HSE
Health and Safety Executive

The dust lamp

A simple tool for observing the presence of airborne particles

MDHS82/2

Methods for the Determination of Hazardous Substances

Health and Safety Laboratory

Scope

1 This guide is written for occupational hygienists, ventilation engineers, health and safety practitioners and others interested in how exposures to airborne particles occur. It briefly explains the principles of the dust lamp, its use in observing the presence of airborne particles, and identifies its advantages and limitations

2 The presence of many different types of particles, both solids (eg dusts, fumes and fibres) and liquids (organic or inorganic mists), can be revealed by the dust lamp. However, it does not give a quantitative measure of either particle concentration or size.

Summary

3 In the absence of effective control measures, airborne particles are released into the workplace atmosphere by many industrial processes. Such particle clouds can be invisible under normal lighting conditions, but may be made visible by the use of a high-intensity beam of light. This technique is commonly referred to as the dust lamp. Use of the lamp enables the existence of particle release at a process to be simply demonstrated, or the performance of an extractor system to be qualitatively assessed.

4 The dust lamp is a simple qualitative tool for making fine particle clouds visible or enhancing the visibility of partially visible clouds. With a certain amount of experimentation, observations can be recorded on still or video film. The dust lamp is a powerful tool in experienced hands and can be used in a variety of ways to gain understanding of how work processes cause exposure or controls fail to prevent emissions. The very fact that the technique makes the invisible visible explains the impact it can have on employers and employees.

Prerequisites

5 The dust lamp is a useful tool in the investigation of processes, controls and exposure but it must be seen in context. It is an occupational hygiene tool that can be applied to exposure and control problems. As with any other occupational hygiene investigation, the user should have a good understanding of the process and work method, and be able to relate dust lamp observations to other occupational hygiene data and findings.

Safety

6 Users of this guide should be familiar with the equipment used and carry out a suitable risk assessment for the particular application. It is the user's responsibility to establish appropriate health and safety practices and to ensure compliance with regulatory requirements.

Principles of use of the dust lamp

7 The main use of the dust lamp is to make fine airborne particles visible (ie particles below ~10µm aerodynamic diameter, usually termed respirable[1]). Some of the important general properties of fine particles can be summarised as follows:

- they move with the air in which they are suspended;
- they settle out of the air slowly and can remain airborne for long periods of time.

8 They can be revealed by the beam of the dust lamp as particles swirling and flowing with the air in which they are suspended. The dust lamp in this context usually shows that particle clouds occupy a far greater volume of air than is suspected.

9 Although the main use of the dust lamp is to make fine airborne particles visible, it can also enhance the visibility of dust clouds containing coarser particles, such as those generated from woodworking operations. Through experience and careful use of the dust lamp it is possible to observe the extent, pattern and direction of a particle cloud's movement.

10 For fine particles, the intensity of the scattered light is greatest at a small angle to the incident light beam, as shown in Figure 1 (the actual values of intensity differ for different dusts and incident light beams and the units are therefore not specified). As the angle is increased, the intensity of the scattered light falls rapidly, consistent with diffraction theory, but at angles greater than about 120° the intensity increases somewhat as the diffracted light is augmented by reflection. For particles smaller than 0.1 µm, scattering by mechanisms other than diffraction occurs and the variation in intensity with angle is reduced; the intensity of the light scattered by such mechanisms is relatively low, however, and is not important in dust lamp use.

11 The curve in Figure 1 was obtained from photometer readings. To the human eye, however, the visibility of the particle cloud depends not only on the intensity of the scattered light (I_s) but also on that of the background (I_b), ie on the contrast, defined as $(I_s - I_b)/I_b$. Thus, if viewing at a small angle results in appreciable background illumination, or exposes the observer to glare from the direct light beam, it may be preferable to view the cloud at a larger angle. In practice, an observer must make a judgement as to the viewing angle that provides maximum contrast between the scattered light and the background.

12 At small viewing angles, the wavelength of the scattered light will be that of the incident light beam, ie a white light will show the dust as white, regardless of the true colour of the dust. At larger viewing angles, however, reflected light may show the true colour of the dust.

13 The greater the intensity of the incident light beam, the greater will be the intensity of the scattered light and the more visible will be the particle cloud; thus the principal requirement for a dust lamp is that it should give a defined beam of high intensity. A parallel or near parallel beam is desirable, so that the intensity does

not fall off rapidly with distance, thus giving a greater range. Such a beam is produced by a parabolic reflector having a small, compact filament at its focus and a plane lens, solely for protection. However, if the narrow beam of a spot lamp does not illuminate a sufficient area it may be necessary to use a divergent beam lamp. The latter usually requires mains power to obtain the necessary illuminance, and may require a dark background to give sufficient contrast.

14 It is difficult to specify a minimum intensity requirement for a dust lamp since this depends on the nature and concentration of the particles, the distance of the lamp from the cloud, the background illumination and the skill of the operator.

Equipment

Battery powered lamps

15 Battery powered lamps are convenient and easy to handle, making them particularly convenient for routine hygiene surveys or when visiting a number of different installations. Most battery powered lamps produce a narrow beam of high intensity light based on the use of a halogen bulb and a parabolic reflector. The limited area illuminated is not usually a problem as the lamp can be readily panned around the area under investigation.

Mains operated lamps

16 These are mostly diverged beam devices providing even illumination over a wide area. The use of this type of lamp enables the whole volume of the particle cloud to be illuminated at the same time.

Still photography and video recording of particle clouds

17 With the use of a still camera (with the flash switched off) or a video camera, permanent records of the observations can be made. The technique of taking good images can be developed by experience and experimentation. However, this should not deter those with a limited knowledge of photography from using the dust lamp.

Practical applications

18 The dust lamp can be used in a variety of ways:

- as a tool to investigate work operations and processes to gain an understanding of the potential for exposure before any air sampling is done;
- where air sampling has demonstrated significant over exposure, as an aid to understanding how and why exposure is occurring; and
- as a tool in investigating the effectiveness of controls during their development in confirming effectiveness after installation and as part of routine monitoring of controls.

19 The method of operation is demonstrated in Figures 2 and 3. A bright beam of light is shone through the area where it is thought a particle cloud may be present. The observer's eyes are shielded from the main beam by means of a flat panel, eg a piece of card, or by using the worker's body or a convenient piece of machinery as a shield. The particle cloud should be observed looking up the beam

towards the source of illumination, preferably at a small angle off the centre line of the beam, and, if possible, against a darker background, for instance a black 'pop-up' background. Dense clouds can be made visible with the dust lamp under normal lighting conditions but to see a small leak, for instance, or to trace the extended movement of a cloud as far as possible, the ambient lighting may need to be suppressed.

20 The four examples of the use of the dust lamp which follow illustrate the diversity of application in terms of particle composition, concentration, particle size and industrial process.

21 The photographs in Figure 4 show a finishing job in a woodworking shop, using a vertical belt sander. The operator is holding the piece of hard wood against a fast-moving sanding belt, and dust particles up to 2 mm in diameter are generated. A LEV system at the end of the table collects most of the dust. (The LEV was shut off during photography to show the technique to good effect.) Figure 4a shows the positions of the camera, the machine and the dust lamp. The camera was shielded from the main beam by parts of the machinery. Using a mains-operated diverging beam, a wide area was illuminated, and a dark background was utilised to enhance the contrast (see Figure 4b and 4c). The technique shows the large volume into which the dust disperses and the swirling motion of the cloud. Some large individual particles can be identified.

22 The second example shows a typical bagging operation in a mineral processing plant. The operator fills a bag with the finely ground mineral by holding it over the filling spout. The feed stops automatically when a pre-set weight has been bagged and the operator then withdraws the bag and tucks in the flap to seal the bag.

23 Clouds of dust are produced during feeding, as the bag is withdrawn from the spout and when tucking in the flap. The particle size (~90% less than 25 μm) of the material made the airborne dust almost invisible under ambient lighting. Figure 5a is a photograph of the operation taken with flash photography which shows no sign of the dust cloud. Figure 5b is a similar shot but this time a narrow beam lamp has been shone from the far side of the operator. A dust cloud within the operator's breathing zone is now clearly visible. When shot from the same side as the lamp (Figure 5c) there is little evidence of the dust cloud apart from reflected light showing up some particulate. For best results, however, the set-up in Figure 5b was repeated but without flash. As shown in Figure 5d, the swirling dust cloud is clearly seen enveloping the operator.

24 The third example (Figure 6) shows the products (tennis balls) of a moulding press where rubber fume is released for a short time when hot. In this process the rubber contained only a small amount of oil so the volume of fume released was low. Using black and white photography and a dark background, the fume appeared as a hazy white cloud hanging above the products. A narrow beam dust lamp was used in this instance. Under ambient light it would be impossible to see such a low-level emission.

25 Solder fume exposure can be visualised using the dust lamp, as shown in Figure 7. In this example, the operator was enveloped in a plume of fume as he was soldering components on an electronic circuit board. The fume was only just visible in ambient light or using flash photography (see Figure 7a).

26 When the process was repeated in reduced light without flash but with a narrow beam dust lamp looking into the main beam at a small angle and using the operator's body to obscure the main beam to get the maximum contrast, the plume of fume appeared like a flame (Figure 7b). For best results, Figure 7c was

taken in identical conditions but with a separate flash unit pointing slightly downward behind the operator's shoulder, acting as an additional wide area dust lamp. The flash was used to freeze the motion of the fume. The photograph revealed the whole volume and detail movement of the fume.

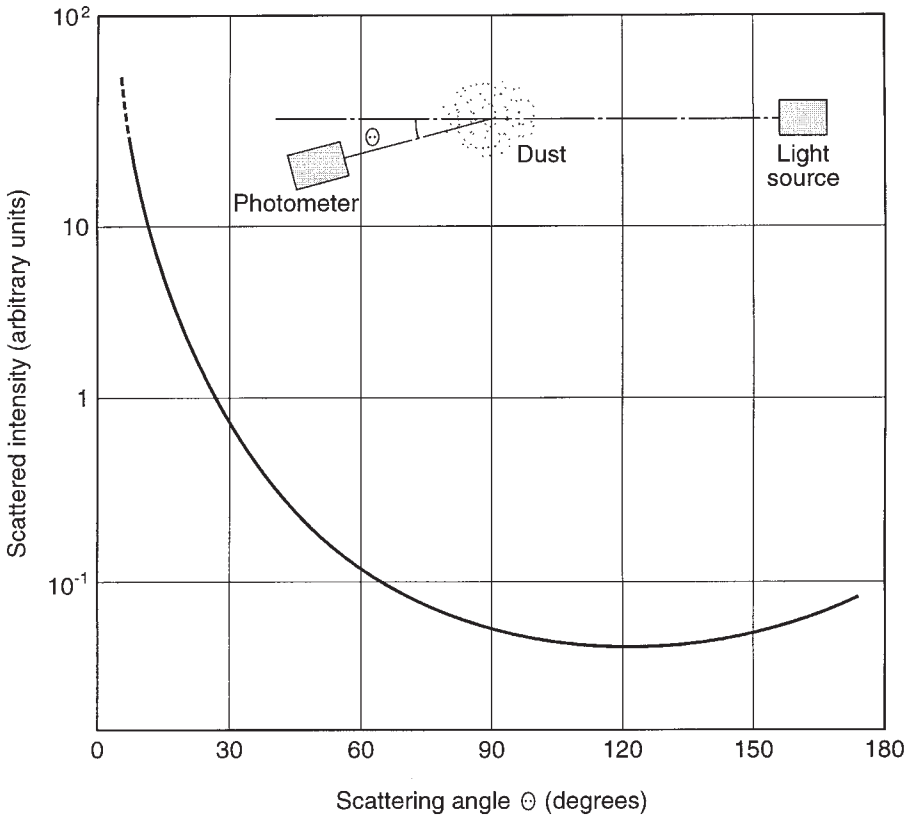

Figure 1 Intensity of scattered light as a function of angle

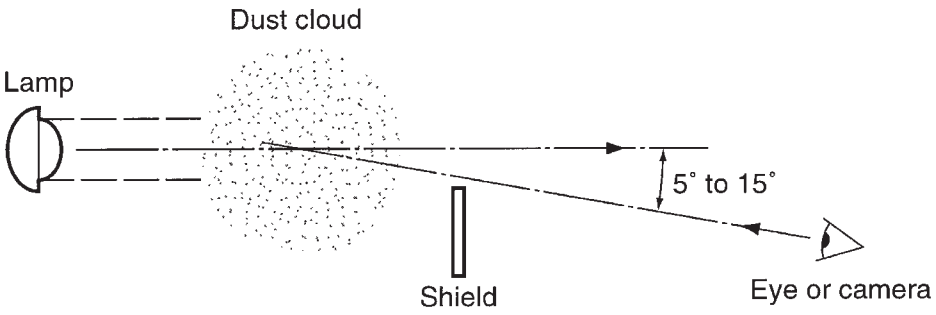

Figure 2 The use of the dust lamp to observe the presence of airborne particles

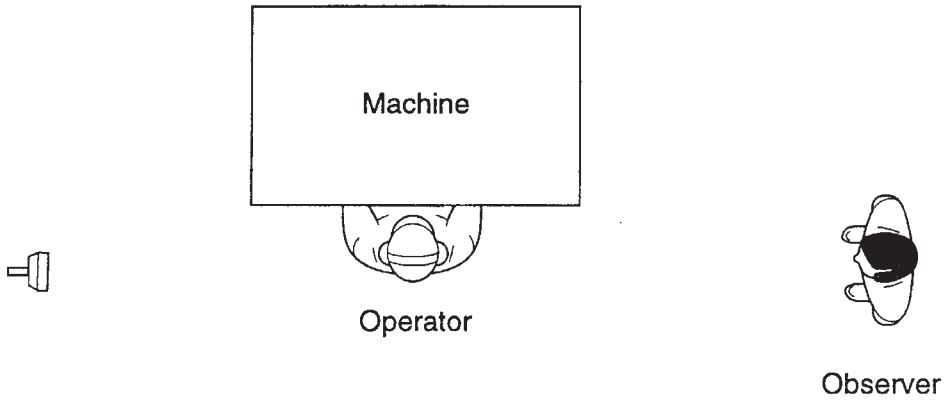

Figure 3 Diagram of an example of the dust lamp in use

Figure 4a The arrangement of the lamp, sanding machine and camera for dust lamp photography, set up on a vertical belt wood sanding machine

Figure 4b Photograph showing dust cloud from the sanding operation

Figure 4c Wood dust cloud from sanding

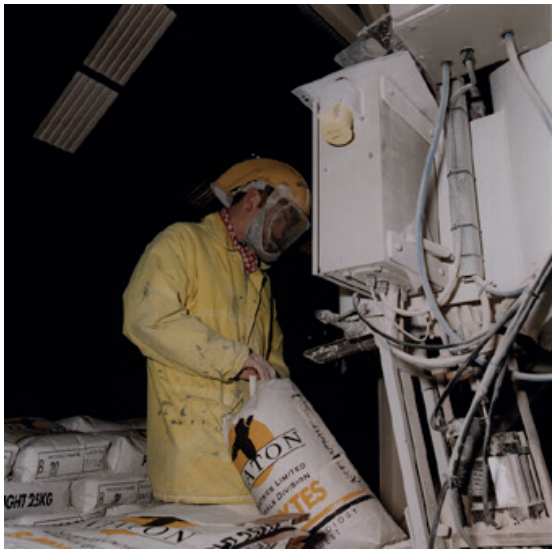

Figure 5a Bagging operation in a mineral processing plant: under ambient light and with flash, dust cloud is not visible

Figure 5b View from small angle towards lamp and with flash: small volume of dust cloud is visible

Figure 5c View from the same side of the lamp and with flash: dust cloud is not visible

Figure 5d View from small angle towards the beam of light and without flash: a dust cloud is clearly seen enveloping the operator

Figure 6 Rubber fume is revealed using the dust lamp

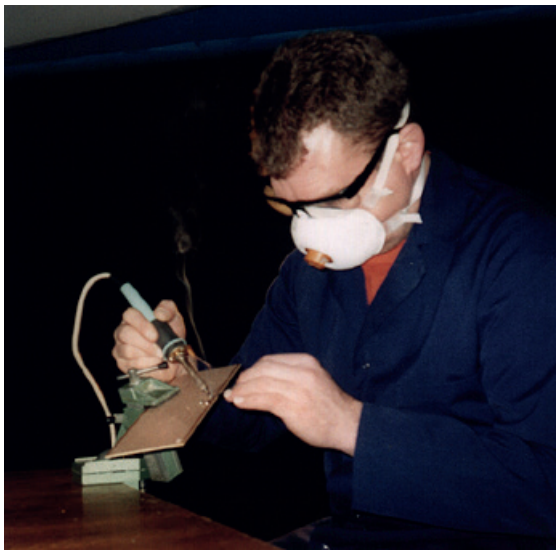

Figure 7a Solder fume viewed under ambient light and with flash

Figure 7b View using dust lamp, under reduced light, without flash

Figure 7c View from small angle of the dust lamp, under reduced light

References

BS EN 481: 1993 *Workplace atmospheres: Size fraction definitions for measurement of airborne particles* British Standards Institution

You should use the current edition of any standards listed.

Further information

For information about health and safety, or to report inconsistencies or inaccuracies in this guidance, visit www.hse.gov.uk/. You can view HSE guidance online and order priced publications from the website. HSE priced publications are also available from bookshops.

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