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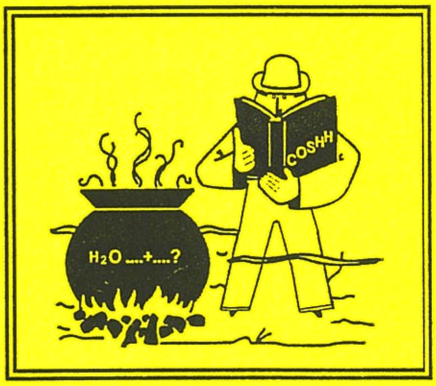
British Occupational Hygiene Society

General Guide No. 1

The Manager's Guide to Control of Hazardous Substances



with

21 Case Studies

by The BOHS Technology Committee

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1996

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Preface

It is with pleasure that the British Occupational Hygiene Society, through its Technology Committee, introduces this *General Guide* and wishes to thank the Working Group for their part in its production. The *Guide* is based on well-tried principles, as is shown in the practical examples which form part of the book.

As a manager you have to come to terms with what you need to do to make the place of work as healthy and safe as possible. Hazardous substances have the potential to cause ill-health. Often the control of these substances seems to present more difficulties than many other health and safety issues.
This *Guide* is designed to put you in the picture, explaining simply some of the legal and technical jargon. This will put you in a better position to make sound decisions related to the control of hazardous substances.

The *Guide* falls conveniently into two parts. Both are intended to be read by managers, safety staff, occupational hygienists and all who have responsibility for Health and Safety at the workplace.

The first part sets out the main points to be considered when hazardous substances are present in the workplace, which is defined in the broadest possible terms. It begins with looking for potential trouble and carries on right through to the design of a system of control which has to be effective and sustainable. The "system" is not just the hardware, like ducts and fans, but includes personnel training, maintaining the system and recognising that process changes call for the reassessment of the control system.

The second part consists of a series of ***Case Studies*** giving some workable solutions to problems of control, often at a cost considerably lower than the "conventional" control method. Clearly the ***Case Studies*** will not be universally applicable, but they do suggest that a bit of lateral thinking can go a long way. The members of the Technology Committee were much taken by some of the solutions. At the same time we would expect there to be other ideas which would have been just as suitable.

Finally there is a short list of references for further reading if you want more detailed information on particular topics.

This is a book to be read, and can be taken from the shelf and read again.

P. Dewell
Chairman, BOHS Technology Committee

April 1996.

1 Introduction

WORKPLACES range from schools to major construction sites, from quarries to research laboratories, from dry cleaners to foundries, farms, factories and offices. Because of the vast variety of work activities and substances involved, it is not possible to produce detailed advice for each individual circumstance.

In the modern workplace there is often the possibility of exposure to substances which may adversely affect the health of people at work. These substances may be solids, liquids, gases, vapours, or even infectious micro-organisms. Well-known examples are dusts such as silica, toxic metals such as mercury, gases such as hydrogen sulphide, organic solvents such as toluene and micro-organisms such as legionella; there are thousands of similar materials. Substances that can cause harm include more familiar materials such as grain dust, flour, cleaning agents such as bleach, and exhaust fumes.

Products used at work are often brand-named mixtures or your own mixture of various substances. These are generally known as *preparations* and often exhibit similar hazards to health as single substances. Substances or preparations may affect the skin, eyes, internal organs, nervous system, and many may have unknown long-term effects resulting from exposure. They may be breathed in or be swallowed or enter through the skin. Exposure will vary by the day, by the hour, and by the minute. The effects of exposure also vary - the concern may be when substances are used over a working lifetime, or may be from short duration work, or both. In each case ***the prime objective is to prevent or, if this is not possible, adequately control personal exposures to avoid effects on health.***

Important sources of information include material available from:

- trade associations
- manufacturers
- trades unions
- professional bodies
- societies
- *British Occupational Hygiene Society*
- *Institute of Occupational Hygienists*
- consultants
- academic institutions
- *Health and Safety Executive (HSE)*.

2 Where does the law ^fit in?

2.1 The Control of Substances Hazardous to Health Regulations

Under COSHH, employers: recognise where hazardous substances are used, decide if they cause a potential health problem, consider ways of avoiding hazardous substances.

As with seemingly everything in our lives, there are legal requirements that affect the way exposure to substances ought to be controlled in the workplace. Specifically in the UK, ***The Control of Substances Hazardous to Health Regulations***, commonly known as ***COSHH***, which come under ***The Health and Safety at Work etc Act (1974)***, is the main piece of legislation in this area. It covers most situations when substances are encountered at work and when they are potentially a problem to health. *Substances*, in this context, are those that are regarded as being hazardous to health. Asbestos and lead have their own sets of regulations at the moment, but the philosophy is the same as for COSHH.

These ***sensible legal requirements*** aim to get employers to:

- Recognise where hazardous substances are used at work;
- Work out whether that use causes a potential problem to the health of people at work;
- Make decisions on whether there are ways of avoiding using or producing hazardous substances.

If it is not possible to avoid using a substance, COSHH, very sensibly, offers a series of ***ways of controlling*** the inevitable exposure.

You can:

- Try to enclose the source of the problem;
- Try to engineer the problem away;
- Use administrative (including management) methods to reduce exposures.

Finally if the problem is still there (*ie* there is a *residual risk*) you can **use personal protective equipment** as a last resort. This final option is the least preferred as it is often fallible for a number of reasons and does nothing for anybody who is unprotected.

2.2 Exposure

What does 'exposure' mean? Essentially it is all the different ways that a substance can get onto or into the body and potentially cause a degree of harm.

This obviously depends on what sort of effect you might expect and where the main concerns are. It is not just a question of looking at the most common problem which occurs, *ie* when materials get into the air. Skin contact frequently happens as a result of contamination spreading unseen across work surfaces. Often, exposures to airborne substances can be well characterised by taking measurements of different types. These measurements can be related to *occupational exposure limits*. These can help you to assess whether you are controlling the exposure problem properly. The legal term for this is ***adequate control***.

HAZARD: *potential* harm caused by a substance.
RISK: *likelihood* of actual harm occurring.

Hazard and ***risk***. You will hear these two terms. They have quite different meanings in the context of exposure. The ***hazard*** is the inherent or total potential *harm* that a substance may cause to a person's body. The ***risk*** is the likelihood of that harm actually occurring.

For example:

> Cyanide can be used without *risk* to health if the right safeguards are in place, even though it is well known that the *hazard* can result in fatal consequences.

2.3 Reasonable practicability

REASONABLY PRACTICABLE means balancing the risk against the time, trouble and cost.

The law often talks about ***reasonable practicability***. What is this concept and how does it apply to controlling substances at work?

Reasonably practicable has a specific meaning in law outlined below. However, deciding what is or is not reasonably practicable depends on individual circumstances and cannot be subjected to standard formulae. In other words, every case is different and needs its own consideration.

'Reasonable practicability' is a matter of balancing the degree of risk against the time, trouble, cost and physical difficulty of the measures necessary to avoid it. Clearly the greater the risk, the more reasonable it is to do something about it; and *vice versa*. It is important to remember that ***the judgement is driven by the risk*** and ***not*** the size or financial position of the employer.

In summary, as with most health and safety legislation, COSHH is really attempting to get an appropriate level of response to the size of the problem encountered - that's all it's saying.

If the risk is very small - and no matter how much money, technology or effort is thrown at the problem the risk remains about the same - then it is possible to argue that it would not be reasonably practicable to improve the way a substance is used or controlled. However, if the risk is real, and there are ways and means of fundamentally doing something about it, then it is very likely the balance would come out in favour of the need to make improvements.

Of course, if there are other benefits besides direct health and safety advantages these can greatly enhance the desire to control properly substances in the workplace. Control of substances can best be achieved when other advantages, possibly linked to production demands, product quality, improvements in working conditions, *etc*, are also entered into the equation.

If many people are exposed to hazardous substances it is normally better to deal with the problem at the root rather than trying to keep on top of it once established - a bit like weeding the garden really!

2.4 Adequate control

ADEQUATE CONTROL OF EXPOSURE by: design concepts engineering human factors organisational factors.

To achieve ***'adequate control'***, the fundamentally important objective is ***to reduce personal exposure to a suitably low level*** - with the main intention of ***avoiding undesirable effects on health.***

This *Guide* is designed to give you some ideas on how you might go about meeting this objective. Adequate control of personal exposure is achieved by application of *design concepts*, *engineering*, *human* and *organisational factors.* When all of these avenues have been explored this should lead to an integrated control package.

How to start this process and how to recognise when it is completed is not always clear. However it is not that difficult to grasp the main elements of a successful approach to control when the process is taken step by step.

Step 1 **is to recognise the problem** in the first instance. Once you've got that far the ***next step*** **is to look at that problem** to see if you need to improve the situation.

You need to gather some information about;

- what causes the problem;
- when and where it occurs;
- the scale of the problem and how many people it affects.

The workplace assessment is vitally important. Some simple measurements may help you at this early stage. You may be able to compare your findings against occupational exposure limits if the problem is from airborne emissions.

PRIORITISE THE RISKS: produce **action plan** implement **control measures.**

If the problem is related to exposure of the skin or ingestion, a more subjective assessment will have to be carried out. It may be possible to use chemical analytical methods to help you identify the problem. There may be ways of visualising what is going on and simple observation of the workforce and process is a powerful tool for this purpose. It is important to remember that exposures can often be made worse because of poor work practices. After you have assessed all the exposure you will need to *prioritise the risks* to produce an **action plan** to implement the necessary **control measures.**

2.5 Exposure limits and control

HSE BOOKLET EH40 gives: maximum exposure limits (MELs) occupational exposure standards (OELs)

Exposure limits have particular relevance to control where the major concern is avoiding inhalation of a substance. They can give a good guide to answering the questions relating to adequate control. COSHH has introduced two types of limit which apply in the UK, the ***Maximum Exposure Limit (MEL)***, and the ***Occupational Exposure Standard (OES)***. These two limits have very different meanings and the control requirements may differ markedly. The Health and Safety Executive annually publish an updated booklet entitled 'Occupational Exposure Limits', also referred to as EH40. This booklet explains the way in which 'indicative criteria' are used to help select the type of limit that is appropriate. It also explains in some detail what the limits mean.

> **To achieve adequate control when a substance has been assigned a Maximum Exposure Limit you should reduce the levels of personal exposure to** ***below the MEL*** and then ***further reduce them so far as is reasonably practicable***. One of the main features of ***a MEL*** is that it ***does not necessarily represent a safe level of exposure.***

The **MEL** is the maximum concentration of an airborne substance, averaged over a reference period (usually 8 hours or a working shift), to which employees may be exposed by inhalation under any circumstances. It is not normally good enough to reduce exposures to the MEL and stop there. MELs often apply to substances that have health effects for which it is difficult to determine a threshold or a ***'no observed adverse effect'*** level. Examples include substances that cause cancer or some that cause occupational asthma. MELs also apply to substances where the no observed adverse effect level is known, but it is not appropriate to set a health-based limit. The reasons for this may include, for example, current difficulties in achieving a health-based limit on a regular basis across the whole spectrum of industry. Finally, MELs often apply to substances where the effects of short-term exposure are severe, eg hydrogen cyanide.

MELs should not be exceeded **OELs** indicate adequate control.

By definition, MELs should not be exceeded. There is residual risk of ill-health from exposure at the level of the MEL, so it is quite easy to see why exposures should be driven as far below the limit as you can using suitable control measures. For some industries there is an understanding of what (reasonably practicable) level they need to achieve for particular substances. For instance it is normally accepted that the pottery industry can achieve levels of silica exposure below $0.1 mg.m^{-3}$, which is currently a quarter of the MEL for respirable crystalline silica and this level is regarded as being reasonably practicable. For most substances and for most of industry the situation is not as clear cut and the balance of risks and costs needs to be analysed.

Many more substances have been assigned Occupational Exposure Standards. **To achieve adequate control when a substance has an Occupational Exposure Standard**, exposure should, simply, be reduced to that level. Control is then adequate, by definition. However, if exposure exceeds the OES, control could still be adequate if action is in hand to do something about it. You need to have identified why the OES has been exceeded and be prepared to take steps to comply with the limit as soon as reasonably possible. This is not an open-ended get-out clause!

For example:

> A company may be planning process modifications which will bring about reduction in exposure levels. It may be acceptable to continue operating above the OES for a limited time until these modifications have been made. Delay in making the changes may result in a need to reduce exposures by other means within an appropriate timescale. In this case, using respiratory protective equipment may be an acceptable control measure in the interim. It may make sense to reduce exposures below the OES if the opportunity arose and the costs were acceptable, but the law doesn't make that necessary.

2.6 Substances without occupational exposure limits

CHIPS with everything.

Many substances have not been assigned occupational exposure limits. Employers will need to work out their own standards for control. This assessment will need to take into account available information on likely health effects from exposure to a substance. Once a view has been established, appropriate working standards should be developed and kept to. **A good information source is the supplier** of the substance, who should be providing data sheets in a specific format. The ***CHIP Regulations, (The Chemicals (Hazardous Information and Packaging for Supply) Regulations 1994)*** set the legal requirements. Some user-friendly Guides to CHIP are available (see References).

For many other substances, where there is an indication of ill-health, adequate control will be defined by reference to in-house or industry standards and this is particularly true in the chemicals and pharmaceuticals industry. Substances that have similar properties to those that have been assigned an occupational exposure limit could be deemed to have a similar limit. This can then be used as an indicator of adequate control.

Some dusty materials don't appear in the occupational exposure limit listings. The full requirements of COSHH apply to dusts if exposures are above 10 $mg.m^{-3}$ total inhalable dust, or 5 $mg.m^{-3}$ respirable dust, ***where there is no indication of the need for a lower limit value.*** In essence, if these dust concentrations are kept below the two limits they cease to be substances hazardous to health. However, you need to be careful because lack of a limit does not imply an absence of a hazard to health.

Biological agents are also dealt with in the UK by application of the principles of occupational hygiene embodied in *COSHH*. Control strategies for these agents are covered under 'special provisions relating to biological agents' which can be found in *Schedule 9* of the *COSHH Regulations*. Further advice is given in the associated *Approved Code of Practice*. This is a specialised area and outside the scope of this *Guide*.

HSE guidance note EH42 gives details of factors affecting personal exposures.

Control strategies ought not to be too dependent on current occupational exposure limits. In the first instance, exposures by inhalation may be subject to large variation. To be certain about reaching adequate levels of control you need to set a target well below the limit. (HSE guidance note EH42 'Monitoring strategies for toxic substances', gives details on the variety of factors that affect personal exposures).

A second consideration relates to the general downward movement of occupational exposure limits over the years as a response to new evidence on adverse health effects. You could consider the consequences of a possible future reduction in limit values when deciding on control options. Often the most beneficial control strategy may lead to personal exposure levels which are a small fraction of the current limit. This approach often makes sound business sense, whilst at the same time fitting in with the principles of good occupational hygiene control.

HSE's EH40 shows: *skin (Sk)* hazards *sensitiser (Sen)* hazards.

Where skin exposure or ingestion is a particular cause for concern there is generally little help from standards. It is difficult to assess the level of skin contamination in a quantitative manner. An understanding of whether adequate control has been achieved in these circumstances probably comes from a lack of incidence of effects from exposure. This is very imprecise. What is needed is a control strategy that has developed to meet the needs within a particular workplace. HSE's EH40, 'Occupational Exposure Limits', referred to above lists substances for which *skin (Sk)* or *sensitiser (Sen)* notation has been allocated to indicate where such hazards exist. This assists the employer to ensure that skin contact is avoided for such substances.

For some substances it may be possible to look for specific effects either on the skin or even by various forms of biological monitoring. Monitoring of levels of lead in blood has been a well-established procedure for many years and it is thought to be quite a sensitive indicator of over-exposure. However this level of knowledge may not be available for many other substances. Often, other than indicating that the substance has entered the body, it is difficult to draw conclusions on what the results mean in terms of acceptable levels of exposure and adequacy of control. Biological monitoring may be an expensive and imprecise tool for judging exposure.

3 Control measures: the choices

PREVENTION OF EXPOSURE: elimination substitution.

CONTROL OF EXPOSURE: engineering options *first* administrative controls personal protection *if necessary.*

Once you recognise you have a control problem in the workplace what do you do about it? There are many options open to you. Try to take a step back before tackling the problem. Assess where the process fits into the overall scheme of things and see if fundamental changes can give you the benefits you need at a cost you can afford. The best practice dictates that prevention of exposure should be the first priority. Can you eliminate the substance? Can you work with it in such a way that it is not normally possible for people to come into contact with it? Can you substitute something else which gives you fewer difficulties?

If you must use a substance so that people become exposed what are the options? In general, process or engineering options are preferred to procedural or administrative controls. Personal protective equipment may be used as a *last resort* and can be effective given proper selection and training in its use; if not, it can be unreliable and give a false sense of security.

The power of human intervention to defeat the best laid plans should never be underestimated!

For example:

Consider how a particular amount of a volatile organic chemical is added to a reaction vessel. It has to be weighed out, transported to the vessel and tipped in. It cannot be substituted because it is an essential reactant in the process. Going down the list of control measures, local exhaust ventilation is applied at the weighing-out point and while tipping into the reactor. An alternative method relies on using a lance to transfer from container to reactor. This lance could be fitted with a ventilation collar to minimise emissions.

To reduce exposure still further a closed transfer vessel is used. There is still the possibility of skin absorption so personal protective clothing has to be considered.

At a future date, production increases mean that this operation will be carried out many times a day. Another assessment of the control measures in use results in design changes to accommodate a closed system for weighing and addition of chemicals. Local exhaust ventilation and personal protective equipment are no longer required.

The example above shows how control measures are applied and reassessed as production changes occur, and how different control measures are introduced.

3: Control measures: the choices

Figure 1, Factors affecting control, gives an idea of how the many and various factors interact to affect exposure to substances. These factors include elements such as cost because fundamental business decisions may have to be made. Importantly occupational hygiene controls need not always entail extra expenditure or inevitably result in great losses to companies. The best solutions derive from a reassessment of the process and often incorporate benefits in other areas such as increased production or better quality. The way people tackle jobs also needs to be thought about. Successful control of substances depends upon looking at the problem with an open mind and considering all the factors.

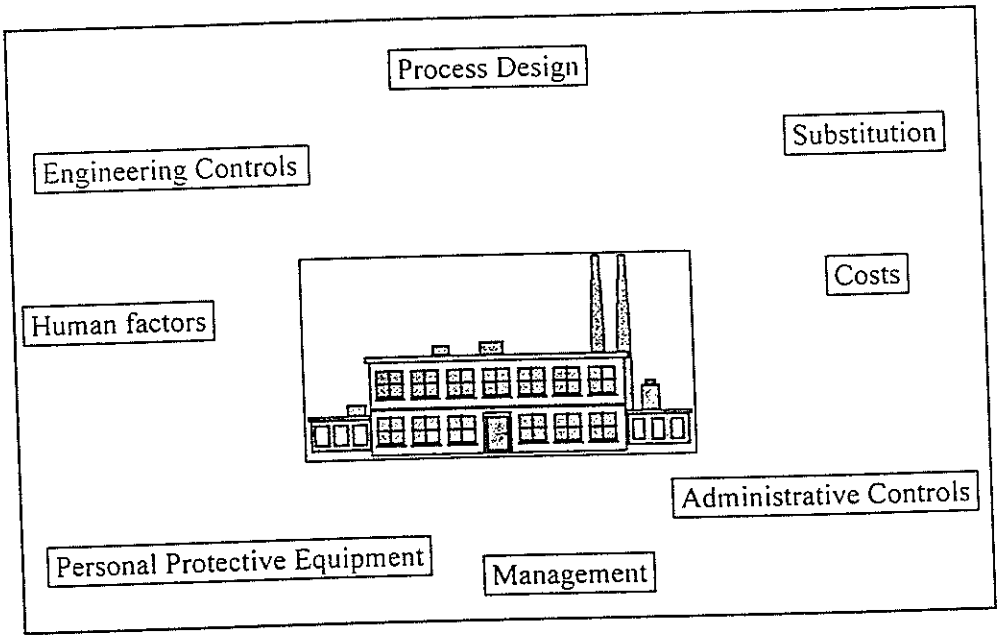

Figure 1: Factors affecting control.

PREVENTION is the preferred option for controlling exposure

Prevention (by elimination or substitution) **is the preferred option** for controlling exposure. Failing this, as a general rule, the greater the degree of ***enclosure*** and ***automation*** associated with a process the lower is the chance of human interaction which inevitably results in exposure.

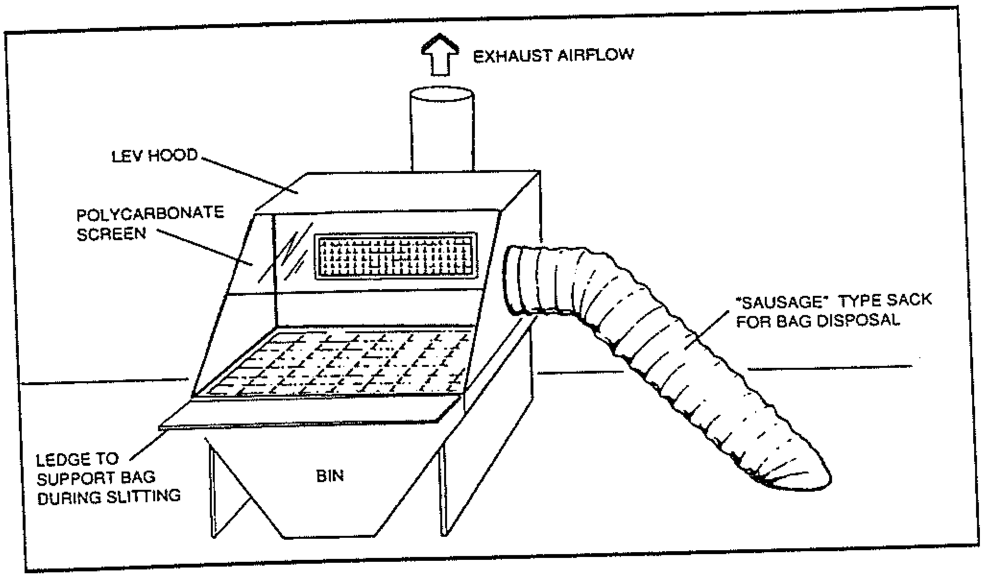

Figure 2: Bag tipping and disposal within an enclosure with LEV.

Figure 2 is a good illustration of ***enclosure.*** Bags are emptied by tipping when inside an enclosure formed by a hood with local exhaust ventilation (LEV).

The operation is then completed by disposal of the empty bag straight into the disposal sack without removal from the enclosure.

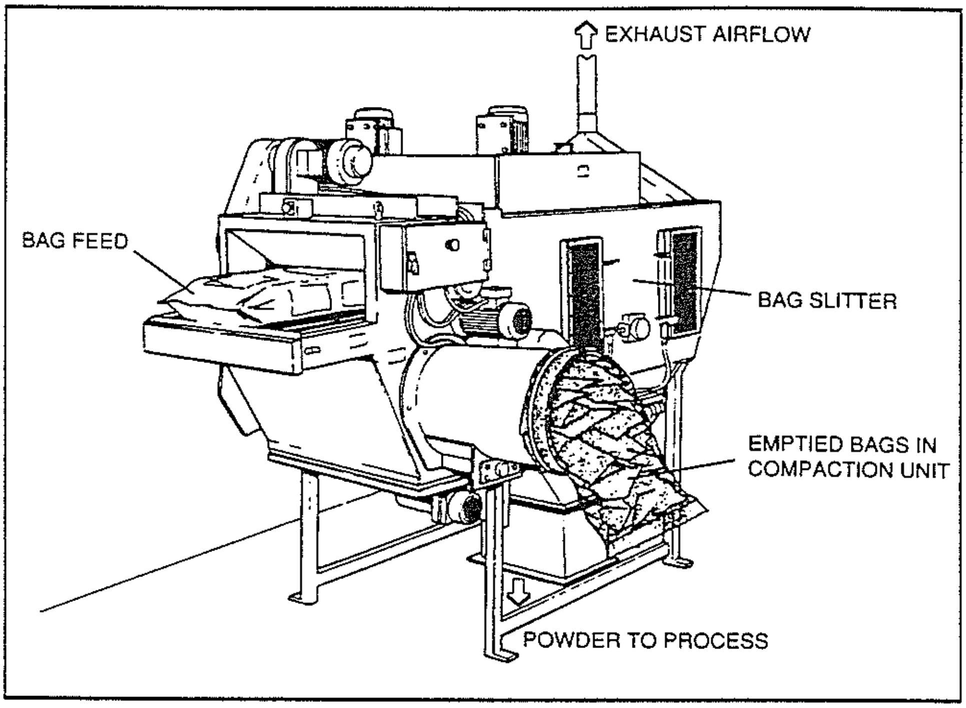

Figure 3: Automated bag opening, emptying and disposal.
(Illustration courtesy of Chronos Richardson Ltd, Nottingham.)

AUTOMATION: all steps untouched by human hand!

Figure 3 takes the action one step further. Here ***automation*** is employed for bag opening, emptying and disposal - all steps untouched by human hand!

For each process or workplace *the best solution should be sought.* It is often all too easy to come to the conclusion that control of the process is impractical and personal protective equipment (PPE) is the only option left.

Very often a control solution is provided by a combination of methods. Basic consideration of the design of the process may result in some surprising cost-effective solutions to problems.

Questions that might be asked include:

- How long have we done it this way?
- Why do we do it this way?
- Do we need to use this harmful substance?
- Can we automate the system?
- Does the operator need to be close to the process?
- Are the existing controls effective?
- Can we segregate the process?
- What is the cost and effectiveness of our PPE programme?

Always ask those on the *shopfloor* early in your investigation. Only by doing this are you likely to arrive quickly at *cost-effective and practical answers*. By this involvement, your proposals will be more readily accepted and then used.

OCCUPATIONAL HYGIENE HIERARCHY:
1. prevention of exposure
2. control of exposure
3. personal protective equipment.

Remember, occupational hygiene principles indicate a hierarchy of control. This is based on prevention of exposure being better than control which in itself is preferred to the use of personal protective equipment as a primary measure. These three aspects are considered in the next chapters.

4 Prevention of exposure

You can prevent exposure by:

- eliminating the substance,
- substitution with a less hazardous substance, or
- changing the form of a substance so that exposure is negligible.

Given below are some examples of the three modes of exposure prevention.

ELIMINATION: cadmium from silver solder, asbestos from plasters and beer filters, solvents from paint systems, pesticides from pest-control, humans from mechanical systems.

4.1 Elimination

Elimination of the substance generally ***means process alteration***. Examples of this include the use of cadmium-free silver solders, removal of asbestos from decorative plasters and beer filters, and the use of powder coating in the place of solvent-based painting systems. The move from pesticides towards pest control using natural predators could be seen as the elimination of hazardous substances which affect both man and the environment. Some museums control fabric pests using deep-freeze techniques instead of pesticides. The use of robotics and automation could be seen as a way of preventing exposure to operators, but there are residual problems for those involved in maintenance and repair work.

SUBSTITUTION: water for solvents, low volatility for high volatility solvents, aluminium oxide for silica. *Beware of new problems!*

4.2 Substitution

Substitution with a less hazardous substance has been used with great success in a number of situations. There is the possibility of using water-based paints in place of more harmful solvent-based formulations; low volatility solvents may replace those that give off high vapour concentrations, as in the case of paint stripping; aluminium oxide is regarded as less toxic than silica and has been used as a substitute refractory-placing medium in the ceramics and similar industries.

Substitution may create its own problems and different types of risk or disadvantage will need to be weighed against the health problem, for instance flammability. Aluminium oxide in place of silica may create erosion problems in plant and ventilation systems because of its very abrasive nature. For situations where organic compounds have been substituted by others you need to remember that control of the inhalation hazard may result in the use of substances that create a skin or ingestion problem. (***The Health and Safety Executive*** have produced a *booklet* ***'7 steps to successful substitution of hazardous substances'*** which explains the principles behind this approach to control).

REPLACE ozone-depleting substances.

One particular area of concern is the need to **replace ozone-depleting substances** with other compounds. This is a requirement of agreements reached under the ***Montreal Protocol*** and is required by ***European legislation***. This impacts on COSHH through methods of work and environment control issues. Degreasing is a common process with heavy usage of ozone-depleting chlorinated solvents. Environmental concerns will force a move away from cold degreasing and there is the opportunity to incorporate water-based detergent systems, as are commonplace in the electroplating industry. Whatever new process is used, you will need to consider different hazards which may result from exposure to new chemicals or from skin contact with materials that could cause dermatitis or chemical burns.

4.3 Change of form

CHANGE FORM: dusty materials pelletised or suspended, chemicals pre-packed for addition to process, pumped instead of pouring.

It may be possible to change the form in which a substance is used so effectively eliminating exposure. Some dusty materials can be pelletised or used in liquid suspension. Chemicals in the rubber industry have been pre-packed or incorporated in a rubber pre-mix for addition to the process avoiding the possibility of exposure. Chemicals, for addition to electroplating and photographic developing baths and also boiler-feed water tanks, can be added by closed circuit pumped systems as concentrated solutions rather than manually as dusty solids. Another example is in the paper industry where china clay is supplied as a slurry, eliminating most of the potential dust problems. Consult your suppliers!

5 Controlling exposure

5.1 Reducing the amount of contaminant generated

NO ELIMINATION OR SUBSTITUTION then control emission.

If you can't get rid of a problem substance by elimination or substitution, then control of emissions from the process should be looked at. How do you deal with *dusty solids*? One thing you may be able to do is to make them less dusty *by adding oil or water*. Specialist contractors can mix and blend raw materials to provide a dustless product. **Mineral wool** is an example where the addition of a small amount of oil has significantly reduced the emission of the fine respirable sized fibres. The use of slurries and wetted materials has long been an accepted method of controlling dust exposures in the **ceramics industry**. Bath formulations in the **electroplating industry** have been developed to minimise the release of chromic acid mist by creation of a foam blanket over the plating tank.

5.2 Containment

CONTAINMENT by plant, of plant, of operator.

Containment can be viewed in three ways:

- Containment by plant, (for example, vat, flask, *etc*)
- Containment of plant, (for example, plant house, glove box, *etc*)
- Containment of operator, (for example, tractor cab, gloves, control room)

TOTAL ENCLOSURE: glove boxes, process plant, safety cabinets.

Control of exposure by **total enclosure** of process and handling systems is appropriate for many processes. This means of control has often been used when particularly hazardous substances are being handled, or where the consequence of contamination of a larger area has been unacceptable. Laboratory **glove boxes** are at one end of the scale of full process containment, and a nuclear power station at the other. Examples include **process plant** in the chemical industry and full enclosures around **dusty machinery** like cotton carding machines. Containment within Class III **microbiological safety cabinets** is the standard when working with all Hazard Category 4 pathogens, *eg* Ebola virus and other high-risk pathogens such as rabies. These enclosures are exhaust-ventilated. They operate below atmospheric pressure to ensure air movement is inwards, preventing release of contaminant to the general workplace atmosphere.

With totally contained processes, there might be a need to have well-developed procedures for **maintenance and repair**. This need arises from the possibility of extreme exposures when the integrity of the containment is compromised. *Grave consequences may follow if procedures break down.* Management control is an essential part of the overall strategy.

A leaking system leads to trouble. The level of control depends critically on the design and integrity of the engineering. Construction materials need to be of the right specification to do the job. Temporary repairs may create bigger problems in the future. Depending on the substance, special care might be needed when inspecting or changing panels, filters, valves, pumps or flanges.

5.3 Removal at source

5.3.1 Local exhaust ventilation

LEV - see: HSE booklet HS(G)37, Introduction to local exhaust ventilation.

The use of ventilation to remove a pollutant close to its source of production is generally known by the term **'local exhaust ventilation'**, usually abbreviated to **LEV**. This control method is used at many processes where hoods and partial enclosures can be designed to make best use of the airflows.

Hand tools with integral extraction systems have been designed, finding use in applications such as hand sanding, soldering, stone cutting, and surface preparation in the car industry. These are known as ***LVHV systems* - low volume high velocity systems**.

Downflow or laminar flow booths with either recirculated air or extraction of cleaned air to outside may offer a highly effective alternative approach to control. Downflow technology prevents airborne substances reaching up into the breathing zone of the operator (Figure 4). It has been used effectively in the pharmaceuticals and food industries. The *Health and Safety Executive* produce a guidance document *HS(G)37 - 'An introduction to local exhaust ventilation'*, which fully describes the principles and uses of LEV in relatively non-technical terms.

LAMINAR AIRFLOW in breathing zone.

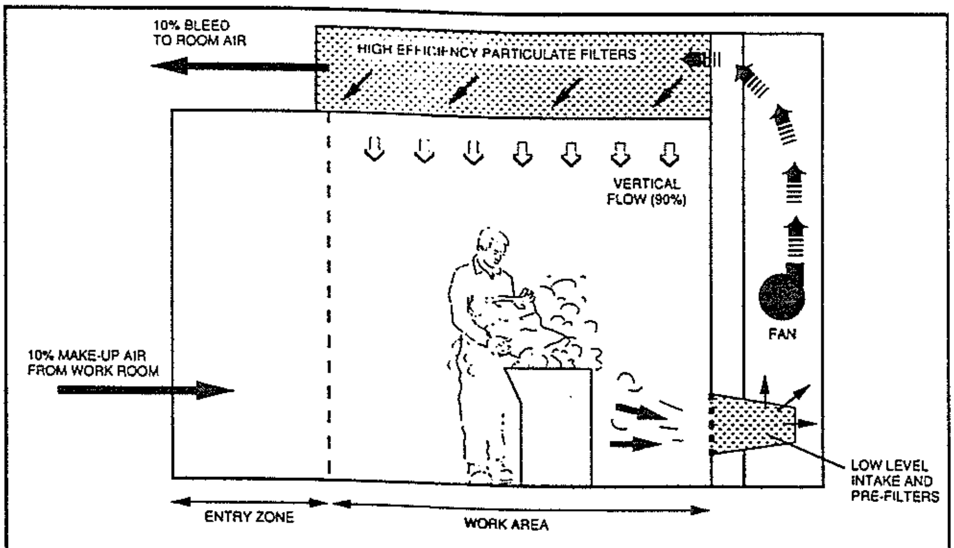

Figure 4: A typical downflow booth - principle of operation

Figure 4 shows a downflow booth. Some 90% of the air is recirculated after passing through high efficiency particulate air (HEPA) filters. This forms a uniform or 'laminar' downward flow of air which passes the breathing zone of the worker before reaching the level at which the contaminant is released. The operator must work within the designated work area.

In designing and constructing inlets for local exhaust ventilation systems some important *features of the source of contamination* need to be taken into consideration. These features include:

- the size, shape and the position of the source;
- the physical nature of the contaminant (is it a dust, fume or vapour? If it is not a vapour, what is the range of particle sizes?);
- the speed and direction of the contaminant as it moves away from the source (is it subject only to ambient air currents or is it projected in a high velocity stream of particles in one particular direction?);
- the rate of generation of the contaminant (how much is being produced?);
- the nature of the operation which generates the contaminant;
- the position and movements of the plant, machine tool or operator;
- local air movements due to general ventilation of the workroom, hot surfaces, the operation of nearby machinery *etc*.

5.3.2 Hoods

EXHAUST HOODS: capture efficiency falls very rapidly with distance from the face of the hood; *place the hood very near the source.*

Hoods range in size from **small nozzles** to **large canopies** and may be positioned above, below or to the side of the source. They should be located close to the source, enclosing it if possible, and designed so that the flow pattern of the air will make sure the contaminant is captured and retained. ***The efficiency with which a hood captures dust or fumes drops off very rapidly with distance.*** Much of the effect can be lost by the hood being just a few centimetres too distant!

The velocity of the air flowing into the collection system is critical to performance. **Light dust**, perhaps generated from weighing operations, may typically be controlled by **air velocities in the region of 0.5 - 1.0 metres per second.** This may be controlled within a *booth-type* partially enclosed weighing station. Some **heavier dusts** are generated by high-speed mechanical processes. In these circumstances the dusts have wide aerosol size distributions and the larger particles possess considerable momentum. Hoods will need to be carefully designed and positioned to surround the source of emission and to ensure maximum efficiency of dust collection. Air velocities at the entrance to the collection system may need to be **in the region of 5 - 10 metres per second** if the material is to be captured efficiently and transported without deposition through the ductwork.

5.3.3 Ductwork

Ductwork carries the extracted air and the contaminant from the inlet to the air cleaning device or, in appropriate cases, direct to outside atmosphere. For dusts and fume, the ductwork should be designed so that the air velocity in the duct is high enough to keep the particles suspended in the airstream. This applies particularly to long horizontal runs of ducting, where the build-up of settled dust or fume particles could reduce the airflow in the duct and adversely affect control performance at the inlet to the system. Occasionally, vertical duct runs may be designed with a low air velocity so that the larger dust particles fall out of suspension into a collecting bin at the bottom of the duct. Minimum duct velocities for various types of contaminant are given in Table 1.

Ductwork should be made of material which is sufficiently strong and well-supported to withstand the wear and tear it is likely to receive in service and have walls sufficiently thick to accommodate wear by abrasive materials. Fire precautions will also be a consideration if the duct penetrates fire breaks in the building. For many applications galvanised sheet steel is suitable material and Table 2 gives information on the wall thicknesses for a range of duties. For light duty and low temperature applications (less than 40°C) sheet aluminium or plastics such as PVC and polypropylene may be used.

Table 1
Recommended minimum duct velocities

Type of contaminant	Duct velocity/ $m.s^{-1}$
Gases, non-condensing	No minimum limit
Vapours, smoke, fume	10
Light/medium density dust (*eg* sawdust, plastics dust)	15
Average industrial dusts (*eg* grinding dust, wood shavings, asbestos, silica)	20
Heavy dusts (*eg* lead, metal turnings, damp dusts or those which tend to agglomerate)	25

Table 2
Wall thickness, galvanised sheet steel ductwork, for various duct diameters and duties

Duct diameter	Thickness / mm		
mm	*Light*	*Medium*	*Heavy*
0 - 200	0.8	0.8	1.2
200 - 450	0.8	1.0	1.2
450 - 800	1.0	1.2	1.6
800 - 1200	1.2	1.6	2.0
1200 - 1500	1.6	2.0	2.5

Light duty: Non- abrasive materials (paint-spray, wood, pharmaceuticals, food products).
Medium duty: Non-abrasive in high concentrations, abrasive in low concentrations.
Heavy duty: Highly abrasive materials (*eg* sand, grit, rock, ore, fly-ash).

The key elements of an *effective* local exhaust ventilation system are:

EFFECTIVE LEV: design, position, construction, filter, fan, discharge, maintenance, replacement air.

- A **well-designed and positioned** hood, enclosure or other inlet, to collect and contain the contaminant close to the source of its generation. (*Note: The design of hood should allow the job to be carried out with the minimum of interference, or, if possible, without any interference at all. The design should be capable of dealing with potential exposures across the whole spectrum of work activity for which it is used.*);
- **Properly designed and constructed** ductwork, to convey the contaminant away from the source. The design should include the provision of safe access to ductwork and facilities for cleaning out the ductwork should it become blocked;
- An **appropriate** filter or other air-cleaning device to remove the contaminant from the extracted airstream (*Note: The filter should normally be located between the hood and the fan.)*;

- A **correctly selected and rated** fan or other air-moving device to provide the necessary airflow (*Note: The fan has to be able to provide enough air movement at the hood to capture effectively the hazardous substance. The fan must also provide a sufficiently high velocity in the ductwork to ensure that contaminants are transported through the system.*);
- A **properly designed and constructed** discharge system. (*Note: the ductwork after the fan should be kept to a minimum.)*;
- **An effective** maintenance programme to help ensure a continued high level of performance;
- **Properly designed** arrangements for providing replacement air. (*Note: the cost of heating replacement air is a major consideration in the overall running costs although sometimes it is acceptable to recirculate well-filtered air when low toxicity or easily collected dusts are involved.*)

The design and installation of *effective* local exhaust ventilation is specialised work and you may need help.

In summary what is needed to manage effectively a ventilation system is:

- A system that works;
- A system that is inspected and maintained to ensure it still works;
- Procedures to remedy defects;
- Knowledge of the system to let you get the best out of it.

5.4 Controlling general spread of contaminant in the workplace

It is easy to think of exposure as only occurring close to the source of release of a substance. In some circumstances general spread of contamination is the major problem.

Workshops can quickly become thick with **welding fume** or **fine dust** if the control is not very good. In the same way, it's no use applying **adhesive** in a booth if the glued articles dry outside the influence of the ventilation system letting solvent fumes permeate everywhere. Everybody gets a share! *If the substance is deposited on surfaces, skin contact and ingestion can be of concern.*

CONTAMINANT CONTROL:
containment
control of waste
general cleaning
dirty workwear
spillages
maintenance.

General spread of contamination also contributes to raised airborne contamination, for example by disturbance of settled dust. At **drum- or bag-filling operations** personal exposures are directly related to the cleanliness around the process. For these reasons, control measures include everything which stops contamination spreading. This includes containment, control of waste, general cleaning, control of dirty overalls, cleaning up spillages, and maintenance.

An example of a control measure to prevent the escape of a contaminant is the filling of lined drums using an ***inflatable gaiter*** to close the gap between the filling pipe and the drum liner. This is illustrated in Figure 5, combined with a local exhaust ventilation system.

GAITER prevents escape during filling.

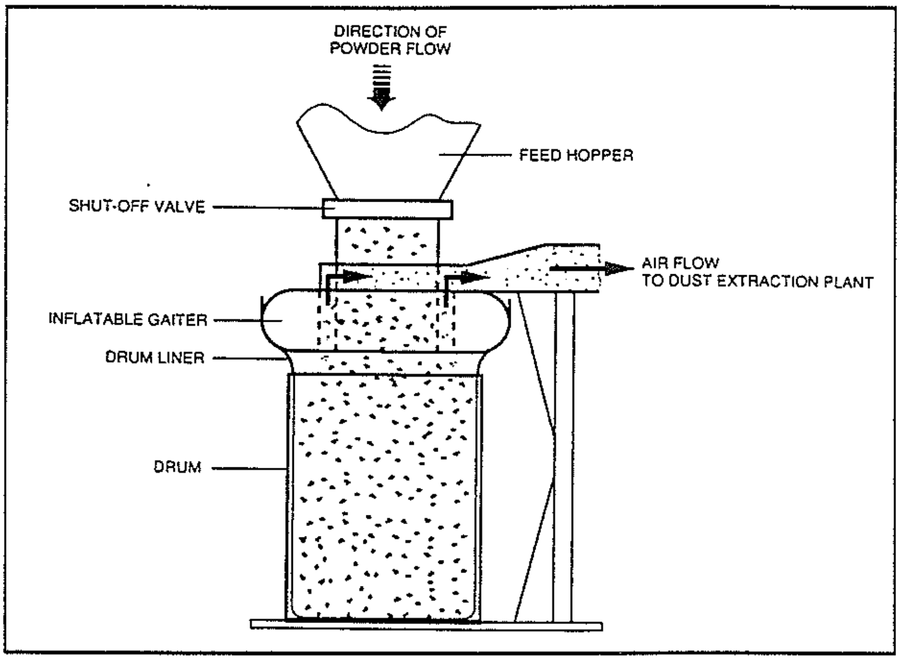

Figure 5: The filling of lined drums using an inflatable sealing gaiter.

CLOTHING: remove before transit and shower.

In some places sophisticated procedures are used to stop contaminants being spread from one part of the site to another. The workforce may have to *remove all clothing before transiting* to an area where they put on their working clothes. On return, it may be necessary to *remove all work clothing and take a shower*, before being allowed to return to the clean, segregated, part of the facility to dress to leave the site. The need for this type of facility is obviously dependent on the level of risk but the illustration shows how control is an all-embracing matter.

Natural or general ventilation can be used to good effect at some processes. The **foundry industry** traditionally **uses roof louvres** to discharge molten metal and casting fume from its activities, *although environmental considerations may impact on this practice in the future*. In this case the fume rises with the thermal currents. But, if the louvres are closed, it quickly begins to circulate in the building. Another example is control of exposure to **styrene vapour** in the manufacture of large **glassfibre reinforced plastic (grp)** products. The size of the items often prevents the use of conventional LEV, and the need to work from all sides prevents enclosure. Natural ventilation within a spacious work area is often a major factor in achieving adequate control. Enclosed grp work may need mechanically induced forced ventilation to achieve this goal.

5.5 Control of access

CONTROL OF ACCESS? prevent or minimise need for access.

A very effective way of controlling exposure is to *prevent or minimise the need for access* to high risk areas. This approach is also valid for noise, radiation and biohazard containment areas. It may be that a process or substance is particularly difficult to control at source, but at the same time there is little need for an operator to be in constant attendance.

If the operators are there only to ensure normal plant operation, you can secure a high degree of protection by placing them in a *purpose-built refuge* with access from clean areas. The refuge will also protect the operator against other workplace hazards such as noise or extremes of temperature. Control rooms and refuges can even be built away from the main plant with operations being monitored by *closed-circuit television cameras*.

PSYCHOLOGY helps!

A little bit of psychology often helps. If a control room is well-designed and comfortable, the operator is more likely to remain within its protective confines and not be tempted to wander into areas of high exposure. In the event of plant breakdown, the well-trained operator should be provided with appropriate personal protective equipment (PPE). This approach has been shown to be effective in the **quarry industry**, **cement making** and **refuse incineration**. Another example along the same lines is the continuing development of clean-air cabs on **combine harvesters**. In this case the driver is isolated from the vast dust clouds that can be produced....... as long as the door is kept closed!

5.6 Administrative aspects

MANAGEMENT: risk assessment, work areas, access, respirators, permits, training, tools, systems, records, PPE, housekeeping.

Administration and management are often the most important aspects of a control regime. From the point of view of the employee, the use of control features needs to become an integral part of the job activity.

What managers need to do stems from actions identified in the ***risk** assessment*. You will need to enforce well-defined segregated work areas. You may have to determine the extent of areas where access is restricted or respirators need to be worn. It may be necessary to establish procedures for particular jobs or set up *permit-to-work systems*. You need to be sure that employees are properly trained and provided with tools and equipment that are best suited to them and the job. In **woodworking**, for instance, some forms of hand sanding equipment gives better dust control than others. Is this one of the criteria to be used in selection?

You need to be sure employees are not taking short cuts that could endanger them. Systems can be developed to check that controls are operating properly. Records of maintenance activities are essential to you as an indicator of the success of control features, as well as being necessary for future reference.

If people are still likely to be exposed after other control measures have been applied there are ways of dealing with the residual problem. Procedures should be adopted to enforce *wearing of PPE*. Ensure cleanliness and housekeeping are up to standard, and make sure engineering controls are used and working properly. Use of respiratory protective equipment (RPE) also involves satisfactory systems for ensuring that it is cleaned, maintained, and, if battery-powered, kept charged. It is essential that users are adequately trained!

5.7 Control of skin exposure and ingestion

ROUTES: absorption, ingestion, injection.

The most important route of exposure may not be by inhalation at all. *Absorption* through the skin or by inadvertent *ingestion* can be causes of real concern. In the laboratory environment there might be particular worries about *injection*. The approach to control of exposure is essentially similar to that for airborne substances. Guidance in this area is less readily available than for control of airborne hazardous substances. There are few standards. Personal protective equipment is too often seen as the main control measure. HSE booklet EH40, 'Occupational Exposure Limits' might be a useful source of information. It sometimes gives an indication that substances may cause harmful effects when in contact with the skin. Of course, the supplier of the material is legally obliged to provide information to allow you to use the substance safely.

Examples of where problems occur include the use of **solvents to clean paint brushes** where prolonged skin contact can lead to defatting of tissue. This causes a decrease in the natural protective properties and may lead to dermatitis. In the **electroplating industry** individuals are particularly at risk from skin contact with toxic and corrosive chemicals. Some metal salts, such as those containing nickel, are *sensitisers* and they may also cause intense irritation. In engineering, **degreasing solvents** may penetrate the skin. **Phenol**, which is a commonly used laboratory chemical, not only causes burns but can penetrate the skin to cause effects on internal organs. Similarly, serious skin effects and longer term internal problems can be caused by contact with **hydrofluoric acid**. **Dichloromethane**, used as a paint stripping agent, penetrates almost all types of protective glove in a short time. Of course there is a particular need to protect against skin exposure for **pesticides** and **veterinary medicines** which are designed for biological effectiveness.

WATCH OUT FOR PEOPLE WHO
rub their eyes
pull their ears
scratch their head
stroke their nose
bite their nails
(smoke).

The above examples are well-recognised as possible problem areas, but skin exposure and inadvertent ingestion may arise anywhere. *Watch people rub their eyes, pull their ears, scratch their head or the end of their nose.* If they happen to be wearing protective gloves covered in a chemical, and have such a simple reflex, there is the possibility of exposure. Some workers may be particularly prone to ingestion problems if they are habitual nail biters or smoke at work.

PROCESSES SHOULD:
prevent exposure,
use least hazardous substances,
contain hazardous substances,
minimise manual tasks.

Processes should be designed *to prevent* exposure in the first instance and, as a matter of course, you need to select substances which present least risk. *Contain* hazardous substances as far as possible; the transfer between processes should aim to avoid contaminating other areas. An example of this is the development of returnable, refillable pesticides containers designed to complete a closed transfer system for inducing pesticides into crop sprayers. *Minimise manual tasks* and where possible automate or remotely handle to avoid unnecessary worker-contact with the hazardous substance. All good common sense principles.

Administrative controls are particularly important as part of your strategy for the prevention of exposure by skin contact or inadvertent ingestion. You may need to develop, with your workforce, firm policies *to restrict eating, drinking, smoking and use of cosmetics* in the workplace. The quantities of hazardous substances held in the workplace may affect the way in which contamination spreads. For example, unnecessarily large amounts in store may be prone to leakage or fork-lift truck damage. Prepacked quantities in process-compatible packages may effectively eliminate exposure. High quality housekeeping and effective cleaning routines are essential.

For some substances you may need to *record the exposures* that occur or to establish *routine examination of skin,* to ensure that controls are effective. ***Unlike airborne exposures, there is little guide to the success of contact control strategies beyond the prevention of recognisable health effects.***

6 Personal protective equipment (PPE)

REAL WORLD: residual risks, PPE

In an ideal world, a selection of techniques involving plant and process design, good work practices, supported by administrative and management methods, would result in acceptable levels of exposure in the workplace. *In the real world*, all too often there is a need to deal with residual risk brought about by inadequacies in process design that allows residual personal exposure. The enlightened approach is to persevere with innovative solutions but eventually there is a point reached where ***personal protective equipment (PPE)*** begins to play an important part in the control strategy. For ease of presentation this chapter on PPE will deal with respiratory protective equipment followed by discussion of some of the criteria for selection of adequate clothing to act as a barrier to materials. Many of the elements regarding management of a respirator programme or chemical protective clothing programme are common to both.

6.1 Respiratory Protective Equipment

SHORT-TERM: PPE; LONG-TERM: other options.

There are a number of instances where the use of respiratory protective equipment is likely to be the *final, but adopted*, option for achieving acceptable long-term exposures to a substance. Generally respiratory protection is of great importance when operators are exposed to high concentrations of a substance for short periods of time - situations frequently encountered by cleaners and maintenance staff. ***Long-term exposures to high concentrations should ideally be dealt with by other control options.***

Assessments of the workplace concentrations will give an indication of the standard of respiratory protection required. For dusts, equipment needs to be effective against *respirable sized particles*. Useful guidance in this area has been issued in the UK, but of course, other countries may have a different approach to selection and use of equipment.

Various types of respirator are marketed. They may be tested to an array of national or international standards but the manufacturers' information should make it clear what level of performance could be expected. For some substances, notably dusts, the lowest form of protection is afforded by **disposable filtering facepiece respirators** and by **half-mask respirators acting under negative pressure.** A somewhat higher standard of protection may be provided by **full-face respirators** and by **powered respirators with helmets or hoods. Powered respirators with a supply of fresh filtered air** to the face-mask provide a relatively comfortable option. In some instances the best option might be to use a full-face mask or half-mask supplied with breathing quality air from a compressor system (see BOHS Technical Guide No.6, *The Sampling and Analysis of Compressed Air to be Used for Breathing Purposes*).

NO RESPIRATORS if oxygen level low.

It must be remembered that filtering respirators should not be used in atmospheres where the oxygen levels are depleted. Also, users of respirators frequently confuse particulate and vapour filters. Each may be completely ineffective against the other hazard.

The higher levels of a substance will in general require the better standard of respiratory protection and it is a sensible decision to choose equipment which will be operating well within its normal designed capability. Powered respirators need careful maintenance and recharging facilities if they are to remain effective in use.

The key to successful use of respiratory protective equipment is in identifying those areas where it is needed. The establishment of well-defined mandatory respirator zones should also be a priority. For instance, in a quarry, it is not necessary for operators to enter the screening sheds on a regular basis. Dust levels inside the sheds can be very high, so if someone has to enter, they need to be properly protected against these high short-term exposures. It should be straight forward to ensure that anyone entering this area is well informed of the problem and provided with the necessary equipment to protect against the dust. An assessment of the dust levels, along with a knowledge of the parent mineral, will allow correct selection of equipment of the right performance. Careful use of respiratory protective equipment can result in dramatic reductions in personal exposures.

FIVE ELEMENTS of a respirator programme.

For a respirator programme to be successful there are five elements to be considered. Failure in any one of these five elements results in loss of protection and exposes the operators to greatly increased risk from exposure. The five elements are:

1. selection;
2. training;
3. use;
4. fit;
5. maintenance.

1. Selection:

Selection is in itself a two-stage process relating to performance of the equipment and consideration of the conditions of use. Respirators should be selected that are to be used well within their designed operating range. Selection criteria will include comfort and fit factors and the ease of use of the equipment. It is important that wearers are given a choice of equipment whenever possible.

2. Training:

Training is a vital component and includes information on how to use the equipment, why it is necessary and when it should be used to gain greatest benefit. A training programme makes the user completely familiar with the equipment.

3. Use:

> The use element relates to knowing when the equipment is required and links in with clear instructions on which part of the plant are mandatory respirator zones.

4. Fit:

> Fit relates to ensuring that the operator achieves the essential face seal with the equipment which is absolutely necessary if the suggested level of performance is to be reached. Many respirators will not give an efficient face seal for all potential users, with the consequence that protection may not be as good as expected, *eg* beards or stubble interfere with the seal.

5. Maintenance:

> Maintenance and a programme of inspecting the equipment ensures that the initial performance characteristics continue throughout its life. Respirators need to be looked after. Seals deteriorate, filters block up or lose their effectiveness, exhalation valves may stick in the open position or come off entirely. Powered respirators rely on a well-charged battery for extended use and of course the more complex equipment has more things to go wrong.

The use of respiratory protective equipment is not a substitute for proper control measures but is an extremely important part of the overall strategy to minimise personal exposures at processes. Failure to recognise the need for a respirator programme and poor management of the implementation of that programme will result in completely unnecessary operator exposures, which of course in turn will lead to greater incidence of occupational ill health.

6.2 Protective clothing and control of exposure

6.2.1 Selection of protective clothing

For many substances the main concern is about exposure by inhalation. For materials that are also toxic by ingestion or where skin contact creates problems there is a need to develop a programme for effective selection and use of work clothing. Effective programmes are linked with good systems for decontamination and prevention of spread of contamination.

FABRICS vary greatly in characteristics; obtain information from manufacturers.

The selection process for protective clothing has to take into account the conditions under which it is to be used. A completely effective barrier to dust penetration or solvent permeation may lead to the situation where heat stress becomes a major factor. Very often clothing may be chosen to offer the best compromise solution. Fabrics are available that have a range of characteristics not only in terms of barrier performance but also in terms of their permeability to air and moisture. The more comfortable garments are those that display low resistance to air and moisture movement, helping to prevent the conditions that lead to heat stress. Garments may be disposable, limited life, or designed for longer term use with regular laundering. Often, protective clothing, in dusty occupations, also doubles as the normal workwear.

At the other end of the scale, some chemical protective suits may be manufactured to the highest specification and provide protection against extremely toxic, life-threatening substances. The use of high-specification equipment is a specialised area which requires a complete understanding of the conditions of use and training to match the high level of risk to be encountered.

CHECK: seals at wrists and ankles; need for hood; compatible with ear defenders, eye protection, respirators.

Just as with respiratory protective equipment, there is a need to ensure clothing fits properly. Factors to consider include whether the garments need to be sealed at the wrist and ankles and be provided with a hood and whether the material and seams are strong enough to withstand tough working conditions. Personal protective clothing needs to be compatible with other items of personal protective equipment such as ear defenders, eye protection and respirators. Not all jobs will call for the use of garments that offer the highest degree of protection against specific chemicals, as the nature of the work may only cause low-level contamination. Information from manufacturers or suppliers will be helpful in deciding whether their products are the correct ones to use in given circumstances. Users will need to know if garments can be satisfactorily cleaned for re-use or whether they must be regarded as disposable.

6.2.2 Gloves

SKIN CARE: programme may be needed.

Protection of the hands may be the most important part of a programme designed to prevent skin exposure. The options may be the use of gloves or, depending on the circumstances, the application of barrier creams. A skin-care programme may also be needed.

GLOVE TYPES: check with manufacturers.

Correct selection of gloves is vital if they are to provide adequate barrier properties. Gloves may only provide an effective barrier against a hazardous substance for a limited period of time. Some substances, for example many organic solvents, are particularly penetrating and test information, which should be available from the manufacturers, is vital for correct selection of gloves. Manufacturers should be able to supply performance data which will let you select the right glove for the job. Gloves are manufactured from a wide range of polymer materials and the protection characteristics ultimately depend on the inherent ability to prevent permeation and the thickness of the barrier. For some substances it is very difficult to find a glove that will give assured protection for realistic timescales. For many substances there is just no information available on barrier properties.

Be warned though; the ability of a glove to prevent permeation can vary enormously depending on the quality of the product. Even products with the same apparent specification can give very different levels of performance. Factors that are important include the formulation of the polymer, the thickness of the glove and the level of product quality control. In short, chose a reputable manufacturer who is willing to provide you with information on the product.

GLOVE LIFE: causes and indication of failure.

How often gloves are changed depends on the potential for degradation and the type of use to which they are put. Some substances seriously degrade the glove material making it more prone to splitting or cracking, with resultant loss of barrier protection. Perspiration softens the skin, which could lead to increased likelihood of substance absorption if the inside of the glove becomes contaminated. (Gloves that become contaminated on the inside increase exposure rather than minimise it). Other possible problems associated with gloves include loss of dexterity and a false sense of security for the operator. Products are becoming available which give an indication when chemicals have broken through a protective glove barrier. At present these products, small patches worn on the skin, are only available for a limited number of substances. They could provide useful information to help you determine glove replacement times.

Inorganic dusty materials are probably less likely to degrade gloves than organic substances. The main emphasis should be placed on effective procedures to ensure the gloves are carefully removed and properly cleaned after use prior to storage away from contaminated surfaces.

6.2.3 Managing the programme

MANAGEMENT: selection, training, re-training.

For a PPE programme to be really effective the whole thing has to be managed properly. As with respirators, the job of managing the programme does not end when the correct equipment has been selected. It is a continuing battle to educate the workforce about why PPE is needed and how to gain greatest protection from its use. This includes correct methods of taking off PPE as well as putting it on. Problems may occur when workers remove protective clothing, especially if gloves are taken off first and the hands become contaminated.

PERSONAL ISSUE; CENTRAL MAINTENANCE.

Personal issue of equipment is often the preferred method of ensuring control over a programme as it involves the workforce to a higher degree. Centralised maintenance and repair will often result in the best standards being achieved. Also if somebody on site fully understands the PPE needs there is a good chance the right equipment will be used for the right job. Finally, an effective personal protection programme is often an expensive option when compared with innovative process change.

7 Maintenance, repair and emergencies

CONTRACTORS get the dirty jobs.

Frequently the control needs for maintenance, repair, and non-routine activities receive less attention than they deserve. Bear in mind it is not just immediate employees who may get contaminated.**Contractors** sometimes get the difficult or dirty jobs.*Experience shows it is often these types of job that result in gross exposures and heavy contamination* Workers may be asked to make process repairs when the plant is still operational. Whenever possible it makes sense to shut plant down for repair work and clean away or remove the substances likely to cause problems. There is particular concern when substances are known to have dangerous short-term exposure properties. Many fatal accidents have occurred through planning failures when proper control procedures have not been put into operation.

PARTICULAR CONCERN: substances for which short-term exposures are dangerous.

Routine maintenance jobs may also result in short-term high exposures by inhalation. There is a greater chance of skin contact and ingestion, which suggests the need to enforce washing, changing and decontamination procedures. Elimination and other options should be considered, but in practice maintenance staff are likely to need to use personal protective equipment on a more regular basis than most process operators. Their training will therefore be an important aspect of the control package. Particularly high risk occupations may be work on dust-collection plant, work on process plant handling toxic chemicals, removing blockages from drains. Planning and the avoidance of manual tasks are the key to effectively minimising exposures.

MAINTENANCE STAFF need to use PPE.

CONFINED SPACES are dangerous.

Confined spaces can be especially dangerous. These are often encountered during maintenance activities. Some examples of what happens when situations are inadequately assessed are given below. These examples illustrate the need for stringent precautions to be adopted before and during any work in areas where conditions may be immediately hazardous to life. (see Health and Safety Executive Guidance Note GS5 'Entry into Confined Spaces' for information on the procedures and precautions to be taken).

- Deaths have occurred during cleaning of degreasing baths where employees have been overcome by high concentrations of vapour. Planned preventative maintenance, based on changing the degreasing solvent at appropriate intervals before residues build up, effectively eliminates the need for entry into tanks.
- Maintenance workers have died as a result of entering a confined area where the oxygen has been depleted through rust formation. Recognition of the potentially dangerous situation is fundamental to preventing this type of tragic event.

- Welders have been overcome because shielding gas cylinders have been inadvertently left on in a small space and oxygen levels have dropped below that needed to sustain life.
- Farm workers have died from exposure to hydrogen sulphide after disturbing the settled contents of slurry pits. This type of event can be prevented by regular stirring of the slurry to prevent formation of toxic gases which tend to build up if the contents are deprived of oxygen. A further safeguard is to operate controls from outside the farm building. The potential rate of release of toxic gases increases if high-powered equipment is used to agitate the slurry. Accidents like this can happen in quite large open buildings, not just confined areas.

PROPER PROCEDURES:
permits to work
escape facilities
drench showers
air monitoring
personal alarms.

The first step is always to try to *devise systems of work* that do not require entry into the types of area found in the cases above. These examples illustrate the need for procedures which are designed to allow *cautious entry* into areas where conditions may be *immediately hazardous to health.* Proper procedures may include permit-to-work systems, emergency escape facilities, emergency drench showers and comprehensive atmospheric monitoring arrangements including personal exposure alarms. ***Recognition of the potential problems, which arises from a full assessment, is critical to overall safety.***

Emergencies may arise during the running of a process and established contingency procedures should be reviewed at regular intervals.

Emergencies may result from:

- loss of containment of the substance,
- unexpected chemical reaction,
- failure of engineering controls,
- operator illness or error.

PROCESSES should ***fail-to-safe.***

Obviously it is not possible to plan beyond *foreseeable* situations and consequences but wherever possible processes should be designed to operate in a *failure-to-safety mode.* Rather than dealing with the problem *after* it has arisen it is much better to design inherently safe plant. The process development and conceptual design stage are the times to really think about this approach.

Emergency procedures may rely heavily on the use of personal protective equipment and it is vital that all staff who could be involved are properly trained. In the case of *loss of containment during transport*, it is essential that individuals understand their limit of involvement and the circumstances in which they should call for external assistance. They need to be aware of any action they ought to take in the interim until assistance takes over.

8 Keeping things under control

MONITORING PROGRAMMES by competent and responsible persons.

Once you have decided upon a control strategy and put it into operation you need to make sure that the level of protection is maintained or improved. Control measures need to be maintained in efficient working order.*Somebody who is competent and responsible should monitor when things begin to go wrong.* **Engineering controls**, such as local exhaust ventilation, have to be regularly examined and tested to make sure you are getting the best from it. The *Health and Safety Executive* produce a booklet *HS(G)54 - 'The Maintenance Examination and Testing of Local Exhaust Ventilation Equipment'* which gives much useful information about what needs to be done. The **maintenance of respiratory protective equipment** is considered in another *HSE* booklet, *HS(G)53 - 'Respiratory Protective Equipment: A Practical Guide for Users'*.

Practical advice is available in the two well-defined areas mentioned above. But it is just as important to review regularly the way in which the hazardous substances are being controlled in totality.

A ***monitoring programme*** may be desirable to prove that there is not a trend towards increased exposures. Monitoring can be carried out by consultants or you may wish to do the job in-house. It is often possible to carry out the sampling work yourself and let a qualified laboratory undertake the analysis. It is important to be sure you know where the sample comes from and you know what the results mean when you get them. Often just a simple set of tests using simple instruments or smoke generators will give you all the information you need. If you manage to identify particular areas of concern, it may be necessary to carry out some more-sophisticated assessment of the operation. Do the simple things first!

LEAD by example.

You should supervise the system of controls: observe whether control features are being used properly. For example, are segregated areas and respirator zones being used properly? *If you are in a responsible position, lead by example* and comply with every requirement being imposed on others. This reinforces the message. Review of information from sources such as atmospheric monitoring, and maintenance records will allow proper evaluations to be made on the continuing effectiveness of the control strategy.

Where personal protective equipment is required in a company, a system of monitoring by supervisory staff of the wearing of the equipment may be needed, with appropriate disciplinary procedures for offenders.

9 Getting the message across

KEY ELEMENTS: information instruction training.

Information, instruction and *training* are key elements in control. Once again, this has been recognised in the various pieces of control legislation. Employees need to understand the risks to their health created by their exposure to the hazardous substances. They should also know how control features can be operated effectively. You then have a better chance of them operating the system properly.

SAFETY DATA SHEETS provide information.

Where can you find information? The **safety data sheet** may help you to do this if there is one - but you will need to explain technical details to people on the shop floor. Employees should be aware of early signs of over-exposure and should understand the ultimate consequences of prolonged exposure. They will need to be thoroughly acquainted with personal protective equipment. This includes getting the right equipment for the job and understanding when and where to use it. Repair, maintenance and when to replace are all important. *Employees need to understand the reasons for a monitoring programme*, which could be an important part of the overall control strategy - else they may not co-operate with it.

Instruction for employees on process operation is vital. They need to know what precautions should be taken and when to take them. They should know about cleaning, storage and disposal procedures, and they should understand why all of this is necessary. Instruction on disposal could be very simple. Putting **solvents** in the correct container to ensure there is no adverse reaction is often important. Making sure **acid and cyanide** residues from plating processes are not mixed or putting **solvent-soaked wipes** into a lidded metal bin are further examples. In the case where foreseeable emergency situations might arise, employees need to be instructed in procedures to be followed.

EXPLAIN procedures and precautions to employees.

Training and instruction are often interlocked. The practical experience of going through a procedure relating to aspects of control reinforces the message to be learnt. For example, operators may need to make minor adjustments to ventilation arrangements (*eg* inserting dampers in unused ductwork), depending on what they are doing. Too much freedom to tamper with the control measures might lead to exposures as the system becomes inefficient or out of balance. Process emissions may depend on parameters over which the workforce have control.

EVERYONE needs continuing training.

Training should be appropriate for the job and be seen as a continuing requirement. Refresher training may be occasionally necessary. Training requirements apply to supervisors and managers alike. Everybody needs to appreciate why effective control is needed and how to achieve it.

TRAINING RECORDS should be kept.

In order to manage these important elements of the control package, many companies keep detailed **records** of when and how their staff have been trained. Conscientious record keeping allows planning of refresher training as and when required.

10 In conclusion

UNDERSTAND HAZARDS; CONTROL MEASURES; RECOGNITION; EVALUATION; CONTROL STRATEGY; ACTION PLAN.

This *General Guide* illustrates the many aspects that go towards achieving acceptable levels of control of substances at work. A successful approach relies on a good understanding of the hazards of substances, but more especially of the range of control measures, procedural, mechanical and managerial, that allow hazardous substances to be used with the minimum of risk. Recognition and evaluation are essential steps, but of no value unless they are teamed with an effective control strategy, in order to prevent disease, and a prioritised action plan to make improvements where these are deemed necessary.

Occupational hygienists are skilled in the science of recognising hazards, evaluating the risk they present and in their control. They can also contribute to effective training and other aspects discussed in this part of the *Guide*.

OCCUPATIONA L HYGIENISTS recognise hazards, evaluate and control.

There are two organisations which are active in this field. These are:

The British Occupational Hygiene Society (BOHS)
and

The Institute of Occupational Hygienists (IOH).

Both have offices at:

Suite 2, Georgian House
Great Northern Road
Derby DE1 1LT.
Tel: (BOHS) 01332 298101,
(IOH) 01332 298087.
Fax: (both) 01332 298099.
Email: (BOHS) 100705.3356@compuserve.com

The Institute, which deals with professional matters in occupational hygiene, publishes a list of consultant occupational hygienists.

CASE STUDIES from ***real*** companies follow.

The ***case studies*** that follow illustrate how ***real*** companies have approached problems of workplace exposure. The main theme relates to the way changes can be cost-effective. Often tackling problems in an innovative way will enhance performance in areas such as quality, profitability, production capacity or company image. The approaches to control fit in with the ideas in the first part of the *Guide* and show how they can be applied with success.

How can we control?

The basic ideas are:

BASIC IDEAS:
get rid;
contain;
control locally;
segregate;
train;
PPE.

- Get rid of the substance; change the process or use something else instead.
- If you can't, contain it; fully enclose the source to stop spread of contamination.
- If you need to work with the substance, stop it affecting the operator - control it locally.
- Make sure areas of high exposure are well defined and segregated from other work areas.
- Train your staff properly.
- If, after everything else you are still unhappy about the level of exposure, think about a programme of personal protective equipment.

11 Case studies: what are these for?

The following *case studies* in this *Guide* illustrate a number of different ways of dealing with problems at work where people are exposed to substances. Answers to problems are often so simple you might ask yourself - why didn't I think of that? Sometimes a little specialist help provides all you need to get onto the right track.

It is hoped the examples will give you some ideas - spur you on to solve some of the problems where you are concerned about reducing the level of exposure of people at work.

What comes out clearly from many of these examples is that a little invention and a bit of investigation brings rewards in all sorts of unexpected areas. There are cases of increased productivity, better product quality, decrease in outlay on raw materials, improvement of company image - all linked to improvements in controlling substances in one way or another. Many companies when asked to cost out improvements in controlling exposure will say - 'We are not quite sure what it costs but we know it is worth it'.

What is the right answer in one case may not be the right answer in another. It wouldn't be possible to provide chapter and verse on the best way to control exposure at the vast range of activities that take place in industry. That's where this part of the *Guide* comes in. It may trigger ideas, because after all, you know your business best.

11.1 Improving production through automation

Anyone who's seen a carpenter at work will know that wood sanding using traditional methods produces a large and seemingly uncontrollable amount of fine wood dust. As well as the problem of cleaning up the workplace at the end of the day, this dust can cause health problems if breathed in by the machine operator or others working nearby.

THE PROBLEM

When an upholstery firm was asked to fine-sand the arms of its wooden chairs, the company's managers made a conscious decision to reduce the amount of hardwood dust produced while at the same time increasing production.

THE SOLUTION

The taking advantage of technological progress provided the solution to the firm's problem! By investing in an automatic sanding machine coupled with the use of local exhaust ventilation, the company solved its problem and at the same time achieved its objective of increased production.

☹ THE COST

The automatic sander and local exhaust ventilation cost £4400 - money well spent when the benefits are considered!

☺ THE BENEFITS

The return on the initial investment exceeded expectation. Within four months, the firm was producing 70 chairs per week - a 100% increase in output.

In addition, the fine hardwood dust was eliminated from the atmosphere. The local exhaust ventilation system carried the dust away to the dust collection system. As a result, the health risk posed by the dust was removed.

Safety was further improved by removing the need for sanding to be done by hand. The automatic sanding machine meant that the danger of accidents happening was virtually removed.

The whole process was speeded up greatly. The automatic sander produced seven finished arms in one minute, whereas using the belt sanding machine took five minutes to sand one wooden arm!

"Making use of modern technology can kill two birds with one stone - removing the problem and improving production at the same time. Definitely money well spent!"

11.2 Boxing clever

Different problems can arise at different stages in a production process. It is important to look at the various activities carried out in the workplace and assess the risks they pose individually.

THE PROBLEM

A ceramics producer was faced with the problem of controlling dust clouds created during the opening and weighing of bags containing silica, dried porcelain and other dusty materials.

Not only did the dust which escaped when the bags were opened pose a health hazard to the worker involved, but it spread around the workplace, posing a threat to all those who came into contact with it.

THE SOLUTION

The company adopted a very simple solution to the problem. It set up a three-sided booth with a top canopy with local exhaust ventilation attached. Scales were placed in the booth so that the operator placed the bag on the scales, slit it open and removed or added contents to the required weight. The local exhaust ventilation removed any dust clouds which formed.

☹ THE COST

In this case where local exhaust ventilation could be adapted, the cost was no more than the price of a three-sided booth and canopy, designed and made on the premises.

☺ THE BENEFITS

This simple but effective solution removes dust from the operator's breathing zone and from the workplace as a whole. Money which would otherwise have been spent on purchasing dust masks can now be put to other uses.

"A clean working environment is a healthy working environment - and with a little thought is not as difficult to achieve as you may think!"

11.3 Exhausted - and proud of it!

A problem common to many motor workshops is the exhaust fumes emitted into the atmosphere when engines are left running.

These fumes can quickly accumulate in the workshop, posing a health hazard to employees.

THE PROBLEM

A new car dealership with extensive workshop facilities was being set up in the West Midlands. Aware of the exhaust fume problem, the owners decided to address the situation when designing the new premises.

THE SOLUTION

The firm installed dedicated local exhaust ventilation at car bays to remove the fumes produced by the cars.

Truncated hoses hanging from the ceiling can be extended by pulling them down to ground level and passively fitting them around a car exhaust. When fitted, a fan in the roof area is switched on, drawing the exhaust fumes out of the building.

☹ THE COST

A moderate outlay of a few hundred pounds during the design stage creates a much more professional looking enterprise. The cost is spread across a number of years and is easily offset against the increased trade stimulated by a clean efficient workshop.

☺ THE BENEFITS

Workers are no longer exposed to exhaust fumes, thus providing them with a clean and healthy working environment. This leads to a reduction in absenteeism due to occupational ill-health, and a happier, more productive workforce.

Also, with the ventilation systems all being housed in the roof, there is less clutter on the workshop floor.

"The system is good to use, easy to maintain - in fact, that's why it works so well. It has been designed with the job in mind!"

11.4 Brushing up on dust control

Some people might be surprised to hear that wood dust can pose health hazards, but it's true. Respiratory problems and allergies are frequently encountered in carpentry and woodworking establishments, especially where hardwood is used.

THE PROBLEM

A firm involved in specialist joinery manufacture deals mainly with oak and mahogany. Because the dust from these hardwoods can be harmful to health, the company decided to take steps to control it.

However, due to the range of machinery involved (circular saws, sanders, lathes and a spindle moulder), flexibility and adaptability was the name of the game.

THE SOLUTION

Each piece of machinery was connected to a local exhaust ventilation system. The trunking of the system is flexible and can be adapted to any machine.

☹ THE COST

The actual installation cost of extractor, ducting and cyclone was £6000, while an additional portable piece of local exhaust ventilation equipment cost a further £250 - a sizeable outlay for a small firm, you might say, but read on ....

☺ THE BENEFITS

The benefits were many and considerable. First, the reduction in the amount of dust in the atmosphere made the workshop a healthier, more pleasant environment for employees.

Secondly, the dust, wood-chips, shavings and off-cuts are used to fire a furnace which heats up the workshop. As a result, the heating costs for the premises are negligible (the firm's heating bill worked out at £42.70 over a three-month period!).

Thirdly, the cost of getting rid of the off-cuts, wood-chips, sawdust *etc* is saved.

There is, however, one extra cost - plant insurance. At £194.30 per 14 months, the plant machinery is examined and inspected by the insurance company, so prolonging its working life and preventing unforeseen breakdowns.

" Making use of waste can pay dividends. Think about what you do with your waste and see if it can work for you and keep your workshop clean into the bargain."

11.5 Keeping it simple

The importance of looking at every stage in the processes carried out in the workplace cannot be over-emphasised. Even when you think the job is done and dusted, there could be hazards which need to be addressed.

THE PROBLEM

A ceramics producer kept its dust well under control during the actual production process, but the problem arose when disposing of the empty bags which had contained harmful dusty raw materials.

These bags were just thrown on the ground, where the operators stood on them, rolled them up and threw them away. And the result - clouds of dust billowed into the air, affecting the operators and coating the working area, which ultimately had to be cleaned.

IDEA! THE SOLUTION

Because the hoppers where the dust was mixed already had dust extraction systems fitted, the company adapted the canopy, attaching a polythene bag to a flanged hole. The empty dust bags were then rolled up above the hopper and pushed through the hole, directly into the polythene bag.

☹ THE COST

Negligible! All this method required was for a hole to be cut in the existing canopy, and the purchase of a supply of polythene bags. Nothing could be simpler!

☺ THE BENEFITS

No more escaped dust to pose health risks to operators or mess up the working environment. A simple solution to the problem means no need to fit special exhaust ventilation.

"A dust-free environment means a happier and more productive workforce - and at negligible cost!"

11.6 The times they are a-changing

Keeping up-to-date with advances in modern technology can often provide a simple solution to a problem which previously seemed difficult to overcome, as a paper producer found out.

THE PROBLEM

This firm produces paper for cardboard boxes. The process uses gallons of water - in fact, 30,000 gallons per hour are required to produce 18 tonnes of paper!

Because the water in this area is 'hard', scale builds up in the pipework similar to that in a kettle. This reduces the diameter of the pipe, can block narrow jets, reduces plant efficiency and is costly to clean up.

The conventional solution is to pump acids through the pipework, but this brings its own hazards and is expensive. Of course, when the acid is being passed through the pipes, this means loss of production and, if descaling is not carried out, the quality of the product may be put in jeopardy. A real 'catch 22' situation!

THE SOLUTION

The solution to this problem has a certain attraction!

This system basically involves fitting a tube to the existing pipework where the water passes through. Inside the tube is an array of magnets which prevent the formation of scale inside the pipe. No external power supply is necessary and maintenance is minimal. The magnetic field prevents solid residues forming inside or around the pipework and prevents build up of scale that blocks jets. No more nasty acids and far less plant downtime for maintenance.

☹ THE COST

The average pay-back period is between six months and a year based on cost of chemicals and maintenance costs for descaling procedures. If savings in energy consumption, higher productivity because of reduced downtime and improved quality are brought into the equation, the cost-effectiveness of the magnetic treatment is even greater.

☺ THE BENEFITS

Improved safety as use and handling of corrosive acids is no longer necessary.

No need to shut down machinery for descaling, so production increases.

" These magnets are poles apart from traditional methods."

11.7 When you can't see the wood for the trees

Controlling substances hazardous to health is not just a problem when working indoors.

Many people who work outdoors come into contact with dangerous substances or processes, and safety must be taken seriously wherever you work.

THE PROBLEM

Pesticides should always be handled carefully, as they are potentially hazardous to health.

A forestry company used to dip the roots of its trees in pesticide to protect them from beetle-attack. However, this process was carried out by hand, placing the operators at risk. Also, excess pesticide was used which may have been harmful to the environment, as well as being wasteful.

THE SOLUTION

A conveyor system was designed so that the spraying could be carried out automatically.

Plants are placed on one end of the conveyor and travel to an enclosed spray chamber in the middle. Here, the pesticide is electrostatically charged so that the droplets are attracted to the nearest earth target (*ie* the roots of the trees), and the droplets of pesticide spread themselves evenly across the tree roots. Any vapour is vented to the atmosphere, and by the time the roots reach the end of the conveyor, they are dry and ready for immediate packaging.

☹ THE COST

The initial cost of the machine was £5000. The machine processes about 2500 plants per hour, with a total treatment cost (including labour) of about £13 per 1000 plants.

☺ THE BENEFITS

Using the conveyor system, only the minimum amount of pesticide required for treating the plants is used, so reducing exposure of operators and planters. The ergonomic design of the conveyor also means that operators are working at waist height for added comfort. The whole process is speeded up beyond expectations.

"Less danger to people and to the environment, faster working and reduced costs gives a four-ways benefit from using this system."

11.8 Give dust the brush off

Whether your company is involved in producing goods or providing a service, it is important to consider the health and safety not just of employees, but of the customer or user of the end product.

THE PROBLEM

A company was facing a dust control problem.

After bagging the product and sealing the bag, there was always some degree of dust contamination. As a result, there was a problem of airborne dust, as well as skin exposure to employees and to the end user, including members of the public buying from DIY stores.

Various methods were tried by the company to control the dust, such as sweeping the bags or blowing the dust off with compressed air, but these methods simply created greater dust clouds near the operators.

THE SOLUTION

The company's engineers developed a system similar to a car wash.

Bags are carried down from the bagging plant on a conveyor. Half-way down is an enclosed chamber housing two brushes and fitted with local exhaust ventilation. The brushes sweep each bag clean while the ventilation system prevents the dust entering the workplace.

☹ THE COST

As the company's own engineers designed and built the system, the main cost was parts. The local exhaust ventilation system was already installed, and simply had to be extended to the bag cleaner.

☺ THE BENEFITS

Removing the dust from the outside of the bag meant no airborne exposure to employees. Clean bags also meant no dust on the hands.

Finally, cleaning up its act meant an improvement in the company's image at both wholesale and retail outlets.

" Using your own experienced staff saves a lot of money for this type of problem, but be careful not to ask too much of your ventilation systems."

11.9 Milking technology for all it's worth

Machinery maintenance is essential if production standards are to be maintained.

However, safety during maintenance is just as important as during the main production process, and sufficient care and attention should be paid to ensuring that health and safety precautions are always taken.

THE PROBLEM

On dairy farms, cows are normally milked mechanically. Because cleanliness is essential, the pipework has to be cleaned and disinfected regularly.

Some farmers do this by tipping concentrated bleach from a five-gallon drum into a bucket, diluting it with water and pouring the mixture into the pipework. But just imagine the potential spillage from tipping a five gallon drum of bleach!

IDEA! THE SOLUTION

A dairy supplies firm in Preston came up with the idea of a vacuum-operated liquid chemical dispenser. The dispenser draws the bleach directly from the drum, passes it into a holding tank, and then a pressure differential forces it through the pipework.

Almost anyone who has to transfer liquids can use this type of system.

☹ THE COST

This simple solution to a potentially dangerous problem costs just £65!

☺ THE BENEFITS

The benefits are enormous. No spillage and no direct handling of the bleach means no chance of contamination to the farmer or employees.

Careful control of the amount of bleach used means no wastage. Also, the bleach or any other chemicals can be physically locked away - always good practice where children are concerned.

" It doesn't take a lotta bottle to make use of advances in technology to improve health and safety in the workplace."

11.10 Tricks of the trade

Hazardous substances come in many varieties and are used for a huge range of different purposes.

If you have chemicals in the workplace, ask yourself if they are being used safely, or even better, can you replace them with safer alternatives.

THE PROBLEM

A company making metal control-boxes for electrical equipment needed to clean and de-grease its products before spray-painting them.

Previously, the company immersed the panels of its boxes in a trichloroethane tank. However, trichloroethane gives off a lot of vapour and is harmful to health. The work methods used led to this solvent being 'slopped' around the tank where employees were working. Also, some workers tended to carry around rags soaked in it to wipe dirt and grease off the panels when necessary - not exactly good health and safety practice!

THE SOLUTION

When the time came for the company to move to new premises, it decided to review its working practices. As a result, it was decided to stop using trichloroethane for de-greasing, and to change the type of paint used to coat the boxes.

Lack of space led the company to design a U-shaped continuous track system. Panels are loaded onto jigs which pass into the de-greasing tank, where they are washed with an aqueous acid solution which is subsequently drained away with other water from the premises.

When dry, the jigs pass into a spray booth, where an employee sprays them with powdered paint. The local exhaust ventilation in the booths prevents workers being exposed to the paint - in fact, it is so effective that workers have no need of facemasks or personal protective clothing.

☹ THE COST

The initial cost was £120 000, but because of redeployment of labour and better quality of the finished article, this expense has been more than justified.

☺ THE BENEFITS

The potentially hazardous trichloroethane has been replaced with a much safer water-based de-greaser. No more hazardous vapours! Good local exhaust ventilation means workers no longer have to wear facemasks or personal protective clothing. Product quality is improved.

" Better working practices lead to a better end-product - and satisfy health and safety requirements to boot!"

11.11 Look after the pennies -

Technology is forever advancing, with new products coming onto the market almost daily. When was the last time *you* looked at the potentially dangerous substances in use in your workplace, and asked yourself: *"Is there a safer alternative?"*

THE PROBLEM

Once again, highly volatile chlorinated solvents were the problem.

A company is involved in producing metal castings for the aerospace industry. These castings are produced in ceramics moulds able to withstand high temperatures, the required shape being formed in the uncured ceramic by a wax pattern. However, each new mould requires a new wax pattern which when it is made commonly has a few rough edges which have to be removed before forming the mould.

However, when a new mould is formed, it contains a few rough edges which have to be removed before casting. Until recently, these rough edges were removed using chlorinated solvents, which should only be used in well-ventilated areas or where local exhaust ventilation is provided.

IDEA! THE SOLUTION

The firm decided to substitute the solvent with a water-based citrus oil product. This is kept in small open pots on the bench, and is applied using a cotton bud.

☹ THE COST

Although the citrus oil costs a bit more, there is no need to use local exhaust ventilation. The slightly higher cost is vastly outweighed by savings in electrical costs and maintenance of the local exhaust ventilation equipment.

☺ THE BENEFITS

No more harmful organic solvent endangering workers' health and safety, plus considerable financial savings. Even small amounts of volatile chlorinated solvents can quickly produce high levels of vapour in a large workroom.

"Just the job. Immediate savings and a safer working environment - isn't it time you looked carefully at using alternative products?"

11.12 A change is as good as a rest

Certain products need to be handled with great care, whereas less harmful ones can be more freely used. Could you use a product from the second category in place of one of the more dangerous alternatives?

THE PROBLEM

A small building firm near Eastbourne was using a powerful pesticide to clear weeds etc. before laying foundations. This product, intended for professionals, required the use of personal protective equipment especially when handling the concentrated product.

THE SOLUTION

The firm changed to a readily available proprietary weedkiller available in most DIY outlets and garden centres. Because of stringent registration requirements this product, suitable for use at home, it doesn't need the same level of precaution when using it.

☹ THE COST

Cost isn't the word to use - changing to the new product saved the firm £500 a year!

☺ THE BENEFITS

As well as the financial savings, the proprietary weedkiller is also a safer product, does the job just as well and requires no personal protective equipment to be used.

"Nothing could be simpler! Changing products could save you money, too."

11.13 Getting rid of your worst bugbear

As some of the case studies contained in this Guide show, human ingenuity is a marvellous thing. However, this one takes the biscuit!

THE PROBLEM

Have you ever wondered how much work goes into preserving pieces of historical clothing on display in museums? A number of London museums adopted a clever solution to the problem.

Previously, pesticides were used to prevent damage by pests such as moths and woolly-bear. However, a far safer and simpler method was devised to keep these valuable garments bug-free.

THE SOLUTION

The museum devised a process to fool the insect eggs into believing it was time to hatch.

Articles are placed in a freezer for a short time, before being returned to the warm. After a suitable period (determined by eminent entomologists), the articles are bundled back into the freezer. The newly hatched larvae perish before doing any damage. After a vacuuming down, the articles are ready for exhibition.

☹ THE COST

What cost?

☺ THE BENEFITS

No need to use pesticides, which could prove harmful to workers and exhibits alike.

"The simple methods are often the best. A little lateral thinking can go a long way."

11.14 If safety in your workplace is becoming a bit of a bind -

Often, dangerous substances used in the workplace require expensive and inconvenient procedures to be adopted to allow them to be used safely. Find a safer substance and the safety precautions become redundant.

THE PROBLEM

A firm making metal castings for the aerospace industry encountered problems with its mould-making process.

Part of this process involves adding a binder containing alcohol, ammonia and ethyl silicate. Unfortunately, alcohol and ammonia can be harmful to health, and alcohol is flammable.

To ensure that employees are not exposed to these compounds, the firm fitted elaborate local exhaust ventilation on their mixing vessels, which were also fitted with flameproof motors to avoid igniting the alcohol. This cost a considerable amount, with further expenditure on maintaining the machinery. Time for a rethink!

THE SOLUTION

The solution was straightforward - simply find a safer binder, in this case a proprietary colloidal silica water-based product.

☹ THE COST

There is a short-term increase in cost, but this will be quickly recouped because of energy saving.

☺ THE BENEFITS

There is no longer any need to flameproof the motors (although they are still fitted, when they need replacing, cheaper motors can be purchased).

There is no need to run or maintain local exhaust ventilation as it is no longer required.

Risk of worker exposure is removed.

"Remove the root of the problem and the benefits come tumbling in."

11.15 A burning problem

Some processes are inherently dangerous and would require the wisdom of Solomon to make safe. However, that is not to say that you shouldn't look at ways of making them *safer*.

THE PROBLEM

In the molten metal industry, workers have to work very close to the furnace. To do this, they have to wear personal protective clothing to guard against the excess heat and splashes of molten metal. Fumes from the furnace can also be a problem.

The company in question had a problem in pre-heating its moulds in the furnace (temperatures of around 1000°C can be reached) and then transferring them to the pouring furnace, where the molten metal is poured into the mould, producing a casting.

This work means that employees have to wear personal protective clothing, including a visor. This clothing protects them from burns, but not from the fume.

THE SOLUTION

The company adopted a 'safe by distance' solution. It constructed a set of tongs about 5 metres long which are pivoted in the middle by a small bogey on wheels. This allows the operator to pick up the mould and move it round the workshop while maintaining a safe distance.

☹ THE COST

The main cost came from making the tongs, but this involved no large expenditure as the company did the work itself.

☺ THE BENEFITS

Workers have to come no nearer to the furnace than 5 metres. Excess fume, which escapes when the furnace door opens, rises quickly and is diluted in the atmosphere. The workforce are no longer exposed to high levels of fume.

Heavy personal protective clothing is no longer required, meaning savings for the company and a more pleasant working environment. Also, lifting and handling is reduced as moulds and casts are wheeled around the shop floor.

"A little ingenuity can make a big difference when tackling these kinds of problem. Ask the workforce - they may have a few ideas up their sleeves which could benefit both themselves and the company."

11.16 Far away = far safer

Better than allowing your workers to operate near to a potentially dangerous and dusty process, why not put them in a separate room and let them do their work by remote control?

THE PROBLEM

Lime is used in the production of steel to remove impurities such as phosphorus and sulphur. The lime starts as limestone, which is blasted from the quarry face, loaded onto dump trucks and taken to the plant for crushing and screening to a fine powder which is heated to produce almost pure lime.

However, the process of converting the stone to a fine powder is very dusty, very noisy and very hazardous. If inhaled, the dust may cause health problems, and if the crushing plant can crush stone, it can also crush people!

THE SOLUTION

As it is difficult to control the dust (*ie* local exhaust ventilation would be inappropriate and the process is hazardous), closed circuit television cameras were installed along the production line, with monitors in an adjacent control room.

☹ THE COST

In this case, the total cost came to about £15 000 a few years ago. However, in 1995 the cost has tumbled with the availability of high-quality camcorders at modest prices.

☺ THE BENEFITS

Workers operate the plant from a comfortable control room, out of harm's way and outside the dusty environment. Making life comfortable for the operator solves the problem!

"Separate the worker from the danger if the danger can't be eradicated."

11.17 Beat the drum

Anyone who has to handle drums of chemicals realises that one of the major risks of exposure to fumes or vapour comes from the transfer pipe. An ingenious device gets round this problem by enclosing the transfer pipe in a ventilated outer sheath located above a gas-tight valve.

THE PROBLEM

A chemical company in the north-east had to transfer an irritant liquid into its reaction vessels from drums. Even with local exhaust ventilation around the transfer point, the operator still needed to wear a respirator to avoid uncomfortable exposure to the chemical. The main problem was the evaporation of the liquid from the transfer pipe after it had been removed from the drum.

THE SOLUTION

The firm installed a system where the transfer pipe was enclosed in its own flexible, ventilated sleeve. When the transfer pipe was in the drum it was not possible for any irritant vapours to escape. When the pipe was removed from the drum the ventilated sleeve extended over the contaminated section, totally enclosing the pipe and preventing the vapours reaching the operator.

☹ THE COST

The whole system cost in the region of £1200 including rotating arm brackets to help manoeuvre the transfer pipe. There was no extra cost for changes to the ventilation arrangements as these were already available. Systems can be in anti-static PTFE or highly chemically resistant stainless steel, which makes them compatible with a wide range of chemicals.

☺ THE BENEFITS

Workers no longer need to wear respiratory protective equipment. There is little chance of exposure to the liquid or vapour. The whole operation is cleaner and faster. No contaminated transfer pipes are left for someone to touch. Measured concentrations of vapour were reduced over the transfer period from an average of 90 ppm (with a peak of 300 ppm) to levels below 0.1 ppm. During filling operations the system takes away any vapour expelled from the drum and again eliminates the immediate need for local exhaust ventilation and respiratory protection.

"A simple, yet ingenious, solution to an age-old problem. An ideal example of contain and control."

11.18 If you want to know the answer, ask a specialist

Sometimes, specialist knowledge can be brought in to solve a difficult problem.

If you are using, for example, chemicals in a potentially dangerous way, the obvious remedy is to seek the advice of a specialist chemist. By bringing in such knowledge, a solution might be found which would not have occurred to anyone else.

THE PROBLEM

A firm produces a specialist floor-polish stripper. Part of the manufacturing process involves adding ammonia to the reaction vessel. During this procedure, the operator has to wear personal protective equipment and the surrounding area has to be cleared of employees due to the presence of ammonia vapour in the air.

Clearly, this system of work was unacceptable as there was no control.

THE SOLUTION

Local exhaust ventilation was suggested, but rejected as being unsuitable.

A development chemist came up with a chemical solution. Rather than adding ammonia in liquid form, solid crystals of ammonium chloride were added to the reaction vessel, so preventing ammonia vapour escaping into the workplace. When the crystals have been added, a solution of sodium hydroxide is poured in to release the ammonia into the solution.

☹ THE COST

There was an initial increase in cost of about 10%, but this was outweighed by the reduction in outlay for personal protective equipment and time savings compared with the previous more hazardous process.

☺ THE BENEFITS

Previously the operator was exposed to high levels of ammonia during the pouring process, and had to be provided with a canister-type face mask. These levels have now been drastically reduced.

The operator no longer requires a face mask, the work process is safer and quicker, and workers in the surrounding area need not be 'evacuated'.

"Seeking specialist help can bring fresh (and expert) ideas for solving a seemingly intractable problem."

11.19 Get into gear

As the saying goes, there is more than one way to kill a cat. The first line of attack when dealing with a problem such as emissions from machine tools is often to add on some ventilation. An engineering company, with a little expert help, have developed a different approach.

THE PROBLEM

A firm manufacturing gears found they had very high levels of oil mist being generated. The problem was so bad there was literally oil dripping everywhere. They thought about adding on some local exhaust ventilation but soon realised this was impractical. In the first instance oil and air cleaning systems are not compatible and secondly the cost was likely to be high for a system which probably would provide only a partial cure.

THE SOLUTION

It was decided to try changing the way in which the cutting oils were used. A new arrangement was designed to put oils onto the workpiece. Less oil was applied and the reduction in airborne oil mist was remarkable - a fraction of what it had been previously.

☹ THE COST

Traditional methods of controlling after the event would have been very expensive and with no real certainty of success. The cost of redesigning the cutting oil flow was minimal, largely being trial and error.

☺ THE BENEFITS

Apart from the obvious benefit of keeping personal exposure to oil mist really low, the company soon realised the advantage of not having to manage the problems resulting from spread of contamination. Housekeeping costs were much lower. Skin exposures were much lower and this could mean less chance of damaging dermatitis reactions.

"A little bit of creative thinking and some trial and error pays dividends. Cut the cost and get rid of the problem - you know it makes sense!"

11.20 Stop messing about

Sometimes trying to control dusty raw materials seems beyond technical possibility. One of the early thoughts with this type of problem is to try to get someone else who is properly equipped to do the work for you.

THE PROBLEM

An industrial polymer products manufacturer was determined to do something about the dreadful problems associated with handling carbon black. They considered all sorts of material handling arrangements but try as they might the dust problem and housekeeping problem would not go away. They decided on a different approach.

THE SOLUTION

Industrial polymer manufacture is all about mixing the right quantities of all sorts of chemicals together to create the final uncured product. Why not buy in pre-prepared raw materials already incorporated in a rubber base. No dust, no exposure, no housekeeping problem.

☹ THE COST

There are costs associated with buying raw materials already partly processed. However when weighed against the savings to be made from no longer having to control a notoriously difficult material the cost was worthwhile.

☺ THE BENEFITS

No dust, no exposure, no housekeeping problem. The workforce at last have a clean environment to operate in. The company further decided to buy in other pre-mixed dusty raw materials in process-compatible plastic bags for adding to mixers and roll mills. This effectively eliminated exposure to dusty solids for operators.

"It is not just the rubber industry that can use this approach to handling raw materials - if you've got a dusty process think about whether you can do likewise."

11.21 Don't ventilate - automate

A complete reappraisal of the way you do things can come up with some surprisingly good ideas and lead you to making investment for the future - and there is no more certain future than the advance of robotics as a major force in manufacturing. See how this study lets a manufacturer include health and safety benefits when making major investment.

THE PROBLEM

A Midlands plastics moulding company realised that their employees' exposure to dust was about five times higher than allowed. The company management decided enough was enough and set about the problem in a radical way.

THE SOLUTIONS

Most of the dust exposure occurred during sanding down of finished mouldings. This happened because the moulding tool was a lightweight porous casting. It was prone to leakage of the molten plastic which led to an uneven surface finish. By investing in a new moulding tool, machined from a solid block of metal, the surface finish of each moulding was improved dramatically. This improvement made the final sanding of each moulding unnecessary.

The remaining source of dust was found to be from hand routing to trim excess material from the edges followed by sanding. This problem was dealt with by automating the process and installing an industrial robot. The robot was fitted with a high-pressure water jetting system. The process was completely enclosed and all waste removed with the water discharge.

Exposures have been eliminated and the quality of the finish of the final cut has made sanding unnecessary.

☹ THE COST

OK this system isn't cheap. Moulding tools cost around £3,000, robots cost about £40,000 and the high-pressure water jetting system about £60,000, at 1994 prices.

☺ THE BENEFITS

Dust exposures have been eliminated while productivity has increased by 500%. Such a dramatic improvement means that the company are looking at payback inside two years. There are other benefits linked to improved safety and elimination of a vibration hazard.

"Although the costs seem very high, a knowledge of your business can let you make some sound decisions which include health and safety benefits as well."

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