshire, KA4 8HH
Telephone: 01563 820444

(ii) Anachem Ltd
Anachem House, Charles St., Luton
Telephone: 01582 747500

Kitigawa agents
Environmental and Gas Monitoring Services
Unit 5, Barrmill Road
Galston, Ayrshire, KA4 8HH
Telephone: 01563 820444

Sabre Safety Ltd
Sabre House, Cupar Trading Estate
Cupar, Fife, KY15 4SX
Tel: 01334 656645
Web: www.sabreh2s.com

VWR Merck Ltd (Scottish agents)
McQuilkin & Co.
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service@a1-cbiss.com
gastecsales@encirosciences.com

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Anemometer Testing and Calibration

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Fax: 0141 8496006
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