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HSE CONTRACT RESEARCH REPORT No. 73/1995

**DUST AND NOISE IN THE
CONSTRUCTION PROCESS**

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This report is concerned with methods of avoiding and controlling the hazards and risks associated with dust and noise on construction sites. Terms are defined and the principles of risk assessment and control are discussed. The natures of the differing hazards are then explored: dust hazards and risks arising from twelve major activities are identified, many of which can lead to disability or death unless either avoided or controlled. The hazards associated with noise are reviewed in a similar way, with descriptions of what actions must be taken when the different Action Levels are reached or exceeded. A final major section identifies at which points in the building sequence designers can help to avoid or mitigate hazard and risk by altering their designs or specifications. Appendices contain definitions of the terms 'designer', 'planning supervisor' and 'principal contractor' and describe various forms of personal protection equipment. There is a selected set of references and a short bibliography.

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INTRODUCTION ;

At first glance, it may not seem important to designers to design buildings which are safe to construct, much less to consider the particular hazards and risks associated with dust and noise. Surely this is 'the contractor's problem'? But nothing could be further from the truth. If such attitudes still prevail, they arise from the continuing belief that getting a building built is a confrontational rather than a cooperative endeavour. In fact, amongst the many hazards facing construction workers, dust and noise can be as injurious and life-threatening as falling off the edge of a roof. Designers can often greatly reduce their adverse effects by first, fully understanding how their buildings will be put together and then taking the appropriate action to avoid the hazard or mitigate the risk by redesigning or respecifying.

1 SCOPE :

This Research Report gives advice on various methods of eliminating and controlling dust and noise hazards and risks during the construction process by means of the correct specification of materials, components and assembly processes. It sets this advice in the context of the activities performed by the principal contractor, illustrating how the achievement of health and safety is a joint responsibility. Reference should be made to the Construction (Design and Management) Regulations (CDM) for formal definitions of the legal duties and responsibilities of the different parties.

It should be emphasised that it is not the purpose of the Report to cover again ground which is better covered elsewhere, for example in those publications listed in Appendix 3. Rather, it is to focus the designer's attention upon various ways in which the health and safety problems associated with dust and noise can be designed out or at least mitigated, both for those undertaking construction work and those who may be affected by it.

2 DEFINITIONS :

DUST Any product of a construction process which forms a powder or cloud and is injurious to health or is in a substantial concentration, including cement, wood, stone, silica, fillers and plastics. The high speed cutting and grinding of most products can cause dust. Those dusts which are known to be injurious to health are listed in the HSE Publication EH40/94 'Occupational Exposure Limits' and concentrations which should not be exceeded can be found there.

Concentrations of any inhalable dust in excess of 10mg/cu.metre of air averaged over 8 hours, or any

respirable dust in excess of 5mg/cu.metre averaged over 8 hours are deemed to be substantial concentrations of dust and therefore within the definitions of substances hazardous to health contained in the Control of Substances Hazardous to Health Regulations 1994 (COSHH)

NOISE There is a statutory duty to control noise and to protect workers and other persons from its effects. The Noise at Work Regulations, 1989, sets three noise exposure levels :

First Action Level : daily personal noise exposure of 85 dB(A)
Second Action Level : daily personal noise exposure of 90 dB(A)
Peak Action Level : a peak sound pressure of 200 Pascals

HAZARD The POTENTIAL to cause harm. During the risk assessment process, ALL the hazards associated with an activity must be identified. The methods of identifying hazards are therefore important.

RISK A function of the likelihood that harm resulting from a hazard will actually occur AND the severity of its consequences. The degree of risk should take into account the number of persons likely to be exposed to the harm.

RISK ASSESSMENT : An identification of the hazards present in a particular activity and an estimate of the extent of the risks involved, taking into account whatever precautions are already being taken. It is essentially a three stage process :

- (1) Identification of all hazards ;
- (2) Evaluation of risks ;
- (3) Measures to control those risks.

3 PRINCIPLES OF RISK ASSESSMENT AND CONTROL :

It is not the function of the designer to evaluate all likely hazards and risks on site ; that is the job of the principal contractor, perhaps in conjunction with the planning supervisor. But the CDM Regulations impose upon the designer a duty to ensure that, so far as is reasonably practicable, any design which he or she prepares will conform with the hierarchy of risk control, that is :

- 3.1 To avoid altogether, if possible, risks to the health and safety of any person at work on building, maintaining, repairing or carrying out cleaning work on a structure ;

- 3.2 To combat at source risks to such persons, and
- 3.3 To give priority to measures which protect the whole workforce over any measures which protect only the individual.

The designer must therefore, during the development of the design, evaluate likely hazards and the risks likely to be attendant upon each activity likely to be required to construct the building and seek ways of avoiding or reducing them within the design. It is not enough merely to rely upon common methods of control which contractors may employ. Designers must try to eliminate or reduce risk before the contractors begin their work.

4 NATURE OF THE HAZARDS :

4.1 DUST :

The harmful effects of dust can range from skin irritation to cancer, with the degree of risk dependent upon the nature and degree of exposure. Dust is not always an obvious hazard, however, since the particles or fibres which cause most damage are often invisible and the health effects of exposure may take years to develop. Chronic effects of dust in the lungs are usually permanent or disabling ; the prevention of onset of disease is therefore of prime importance.

The widespread use of power tools, especially portable ones, has markedly increased the health risks from dusts on construction sites. Unlike workshops and factories, where tools, plant and equipment are fixed and where waste products can be effectively controlled, for example by the use of exhaust ventilation, construction sites present a wide variety of workplaces. Many of these may be in confined spaces or poorly ventilated. The work itself may be brief. But a worker carrying out milling or grinding activities in several different locations each working day may be at risk through cumulative exposure.

In the construction industry, the most likely sources of dust are to be found in the following activities :

- 4.1.1 Demolition, including the use of concrete crushers ;
- 4.1.2 Grit blasting ;
- 4.1.3 Asbestos removal ;
- 4.1.4 Handling loose powders, e.g. cement, gypsum ;
- 4.1.5 Cutting and sanding wood and wood products ;
- 4.1.6 Handling and spraying man made mineral fibres ;
- 4.1.7 Scabbling concrete ;
- 4.1.8 Disturbing dust concentrations in existing structures ;
- 4.1.9 Sweeping up the workplace ;
- 4.1.10 Cleaning out ducts and trunking during commissioning ;
- 4.1.11 Carrying out maintenance ;

- 4.1.12 Rubbing down lead paint.
- 4.1.13 Stone cutting, eg sandstone, concrete blocks and paving slabs ;
- 4.1.14 Diamond drilling and sawing.

Most of these activities are discussed in turn and the particular hazards and risks associated with them identified. Methods of avoiding or controlling them are reviewed.

4.1.1 DEMOLITION :

The designer's input in demolition may be limited, but it is essential that the potential dust hazard is assessed during the preparation of the demolition method statement. Guidance on appropriate health and safety measures is contained in a series of HSE Guidance Notes and in two British Standards Codes of Practice (Appendix 2). The health risks from the dust created during demolition include inhalation, especially of asbestos fibres, and the presence or absence of asbestos should be established before demolition commences. 4.1.3 deals with this topic more fully.

A particular problem with demolition is the effects upon neighbouring areas : if dust is likely to spread into areas beyond the site, as it may do given unfavourable winds, steps must be taken to assess the risk and devise appropriate measures. For example, hand or mechanical rather than explosive methods will reduce the exposure to members of the public, but may increase the exposure to operatives. And in some cases overall dust exposure may be less with explosive methods.

4.1.2 GRIT BLASTING :

Grit blasting may be carried out using either dry or wet processes. The former involves blowing abrasive grit under air pressure to scour away surfaces, causing both dust and noise. Silica free material should be used for abrasive cleaning, since the inhalation of silica dust is harmful. Wet processes should be used wherever possible. These introduce water into the air/grit stream, greatly reducing the hazard to both building occupiers and the general public, although problems can still occur when slurries dry out. Designers can influence the selection of methods.

Where use of the dry process is unavoidable, likely levels of respirable dust should be assessed. Control of the risk should then be effected by use of some or all of the following :

- (1) Close sheet the workplace to reduce escaping dust to a minimum ;
- (2) Protect all windows and openings in the structure with polyethylene sheeting ;
- (3) Seal all joints ;
- (4) Protect pipework and electrical wiring, conduit and ducts ;
- (5) Protect or remove street or floodlighting ;
- (6) Cover all open inlets to drains ;
- (7) Protect valuable features on the building ;

- (8) Dust proof entrances which must be kept open ;
- (9) Erect protective barriers to prevent the public passing under or near the workplace ;
- (10) Collect all spent abrasive material and remove from the site at regular intervals.

4.1.3 ASBESTOS REMOVAL :

The Control of Asbestos at Work Regulations, 1987, (CAW), apply to all work connected with asbestos containing materials. In addition, there are two Approved Codes of Practice (ACOPs) and several HSE Guidance Notes. The Asbestos (Licensing) Regulations, 1983, prohibit anything other than short term repair work, unless it is carried out by a contractor holding a licence granted by HSE. The Regulations also cover the notification of removal work to the appropriate enforcing authority.

The CAW Regulations set control limits and action levels for asbestos. Control limits are expressed as concentrations of airborne fibres averaged over any four hour or ten minute period. Action levels are expressed as cumulative exposures over any continuous period of twelve weeks. The average level of asbestos fibre in the air inhaled by anyone must not exceed the control limits.

Before removal of asbestos products begins, the type of asbestos should be identified. There are three main types of asbestos found in buildings : chrysotile (white), crocidolite (blue) and amosite (brown). Chrysotile is the most common form and is still used, being found in insulation, asbestos cement products, roofing and decking tiles, insulating board and a wide range of lesser applications such as fillers, gaskets, decorative plasters and coatings. Many board and cement products now contain substitute materials. Crocidolite and amosite were used as sprayed coatings on structural steelwork for fire protection and for insulation against heat and noise. Many structures still contain large quantities and they are often found when insulation is stripped or disturbed during repair or demolition work. Removal of asbestos is likely to produce dust levels which will exceed the control limit or action level and the removal of sprayed asbestos is especially prone to produce high dust levels. Amosite was used to give structural strength to some asbestos cement products, such as high pressure water pipes. It may also be found in thermal insulation boards, ceiling tiles and as a sprayed coating. The specification of these products was often carried out by designers.

Next, a proper assessment must be made of the potential hazards. The assessment should :

- (1) Specify the type of work proposed ;
- (2) Identify the type of material ;
- (3) Detail the anticipated exposure, noting whether action levels or control limits will be reached or exceeded ;
- (4) Select the appropriate respiratory protective equipment ;
- (5) Estimate the frequency and duration of the exposure ;
- (6) Consider whether persons other than employees may be exposed to risk ;

- (7) Consider air monitoring reports, if available ;
- (8) Consider steps to be taken to prevent the spread of asbestos into the environment ;
- (9) Consider appropriate methods of removal prior to demolition work ;
- (10) Establish emergency procedures ;
- (11) Organise the safe disposal of waste.

Reference should be made to detailed guidance contained within the Approved Codes of Practice before removal begins to ensure that correct methods are being used and the appropriate precautions taken. In principle, these require :

- (A) The prevention of dust emission by careful choice of tools and work method, such as wet stripping techniques ;
- (B) Reducing exposure by dust control, for example by cutting asbestos containing materials at fixed locations on site where local exhaust ventilation can be provided economically ;
- (C) The containment by enclosure and the prevention of spread of asbestos from the workplace. Enclosure is particularly relevant to asbestos removal and will usually require the use of negative pressure equipment;
- (D) The correct use of protective clothing and respiratory protective equipment.

It should be noted that the use of water jetting to dampen asbestos prior to removal, for example on crocidolite insulating steelwork, will generate slurry which, unless contained, will dry out to form a dangerous dust. All contractors licensed to remove asbestos have been provided by the HSE with guidance on the successful application of wet stripping techniques.

4.1.4 HANDLING LOOSE POWDERS :

The loose powders most commonly found on construction sites are cement, gypsum and silica. Cement is present in concrete and mortar, gypsum is a constituent of cement and most plasters and silica is a common result of grit blasting, cutting, drilling, scabbling and polishing.

CEMENT contains calcium silicate, aluminium and iron compounds and small amounts of gypsum. In addition, there may be a variety of additives. Workers are most at risk during handling, for example when emptying and disposing of bags. The effects of exposure to cement dust include, in the short term, irritation of the nose and throat and possible difficulty in breathing. In the long term, chronic chest disorders may occur. It can also give rise to dermatitis.

Where assessment indicates the presence of a cement dust hazard, risks can be controlled in the following ways :

- (1) Increase the size of concrete pours to reduce the need for scabbling at construction and daywork joints ;
- (2) Design to fill joints rather than cut back oversize work ;

- (3) Handle cement bags carefully ;
- (4) Practise good personal hygiene.

GYPSUM is a naturally occurring mineral containing impurities such as anhydrous calcium sulphate, magnesium carbonate, silica, clay minerals and a variety of soluble salts. It can be manufactured synthetically, the impurities then depending upon the manufacturing process.

The effects of exposure to gypsum powders are relatively minor causing reversible health effects on the lungs and, in high concentrations, increased mucous flow in the nose and airways. Nevertheless, since the long term consequences are not yet fully understood, control of the possible risks should be practised by:

- (1) The use of pre-mixed plasters and masonry compounds ;
- (2) Careful handling ;
- (3) Use of personal protective equipment ;
- (4) Good personal hygiene.

CRYSTALLINE SILICA is present in sand, sandstones and granite and often in clay shale and slate. It also forms a constituent of a number of man-made products, such as concrete and mortar (see above).

Workers are likely to become exposed to silica when drilling, grit blasting, scabbling, stone and concrete cutting and during many demolition processes. The widespread use of portable power tools has greatly increased the level of risk when carrying out these activities.

All adverse health effects are to the lungs : progressive silicosis may result from exposure over long periods. In particular fibrosis, the hardening and scarring of the lung tissue, will result in severe shortness of breath, a condition which continues to worsen even after exposure has ceased.

Where assessment indicates the probable presence of the hazard, that is when concentrations of silica dust are likely to exceed 0.4 mg/cubic metre in an 8 hour Time Weighted Average (TWA), health surveillance should be carried out and control procedures introduced. These include :

- (1) Respecifying work to eliminate or reduce the hazard, for example by avoiding the need for stone cutting or scabbling ;
- (2) Using exhaust ventilated tools ;
- (3) Dampening work before or during cutting ;
- (4) The correct use of respiratory protective equipment.

4.1.5 CUTTING AND SANDING WOOD AND WOOD PRODUCTS :

The principal activities likely to produce high concentrations of wood dust in the construction industry include machining operations such as sawing, routing and turning, sanding by machine and by

hand and the use of compressed air lines to blow dust from workpieces.

The likely adverse effects of exposure include skin disorders, nasal obstructions, a type of asthma and occasionally in susceptible persons a form of nasal cancer.

A distinction is made between hardwood and softwood dusts. The former has been allocated a Maximum Exposure Limit (MEL) of 5 mg/cubic metre in an 8 hour TWA in Schedule 1 of the COSHH Regulations. Softwood dusts have not been allocated a MEL, but it is likely that a limit similar to hardwood will be prescribed in due course.

Assessment is usually subjective, but dust lamps can improve this. More precise methods are available, for example gravimetric determination.

Control involves the selection of alternative materials or processes, the provision of dust control equipment such as collection bags on tools and local exhaust ventilation and the proper maintenance of tools and equipment - ensuring cutter blades are kept sharp for example. If these methods are not sufficient to reduce exposure, personal protective equipment may be necessary.

4.1.6 HANDLING MAN MADE MINERAL FIBRES :

Man made mineral fibres (MMMF) may be divided into the following categories :

- (A) Mineral wools ;
- (B) Ceramic fibres ;
- (C) Special purpose fibres ;
- (D) Continuous filament fibres.

MINERAL WOOLS include such substances as glass wool, rock wool or slag wool, the differences depending upon the materials from which they are manufactured. Typical applications are in the thermal and acoustic insulation of buildings and in structural fire protection. The wools are often supplied as mats or blankets, although preforming is possible. CERAMIC FIBRES are usually of smaller diameter than mineral wools (2-3 micrometres). They are used mainly in insulation boards and blankets and, owing to their ability to withstand extreme heat (1000-1600 degrees C), in refractory products. SPECIAL PURPOSE FIBRES are little used in the construction industry, where their light weight is of less importance. CONTINUOUS FILAMENT FIBRES can be woven into cloths and find their construction industry applications in the reinforcement of cement and plastics products.

The health effects of MMMF are irritation of the skin and eyes and, in excessively dusty conditions, of the upper respiratory tract. Most people's skin becomes resistant after time, but some will need protective clothing or moving to other work. MMMF contain fibres of respirable length, but research into their possible carcinogenicity has proved inconclusive. Nevertheless, it is desirable to take precautions until the long term effects are established.

The COSHH Regulations assign a Maximum Exposure Limit to MMMF of 5 mg/cubic metre of total inhalable dust (gravimetric limit) and an Airborne Fibre Limit of 2 fibres/ml, both with an 8 hour Time Weighted Average. The limits are expressed in this way to allow for the differing types of airborne dust produced by the various forms of MMMF.

Assessment of risk should pay particular attention to the following

:

- (1) Location : the fixing of insulation in ducts and roof spaces for example, where ventilation is poor, is likely to result in higher exposure than when working in open shop conditions. It is also riskier to work with these materials above head height ;
- (2) Materials : pre-formed rigid sections, handled with care, will generate less dust than loose mats ;
- (3) Duration : inevitably, prolonged work with MMMF will result in greater exposure than short periods with the materials.

Tasks where special precautions may be necessary include the hand laying of mineral wool quilt, blowing mineral fibre into roof spaces and the cutting of mineral wools and ceramic products without dust suppressants. Careful specification can mitigate many of these problems or avoid them occurring in the first place.

Controlling the risks includes substitution with non-fibrous materials, coating products to seal the surfaces, the use of dust suppressants and the provision of local exhaust ventilation. Settled dust, waste and offcuts should be removed carefully ; an efficient way of removing dusts is by vacuuming.

4.1.7 SCABBLING CONCRETE :

Scabbling is the mechanical chipping by a machine tool of a formed concrete aggregate surface, the purpose being to produce a clean and sound interface for further structural bonding with concrete or other materials. The need for scabbling often results from the forming of daywork joints or the deliberate or accidental oversizing of components in order to achieve design tolerances.

Three principal hazards arise from the scabbling process : dust, noise and vibration. The dust nuisance stems from the grinding operation itself and from subsequent sweeping up. In a recent survey of several sites where scabbling was taking place in poorly ventilated environments, Time Weighted Averages of between 9 and 56 mg/cubic metre (the latter figure for sweeping) were being achieved against a COSHH limit of 10 mg/cubic metre. Since a major constituent of the dust is crystalline silica (see 4.1.4) and since exposures to this substance of 0.42 - 2.2 mg/cubic metre were found against a Maximum Exposure Limit of 0.4 mg/cubic metre, there is cause for concern.

In looking at any design where scabbling might be needed, the designer should consider whether it could be avoided altogether. Alternative strategies might be :

- (1) Redesigning tolerances to allow for infilling rather than cutting back oversize work ;
- (2) The use of bonding agents ;
- (3) Redesigning the concrete components themselves to effect interfaces without the need for grinding ;
- (4) The use of wet grit blasting for outside work.

If scabbling can not be avoided, the contractor will have to assess the dust risk and, if necessary, introduce control procedures. Attention should be directed to the scabbling tools themselves and to the better ventilation of workplaces. Tools should be fitted with dust bags and work surfaces pre-washed. Areas to be scabbled should be screened off to limit dust spread and residual dust vacuumed up rather than swept ; sweeping often generates far denser dust clouds than the scabbling operation itself.

4.1.8 DISTURBING DUST CONCENTRATIONS IN EXISTING STRUCTURES :

During demolition and refurbishment work to older buildings, it is likely that large concentrations of dust will be encountered during the pulling down of ceilings, the pulling up of infested floors and so on.

If it seems likely that a hazard will arise, the work should be assessed and appropriate measures taken to control risk. These may include the screening of the workplace, the dampening of work and the vacuuming up of dust concentrations. Where infestation may have occurred, it is particularly important to avoid the inhalation or ingestion of airborne spores and particles.

4.1.9 SWEEPING UP THE WORKPLACE :

To reduce the risk of accident, the workplace should always be kept tidy and this includes the removal of dust, for example from adjacent to portable saw benches and after the chasing of walls.

Control measures include screening, dampening and vacuuming.

4.1.10 CLEANING OUT DUCTS AND TRUNKING DURING COMMISSIONING :

A potential hazard exists in the possible distribution of dust round a new building via newly installed ducts and trunking, especially during the testing of fans and dampers. Apart from spreading dust to other parts of the building, the ducts themselves will require cleaning out prior to handover, a time consuming business.

Another possible cause of dust pollution at this stage of the work is the late chasing of walls as a result of last minute design changes. Where a dust creating activity is likely to occur, it is important to :

- (1) Decide whether the activity is in fact necessary : can another way be found of solving the problem ?
- (2) Blank off openings in adjacent ducts and trunking ;
- (3) Screen off the work area ;
- (4) Avoid operating any fans within the distribution network ;
- (5) Close dampers to isolate affected sections.

4.1.11 CARRYING OUT MAINTENANCE :

Many of the comments already made apply. Cleanliness is essential if maintenance is to be fully effective. Care should be taken to switch off fans and isolate areas where dust generation is possible. The risk of encountering carcinogenic substances, possibly as a result of normal wear, should be considered.

4.1.12 RUBBING DOWN LEAD PAINT :

A dust hazard exists where paint containing lead concentrations greater than 0.5% is used in new work or is stripped from old work during refurbishment. Particular care should be taken in buildings where the public still have access, such as schools. The problem is not only the generation of lead-containing dust during rubbing down, but also the crumbling of old leaded surfaces : children are prone to pick at window cills, for example, and ingest the resultant particles.

During maintenance, if the presence of old leaded paint is suspected, the workplace should be screened and paint particles vacuumed up. Replacement paint should either be 'low lead' (lead concentration of less than 0.5%), or be water soluble. The latter is greatly to be preferred.

4.2 NOISE :

Noise on construction sites results from the use of machinery used for demolition, piling and excavation and from plant such as compressors, concrete mixers and dumpers. Excessive, albeit short duration, noise results from the use of riveters and cartridge operated fixing tools. The nuisance or damage caused by noise is a function of type (quality) as well as loudness. Intermittent noise may be more disruptive than a continuous pattern and high pitched sounds are more disturbing than low pitched ones. Furthermore, noise repeated day after day can build up until hearing is damaged: the effect is cumulative.

4.2.1 ACTION LEVELS :

There is a statutory duty to control noise and to protect workers and other persons from its effects. General control is exercised through the Health and Safety at Work Act, but the Noise at Work Regulations, 1989, apply specific controls to the amount of noise permissible within the work environment, including construction sites. These, already referred to in Section 2, define three Action Levels :

A First Action Level of 85 dB(A)
A Peak Action Level of 200 Pascals
A Second Action Level of 90 dB(A)

Although the Second Action Level does not appear to be much louder than the First, this is not the case : the loudness scale is logarithmic, meaning, for example, that 90 dB is 10x the intensity of 80 dB and that an increase of 3 dB doubles the sound intensity. Exposure to noise, as with dust, is measured in terms of a Time Weighted Index : noise is averaged out over an 8 hour working day to give a personal daily noise exposure, the 'dose' being recorded as $L_{ep,d}$ or L_{eq} .

Both employers and employees have a duty to control noise. At First Action Level, employers must :

- (1) Have an assessment made by a competent person and keep records ;
- (2) Supply hearing protection to any employee who requests it ;
- (3) Ensure that all noise producing equipment is properly used and maintained ;
- (4) Give information and/or training on how to avoid damage to hearing, including the correct use of ear protectors.

Employees must :

- (1) Use any protective equipment provided and report any defects to the employer.

At or above Second Action or Peak Action Levels, employers must :

- (1) Have a noise assessment made by a competent person and keep records ;
- (2) Reduce the noise as far as is reasonably practicable by means other than ear protectors ;
- (3) Provide suitable ear protectors and ensure that they are worn ;
- (4) Designate an "ear protection zone" and identify the area with signs ;
- (5) So far as is reasonably practicable, ensure that anyone entering an ear protection zone is wearing ear protectors ;
- (6) Ensure that all equipment is properly used and maintained.

And employees must :

- (1) Properly use any ear protectors provided.

4.2.2 EFFECTS OF NOISE :

The effects of noise vary, from simple annoyance to damage to the inner ear and permanent loss of hearing. These are personal consequences, but communal as well as personal hazard results from an inability to hear shouted warnings and the fatigue which continual exposure to noise can induce.

The following examples illustrate the problem which noise can cause on construction sites (levels given are average at the operator's position, measured in dB(A)) :

Electric hand tools	95
Hammer drill	102
Dumper	103
Circular saw bench	107
Excavator	109
Ready mix lorry	112
Batching plant	116
Compressors and compactors	120
Diesel hammer : sheet piles	136

It should be noted that, under the Noise at Work Regulations 1989, manufacturers are required to provide data about the noise levels generated by their equipment if these are likely to be above First or Peak Action Levels. The actual amount of noise generated will also be affected by the manner in which the equipment is operated and its location on site.

4.2.3 METHODS OF CONTROL :

Before methods of control can be determined, where a noise hazard is likely to arise an assessment must be made by a competent person. The purposes of the assessment are to identify all workers likely to be exposed at or above First or Peak Action Levels and to provide sufficient information to enable the appropriate action to be taken. As a rough guide, an assessment of daily personal exposure is likely to be needed if people have to shout to be heard by someone standing 2 metres away. Assessments of peak pressure will be needed where workers are exposed to the effects of explosive tools and equipment, such as cartridge fixers and piling hammers. Noise exposure in the construction industry is particularly difficult to assess, since exposure levels vary throughout the working day as workers move from one workplace to another. Measurement in this environment should therefore be made over a longer period and averaged out - usually over the 8 hour working day. An effective way of doing this is by means of personal dosimeters. These are small devices carried on the person with a microphone close to the wearer's ear - possibly clipped to a safety helmet. Dosimeters are available which store data in a form which enables a time history graph to be printed out, thereby revealing unusually high or low levels.

Control of excessive noise often requires a combination of strategies. The first and most important is avoidance of the hazard in the first place. The designer, having become aware that a noise hazard may arise from a construction activity resultant from his design or specification, should review his decisions and consider whether an alternative assembly method could be adopted. For example, bored piles might be substituted for driven ones, or drilled and tapped holes for cartridge fixing. If a noisy activity is unavoidable, the following actions should be considered :

- (1) Carry out pre-assembly off site, where the hazard is easier to control ;
- (2) Undersize concrete to minimise the need for scabbling (allowing for the movement of the material during setting). This will require an accurate calculation of tolerances ;
- (3) Pre-form holes for services, especially through composite and in situ concrete floors ;
- (4) Specify noise reduced plant from hire firms or manufacturers ;
- (5) Pre-plan to reduce the need to :
 - drill, cut and chase concrete, including precast units and concrete blocks ;
 - grind steelwork to fit ;
 - operate noisy tools over long periods and/or in confined spaces.
- (6) Specify a requirement to satisfy noise standards in instructions to sub-contractors ;

- (7) Provide visual recognition of noisy plant by marking in an obvious place ;
- (8) Consider in detail ways of reducing noise from tools, plant and equipment. For example :
 - enclose hammer and pile heads in acoustic screens ;
 - use vibrating rather than driven tools ;
 - use a resilient dolly between hammer and pile head;
 - fit efficient silencers and exhausts to diesel driven machines ;
 - acoustically dampen compressor casings ; keep enclosure panels closed ;
 - keep saw blades sharp and clamp material whilst cutting ;
 - avoid specifying riveted fixings, for example by substituting high tensile steel bolts ;
 - surround noisy work with acoustic screens ;
 - seal leaks in air lines ;
 - plan site layouts so as to segregate noisy from quiet activities.

4.2.4 NOISE AND THE ENVIRONMENT :

In addition to the effects of noisy equipment upon building site operatives themselves, nuisance can be created in the neighbourhood. Environmental noise is controlled by the Control of Pollution Act 1974, which empowers local authorities to impose limitations both on noise levels and on working hours. The principal ways of controlling noise from construction sites include the use of quieter plant, of plant located away from sensitive areas and of acoustic screens and enclosures. Screens may be simply constructed, for example of 10mm plywood on scaffold frames so placed as to interrupt the line of sight between noise source and receiver. Finally, complaints can be much reduced if there is good communication between the site and the occupiers of nearby buildings, especially where night working is contemplated.

METHODS OF AVOIDING OR CONTROLLING DUST AND NOISE DURING THE ASSEMBLY PROCESS

The following analysis lists and codifies likely dusty and noisy activities during the assembly of a typical building. All relevant activities are noted, whether or not designers can make any input to a particular action. Where they can make an input to avoid or reduce the hazard the item is asterisked (*). It is assumed that risk assessments will be made where appropriate and that PPE will always be worn as a last resort.

ACTIVITY	HAZARD	METHODS OF AVOIDING
1 DEMOLITION : COMPLETE :		
By explosion or forced collapse	Large dust clouds, Flying particles,	Write method statement ; Inform adjoining owners ; Evacuate surrounding area if necessary ; Consider wind direction and speed ; Erect protective screens; Remove asbestos and other dangerous substances ;
Manual	Localised dust clouds, Noise	Inform adjoining occupiers ; Write method statement ; Erect protective screens ; Remove asbestos and other dangerous substances ;
2 DEMOLITION : PARTIAL :		
Shoring, propping, underpinning	Dust arising from cutting, drilling and excavation	Minimal dust risk ; Slight noise risk ;
Removing asbestos	Inhalation of dust	Appoint licensed contractor ; Write method statement ; Identify type/ assume not chrysotile alone; Estimate exposure duration ; Risk to others ; Air monitoring reports ; Steps to avoid spreading into surrounding area ; Methods of removal ; Emergency procedures ; Safe disposal of waste.
Removal of infested woodwork	Inhalation of spores	Identify type of infestation ; Dampen work ; Ventilate enclosed areas
Removal of dust within structure	Inhalation of possibly hazardous substances	Erect protective screens; Dampen if necessary ; Use vacuum extraction ;

Removal of chemical waste

If dry, may be a hazard by inhalation

Identify substances if unknown ;
Screen area ;
Extract using method appropriate to substance

3 SITE CLEARANCE :

- | | | | |
|-----|------------------|---|--|
| 3.1 | Remove topsoil | Noise from plant | Fit efficient silencer and exhaust ;
Keep enclosure panels closed ;
Advise neighbouring owner |
| 3.2 | Reduce levels | Dust from dry soils in still air conditions
Noise from plant | If practicable, work from upwind to downwind ;
Dampen soil ;
As 3.1 ;
*Fix datum levels to minimise cut and fill. |
| 3.3 | Vibro-compaction | Noise from plant
Noise from pile head | As 3.1 ;
Use acoustic screens ;
*Specify alternative consolidation method |

4 SUBSTRUCTURE : FOUNDATIONS :

- | | | | |
|-----|-----------------------|--|---|
| 4.1 | Excavate strip | Noise from excavators, dumpers, tipper lorries | As 3.1 ;
Correct handling of plant to avoid banging bucket, plan transport routes, etc. |
| 4.2 | Excavate raft | As 4.1 | As 4.1. |
| 4.3 | Piling | Noise impact on pile

Crane cables, guides, etc.
Noise from plant

Noise affecting surrounding buildings, streets, etc. | Screen site ;
Resilient dolly between pile and hammer head ;
Use of vibrating pile heads.
Align pile accurately on rig ;
As 3.1 ;
Use acoustic screens.
*Specify alternative foundation method :
- bored not driven piles ;
- diaphragm walls and ground anchors ;
- shaft and kentledge ;
- consolidation technique (3.3)
Advise neighbouring owner |
| 4.4 | Basement construction | Noise and dust during excavation
Noise from sheet piling

Noise from plant handling forms, reinforcement, concrete, etc. | Screen site ;
As 3.1 and 4.1 ;
Acoustically dampen piles
*Specify alternative methods of earth retention :
- bored not driven piles ;
- diaphragm walls and ground anchors.
Use modular forms ;
*Specify precast component |

4.5	Forms for columns	Noise from assembling	Use modular forms
4.6	Placing concrete	Dust from handling bagged cement or into batching plant ;	Handle carefully, including bag disposal ; If practicable, seal connections between bags or delivery vehicle and mixer/plant ; *Specify ready mixed concrete ; *Specify precast components Ensure sufficient space for concrete pumps.
		Noise from plant handling forms, reinforcement, concrete etc.	Locate fixed plant away from noise sensitive area Use electric rather than diesel powered motors on batching plant, cranes ; Advise neighbouring owner if night working necessary.

5 SUBSTRUCTURE : WORK TO DPC LEVEL :

5.1	Building brick/block walls	Dust from handling bagged cement ; Dust from cutting bricks and blocks with high speed tools Noise from mortar mixer and high speed tools	Handle carefully, including bag disposal ; *Design to brick/block modules ; *Specify pre-mixed mortar As 3.1 ; *Specify as for 'dust' ;
5.2	In situ concrete walls	As 4.6 Noise from plant handling forms, reinforcement, concrete, etc.	As 4.6 ; Use modular forms ; *Specify precast components
5.3	Holding down bolts for frames	Dust from drilling Noise from drilling	*Specify cast-in rather than post-drilled ; As above

6 GROUND FLOORS :

6.1	Compacting ground and hardcore	Noise from compactor	Use roller rather than plate compactor ; As 3.1 ;
6.2	Placing in situ concrete	Noise from poker vibrator and vibrating beam tamper	As 3.1 (compressor) ;
6.3	Power floating and trowelling ; Early grinding	Noise from motors	Screen working areas ; use PPE ; Advise L.A. and neighbouring owners if night working necessary ; *Specify levelling screed
6.4	Forms for rafts and in situ slabs	Noise from assembling	Use modular forms.

6.5	Assembling and placing reinforcement cages	Noise from cranes	Use electric powered fixed cranes ; Avoid unsocial hours when using mobile cranes ; Locate cranes where screened by existing buildings.
6.6	Assembling timber ground floors	Noise from cutting timber lengths and sheets	Screen portable saw benches ; Adjust and sharpen blades Clamp timber tight ; Prefabricate off site ; *Specify correct sections
6.7	Assembling precast concrete floors	Noise from cranes	As 6.5 ; *Specify components correctly to avoid on site cutting
7	SUPERSTRUCTURE : EXTERNAL WALLS :		
7.1	Building brick/block walls	As 5.1	As 5.1
7.2	In situ concrete walls	As 4.6 Noise from plant handling forms, reinforcement, concrete, etc.	As 4.6 As 3.1 ; Use modular forms ; *Specify precast component
7.3	Stone walls	Dust from cutting	Fit dust bags to power saws ; Dampen work ; Cut in well ventilated areas ; Provide local exhaust ventilation ; *Specify in pre-cut sizes
7.4	Timber panel walls	Noise from cutting timber lengths and sheets. Noise from assembling : cranes, nailing, etc.	As 6.6 ; As 6.5 *Design panels for manual assembly ; Avoid unsocial hours.
8	SUPERSTRUCTURE : FRAMES :		
8.1	Erecting steel or precast concrete frames	Noise from cranes Noise from drilling, cutting and grinding to fit	As 6.5 ; Ensure accurate fabrication before delivery ; Assemble in correct sequence ; Plumb and align carefully
8.2	Casting in situ concrete frames	As 4.6	As 4.6

8.3	In situ casing of steelwork	As 4.6 Noise from assembling forms	As 4.6 Use modular forms ; Use steel forms ; Maximise use of forms *eg by designing to minimise variations in component sizes.
8.4	Placing concrete in forms	Noise from crane/pump and poker vibrator	As 6.5 and 3.1
8.5	Cladding system	Noise from crane Noise from cutting and grinding metal lengths, brackets and fixings	As 6.5 Screen working area ; *Specify accurate sizes ; *Specify built-in fixings.
9	SUPERSTRUCTURE : UPPER FLOORS :		
9.1	Assembling timber floors	Noise from cutting timber lengths, sheets and boards Noise from assembling : cranes, nailing, etc.	As 6.6 As 6.5 *Specify modular panels ; Prefabricate off site ; Avoid unsocial hours.
9.2	Steel/concrete composite floors	Lifting and placing steel sections Noise from cutting steel to fit round columns, for openings, etc. Noise from plant handling forms, reinforcement, concrete.	As 6.5 *Anticipate needs during design ; Prefabricate off site, code and deliver in sequence for assembly. *Specify ready mixed concrete ; Locate fixed plant and concrete pump away from noise sensitive areas ; Operate and maintain pump correctly.
9.3	In situ concrete floors	As 9.2 (concrete) Noise from assembling forms Noise from poker vibrator and vibrating beam tamper ; Power floating and trowelling ; Early grinding	As 9.2 (concrete) ; *Specify precast concrete components ; Use modular forms ; As 3.1 (compressor) ; As 6.3
9.4	Precast concrete	Noise from cranes Noise from plant handling concrete topping	As 6.5 *Specify components correctly to avoid on site cutting As 9.2 (concrete) ;

10 SUPERSTRUCTURE : ROOFS :

10.1	Assembling timber pitched	Noise from cutting timber lengths and sheets (sarking) ;	As 6.6
		Noise from cranes	As 6.5
		Dust from cutting tiles	Dampen work ; Fit dust bags to power saws and grinders ; *Specify to tile modules
		Noise from cutting tiles.	As for dust
10.2	Steel pitched, including fixing profiled metal sheeting	Noise from cranes ; Noise from drilling, cutting, grinding to fit.	As 8.1
10.3	Timber flat	Noise from cutting timber lengths, boards ;	As 6.6
		Noise from assembling : cranes, nailing	As 6.5 *Specify modular panels ; Prefabricate off site ; Avoid unsocial hours.
10.4	Concrete flat (in situ)	Noise from assembling forms Noise from poker vibrator and vibrating beam tamper	Use modular forms. As 3.1 (compressor) ; *Specify precast concrete components.
10.5	Concrete flat (precast)	Noise from cranes	As 6.5 *Specify components correctly to avoid on site cutting.
		Noise from plant handling concrete topping.	As 9.2 (concrete).

BUILDING ENCLOSED :

At this stage, with roof finishes at least partially in place and doors and windows installed, the building is enclosed. Thus far, apart from activities such as handling cement and cutting tiles, noise rather than dust has been the principal hazard, especially in relation to surrounding areas. From now on, however, both can present much greater risks to workers inside the growing building.

11 SUPERSTRUCTURE : PARTITIONS :

11.1	Building brick/block partitions	Dust from handling bagged cement	Handle carefully, including bag disposal ; *Specify pre-mixed mortar
		Dust from cutting blocks with high speed tools	Fit dust bags to tools ; Locate saw benches in well ventilated areas ; Fit local exhaust vent'n. *Design to brick/block modules.

	Noise from cutting blocks with high speed tools	Avoid cutting in confined spaces ; *Design to brick/block modules ; *Specify timber or metal stud or proprietary partitions ; *Specify blocks cut off site.
11.2	Timber stud	
	Dust from cutting timber lengths	Fit dust bags to tools ; Locate saw benches in well ventilated areas ; Fit local exhaust vent'n. *Specify metal stud or proprietary partitions.
	Noise from cutting timber lengths, nailing.	Avoid cutting in confined spaces ;

12 SERVICES : FIRST FIX :

12.1	Piped services, sprinkler systems, plumbing, etc.	Dust from chasing and drilling masonry walls, concrete floors and ceilings	*Design service routes and ducts/openings to avoid need for chasing ; *Specify stand-off finishes to permit surface fixing ; Fit dust bags to power tools ; Screen areas ; Dampen surfaces where practicable, especially when sweeping up.
		Noise from chasing and drilling	*Design amnd specify as for dust ; Avoid using cartridge fixers in confined spaces
		Dust and noise from notching and drilling timber, cutting and drilling metal pipes and sheets	*Design and specify as above
12.2	Electrical services, conduit, wiring, etc.	As 12.1	As 12.1
12.3	Installing metal trunking	Dust from drilling masonry walls, concrete floors and ceilings	*Specify built in fixing points ; Fit dust bags to tools ; Screen areas ; Dampen surfaces when sweeping up.
		Noise from drilling for fixings	*Specify as for dust ; Drill and tap rather than use cartridge fixers.

13 JOINERY : FIRST FIX :

13.1	Fixing wall linings, noggings, battens, grounds, door frames and casings	Dust from cutting timber lengths	As 11.2 ; *Specify alternative lining methods and doorsets ;
		Noise from cutting	As 11.2 ; *Specify as for dust.

13.2	Installing insulants	Dust from man-made mineral fibres caused by cutting, blowing and placing in confined spaces	*Specify rigid sheets rather than soft mats or blown fibre ; Cut sheets in well ventilated areas ; Provide local exhaust ventilation ; Screen areas ; Blank off ducts and trunking.
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14 PLASTERING, RENDERING AND DRY LINING :

14.1	Wet plastering	Dust containing gypsum from handling bagged plaster mixes	Handle carefully, including bag disposal ; Mix in well ventilated spaces.
14.2	Plasterboarding	Dust from cutting boards	*Specify modular sizes where practicable ; Use sharp tools ; Cut in well ventilated spaces.
14.3	Exterior rendering	As 14.1	As 14.1

15 SERVICES : SECOND FIX :

15.1	Commissioning air conditioning systems	Distribution of dust through system whilst carrying out dust creating activities, including sweeping up	Blank off terminals and dampers ; Do not run fans ; Screen areas ; Programme work carefully *Avoid last minute design changes.
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16 JOINERY : SECOND FIX :

16.1	Fixing skirtings, architraves, window boards, etc.	Dust from cutting timber lengths	As 11.2 ; *Specify pre-moulded sections, eg plastics or metals.
		Noise from cutting	As 11.2 ; *Specify as for dust.

17 TILING AND DECORATION :

17.1	Laying floor and wall tiles	Dust from cutting tiles	*Specify/design to tile modules.
17.2	Applying paints and stains	Lead dust and particles from rubbing down old work and undercoats	*Specify low-lead or water soluble paints ; *Specify pre-primed or pre-finished components ; Screen areas ; Sweep up carefully.

18 EXTERNAL WORKS (SELECTED) :

18.1	Building brick/block screen walls	As 5.1	As 5.1
18.2	Laying concrete pavements	As 4.6	As 4.6
18.3	Laying paving slabs, tiles and kerbing	Dust from cutting stone and concrete	*Design to paving and tile modules ; Dampen work ; Fit dust bags to power tools and grinders.
		Noise from cutting	*Specify as for dust ; Avoid unsocial hours.

19 OTHER ACTIVITIES :

19.1	Scabbling concrete	Dust from scabbling tools	*Specify sizes to avoid having to cut back or roughen concrete ; Dampen work ; Screen areas ; Sweep up carefully or vacuum.
		Noise from same	*Specify as for dust ; Screen areas.
19.2	Maintenance	Dust from cleaning out ducts and trunking	As 15.1 ; Clean out in sections ; Programme work to minimise risks to occupiers ; *Design ducts and trunking to make sectional cleaning easy.
		Dust and particles from rubbing down lead painted surfaces	As 17.2 ; Programme as above ; *Specify low lead or water soluble paints and stains.
		Dust from cleaning up after maintenance work	Dampen area ; Screen area ; Vacuum rather than sweep Programme as above.
		Noise from cutting out and replacing, especially in confined spaces	If reasonably practicable remove complete sections and renew faulty parts elsewhere ; *Design to permit easy access.

PERSONAL PROTECTIVE EQUIPMENT

Although the design team will not be responsible for the decision to require workers to wear personal protective equipment whilst engaged in dusty or noisy activities - this is the responsibility of the principal contractor and relevant subcontractors after carrying out the appropriate assessment - designers should be aware of the implications if hazards can be neither avoided nor controlled. Since all protective equipment restricts the wearer to some extent and since, even with conscientious use, failure of equipment can occur, it should be remembered that its use is the last line of defence after it has proved impossible either to avoid the hazard or to control the resulting risks adequately.

DUST :

Those specifying Respiratory Protective Equipment (RPE) are required to make reference to BS 4275 : 1974, 'The selection, use and maintenance of respiratory protective equipment' and to use only that equipment which carries the HSE's Certificate of Approval (Respiratory Protective Equipment) F2486, published annually.

The selection of the type of equipment appropriate to the hazard should be made by a competent person with regard to the following factors :

- (1) Nature of the hazard and materials ;
- (2) Assessed dust concentrations ;
- (3) Period of exposure ;
- (4) Wearer's field of vision ;
- (5) Provision for communication ;
- (6) Mobility in confined spaces ;
- (7) Weather conditions ;
- (8) Suitability for individuals and circumstances such as thermal environment.

The specifier can call upon the following array of equipment, in order of complexity and therefore, usually, cost :

- (A) Disposable face mask respirators ;
- (B) Half mask dust respirators ;
- (C) Positive pressure powered respirators ;
- (D) High efficiency dust respirators ;
- (E) Ventilated visor and ventilated helmet respirators ;
- (F) Compressed airline breathing apparatus ;
- (G) Self contained breathing apparatus.

Whichever of these types is chosen, it is essential that it is the correct one for the circumstances. For example, dust respirators will protect only against dusts, not against toxic gases. The specific types of dust are also relevant. The general properties of the types are as follows :

- (A) Disposable face mask respirators are simple face masks designed to filter out harmful dust and particles. They are lightweight and cheap. They must not be worn for long periods (over eight hours), nor by more than one person.
- (B) One of the commonest respirators is the half mask dust type. It consists of a face mask containing a filter covering both nose and mouth. Its advantages are low cost, simple maintenance and freedom of movement for the wearer. The filters may be colour coded to indicate the type of contaminant they will protect against and will be stamped with a 'protection factor' (relative levels of dust inside and outside the mask).
- (C) Positive pressure powered respirators are designed for use in particular environments, especially where lengthy exposure is envisaged. The air supply to the wearer is by means of a battery operated pump and filter unit.
- (D) High efficiency dust respirators provide full facial protection. Air is drawn through the filter system by inhalation and both proper fitting and regular maintenance are essential.
- (E) Ventilated visor and ventilated helmet respirators : with this equipment, a small fan in the back of the helmet draws in dust laden air through a series of filters in the crown of the helmet. The filtered air passes downwards over the user's face, maintaining positive pressure in the area of the mouth and the nose. An incidental advantage of this type is that dust protection is combined with protection to the head, face and eyes.
- (F) With compressed airline breathing apparatus, air is supplied to the user via a hose to the mask. The supply air must be pure and optimum air pressure, temperature and humidity must be maintained. The air hose can restrict the wearer's movements in some working environments.
- (G) Finally, in self-contained breathing apparatus, air is supplied from compressed air cylinders carried on the back. Use of such equipment is highly specialised : the competent person should be fully conversant with the equipment and the user be fully trained.

The limitations imposed by protective equipment can be onerous. Workers wearing beards or spectacles should be provided with RPE which does not require a face seal. Heat stress can be a factor in high ambient temperatures or when clothing is fully sealed. Freedom of movement should also be considered. For all equipment, appropriate operator training is needed.

NOISE :

Where it is impossible to avoid a noise hazard or to control the risks arising from it sufficiently, workers are required under the Noise at Work Regulations to wear ear protectors. The trigger points are when noise levels remain at or above Second Action or Peak Action levels (Section 4.2). As with dust masks, ear protectors are only to be used when it has proved impossible to attenuate the noise by any other means.

One reason for this is that workers may be reluctant to adopt ear protection : some forms can be intrusive and inconvenient. Nevertheless, it is essential for the principal contractor and subcontractors to drive home to their operatives that their hearing is imperilled, possibly permanently, if they fail to use the appropriate equipment. One way of countering this reluctance, apart from enforcement, is by training, especially of new workers during their safety induction course. Another is to create a positive site attitude towards safety in general, which will then make enforcement much easier.

In those parts of the site or workshop where Second or Peak Action Levels are likely to be reached, an Ear Protection Zone must be delineated. Special signs will be erected and all persons entering the zone must be equipped with and wearing ear protection. It should be noted that, at First Action Level, employees have the option to wear ear protection and employers have a duty to provide such protection if asked to do so.

There are a number of important points affecting the selection and use of ear protectors :

- (1) They should be provided on an individual basis ;
- (2) They should be supplied and fitted by a trained person ;
- (3) They should be regarded only as an interim measure, pending some better solution to the problem ;
- (4) Workers should be trained in their use ;
- (5) They should be suited to both the user and the type of noise ;
- (6) They must provide a tight seal against the head ;
- (7) They should be stored in a clean place when not in use ;
- (8) They should be inspected regularly for deterioration or damage ;
- (9) They should be replaced when necessary.

There are two basic types of ear protector, the disposable ear plug and the ear muff.

- (A) Ear plugs : Made of very fine mineral fibre, polythene and dense plastic foam, sometimes pre-shaped. They should be inserted correctly and, once removed, should not be re-used. Cleanliness is essential for optimal performance. Reusable types of plug are available made of rubber or plastic. Different sizes may be required for each ear, they must be a good fit and be clean, since dirt can cause irritation.

- (B) Ear muffs : these completely cover the ear and are sealed to the head by means of a foam or liquid filled seal. Badly designed or fitted muffs will give little or no protection. Muffs should be matched to the different sizes and shapes of wearers' heads, to differing hair styles and to whether or not spectacles are worn. Helmet mounted muffs may not fit the ear tightly, or may move as the helmet moves on the head. Muffs should be chosen to meet the particular noise risk : a type good at countering low frequencies may be much less effective against high ones.

Three other points should be borne in mind with regard to ear protectors :

- (1) Where hazard warning signals are likely to be given, for example by cranes or reversing vehicles, either the protectors should permit the signals to be heard or the signal itself should be changed. It is not acceptable to remove protectors in order to hear signals or shouted warnings.
- (2) Ear protectors are only effective when they are being used : if protectors are worn for only 50% of an 8 hour shift, only some 10% protection is gained ; if for $7\frac{1}{2}$ hours out of 8, only 75%.
- (3) Muffs are much more visible to the casual inspecting eye than plugs. Their use in an ear protection zone can therefore be more easily verified.

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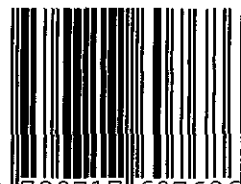
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