MINISTRY OF LABOUR

SAFETY, HEALTH AND WELFARE

Dust and Fumes in Factory Atmospheres

NEW SERIES No. 8

TWO SHILLINGS NET

HER MAJESTY'S STATIONERY OFFICE

INTRODUCTION

It is a requirement of section 63(1) of the Factories Act 1961 that, in every factory where any process is carried on giving off dust, fume or other impurity of such a character and to such an extent as to be likely to be injurious or offensive to the persons employed, or any substantial quantity of dust of any kind, the occupier shall take all practicable measures to protect the persons employed against inhalation of the dust or fume. This booklet offers some guidance in methods of meeting this statutory obligation—by enclosing the process, by providing local exhaust ventilation, by using personal protective equipment and by general 'good housekeeping'. Attempts should, however, always be made in the first place to use as a substitute the least harmful material possible. In all circumstances the aim should be to reduce the concentration of dust or fume in the atmosphere to the lowest practicable level.

We reproduce in this booklet, by permission, a list adopted by the American Conference of Governmental Industrial Hygienists at their meeting in April 1964 of 'threshold limit values' for a number of substances which may be injurious or offensive if absorbed in the form of dust or fume. A condition of reproduction of this list is that it should be published in entirety and without amendment, and careful attention should be given to the Preface which explains the thinking behind it. It must be remembered that it is based on experience, practice and research in the United States. Because of the difference in climatic, genetic and industrial conditions in this country, and because certain materials may be obtained from different sources of supply, British experience is not always the same, and,

therefore, in a few cases, particularly where mineral dusts are concerned, British experts may suggest rather lower values as more appropriate.

It is intended to re-publish the present booklet each year, with the American threshold limit values for that year as an Appendix.

Attention is drawn to the cautions contained in the Preface to the list concerning its use, in particular the need for interpretation by persons trained in industrial medicine. It may be especially desirable to treat with considerable reservation the values set out in Appendix B in view of the very great difficulties involved in the problem of working out values for mixtures.

Methods of detecting certain substances in air are described in the series of booklets 'Methods for the Detection of Toxic Substances in Air', which are listed on page 8. In other cases, or on any point of difficulty, advice may be obtained from H.M. Factory Inspectorate.

BASIC PRINCIPLES OF PROTECTION

The first essential is to be aware that a potentially dangerous material is in use. Whenever new substances or new techniques are introduced, the factory occupier must consider possible hazards.

In all cases where there is a risk from dust and fume it is the factory occupier's duty under the Factories Act to ensure the safest practicable conditions of work for employees. In addition he may be required to take specific measures as provided for under special Codes of Regulations. He must also ensure that workers are given adequate instruction as to the risks involved and the precautions to be taken. And he must take steps to see that these instructions are carried out.

The precautions to be taken are those which provide the greatest degree of safety consistent with the requirements of the work. The following paragraphs set out possible methods of protection in descending order of merit.

SUBSTITUTION

The best way of preventing exposure to a toxic substance is to avoid making or using the hazardous materials. Research into ways of avoiding the creation of such dust or fume or into the possibility of using less harmful or even harmless substitutes should receive first and continuing attention.

Experience from many quarters has shown that such efforts may be rewarded not only by the creation of a safe process, but also by a product which is better than hitherto.

TOTAL ENCLOSURE AND RELATED METHODS

Where a hazardous material must be used, the next possibility to be considered is the prevention of the escape of any injurious dust or fume by totally enclosing the process. It is preferable to keep such an enclosure at a slightly reduced pressure.

Sometimes it has been found possible to reduce the risk associated with the use of harmful powders by converting them to pastes or slurries, which do not so readily give rise to air-borne dust. Care must be taken to remove any drips or splashes from working surfaces or protective clothing before they dry out and liberate dust into the atmosphere again. In suitable cases the wearing of clothing made from a suitable man-made fibre may reduce the risk from chance splashes which dry out on the operator's clothing. Control of air-borne dust in a room by spraying is unlikely to be effective.

PARTIAL ENCLOSURE WITH EXHAUST DRAUGHT

If substitution or total enclosure prove to be impracticable, the next possibility to be considered is partial enclosure. This is an industrial application of the principle of the 'fume cupboard' familiar in chemical laboratories. The hazardous material is placed in an enclosure (which may be of various materials, e.g., steel, wood, glass or PVC sheet, depending on the process), and the worker remains out-

side. Openings are provided for the operation of the process, and suction is applied to the interior of the enclosure so that air moves inwards through the openings.

The sizes of the openings will vary with the degree of manipulation necessary. They should be as small as possible in order to ensure the greatest air flow across the openings.

LOCAL EXHAUST VENTILATION

Local exhaust ventilation attempts to draw off dust or fume at the point of origin.

A local exhaust ventilation system should normally be designed to enclose the source of the dust or fume as far as practicable.

An effective exhaust draught requires large volumes of air, or small volumes of air moved at high velocity in specially designed systems. The hood should be near the source of dust or fume because the velocity of the air being moved decreases rapidly with distance (following the inverse square law). If the source moves appreciably in the course of the process, for example in the case of a swing grinder, it will be necessary to arrange for the exhaust draught to move with it, either by periodic readjustment or, preferably, automatically.

Exhaust draught apparatus should be arranged to collect the dust or fume before it reaches the breathing zone of the workers, and the apparatus must, wherever necessary, ensure that the collected dust or fume cannot be returned to the breathing zone.

AIR VELOCITIES

In all cases, air velocities, measured at the openings where partial enclosure is used or at the point of origin of the dust or fume where local exhaust ventilation is adopted, must be such that control is not impaired by chance draughts, eddies, convection currents, the movement of the operator, or windage from rapidly moving parts of the machine or

of the material being processed. It may be required to control the movement of droplets.

Where the only difficulty to be contended with is the chance draught, an air velocity at the opening or point of origin of less than 150 linear feet per minute is unlikely to secure a positive air movement in the desired direction. In the other cases mentioned, much higher air velocities and expert placing of the exhaust points are likely to be needed.

PERSONAL PROTECTIVE EQUIPMENT

Precautions for the protection of workers should therefore take the form in the first place of such control measures as are practicable, applied to the plant or process to reduce the risk to the lowest possible extent. It is only where some risk is still existing, for example in some types of maintenance work, that reliance should be placed on protective clothing and breathing apparatus.

Where breathing apparatus is required, a suitable air line breathing apparatus, or other apparatus approved in writing by the Chief Inspector of Factories (e.g., a self-contained breathing apparatus, a canister respirator or a dust respirator) may be used.

Protective clothing will be required wherever workers are liable to be exposed to toxic materials which can be absorbed through the skin. (Attention is drawn to the paragraph headed 'SKIN' NOTATION on page 12.) The clothing should be of a material adequate to deal with the particular hazard in question; in dusty processes there may be advantages in using a suitable man-made fibre which is less likely than cotton to release, with the worker's movements, dust picked up in the course of the work.

In the event of accidental contamination by toxic substances as a result of breakages, spills or splashing, the protective clothing should always be removed immediately, but with care, and the affected parts of the skin washed thoroughly. Protective clothing should always be re-

moved, and the hands, face and any other exposed parts of the body thoroughly washed before meals and at the end of the working day.

GOOD HOUSEKEEPING

A certain amount of 'background' dust inevitably disperses into the air or workrooms and settles on beams, ledges, benches and floors and workers' clothing. The vibration of machinery and other movements within the workroom as well as direct draughts will cause such dust to become air borne again. It is therefore important to prevent accumulation of dust by frequent cleaning of the workroom. The method of cleaning should ensure that the dust really is collected and is not just dispersed to settle again. Dry sweeping will cause vast amounts of fine dust to be dispersed into the atmosphere. Suitable vacuum cleaning plant of a permanent or portable character should be provided and used.

Materials which are inherently dusty should be stored in closed containers. Lids should be replaced on partially used containers and the amount of material on the workbench should always be kept to the minimum required for the work immediately in hand.

CONCLUSION

In a short booklet of this character little more can be done than to suggest the broad principles which should govern any approach to the control of dust and fume in factory atmospheres. Each particular material and process may have its own special problem; for example, the dust or fume concerned may also be explosive. Advice can always be sought from H.M. Inspector of Factories on such problems.

PREFACE

The threshold limit values refer to air-borne concentration of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect. Because of wide variation in individual susceptibility, exposure of an occasional individual at or even below the threshold limit may not prevent discomfort, aggravation of a pre-existing condition, or occupational illness.

Threshold limits should be used as guides in the control of health hazards and should not be regarded as fine lines between safe and dangerous concentrations. Exceptions are the substances given in Appendix A and certain of the substances given a C listing. The values not given a C listing refer to time-weighted average concentrations for a normal workday. The amount by which these concentrations may be exceeded for short periods without injury to health depends upon a number of factors such as the nature of the contaminant, whether very high concentrations even for short periods produce acute poisoning, whether the effects are cumulative, the frequency with which high concentrations occur, and the duration of such periods. All must be taken into consideration in arriving at a decision as to whether a hazardous situation exists. Enlightened industrial hygiene practice inclines toward controlling exposures below the limit rather than maintenance at the limit.

Threshold limits are based on the best available information from industrial experience, from experimental human and animal studies, and, when possible, from a combination of the three. The basis on which the values are established

may differ from substance to substance; protection against impairment of health may be the guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance, or other forms of stress may dominate the basis for others. The Committee holds to the opinion that limits based on physical irritation should be considered no less binding than those based on physical impairment; growing bodies of evidence indicate that physical irritation may promote and accelerate physical impairment. On what basis a limit is developed is given separately for each listed substance in 'Documentation of Threshold Limit Values', a publication of the Threshold Limits Committee of the ACGIH.

CEILING vs TIME-WEIGHTED AVERAGE LIMITS

Although the time-weighted average concentration provides the most satisfactory, practical way of monitoring airborne agents for compliance with the limits, there are certain substances for which it is inappropriate. In the latter group are substances which are predominantly fast acting and whose threshold limit is more appropriately based on this particular response. Substances with this type of response are best controlled by a ceiling C limit that should not be exceeded. It is implicit in these definitions that the manner of sampling to determine compliance with the limits for each group must differ; a single grab sample, that is applicable to a C limit, is not appropriate to the time-weighted limit; here, a sufficient number of samples are needed to permit a time-weighted average concentration throughout a complete cycle of operations or throughout the work shift.

Whereas the ceiling limit places a definite boundary which concentrations should not be permitted to exceed, the time-weighted average limit requires an explicit limit to the excursions that are permissible above the listed value. The magnitude of these excursions may be pegged to the magnitude of the threshold limit by an appropriate

factor shown in Appendix C. It should be noted that the same factors are used by the Committee in making a judgment whether to include or exclude a substance for a C listing.

'SKIN' NOTATION

Listed substances followed by the designation 'Skin' refer to the potential contribution to the over-all exposure by the cutaneous route including mucous membranes and eye. This attention-calling designation is intended to suggest appropriate measures for the prevention of cutaneous absorption so that the threshold limit is not invalidated.

MIXTURES

Special consideration should be given also to the application of these values in assessing the health hazards which may be associated with exposure to mixtures of two or more substances. A brief discussion of basic considerations involved in developing threshold limit values for mixtures, and methods for their development, amplified by specific examples, are given in Appendix B.

'INERT' OR NUISANCE PARTICULATES

A number of dusts or particulates that occur in the working environment ordinarily produce no specific effects upon prolonged inhalation. Some insoluble substances are classed as inert (e.g., iron and steel dusts, cement, bentonite, silicon carbide, titanium dioxide, cellulose); others may be soluble (starch, soluble oils, calcium carbonate) but are of such a low order of activity that in concentrations ordinarily encountered do not cause physiologic impairment; still others may be rapidly eliminated or destroyed by the body (vegetable oils, glycerine, sucrose). In the case of the insoluble substances, there may be some accumulation in the respiratory passages. In the case of the soluble substances, this accumulation will ordinarily be temporary but may interfere

to some extent with respiratory processes. Hence, it is desirable to control the concentrations of such particulates in the air breathed by any individual, in keeping with good industrial hygiene practice.

A threshold limit of 15 mg/m³, or 50 mppcf, whichever is less, is recommended for substances in these categories and for which no specific threshold limits have been assigned.

This limit, for a normal work day, does not apply to brief exposures at higher concentrations. Neither does it apply to those substances which may cause physiologic impairment at lower concentrations but for which a threshold limit has not yet been adopted.

PHYSICAL FACTORS

It is recognized that such physical factors as heat, ultraviolet and ionizing radiation, humidity, abnormal pressure and the like may place added stress on the body so that the effects from exposure at a threshold limit may be altered. Most of these stresses act adversely to increase the toxic response of a substance. Although most threshold limits have built-in safety factors to guard against adverse effects of moderate deviations from normal environments, the safety factors of most substances are not of such a magnitude as to take care of gross deviations. For example, continuous work at temperatures above 90°F or overtime, extending the work-week more than 50 per cent, might be considered gross deviations. In such instances judgment must be exercised in the proper adjustments of the threshold limit values.

These limits are intended for use in the field of industrial hygiene and should be interpreted and applied only by persons trained in this field. They are not intended for use, or for modification for use, (1) as a relative index of toxicity, by making a ratio of two limits, (2) in the evaluation or control of community air pollution or air pollution nuisances, (3) in estimating the toxic potential of continuous

uninterrupted exposures, (4) as proof or disproof of an existing disease or physical condition, or (5) for *carte blanche* adoption by foreign countries.

These values are reviewed annually by the Committee on Threshold Limits for revisions or additions, as further information becomes available.

'NOTICE OF INTENT'

At the beginning of each year, proposed actions of the Committee for the forthcoming year are issued in the form of a 'Notice of Intent'. This Notice provides not only an opportunity for comment, but solicits suggestions of substances to be added to the list. The suggestions should be accompanied by substantiating evidence.

LEGISLATIVE ACTION

The Conference does not consider the Threshold Limit Values appropriate matter for adoption in legislative codes and regulations, and recommends against such use.

Radioactivity For permissible concentrations of radio-isotopes in air, see U.S. Department of Commerce, National Bureau of Standards, Handbook 69, 'Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure', June 5, 1959. Also, see U.S. Department of Commerce, National Bureau of Standards, Handbook 59, 'Permissible Dose from External Sources of Ionizing Radiation', September 24, 1954, and addendum of April 15, 1958.

MINERAL DUSTS

SUBSTANCE	mppcf†
SILICA	
Crystalline	
Quartz, Threshold Limit calculated from the formula	$\frac{250††}{\%SiO_2 + 5}$
Cristobalite, „ „	„
Amorphous, including natural diatomaceous earth	20
SILICATES (less than 1% crystalline silica)	
Asbestos	5
Mica	20
Soapstone	20
Talc	20
Portland Cement	50
'INERT' or Nuisance Particulates	50 (or 15 mg/m³ whichever is the smaller)

Conversion factors

mppcf × 35·3 = million particles per cubic meter
= particles per c.c.

TENTATIVE VALUES

SUBSTANCE	ppm*	mg/m³**
++ Anisidine (o, p-isomers)		0·5
++ Benzoyl peroxide		5
Calcium oxide		5
++ Carbaryl (Sevin) (R)		5
Copper Fume		0·1
Dusts and Mists		1