

# **PETRONAS TECHNICAL STANDARDS**

## **HEALTH, SAFETY & ENVIRONMENT**

### **LOCAL EXHAUST VENTILATION (LEV) EXAMINATION & TESTING (GUIDELINE)**

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This new PTS 60.1501.09 LOCAL EXHAUST VENTILATION (LEV) EXAMINATION & TESTING ES has been developed to give a step-by-step direction on how to conduct LEV Examination & Testing to comply to the Use and Standards of Exposures of Chemicals Hazardous to Health (USECHH) Regulations 2000.

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| Chap No. | Sect No. | Description                                                                                  | Issue No. | Date     | Rev No. | Date | App by: (initial) |
|----------|----------|----------------------------------------------------------------------------------------------|-----------|----------|---------|------|-------------------|
| All      | All      | New - PTS 60.1509 Local Exhaust Ventilation (LEV) System Examination and Testing (Guideline) | 1         | Apr 2008 | 0       | 0    | IGA               |

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## 1.0 INTRODUCTION

1. This guidance provides advice to employers and others who operate, service and maintain local exhaust ventilation (LEV) systems. Local exhaust ventilation (LEV) is commonly used to control the release of hazardous airborne substances from a process into the workplace environment. The objective of LEV is to control the emission as close as possible to the point of release, and prevent it from entering the air of the workplace (HSE, 1998).
2. To be effective, LEV must be well designed and constructed, properly used and maintained in good condition. Maintenance is especially important when handling materials that are abrasive or corrosive, and there is also a danger that ducts, filters or other parts of the LEV system may become blocked, all of which impair performance and effectiveness. For this reason, legislation requires that they should be well maintained and thoroughly examined and tested at regular intervals (HSE, 1990).

### 1.1 Scope

1. The guidelines in this document are applicable to all Operating PETRONAS Units (OPUs) where LEV system is provided to control the exposure to substances hazardous to health regardless of the hazard category of the facility.

### 1.2 Definitions

1. Local Exhaust Ventilation systems are used to capture or remove the contaminant at or near to the sources.
2. There are two categories of LEV hood systems: enclosure hoods (complete enclosure/ partial enclosure) and exterior hoods (slot hoods, nozzle hoods). The complete enclosure hood involves the total enclosure of a particular machine or operation. The enclosure or housing is designed to allow make-up air into the housing and to limit openings to the minimum required. The partial enclosure may be large enough to be a “walk in” type that limits the spread of fumes and has one face open, for instance a fume hood cupboard or a spray booth. The exterior hood is without an enclosure to capture the adjacent contaminant from the source [HSE, 1998].

### **1.2.1 Individual LEV equipment is defined as follows:**

#### **1. Fume Cupboard:**

A partially enclosed workspace that limits the spread of fume to operators and other personnel. It is ventilated by an induced flow of air through an adjustable working aperture which contains/limits the release of fumes from the enclosure and by means of an exhaust system, provides for the removal or release of fumes remotely and safely.



**Figure 1: Fume Cupboard**

## 2. Booth:

A partially enclosed workspace (which may be large enough to be a “walk in” type) that limits the spread of fumes and has one face open. It is ventilated by an induced flow of air, through the open face, that contains the contaminants within the booth and, by means of an exhaust system, provides for the removal or release of fumes remotely and safely.



**Figure 2: Spray Booth**

## 3. Process Box:

A partially enclosed workspace that limits the spread of contamination to operators and other personnel. It is ventilated by an induced flow of air through a number of adjustable working apertures which contains/limits the release of fumes from the enclosure and, by means of an exhaust system, provides for the removal or release of fumes remotely and safely.

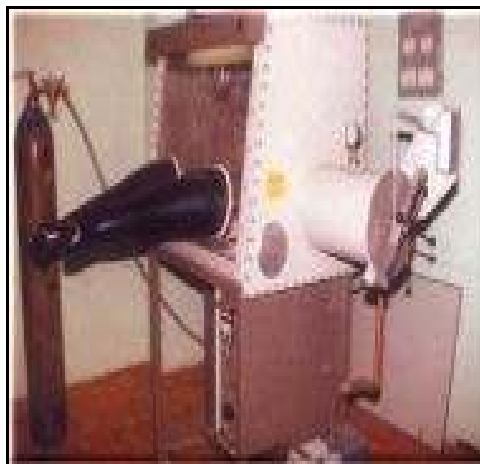


**Figure 3: Glove Box**

#### 4. **Canopy:**

A collection device (not classed as a fume cupboard, booth or process box) located above a process (and covering the plan area of the process) which entrains and draws contaminants having an initial tendency for upward vertical movement into the device (usually from a hot process) and, by means of an exhaust system, provides for the release of contaminants remotely and safely.



**Figure 4: Canopy Hood**

#### 5. **Slot:**

A horizontal slot type suction collection device located alongside a process where the suction pressure at the device generates an inward air flow which entrains contaminants having an initial tendency for movement and draws the contaminants into the device and, by means of an exhaust system, provides for the removal or release of contaminated air remotely and safely. There are two forms: Extract Slots and “Push-pull” Slots.



**Figure 5: Slot Hood**

#### 6. **Nozzle:**

Small circular, oval or rectangular cross section type suction collection devices located adjacent to a process where the pressure at the device generates an inward air flow which entrains any contaminants into the device and, by means of an exhaust system, provides for the release of contaminated air remotely and safely.



**Figure 6: Nozzle**

### 1.3 Components of an LEV system

1. LEVs have five basic components (Figure 7): the hoods or intake, the ducts, the air cleaners, the fans and the outlet or exhaust.
2. The local exhaust hoods are the point of entry to capture the contaminants from which the ductwork connects the suction inlet to the point of discharge, while incorporating other hardware to increase efficiency of the system.
3. The air cleaning devices remove the contaminants from the flow stream while the purpose of the fan is to move air through the systems.
4. The final stage is to release the air flow from the systems to the atmosphere (ACGIH, 1998; Nims, 1999; Hughes, 1992).

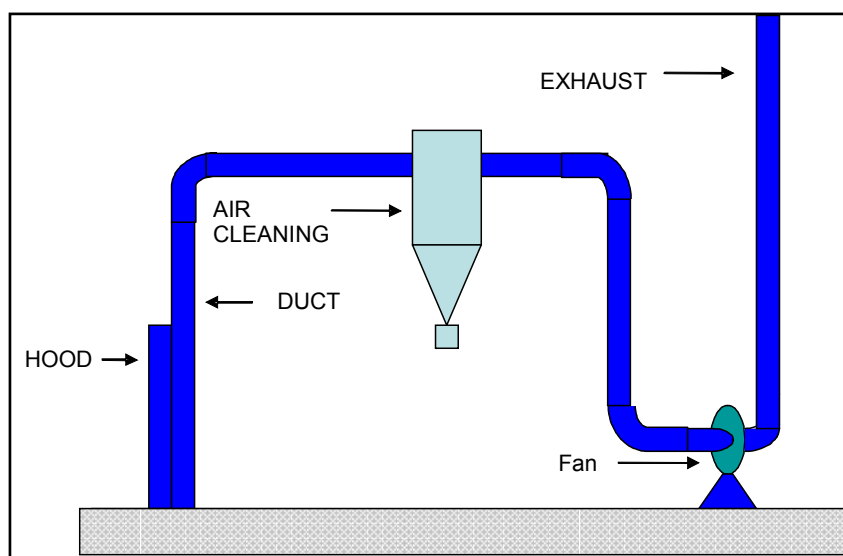


Figure 7: LEVs basic components

#### 1.3.1 Hoods

1. There are two categories of LEV hood systems, enclosure hoods (complete enclosure/ partial enclosure) and exterior hoods (slot hoods, nozzle hoods).
2. The complete enclosure hood involves the total enclosure of a particular machine or operation. The enclosure or housing is designed to allow make-up air into the housing and to limit openings to the minimum required.
3. The partial enclosure may be large enough to be a “walk in” type that limits the spread of fumes and has one face open, for instance a fume hood cupboard or a spray booth.
4. The exterior hood is without an enclosure to capture the adjacent contaminant from the source.

5. Different types of LEV hoods are used depending on the work process involved, although other factors are important in ensuring the effective function of LEV performance. These include the location of the hood in relation to the job, the direction of airflow and the type of material used to make the hood (ACGIH, 1998).

### **1.3.2 Ducts**

1. The duct systems that connect the hoods transport the contaminated air, either gases or particulates, to the exhaust system.
2. A minimum duct velocity is required to transport the material through the duct. The duct velocity is required to prevent settling and plugging of particulates in the duct.
3. Ducts are constructed of black iron, galvanized metal, vinyl chloride polymer and copolymer, vinylidene chloride, aluminium and stainless steel.
4. The choice of construction material depends on the process involved. In the ducting, two components cause restriction of the airflow resulting in a total pressure loss in the duct: frictional losses and fitting losses.
5. The frictional losses are the "losses due to friction in the ducts and are a complicated function of duct velocity, duct diameter, air density, air viscosity, and duct surface roughness".
6. The fitting losses are produced in a duct run by elbows and branches. Thus, the design of the ducting system is important in ensuring effective LEVs (ACGIH, 1998).

### **1.3.3 Air cleaning devices**

1. Air cleaning devices remove the contaminants from the LEV systems. The collectors can be either for particulate or gaseous contaminants.
2. For particulate contaminants, there are two types of air cleaning devices: air filters and dust collectors.
3. Air filters are designed to remove low dust concentrations in ambient conditions, for instance, cotton, polyester, acrylic, nylon, teflon, fiberglass, polyester, polyimide, polypropylene and vinyon. Normally, they will be used for heating, ventilating, and air-conditioning systems.
4. Dust collectors are usually designed to remove large amount of contaminants from the air or gas stream. These are electrostatic precipitators, fabric collectors, wet collectors and dry centrifugal collectors.
5. For gaseous contaminants, the collectors are, for example, absorbers, adsorbers, thermal oxidizers, direct combustors and catalytic oxidizers (ACGIH, 1998).

#### **1.3.4 Air moving devices**

1. There are two types of air moving devices: ejectors and fans. The most commonly used is the fan.
2. Fans create the pressure difference that makes the entire system work. Fans can be divided into axial, centrifugal and special types. Normally, the axial fans are operated at higher flow rates and lower resistances. The centrifugal fans are operated at lower flow rates and higher resistances.
3. Ejectors operate at low efficiency and tend to be reserved for special material handling, such as air streams containing corrosive, flammable, explosive or hot materials. Ejectors use a compressed air supply to transport the contaminant to the discharge (ACGIH, 1998).

#### **1.3.5 Exhaust system**

1. Most industrial effluents are discharged as contaminated air or gas through an exhaust stack or duct after treatment. Thus, the final component of an LEV system is the exhaust stack.
2. The importance of the exhaust stack is to provide sufficient dispersion of the plume so as to allow sufficient reduction of the exhaust plume concentration before it reaches the ground (ACGIH, 1998).
3. The stack velocity should be at least 1.5 times the wind velocity to prevent downwash around the stack and to avoid reverse flow down the stack from wind pressure (ACGIH, 1998). A good stack velocity is 15 m/s to prevent downwash for winds up to 10 m/s (ACGIH, 1998).
4. The height of stack is 3 m above the highest point and the stack location is 15 m from air intakes (Burton, 2003).
5. The exhaust system installation shall obtain a written approval from the Director General of Environmental Department.

## 2.0 LEGAL REQUIREMENTS

1. The Use and Standards of Exposure of Chemicals Hazardous to Health Regulations 2000 (USECHH), regulations 17 and 18 of USECHH requires all control measures to be properly maintained and the regular examination and testing of engineering controls including LEV. It specifies that (DOSH, 2000):
2. Any engineering control equipment provided shall be:
  - a. Inspected at an appropriate intervals by the employer, each interval being no longer than one month
  - b. Examined and tested for its effectiveness by a hygiene technician at appropriate intervals, each interval being no longer than twelve months
3. Every engineering control equipment shall be maintained and operated at all times while any machinery or plant is in operation
4. Design, construction and commissioning of LEV equipment shall be:
  - a. Designed according to an approved standard by a registered professional engineer and constructed according to the design specifications
  - b. Tested by a registered professional engineer after construction and installation to demonstrate that the equipment meets the design specifications

### 3.0 PROCEDURE

1. The ultimate function of the maintenance, examination and testing of LEV system is to ensure that it continues to operate as originally intended and to effectively capture and safely dispose of released hazardous substance. Maintenance and thorough examination and testing need to be planned together in three stages (HSE, 1998; HSE, 1990):

#### 3.1 Initial testing:

1. The initial testing of LEV system serves two functions:
  - i. to show that the LEV system effectively captures and disposes of emissions from the start, and meets its specified performance.
  - ii. to determine operating criteria i.e. air velocities, static pressures and filter or fan specification.
2. For new LEV, the testing will be carried out soon after, or simultaneously with, the commissioning of the LEV. It may be necessary to allow the plant to settle into normal operating conditions for a short period before the initial testing is carried out to ensure that the results obtained are valid to use as a baseline. The baseline to proof of performance of LEV commissioning i.e. design within  $\pm 10\%$  is considered acceptable (ACGIH, 2004).
3. For existing LEV system, a testing will be required if it has not already been done and subsequently if modifications or changes to the LEV system or the process itself are likely to alter its performance or effectiveness.
4. If the testing shows that performance of the LEV system is not satisfactory, any defects or failures should be remedied and the testing should be done again.
5. The following steps outline the recommended procedure and the minimum data necessary for a thorough initial testing (Appendixes 1, 2, 3, 5, 6, 7 & 8):
  - a) Review the system specification and drawings i.e. construction & layout drawings to determine the relative location and sizes of ducts, fittings, and associated system components that shall be endorsed by Professional Engineers.
  - b) Inspect the system to determine that its installation is accordance with the specifications and drawings. Check such items as fan rotation, belt slippage, and damper settings.
  - c) Include the system isometric diagram of the system, annotated with appropriate equipment information and startup values of airflow and static pressure at all test points after system balance.

- d) Measure the volumetric flow rate, fan static pressure, fan speed, motor speeds and motor amperes, noise (65 dBA maximum level) (OSHA, 2000) and lighting (> 400 Lux) for fume cupboards (BS, 1994).
- e) Record the test data and design specifications on the data sheet.
- f) Compare the test data with design specifications ( $\pm 10$  % from the baseline value) (ACGIH, 2004). Determine if alterations or adjustments of the system are necessary to meet specifications, codes, or standards.
- g) If alterations or adjustments are made, retest the system, and record the final test data. On the drawing, note any physical changes that were made in the system as explained in section 3.1.1.2.
- h) LEV equipment should be registered in maintenance management system (e.g. SAP system) for preventive maintenance schedule i.e. fan, motor and filter
- i) All LEV information as Appendixes 1 & 8 shall be submitted to the owner for record purposes.

### 3.2 Maintenance

1. LEV systems consist of four types of component (HSE, 1998; HSE, 1990):
  - a) Static items i.e. rigid ducts and hoods which should not wear unduly with time unless mechanically damaged by external materials and/or worn or corroded by materials carried in the duct.
  - b) Moving items that wear more quickly i.e. fan and motors.
  - c) Components which deteriorate with use i.e. filter and flexible duct.
  - d) Items that may need frequent attention i.e. filter bins and collector.
2. The maintenance program should anticipate potential problems and ensure that the LEV system continues to attain acceptable standards of performance and to control emissions effectively. Effective maintenance should include (Tables 2, 3 & 4):
  - a) Regular inspection of the LEV check for signs of potential damage, wear or malfunction (Table 1).
  - b) Monitoring of performance indicators (Appendix 1) i.e. air velocity and static pressure. Take trouble shooting action if more than  $\pm 10$  % from the baseline of static pressure (ACGIH, 2004).
  - c) Routine replacement of components known to have a limited useful life.
  - d) Prompt repair or replacement of components which are found to be worn or damaged.

Table 1: Typical causes of failure due to damage or inadequate maintenance (other problems may occur due to inadequate design, installation or commissioning)

| CAUSE                                                                                                                                                                                                      | EFFECT                                                                                                                                                                                                                                                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Exhaust hoods, booths etc</b><br>-Physical damage<br>-Blockage of ports/closed dampers<br><br>-Poor positioning                                                                                         | -Loss of enclosure and of control<br>-Reduced air flow and control. Partial blockage may cause flow imbalance and localized turbulence<br>-Poor control                                                                                                                                                                                    |
| <b>Ductwork</b><br>-Physical damage or wear<br><br>-Blockage                                                                                                                                               | -Loss of air volume and hence of control; if the duct is pressurized it results in escape of pollutant<br>-Reduced air flow and loss of control; in extreme cases the duct may collapse                                                                                                                                                    |
| <b>Dust collectors and filter</b><br>-Blockage or blinding of filters and dry collectors<br><br>-Damaged, unsuitable or incorrectly installed filters<br>-Incorrect operation of filter cleaning mechanism | -Reduced air flow and control; it occurs with age but can be accelerated by high filtration velocity, dampness and certain pollutants and necessitates the replacement of the filter or collection medium<br>-Carry-over of pollutant; it necessitates a change of filter or collection medium seals<br>-Results in blocked/blinded filter |
| <b>Carbon filters</b><br>-Filter saturation                                                                                                                                                                | -Results in failure to trap pollutant                                                                                                                                                                                                                                                                                                      |
| <b>Fans</b><br>-Wear or corrosion of blades and build-up of contaminant on blades<br><br>-Slipping drive belts<br><br>-Inadequate lubrication of bearings                                                  | -Causes alteration of the blade shape, loss of efficiency of the fan, and reduction in air flow. Severe vibration and damage to bearings and direct drive motors<br>-Results in reduced fan speed and reduction in air flow<br>-Results in noisy operation, overheating and eventual failure                                               |

- Regular inspection and checking of LEV is not the same as the thorough examination and testing. Its primary function is to identify potential problems so that they can be rectified before they lead to a deterioration of the LEV performance.
- A visual check on each shift or daily, the periodic monthly or quarterly are essential to identify obvious defects (Tables 2, 3 & 4).
- Where the inspection or monitoring reveals a serious underlying problem or where there is a reason to believe that the LEV is no longer operating to specification or adequately controlling emissions immediate repairs should be made.
- If necessary, a more detailed investigation should be carried out of the performance of the LEV, and its effectiveness. If other measures are not reasonably practicable, then respiratory protective equipment will be needed.