Examination and testing of local exhaust ventilation systems

Mr B Fletcher, BSc(Hons), Head of Ventilation Section, RLSD, Health and Safety Executive, Sheffield

ABSTRACT

Requirements under the COSHH Regulations for the examination and test of LEV systems are considered and how these can be met. The concept of containment testing and the means by which it can be carried out are also discussed.

INTRODUCTION

On October 1st 1989 the Control of Substances Hazardous to Health Regulations 1988[1] came into force, setting out the general duties of an employer to ensure that the health of employees is safeguarded. Regulation 7 requires that the exposure of employees to substances hazardous to health is either prevented or, where this is not reasonably practicable, adequately controlled. Regulation 9 of COSHH requires that where control measures are provided to comply with Regulation 7:

(i) it should be maintained in an efficient state, efficient working order and in general repair;
(ii) in the case of local exhaust ventilation (LEV) plant it should be examined and tested at least once every 14 months or in the case of substances and processes specified in Schedule 3, at the shorter intervals stated;
(iii) a suitable record of the examination and test should be kept for at least 5 years from the date on which it was made.

It is perhaps worth saying what is and is not LEV plant. LEV is a commonly used method of controlling dust and fume emitted by processes; the object is to capture the contaminant as close as possible to its point of production, preventing it entering the air of the workplace whilst moving a minimum amount of air to achieve the result. A number of publications describe the design and operation of such systems[2,3]. The prime purpose of LEV is not to move air per se, hence general ventilation plant would not be considered to be LEV; nor would general purpose vacuum cleaners. However the ventilated casing of a pedestal grinder, designed to control dust emissions, would be treated as LEV although its prime function may have been to guard the wheel.

MAINTENANCE AND REGULAR INSPECTION AND CHECKING

Regular inspection and checking should not be confused with the thorough examination and test; its purpose is to identify problems and potential problems which may then be remedied before serious deterioration can occur. In the context of Regulations, maintenance means any work carried out to sustain the efficiency of control measures. It will include a weekly visual check of the control measures with typically checks of:

i signs of wear, damage and malfunction eg accumulations of dust
ii positioning (or even presence) of hoods in relation to the contaminant source
iii functioning of performance monitors eg manometers, ammeters
iv general condition of duct-work, hoods, dust collectors etc

A simple record of the weekly inspections should be kept which should record any defects found. Faults should be rectified quickly and a note made of the action taken and the date. Such a record may be useful in identifying weaknesses in the plant and in minimising their effect.

THOROUGH EXAMINATION AND TEST

The thorough examination and test of an LEV system is a periodic audit of the system and its performance and is distinct from routine maintenance. It will show whether or not the system is performing correctly but will not necessarily identify the precise cause of any failure. It should not be carried out in isolation but should form an integral part of a programme comprising:

i an initial appraisal
ii regular maintenance including weekly visual checks and, where appropriate, more frequent inspection and monitoring
iii statutory examination and testing
iv a method of reporting and rectifying faults found
v a system of recording findings

An initial appraisal should be made of ventilation plant, ideally shortly after it has been installed but also after any major changes have been made. This is important not only in setting a bench mark against which future measurements can be judged but also in making sure that the plant starts life capable of meeting its specified performance. The appraisal is part of the assessment required under Regulation 6 of COSHH.

The examination and test should be sufficient to show that the plant is in good working order, meets suitable performance standards and controls the emission of contaminants satisfactorily. The COSHH Regulations do not specify the tests to be carried out although for LEV plant installed to comply with the COSHH Regulations, minimum frequencies are required ie at least at every 14 months or, for processes specified in Schedule 3 of the regulations, at the minimum frequency specified. Note that the approved codes of practice (ACOP) to the Control of Lead at Work Regulations 1980[4] and the Control of Asbestos at Work Regulations 1987[5] do specify tests as well as minimum frequencies. In the case of LEV plant, the ACOP to COSHH does set out the requirements which the examination and test should meet. Examples of the details which should be available in respect of the main components of the LEV system include:

enclosures/hoods - maximum number to be in use at any one time; location or position; static pressure behind each hood or extraction point; face velocity.
ducting - dimensions; transport velocity; volume flow.
filter/collector - specification; volume flow; static pressure at inlet, outlet and across filter.
fan or air mover - specification: volume flow rate; static pressure at inlet; direction of rotation.
systems which return air to the workplace - filter efficiency; concentration of contaminant in returned air.

The above list will give some idea of the types of measurements which are required and the techniques which will need to be employed. The plant should, where possible, be tested under normal operating conditions. If for example there are several fume cupboards in a system which can be operated simultaneously, then unless there is a good reason to believe that the system is never operated in this way, the test should be carried out with all cupboards in use. The measurements made would depend on the type of plant but would typically comprise:

Visual examination - the whole of the ventilation system and its ancillary equipment should be examined on a weekly basis for wear, damage, leakage and corrosion. The position and condition of hoods, flow dampers and fire dampers should be checked along with the condition of any explosion panels which may be used.
Probably the most useful technique for identifying dust and fume sources and for giving a qualitative assessment of the control of particulate contaminants is the dust lamp. The lamp produces a high intensity beam of parallel light which, on passing through a dust cloud, is scattered in a forward direction by the fine respirable particles.
Smoke can be used to give a general indication of air movements but care is needed in interpreting the observations. Smoke tubes can be used to detect small leaks in ducts or at seals as well as to give an estimate of very low airflow velocities. Smoke pellets produce larger amounts of smoke over relatively short times. The smoke, particularly that from smoke tubes, can be corrosive and care should be exercised in its use. Large amounts of smoke can be produced over long periods by vapourising oil but this can cause damage, for example to HEPA filters, and leaves a film of oil on surfaces.
There are other techniques available (eg infrared and schlieren) but these are best left for laboratory use.

Static pressure measurements - the measurement of static pressure is an easy and convenient way of determining whether or not the performance of a ventilation system has changed. If no change occurs in the volume flow rate or the system resistance, then the static pressure at any point will remain constant; conversely a change in static pressure will indicate a change in the system characteristics. In assessing an LEV system, several pressure measurements should be taken at various points throughout the system such as in the ductwork after hoods and enclosures, at the inlet and outlet of the fan, and across air cleaning units. Ideally the measurement points should be well away from bends, changes in cross sectional area, dampers etc. Measurements at several points may enable a trouble spot to be identified. If the pressure at any point changes by more than 10% of its original value, the cause should be investigated.
The most common instrument for pressure measurements in ventilation has been the liquid manometer, sometimes in the form of a "U" tube but more usually as an inclined single column and reservoir. These instruments are direct reading and require no calibration and are ideal in fixed circumstances eg monitoring pressure drops across filters. They are not readily portable and require levelling before use. There are however several electronic micromanometers available which are readily portable and easy to use.

Air speed measurements - air speeds are measured in two basic situations for different purposes:
i) at inlets to a system, eg at hood or booth faces (to determine a "face velocity", or at the source of pollution as an indication of whether or not a pollutant is likely to be controlled adequately ie by comparing the measured value with a "capture velocity".
ii) in ducts to determine whether the system is handling the required air volume and, in the cases of particulates and condensing vapours, whether the speed is high enough to convey the pollutant to the collector or discharge without settling in the duct.
There are several types of instrument available whose characteristics vary considerably and care should be taken to select an instrument most suitable for the purpose:
i) pitot static pressure tube: this measures the difference between the total pressure in the direction of the flow and the static pressure. It is the primary method for measuring speeds in ducts. It has no moving parts, can be made as small as required, and can be used at high gas temperatures and speeds. It does not need to be calibrated although it must be used with a manometer which may require calibration. A convenient telescopic version is now available. The pitot static is not really suitable for speeds below 2 m/s and its accuracy falls off very rapidly at the lower end of the range. However higher velocities do not present a problem and it is an ideal instrument for making measurements in ducts where, for typical industrial dusts a conveying speed of about 20 m/s is required. Access to the duct can be gained

through a relatively small hole drilled in it. Measurements should be made away from bends, T-pieces, contractions etc where the flow may be unsteady.

ii) rotating vane anemometers: a light vane rotates at a rate which is approximately linear with the airspeed past it. Modern instruments can be fairly small (less than 25 mm in diameter) and the rotational speed of the vane can be detected electronically. The instruments tend to be delicate and, although the larger vane will operate in air speeds down to about 0.25 m/s, a more realistic value is probably 0.5 m/s. The upper end of the range is around 30 m/s. The instruments are fairly directional, need periodic calibration and should preferably be used in a clean airflow.

iii) thermal anemometers: these consist of an electrically heated wire, film or thermistor which is cooled by the airflow past it. The response is rapid, the probes are small and they are convenient to use. Although they will measure to less than 0.1 m/s, the accuracy may not be good at this level. Commercial instruments will typically measure up to 30 m/s over three ranges. The calibration needs to be checked frequently and this is not easy at the lower end of the speed range. Although they are susceptible to fouling, they are easily cleaned. Especially for the measurement of capture and face velocities, this type of instrument has much to commend it.

iv) deflecting vane anemometer: this consists of a pivoted vane enclosed in a case such that the airflow deflects the vane as it passes through the instrument. Although it is a direct reading instrument it needs to be calibrated occasionally. It is sensitive to flow direction, cumbersome to use and not really suited to measurements in ducts. there are however instruments of this type which will measure from 0.2 up to 120 m/s.

Fan performance - in addition to measuring the pressure difference between the inlet and out of the fan, the impeller and motor speeds can be checked, using a tachometer, against the design values. Deterioration of LEV plant which leads to changes in volume flow rates may be reflected in a change in the electrical power consumption of the fan motor and this can be monitored by means of an ammeter. However it is a relatively insensitive measure of change especially for a large system.

Containment testing - containment as such is not mentioned in COSHH, although it can be taken to be implied. The purpose of a ventilated enclosure is to contain within it a contaminant produced by some process. It may be useful to have a rule of thumb by which the enclosure performance can be assessed (for example, a face velocity measurement), but this cannot be expected to give a definite measure of the enclosure's ability to contain the pollutant within it. In the case of microbiological safety cabinets, a British Standards method(6) gives a basis for containment testing using an aerosol of either spores or potassium iodide as a tracer. For fume cupboards there is a British Standards Draft for Development(7) based on a tracer gas method which it is hoped will form the fourth part to the British Standard on fume cupboards[8]. The method could be used for the testing of other types of enclosure and could be developed for measurement of the capture efficiency of LEV hoods. At the moment their effectiveness is assessed on their ability to move air rather than to remove contaminant.

RECORD KEEPING

Following the thorough examination and test, the COSHH Regulations require that a suitable record of the examinations and tests carried out and of any resulting repairs shall be kept for at least 5 years from the date on which it was made. The actions taken and items of data should be recorded. Where possible the records should have a diagrammatic sketch of the plant lay-out, hoods etc, pressure measurement points etc. In the case of LEV plant, the record should contain:

1. Name and address of employer responsible for the plant.
2. Identification and location of the LEV plant, process, and hazardous substance concerned.
3. Date of last thorough examination and test.
4. Conditions at time of test: normal production or special conditions (eg maximum use, stood down).
5. Information about the LEV plant which shows:
a) its intended operating performance for controlling the hazardous substance for the purpose of Regulation 7.
b) whether the plant now still achieved the same performance.
c) if not, the repairs required to achieve that performance.
6. Methods used to make the judgement.
7. Date of examination and test.
8. Name, designation and employer of person carrying out examination and test.
9. Signature or unique authentication of person carrying out examination and test.
10. Details of repairs carried out.

CONCLUSION

The primary function of inspection and measurements made on a ventilation system is to ensure that the system continues to operate in the way it was designed to. Records should be kept, not just because the COSHH Regulation require it, but because these are essential in setting a standard with which to work. They will be useful in identifying weaknesses in the system and in showing up a gradual decline in performance, enabling a more efficient management of the system.

REFERENCES

1 Control of Substances Hazardous to Health Regulations 1988 (SI 1988 No 1657)

2 Controlling airborne contaminants in the workplace, BOHS Technical Guide No 7, Science Reviews Ltd, 1987
3 An introduction to local exhaust ventilation, Health and Safety series HS(G) 37, HMSO 1987
4 Control of Lead at Work Regulations 1980 (SI 1980/1248)
5 Control of Asbestos at Work Regulations 1987 (SI 1987/2115)
6 Specification for Microbiological Safety Cabinets, BS5726:1979 BSI
7 Draft for Development: Method for determination of the containment value of a laboratory fume cupboard, DD191:1990, BSI
8 Laboratory fume cupboards, BS7258:1990, BSI