# A Guide to Understanding Ventilation Systems.

Control of Substances Hazardous to Health Regulations 2002

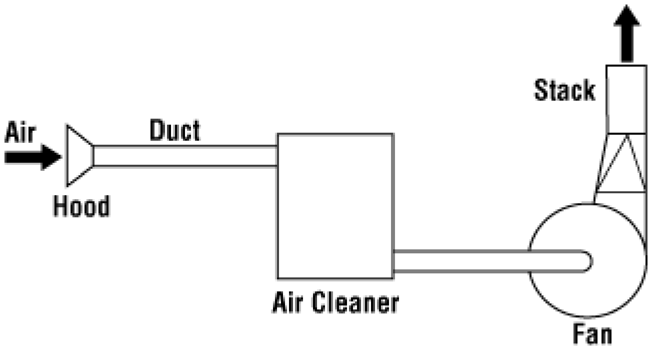
ROHSS
Rundell Occupational Health & Safety Services

**A guide to understanding ventilation systems.**

This document has been compiled to address and differentiate between Local Exhaust Ventilation Systems, Dilution Ventilation Systems and Emergency Control Systems. This document is not a definitive guide and should be read in conjunction with the most recent edition of the Control of Substances Hazardous to Health Regulations.

**Introduction to Local Exhaust Ventilation**

An LEV is a system that uses extract ventilation to prevent or reduce the level of airborne hazardous substances from being breathed by people in the workplace. LEV draws pollutants away from a process or operation that is likely to release a hazardous substance into the air and which consists of an inlet, such as a hood, slot, booth or cabinet placed around or close to the point of release of the substance. This device is connected via ducting to the inlet of a fan or air mover. The extracted air is usually discharged to the atmosphere or returned elsewhere in the workplace, having first been cleaned to make it safe for release.




**Basic components of a local exhaust system**

LEV has an important role to play within the hierarchy of control measures required by the Control of Substances Hazardous to Health Regulations (COSHH). Although it should always be remembered that COSHH strictly requires exposures to hazardous substances to be prevented and control measures only to be introduced where prevention is not reasonably practicable to achieve.

There are two main methods of ventilation, which can be used to control airborne contamination:

**Dilution Ventilation**

Dilution ventilation provides a flow of air into and out of the working area and does not give any control at the source of the contamination. Where the quantity of contaminant is small, uniformly evolved and of low toxicity, it may be possible to dilute the contaminant by inducing large volumes of air to flow through the contaminated region.

Dilution ventilation is most successfully used to control vapours from low toxicity solvents, but is seldom successfully applied to dust and fumes.

**Examples of Dilution Ventilation**

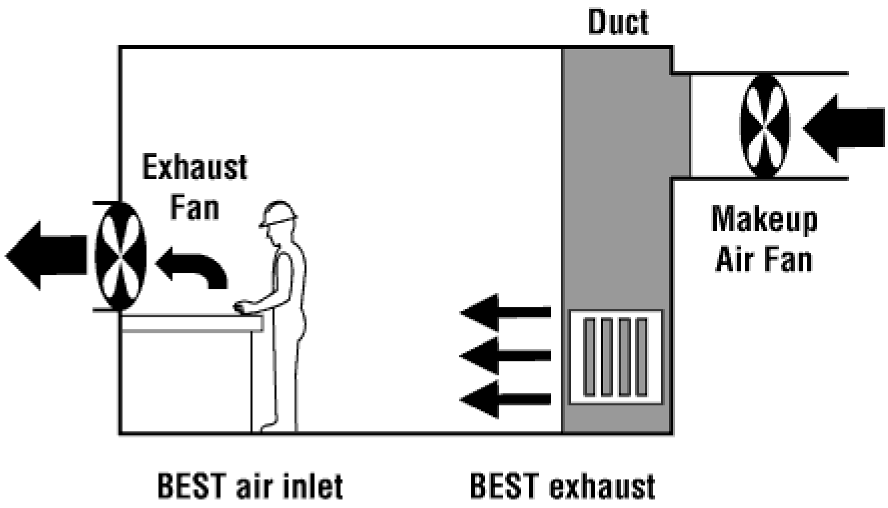



Figure 1

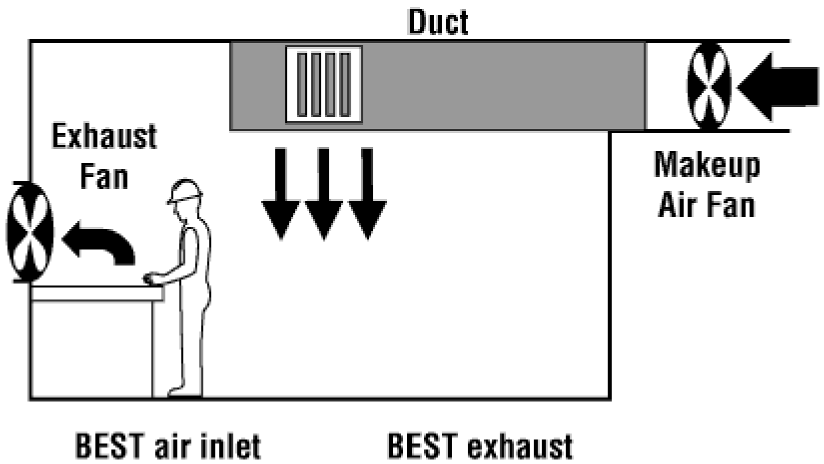



Figure 2

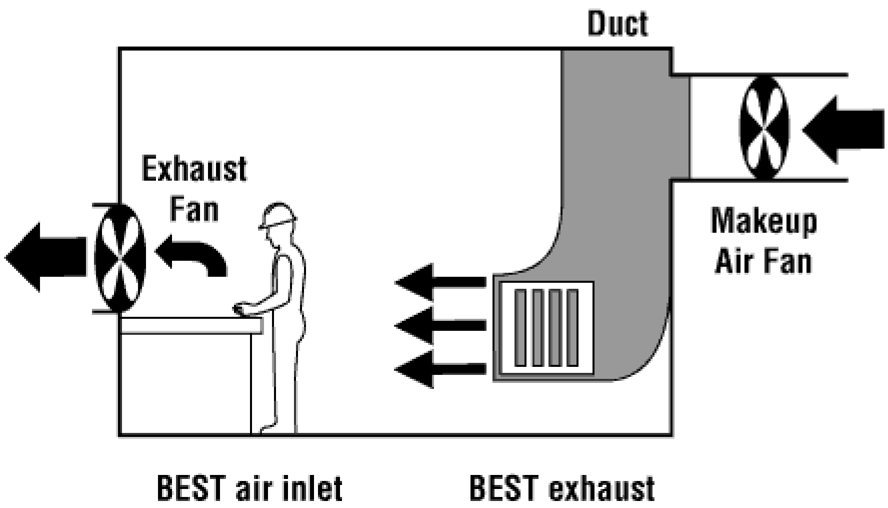



Figure 3

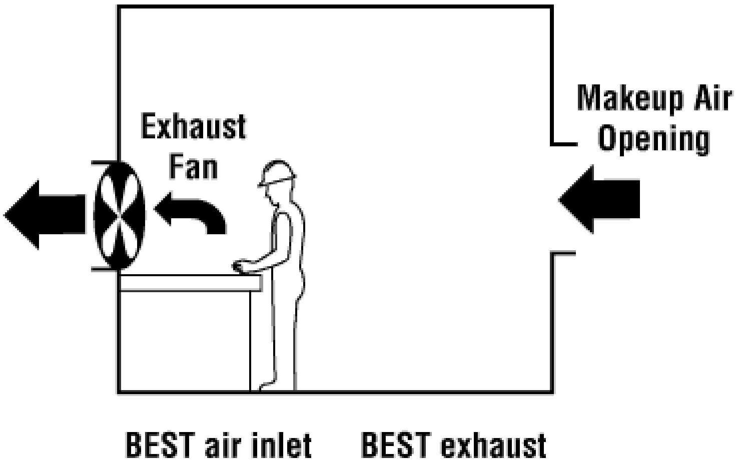



**Figure 4**

**Figures 1 to 4: Examples of recommended dilution ventilation**

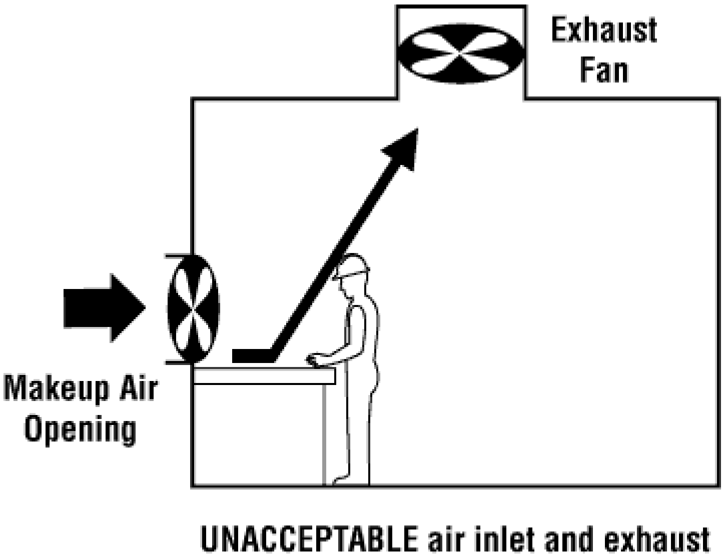



**Figure 5**
**Example of not recommended dilution ventilation**

## Local Exhaust Ventilation System

LEV intercepts the contamination as soon as it is generated and removes it from the workplace before it can be inhaled.

It is important to consider how the air withdrawn from a workplace by a large LEV system is to be replaced and also, if necessary, re-heated. Where re-circulation is involved, it is important to ensure that effective filtering is in place in order that all hazardous contamination is removed from the re-circulated air.

### Design

When designing an effective LEV system, account must be taken of the nature and size of the airborne contaminates that need to be removed. For example, are they dusts, fumes, smoke, mists, vapours or gases?

**Inlets**

Consideration needs to be given to:

- The size, shape and position of the contaminant source.
- The physical nature of the contaminant.
- The speed and direction of the contaminant as it moves away from the source.
- The rate of generation of the contaminant.
- The nature of the operation being carried out.
- The position and movement of the plant or person involved.
- And local air movements due to general ventilation and the operation of nearby machinery.

It needs to be remembered that inlets can only exert effective control at points fairly close to the inlet itself. Therefore the inlet needs to enclose the source as far as possible if good control is to be achieved. Although, in practice, a compromise has to be reached when constant access to the work is required.

**Classification of LEV hoods**

Hoods have a wide range of shapes, sizes and designs.

While they may look similar, they control contaminant clouds in three different ways. The classification' of hoods highlights their essential features and they fall into three basic categories:

- ■ Enclosing hoods;
- ■ Receiving hoods; and
- ■ Capturing hoods.

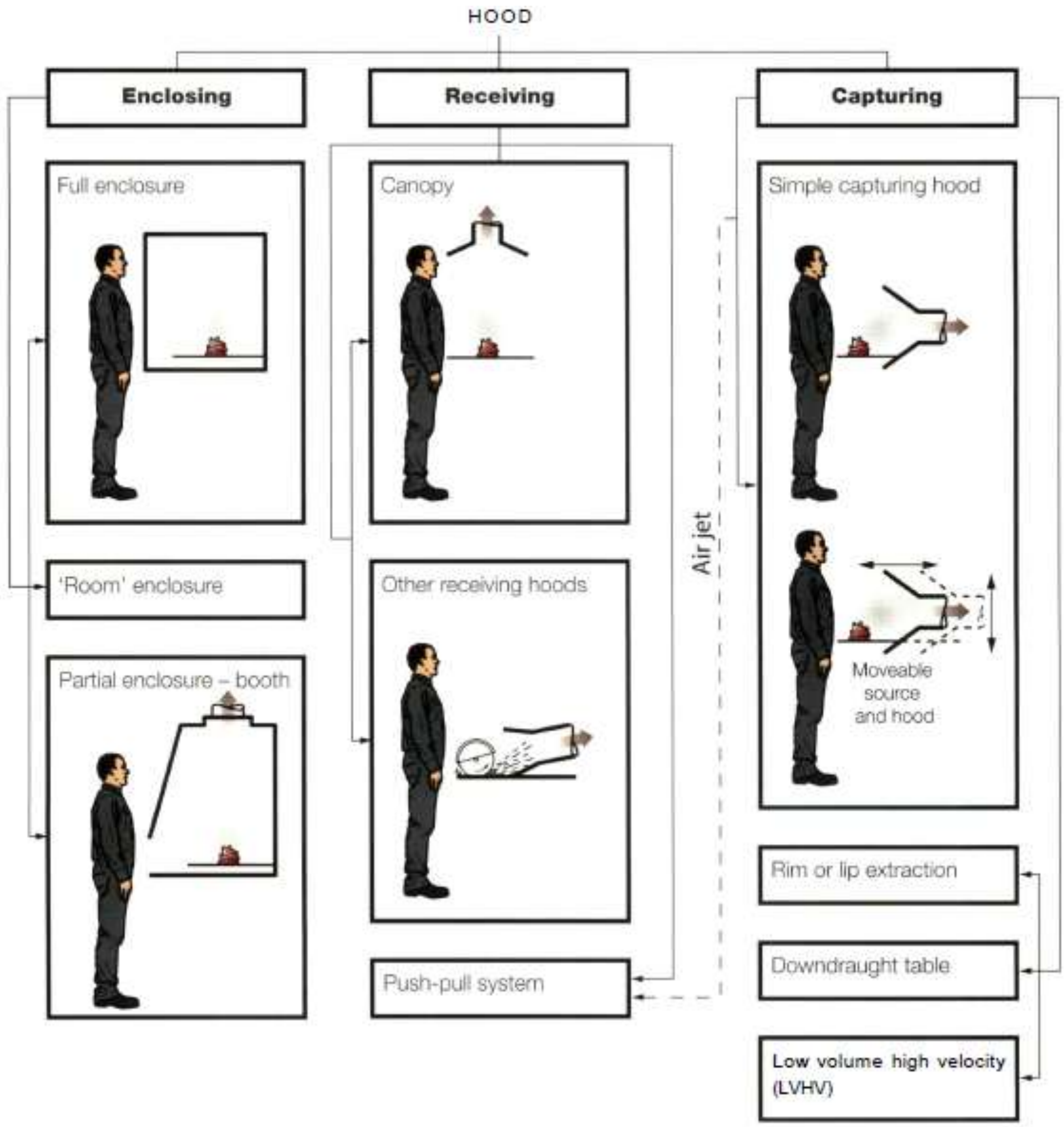



Figure 10 Classification: Types of LEV hood

The three main types of inlet are enclosing, receiving and capturing.

- With partial enclosures the source of contamination is located inside the enclosure. Airflows from the open face of the enclosure and across the source, to extract openings located in the rear, top or bottom of the enclosure.
  - Partial enclosures must be large enough to contain the work and the airflow must be capable of guiding the contaminant towards an exact point once the contaminant

is released into the atmosphere. Along with adequate air velocity the booth must be designed to prevent the contaminant spilling out at the front of the enclosure. As a general principle operators should never be positioned in the airflow path between the source and the opening of the extractor. The airflow in partial enclosures should be smooth and sudden changes in cross-section and protrusions into the enclosure should be avoided as they may lead to local air turbulence. Large-scale turbulence is less likely in deep enclosures than in shallow enclosures.

- LEV hoods should be located as close as possible to the source of contamination and are designed to capture or collect the contaminant and to direct it into the connecting ductwork.
    - LEV hoods vary in size from small nozzles to large canopies and can be positioned above, below or to the side of the source. They should be located close to the source, enclosing it if possible.

There are two main types of LEV hoods: receptor hoods and capture hoods.

- A receptor hood is used where the contaminant is generated with considerable momentum and the hood is placed in the path of the moving airstream to collect and remove the contaminant.
- A captor hood is used where there is no initial tendency for the contaminant to enter the LEV system and the energy required to provide movement in the right direction is supplied by suction at the hood. The minimum air velocity required being termed the capture velocity. Capture velocity and the degree of enclosure are the two most important features of capture hoods. They determine the volume of air that needs to be extracted to give effective control. The lowest volume flow rate will be achieved with a hood design that encloses the source as much as is possible. Due to not being complete enclosures, operator movement and random air currents can be disturbing influences. These effects can be reduced through use of hoods which enclose the source to a high degree.

**Ductwork**

Ductwork needs to be designed so that the air velocity in the duct is high enough to keep the particles suspended in the airstream, particularly with regard to long horizontal runs of ductwork. Runs of ducting should be provided with access holes for internal cleaning and flexible ducting should be frequently inspected for leaks, partial connection and damage.

**Multi Inlet LEV Systems**

LEV systems with more than one inlet need to be designed and constructed so that each branch extracts the right amount of air through the inlet it serves. This involves consideration of airflow distribution and balancing. The airflow in each branch being determined by the resistance of the inlet, the length, diameter and flow resistance of the branch duct and the flow conditions at the junction with the main duct. Standard procedures exist for balancing ductwork.

**Air Cleaners**

Air cleaners can be classified as: air filters particulate dust and fume collectors and devices to remove mists, gas and vapours.

- Filters are mainly used for cleaning air and are designed to handle large air volumes with low resistance to airflow, although high-resistance high-efficiency filters are used for ultra-clean applications and for the control of hazardous dusts such as asbestos.
- Particulate collectors extract large quantities of dust and fume from an airstream at higher inlet dust concentrations than filters. These collectors include: cyclones, fabric filters, wet collectors and electrostatic precipitators. Mists gases and vapours being removed by chemical absorption, combustion or condensation.

When selecting a suitable air cleaner, obviously the features and properties of the contaminant need to be considered. The following points also need to be taken into account: greasy or waxy materials may permanently clog fabric filters, abrasive material may cause problems with fabric filters, flammable and explosive materials require special precautions, corrosive and highly oxidising substances will require special materials of construction and neutralising agents may be needed in wet collectors, some dusts may be difficult to wet, any gas or vapour components will not be removed by particulate air cleaning and filtration systems for hot processes will need to be suitably temperature resistant.

**Fans**

Fans in LEV systems fall into two main categories- centrifugal and axial flow. Although, for special purposes, turbo-exhausters and compressed air driven movers can be used.

- In a centrifugal fan, air is drawn into the centre of the impeller, picked up by the rotating blades and thrown off at high velocity into the fan casing which collects and guides it towards the discharge opening. In this way, airflows can be delivered against considerable resistance. Fans can utilise radial, forward curved and backward curved blades.
- With axial fans, air passes along the duct and is accelerated by the rotating blades. As a result, only low resistance can be overcome and they are mainly used as roof mounted extractor units.

In selecting the correct type of fan, consideration should be given to:

- Required airflow.
- The total flow resistance of the system.
- The type of contaminant.
- The flammability of the contaminant.
- Space limitations.
- The method of fan mounting and the type of drive to be used.
- Operating temperature and the level of noise and the need for silencers.

**Discharge Points**

Buildings have a surrounding 'boundary layer' of air. The objective is to discharge air beyond the boundary layer, and prevent it entering recirculation eddies. The discharge point should be located well above the highest point of a building.

## Commissioning

All LEV systems need to be subject to commissioning to ensure that they are capable of meeting their design specifications.

## Maintenance

Under the Control of Substances Hazardous to Health Regulations all control measures need to be maintained in an efficient state, in efficient working order and in good repair. Maintenance procedures need to include information on: how frequently maintenance needs to be carried out for each component of the system, what maintenance tasks are necessary and how defects are to be detected and remedied, and who is to be responsible for the maintenance. The maintenance procedures should cover the full range of maintenance activities from simple visual checks to detect obvious defects, to major overhauls for preventative and remedial purposes.

## Examination & Testing

In addition to effective preventative maintenance, the Control of Substances Hazardous to Health Regulations and other regulations contain statutory requirements for the undertaking of formal examination and testing of LEV systems. It may be prudent for these examinations to be carried out by persons not normally responsible for the system maintenance in order that an independent second opinion can be obtained. For effective examination and testing ***comprehensive information on the system and its design specification needs to be provided, this is usually known as the Intended Operating Performance Data.*** HSG258 does still refer to the IOP but more emphasis has been placed on the commissioning requirements, commissioning reports, log books etc. Clause 277 of HSG258:

***Technical performance testing***

*277 The LEV commissioner uses various assessment methods. The outcome of observation, testing and measurement is the commissioning report. This sets the benchmarks and standards against which the employer compares the results of statutory testing (see Chapter 10).*

*It also sets the benchmarks for tests in the logbook for the system. The tests include measurements of:*

- *The volume flow rate at various points in the system including hood faces (where appropriate), hood ducts and the main duct;*
- *Static pressures in various parts of the system including hood ducting, and across the filter and fan;*
- *Hood face velocities (where appropriate);*
- *The fan speed, motor speed and electrical power consumption.*

**Examination & Testing (cont)**

The Control of Substances Hazardous to Health Regulations require the thorough examination and testing of LEV systems at least once every 14 months.

However, more frequent thorough examination and testing is required in the following processes:

| Process | Frequency (Minimum) |
|---|---|
| Where blasting is carried out in or incidental to the cleaning of metal castings in connection with their manufacture | 1 month |
| Jute cloth manufacture | 1 month |
| Processes, other than wet processes, in which metal articles (other than gold, platinum or iridium) are ground, abraded or polished using mechanical power, in any room for more than 12 hours per week | 6 months |
| Processes giving off dust or fume in which non-ferrous metal castings are produced | 6 months |

When deciding the frequency of thorough examination and testing:

- Treat parts of equipment such as the machine casing and guards as LEV if they are directly ventilated and if one of their functions is to control emissions.
- Regard make-up air systems that replace exhausted air as LEV if they are an integral part of an exhaust system.
- Treat flues from furnaces, ovens etc, as LEV where the draught created by the flue is necessary to control the release of hazardous substances.
- And only treat vacuum cleaners as LEV if they are connected to a portable machine or tool.

The Control of Substances Hazardous to Health Regulations specify that records be kept of the results of the tests including details of any repairs carried out as a result of the examination and tests, these records being kept for a minimum of 5 years.

Maintenance and thorough examination and testing need to be planned together in 3 stages:

1. Initial appraisal.

2. Regular maintenance including frequent visual inspections, perhaps daily, weekly or monthly.

3. Thorough examination and testing.

**Examination & Testing (cont)**

The information required while carrying out the above includes:

| Component | Detail |
|---|---|
| Enclosures and Hoods | Maximum number in use at one time. Location and position. Static pressure behind each hood or extraction point. Face velocity. |
| Ducting | Dimensions. Transport velocity. Volume flow rate. |
| Filter and Collector | Specifications. Volume flow rate. Static pressure at inlet, outlet and across the filter. |
| Fan or Air Mover | Specifications. Volume flow rate. Static pressure at inlet. Direction of rotation of fan. |
| Systems which return exhaust air to the workplace | Filter efficiency. Concentration of contaminant in the returned air. |

Regular inspection and checking of LEV is not the same as the thorough examination and testing.

The aim of inspection and testing being to identify potential problems so that they can be rectified before performance deteriorates. Weekly visual checks should be carried out to identify any obvious defects, although these may need to be more frequent where certain hazardous substances are involved.

The inspection and checking should cover:

- Ensuring that the LEV is always running when hazardous substances are either being emitted or are likely to be emitted.
- Observing the condition of the suction inlet such as the hood or booth to see if it has moved or been damaged.
- Observing the condition of any visible ductwork etc, observing any evidence of control failure such as unusual dust deposits or stronger odours than usual.
- Observing any local instrument fitted to the LEV to indicate its performance and undertaking any minor servicing such as the emptying of filter bins etc.
- A formal system for dealing with verbal reports from employees should be in place in order that details can be recorded into maintenance reports.

Thorough examination and testing of a LEV system represents a regular audit of the performance of the system and should reveal whether or not the plant is performing correctly and effectively, although it may not reveal the precise cause of the unsatisfactory performance that has been identified.

**Examination & Testing (cont)**

The thorough examination and testing will comprise of:

- Visual checks.
- A measurement of plant performance and an assessment of control.
- An assessment of the performance of the air cleaner or filter where the air is recirculated.

The most common categories of instruments and techniques used for the examination and testing of LEV systems are:

- Direct measurement of emissions through air monitoring (in the breathing zone close to the source).
- Measurement of plant performance (static pressure and air velocity).
- Visualisation techniques (smoke generators and dust lamps).

The type of information kept in the record for a thorough examination and test should include:

- The conditions of the LEV system at the time.
- The intended performance of the LEV system and the way it should be used.
- Methods used to judge the performance of the LEV system.
- Whether it achieves the intended performance.
- Results of routine ventilation measurements.
- Results of tests of the concentration of airborne material.
- Request for remedial action with details of repair or modifications needed.
- The record should be kept for 5 years with a copy being available at the workplace in which the LEV is located.

**Emergency Extraction Control Systems**
Emergency extraction control systems such as Carbon Dioxide extraction fans are controlled by Carbon Dioxide and Oxygen Deficiency Sensors located in the working area. These systems usually only operate in an emergency or alarm situation where dangerous levels of the gas are present, we would not consider this type of system to require inspection under the COSHH Regulations as it is actually an Emergency Control System and not a Local Exhaust Ventilation System.
However the following should be considered in a COSHH Risk Assessment, which may result in the system being deemed to be a LEV.

***COSHH Regulations Paragraph 26 (g)***
*26. When deciding whether substances used or produced in the workplace are covered by the COSHH, employers should also-consider the following.*
*(g) One-off, emergency situations arising out of the work activity, such as a dangerous chemical reaction or fire which could foreseeably produce a substance hazardous to health.*

**Emergency Extraction Control Systems (cont)**

We would however recommend that the sensors and the extraction system are included in a servicing and calibration contract, which should involve testing on a regular basis. Where any doubt exists it may be prudent to arrange an examination of the engineering controls

Further Information.

HSE Publications

HSG258 – Controlling airborne contaminants at work.
A guide to local exhaust ventilation (LEV).

HSG202 – General Ventilation in the Workplace: Guidance for Employers.

EH40 – Workplace Exposure Limits.

L142 - Chemicals (Hazard Information and Packaging for Supply) Regulations.

L5 - Control of Substances Hazardous to Health Regulations.

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